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SIR GEORGE SIMPSON, K.C.B., C.B.E., D.Sc., LL.D., F.R.S.

It is with deep regret that we report the death of Sir George Simpson on 1 January 1965, at the age of 86. He was Director of the Meteorological Office from 1920 to 1938.

George Clarke Simpson was born at Derby in 1878 and was educated at the Diocesan School, Derby, and the Victoria University of Manchester, where he graduated in physics. In 1903 he gained an '1851 Exhibition' and went to study at Göttingen. During this period he also investigated atmospheric electricity in Lapland. On his return to England he became lecturer in meteorology at Manchester and in 1906 was awarded the D.Sc. of that university. In the same year he left England to join the India Meteorological Department in whose service he remained until 1920 except for a two-year absence with Scott in the Antarctic between 1910 and 1912. Here he was engaged as physicist and meteorologist and the work that he did then, ensured that he will always be remembered as one of the pioneer meteorologists of Antarctica. He was elected to the Royal Society in 1915.

In 1920 he succeeded Sir Napier Shaw as Director of the Meteorological Office. The decision had been taken to unite all the meteorological services that had been formed in the war into one service within the Air Ministry, and to Dr. Simpson (as he then was) fell the formidable task of carrying out this policy. At this time one need was paramount—to shape the official meteorological services so that the rapidly growing needs of aviation, both military and civil, could be met. It was here that Simpson's skill as an administrator became evident and when, one year after his retirement, the Second World War began, the Office was able to expand rapidly into the very large organization needed to cope with the demands of the armed forces, especially the RAF, during the years of conflict. He returned to the Meteorological Office in 1939 to take charge of the Observatories, a task very much to his liking, and finally retired from active work in 1946, at first to Putney and later to Somerset.

Of Simpson's scientific work more will be written, no doubt, in memoirs elsewhere and here only a brief summary can be given. His name will always be associated with the theory of charge separation in thunderclouds. The Simpson theory, which was based mainly upon the concept that electrification of thunderclouds is produced mainly by the break-up of drops and by collisions and friction between ice crystals, was long a matter of keen debate among meteorologists, especially when contrasted with rival theories, such as the ion-capture process advanced by C. T. R. Wilson. Simpson's work on thunderstorm theory forms a notable chapter in the history of meteorology.

Another memorable piece of work was his analysis of the radiation balance between the sun and the earth. Mathematically, the problem is almost intractable because of the complex nature of the water-vapour absorption spectrum in the infra-red. Simpson overcame these difficulties by physical insight, adopting a bold simplification of the spectrum into opaque, transparent and semi-transparent bands that enabled him, by simple planimeter measurements, to account quantitatively for the main features of the balance. Finally, mention must be made of his preoccupation in later years with past climates, culminating in his 1959 paper in the *Quarterly Journal of the Royal Meteorological Society* on world temperatures in the pleistocene, a remarkable feat for a man over 80 years of age.

During his 18 years as Director, Sir George not only created an efficient organization but gave considerable attention to the social activities of the Office, especially in sport. He also did much valuable work in the international field and was a well-known figure in the International Meteorological Organization.

He married, in 1914, Dorothy Stephen of Sydney, Australia, and they had three sons and one daughter. To Lady Simpson and the family we send our sincere condolences on their loss.

O. G. SUTTON

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THE STANDARD ERROR OF A SEA SURFACE TEMPERATURE AS MEASURED USING A CANVAS BUCKET

By M. W. STUBBS

Summary.—From 492 canvas bucket observations of sea temperature obtained on voyage six of *Weather Surveyor* in 1962, the standard error of a single observation was deduced, with 95 per cent confidence limits to be 0.202 ± 0.013°F (0.112 ± 0.007°C). This is an upper limit to the instrumental error since it was impossible from the data to separate the instrumental error from the small spatial and temporal fluctuations of the sea temperature; a complete programme of paired observations is required before these latter errors may be separated from the instrumental errors.

Introduction.—The measurement of sea surface temperature from the British Ocean Weather Ships is by means of a canvas bucket when the ship is 'on station' and an insulated bucket when she is 'under-way.' An estimate of the accuracy of the measurements using the canvas bucket is desirable. Provided the errors are normally distributed, the root mean square error or the standard error is a convenient measure of the accuracy since two-thirds of the errors lie in the range plus or minus the standard error. Sufficient data were obtained on voyage six of *Weather Surveyor* in 1962 to define an upper limit to the standard error; *Weather Surveyor* was on station 'Juliet' during voyage six.

Errors in the measurement of the sea surface temperature.—The sea surface temperature is obtained by lowering the canvas bucket into the water over the stern of the ship; it is hauled back on board and the thermometer is placed in the water in the bucket; after about half a minute the thermometer is read.

Ashford[1] has discussed the errors that can arise in this temperature due to the ambient wet-bulb temperature being different from the sea temperature. During voyage six the wet-bulb temperature was, on average, 2.27°C lower than the observed sea temperature; from Ashford's results this deficit would result in an average fall of temperature of water in the bucket of 0.01°C per minute, whilst the largest deficit of 6.9°C would have resulted in a fall of 0.04°C before the thermometer was read. These values are an order of magnitude lower than the standard error found below but may be regarded as a systematic error in the bucket temperature if no correction is applied to the readings.

Although the instrumental error is of interest in this note, local temporal and spatial fluctuations of sea surface temperature can result in the observed value not being a true representation of the sea surface temperature. Åmot[2], for example, has discussed the heating effect of the hull of the ship, especially when the sun is shining; he found that the sea temperature can be raised in such conditions by 0.1° to 0.3°C from its initial value up to a distance of 10 metres from the hull of the vessel.

Stevenson[3] has described how the bucket temperature may be lower than its representative value because of the effect of wind on the hull of a ship; the wind can cause upwelling of water from the region of the keel of the vessel on the lee side. This effect is most marked if there is a definite temperature gradient in the upper layer of the sea. According to Stevenson the fall of temperature associated with this effect can amount to 0.5°F (0.3°C).

Marked inhomogeneities of temperature also exist in the open sea. These can be caused by several factors, changing winds, turbulent overturning and the effect of ocean currents being a few possible causes. The standard error deduced below includes all these errors and may therefore be considered as an upper limit to the instrumental standard error of the method.

The standard error of a bucket observation.—The bucket temperature θ_n measured at hour n may be written in the form:

$$\theta_n = T_n + F_n + e_n \qquad \ldots (1)$$

where T_n is the representative temperature of the water, F_n is the magnitude of the errors due to the small local fluctuations of temperature and e_n is the magnitude of the errors due to the instrumental errors. The observed temperature j hours later, θ_{n+j}, can be written as:

$$\theta_{n+j} = T_{n+j} + F_{n+j} + e_{n+j}. \qquad \ldots (2)$$

On subtracting (1) from (2) and squaring both sides of the new equation, then summing over all the pairs of temperature measurements j hours apart:

$$\Sigma(\theta_{n+j} - \theta_n)^2 = \Sigma(T_{n+j} - T_n)^2 + \Sigma F^2_{n+j} + F_n^2 + \Sigma e^2_{n+j} + \Sigma e^2_n + \ldots \text{cross terms} \qquad \ldots (3)$$

Now $\Sigma F^2_{n+j} \simeq \Sigma F^2_n$ and $\Sigma e^2_{n+j} \simeq \Sigma e^2_n$. It can also be shown that there is little or no relation between T, F and e, thus the cross terms may be neglected. Dividing (3) by N_j, the number of pairs of observation j hours apart, gives

$$\frac{\Sigma(\theta_{n+j} - \theta_n)^2}{N_j} = \frac{\Sigma(T_{n+j} - T_n)^2}{N_j} + 2s^2 \qquad \ldots (4)$$

$$\text{where } s^2 = \frac{\Sigma F_n^2 + \Sigma e_n^2}{N_j}$$

Now $N_j = N - j$ where N is the number of observations, so that when $j = 0$;

$$s^2 = \frac{\Sigma F_n^2 + \Sigma e_n^2}{N}$$

i.e. s^2 is the variance due to local spatial fluctuations of the sea temperature and the instrumental errors.

In equation (4) when $j = 0$ the term $(T_{n+j} - T_n)^2/N_j$ vanishes and

$$\left[\frac{\Sigma(\theta_{n+j} - \theta_n)^2}{N_j}\right]_{j=0} = 2s^2 \qquad \ldots (5)$$

The term on the left cannot easily be measured and, in fact, pairs of observations were not made but the graph of $\Sigma(\theta_{n+j} - \theta_n)^2/N_j$ against j can be constructed, and a value for the left-hand term obtained by extrapolation assuming that the graph is linear. In equation (4) the differences between pairs of temperatures may be expected to increase with increasing values of j whilst the term in s^2 is likely to remain almost constant.

Results.—On voyage six, 492 hourly observations of sea surface temperature were obtained between 1200 GMT on 27 August and 0000 GMT on 17 September 1962. The term $Y = \Sigma(\theta_{n+j} - \theta_n)^2/N_j$ was computed for the values of j from one to six, and the straight line which best fits the observations is shown in Figure 1. The equation of the line was found (the regression of Y on j) and the

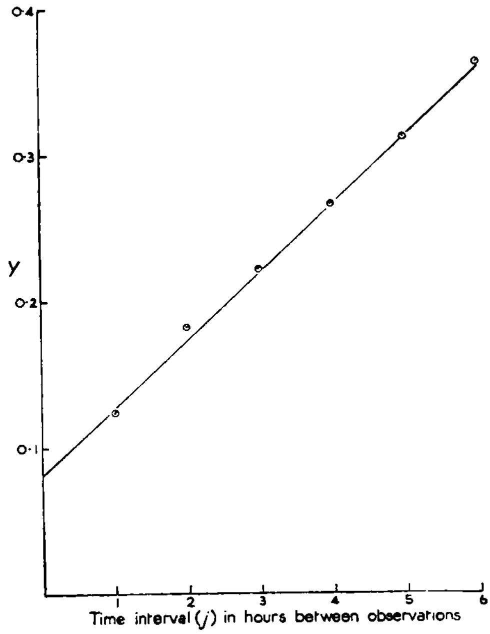

FIGURE 1—GRAPH OF Y AGAINST j

Graph of $Y = \Sigma\, (\theta_{n+j} - \theta_n)^2/N_j$ as a function of j.

calculated intercept on the Y-axis was 0.08166, this being the estimate of $2s^2$ (see equation (5)). Thus the standard error s of a bucket observation was found to be 0.202°F (0.112°C). The 95 per cent confidence limits of this standard error were ± 0.013°F (0.007°C).

The accuracy of a bucket temperature is thus sufficient to reveal fluctuations of sea surface temperature of 1° or 2°F over periods of one or two days. Fluctuations of this magnitude do occur as can be seen in Figure 2 which shows some

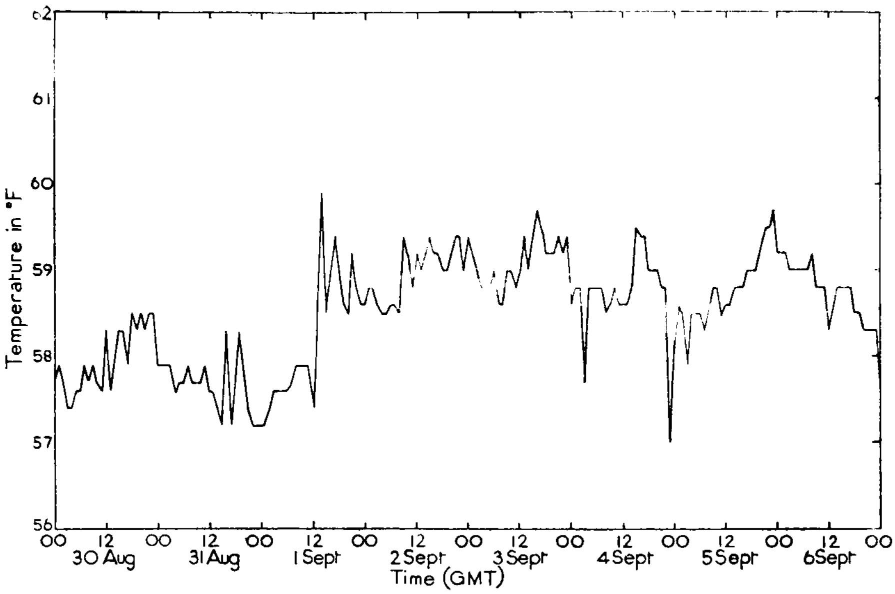

FIGURE 2—SEA SURFACE BUCKET TEMPERATURES MEASURED AT HOURLY INTERVALS BETWEEN 0000 GMT ON 30 AUGUST AND 0000 GMT ON 7 SEPTEMBER DURING VOYAGE SIX OF WEATHER SURVEYOR IN 1962

of the hourly values of sea temperature on voyage six. These fluctuations may be caused by several factors; the cloudiness, the speed, direction and fetch of the wind are a few possible causes.

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A NOTE ON EQUIVALENT TAILWINDS ON THE GREAT-CIRCLE ROUTE PRESTWICK TO MONTREAL

By R. E. S. McGAIN

Introduction.—In planning flying services on air routes there is a need for information concerning the effect of wind at the chosen flight level. The aircraft operator is primarily interested in the expected duration of the flight and thus the frequency of headwinds or tailwinds over the route is important. It has been found convenient to produce statistics in the form of equivalent headwinds (or tailwinds) over a route.[1,2,3] The equivalent tailwind over a route may be defined formally as that wind which blowing uniformly along the track of an aircraft in a direction similar to the direction of the flight would result in the same duration of flight as required by the actual system of winds.[1]

This note examines statistics of actual and forecast equivalent tailwinds (as found from routine working charts) over the great-circle route Prestwick to Montreal (2700 n.miles) at 500 mb and 300 mb during the period January 1961 to October 1963 inclusive.

Method of measurement.—From January 1961 to March 1962 inclusive the forecast charts were composite-time charts with a time difference between Prestwick and Montreal of nine hours (assuming an airspeed of 300 knots), and valid for departure from Prestwick during six-hour periods, 0000–0600 GMT, etc. From April 1962, 300 mb charts were drawn using the 1000 mb pattern combined with the 1000–300 mb thickness pattern. In the earlier period 300 mb charts had been constructed from the 500 mb contour pattern and the 500–300 mb thickness pattern.

A transparent template marked with the great-circle track was used for measuring the tailwind components. This track was divided into 10 equal sections with a pair of points marked at the mid-point of each section, the points being spaced 100 n.miles on either side of the track. This distance was chosen so that a difference in contour height of 200 feet or 60 metres between the points was equivalent to a tail component of 20 knots (chart scale being taken as constant throughout the route). When making the measurements the number of contour lines between each pair of points was counted and the sum of the 10 counts multiplied by two to give the tail component along the route. The effect of the beam component was calculated by counting the number of contour lines crossed by the great-circle track, and converting this value into a beam component (using prepared tables) and then into an equivalent tail component. This, added to the tail component, gave the equivalent tailwind (ETW).

The calculated components were plotted against date and time on a graph, the successive 'actual' values (at 0000 GMT and 1200 GMT) being joined by straight lines. The forecast values were unjoined and, with the introduction of fixed-time charts, were plotted at times corresponding to these charts.

With the earlier, composite-time charts, the time chosen for the plot was four and a half hours after assumed departure (the mid-time of the period of validity), e.g. the value calculated on the forecast chart of validity 0600–1200 GMT was plotted at 1330 GMT.

The time difference between the forecast components and the upper air data on which they were based varied between 19½ and 26 hours. The assumption was made that the actual ETW varied during a 12-hour period so as to lie on the straight line joining successive plots and errors were calculated from these assumed values.

Frequency distribution of errors.—A positive error in the forecast values is one in which the forecast component is less than the head component or greater than the tail component calculated from actual charts. In the calculations the errors were grouped in 5-knot bands against 10-knot bands of actual ETW's. The errors arising from the method adopted are discussed by Harley[4] on whose paper this note is based. Table I (*a*) and (*b*) shows the seasonal distribution of errors during the period, and Table II (*a*) and (*b*) shows for each season the means and standard deviations of the actual ETW's.

The mean errors in Table I are mostly small and the majority are positive, i.e. the headwind component tends to be underestimated. The values of the mean errors vary erratically except in winter at 500 mb. For the whole period the mean error at 500 mb was 0.3 with a mean standard deviation of 9.0 while the mean error at 300 mb was 0.7 with a mean standard deviation of 12.0.

TABLE I—ERRORS IN FORECAST EQUIVALENT TAILWINDS (*a*) AT 500 MB AND (*b*) AT 300 MB

Season	Year	(*a*) Mean of errors	(*a*) Standard deviation from actual	(*b*) Mean of errors	(*b*) Standard deviation from actual
		knots		*knots*	
Winter	1961*	0.2	11.2	1.7	12.4
(Dec., Jan., Feb.)	1962	0.3	10.3	−1.5	13.2
	1963	0.3	10.0	−0.1	12.8
Spring	1961	−0.5	8.7	2.6	12.0
(Mar., Apr., May)	1962	0.6	8.6	0.7	11.6
	1963	0.8	8.4	0.3	11.4
Summer	1961	1.3	7.9	1.4	11.6
(June, July, Aug.)	1962	0.1	7.1	−0.5	10.2
	1963	−0.9	7.3	0.3	9.7
Autumn	1961	0.9	9.3	1.1	10.8
(Sept., Oct., Nov.)	1962	0.6	8.3	−1.5	13.6
	1963†	2.0	9.3	1.0	15.0

*Winter 1961 refers to January and February only.
†Autumn 1963 refers to September and October only.

TABLE II—ACTUAL EQUIVALENT TAILWINDS (*a*) AT 500 MB AND (*b*) AT 300 MB

Season	Year	(*a*) Mean ETW	(*a*) Standard deviation of ETW	(*b*) Mean ETW	(*b*) Standard deviation of ETW
		knots		*knots*	
Winter	1961*	−23	14	−35	16
(Dec., Jan., Feb.)	1962	−31	24	−45	29
	1963	−22	21	−35	25
Spring	1961	−15	15	−25	20
(Mar., Apr., May)	1962	−11	23	−24	24
	1963	−20	18	−28	21
Summer	1961	−32	10	−46	16
(June, July, Aug.)	1962	−14	16	−32	20
	1963	−20	12	−30	16
Autumn	1961	−32	15	−43	19
(Sept., Oct., Nov.)	1962	−29	15	−42	20
	1963†	−39	17	−57	20

*Winter 1961 refers to January and February only.
†Autumn 1963 refers to September and October only.

At 500 mb the standard deviation of the errors from the actual is lowest in summer and highest in winter. The difference is not so marked at 300 mb although the standard deviations in spring and summer are lower generally than those in autumn and winter.

Table III shows the percentage distribution of errors at 500 mb and 300 mb for the whole period. The individual years show similar distributions.

TABLE III—PERCENTAGE DISTRIBUTION OF FORECAST ERRORS AT 500 MB AND 300 MB

	5-knot band centred on																		
	50	45	40	35	30	25	20	15	10	5	0	−5	−10	−15	−20	−25	−30	−35	−40
	per cent																		
500 mb					0.2	0.7	1.8	5.2	12.4	19.8	23.9	18.2	10.8	4.3	2.0	0.6	0.1	0.1	
300 mb	0.1		0.2	0.3	1.0	2.0	4.3	7.4	11.4	15.3	19.8	15.1	10.5	6.5	3.1	1.7	0.8	0.3	0.1

A forecast error is taken as positive when the forecast ETW is greater than actual.

The extreme errors were greater at 300 mb than at 500 mb, particularly in the case of positive errors. The largest errors (50 kt at 300 mb) occurred in September 1963 and refer to one day only. The distribution of errors can also be shown by the percentage frequency of error less than any given amount disregarding the sign of the error (see Figure 1).

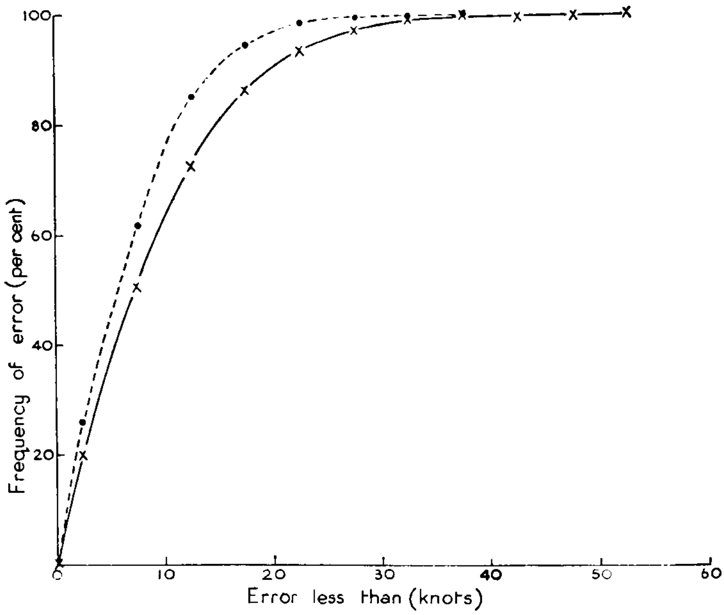

FIGURE 1—PERCENTAGE FREQUENCY OF ERRORS IN FORECAST EQUIVALENT TAILWINDS LESS THAN VARIOUS AMOUNTS

x————x 300 mb •– – – –• 500 mb

Actual and forecast ETW's at both levels were correlated for 1963 and the results are shown in Table IV.

TABLE IV—CORRELATION BETWEEN ACTUAL AND FORECAST VALUES OF EQUIVALENT TAILWIND DURING 1963

Level	Mean of actuals	Standard deviation of actuals	Mean of forecasts	Standard deviation of forecasts	Correlation coefficient
		knots			
500 mb	−23·7	17·0	−23·5	17·3	0.88
300 mb	−34·3	22·3	−33·5	22·9	0.85

At both levels the mean of the forecasts is slightly lower than that of the actuals, while the standard deviations are slightly higher. The difference between the means of actuals and forecasts at each level for the one year of 1963, i.e. 0.2 and 0.8, can be compared with the mean errors for the whole period, 0.3 and 0.7, and are of the same sign.

The errors at 300 mb in individual 10-knot bands of actual ETW's were also examined and the results are shown in Table V.

The mean value of the 300 mb ETW was about −35 kt for the whole period and the figures in Table V suggest that forecasts tended to err in the direction of this mean value. The smaller positive or negative values of ETW are often persistent, and show less variability over a period. In Table V, between +10 and —9 knots, the mean errors are relatively large, but the standard deviations of the errors have their lowest values, corresponding to the smaller variability.

TABLE V—ERRORS IN FORECAST EQUIVALENT TAILWIND FOR VARIOUS RANGES OF ACTUAL VALUES AT 300 MB

Range of ETW	Mean of errors	Standard deviation of errors	Number of occurrences
	knots		
−90 to −99	16.3	13.5	15
−80 to −89	7.1	16.0	44
−70 to −79	6.7	13.5	110
−60 to −69	5.7	12.7	227
−50 to −59	2.5	11.5	333
−40 to −49	2.3	12.3	456
−30 to −39	−0.5	11.4	543
−20 to −29	−1.9	11.7	431
−10 to −19	−1.6	10.2	335
0 to −9	−2.7	10.1	199
10 to 1	−2.7	9.9	86
20 to 11	−2.9	11.4	54
30 to 21	−7.5	12.1	24

Actual equivalent tailwinds.—The actual equivalent tailwinds measured during the period January 1961 to December 1963 were investigated and mean seasonal values were included in Table I and II. Mean values at 300 mb for individual months were calculated for comparison with climatological values given in *Meteorological Reports* No. 20.[3] This comparison is shown in Table VI.

TABLE VI—COMPARISON BETWEEN MEAN EQUIVALENT HEADWINDS AND STANDARD DEVIATIONS ON THE GREAT-CIRCLE ROUTE PRESTWICK TO MONTREAL AS GIVEN BY METEOROLOGICAL REPORTS NO. 20 AT 30,000 FT AND VALUES FROM 300 MB CHARTS DURING 1961–63

Source of data	Mean equivalent headwind				Standard deviation			
	Jan.	Apr.	July	Oct.	Jan.	Apr.	July	Oct.
	knots				*knots*			
Met. Rep. No. 20 at 30,000 ft	53	41	35	44	19	19	15	18
300 mb charts	38	18	31	48	24	21	21	22

The 300 mb values are the means for three years, and show considerable variation from the climatological values, but the differences are probably due to the short period for which data were extracted for this investigation.

The extreme values found in individual months are shown in Table VII.

TABLE VII—MONTHLY EXTREMES AND EXTREME RANGES OF EQUIVALENT TAILWIND JANUARY 1961 TO DECEMBER 1963

Month	Least favourable winds		Most favourable winds		Extreme range	
	500 mb	300 mb	500 mb	300 mb	500 mb	300 mb
	knots		*knots*		*knots*	
January	−69	−96	+32	+33	101	129
February	−87	−108	+20	+16	107	124
March	−54	−69	+21	+25	75	94
April	−59	−89	+24	+28	83	117
May	−52	−73	+27	+29	79	102
June	−61	−77	+25	+22	86	99
July	−46	−71	+11	+24	57	95
August	−57	−89	−2	−11	55	78
September	−82	−120	+12	+7	94	127
October	−70	−104	+4	+8	74	112
November	−77	−90	+7	+7	84	97
December	−79	−96	+23	+32	102	128

At 500 mb, the greatest range of monthly extremes over the period was that of February (107 kt), although December and January also had ranges exceeding 100 kt. At 300 mb, December, January, February and September all had ranges between 124 and 129 knots. The months with positive ETW's in each year were July and December. August, the least variable month, was the only one showing no positive ETW, but positive ETW's occurred in only one year of the three in January, September, October and November. The greatest extreme range within a single month occurred in February 1962 (124 kt).

The pattern of ETW's plotted on a day-to-day basis shows very marked variations over short time intervals, and the ETW's were therefore compounded into overlapping five-day means (pentads) to show the main changes of the

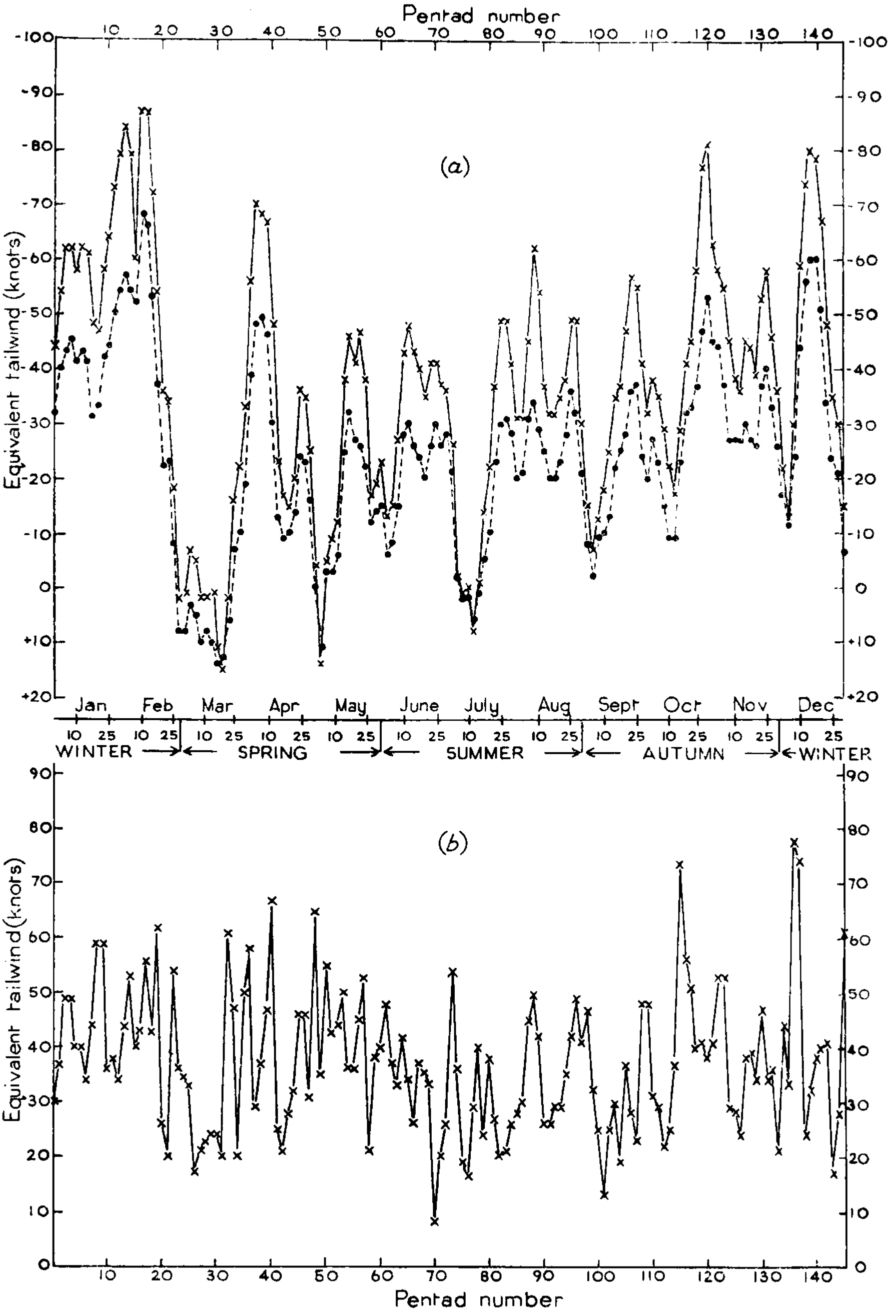

FIGURE 2—PENTADS OF EQUIVALENT TAILWINDS FOR 1962

(*a*) Pentads of actual ETW's.
(*b*) Range within each pentad.
x———x 300 mb •- - - - -• 500 mb

pattern with time. Each pentad is the mean of 10 successive actual values, No. 1 covering the period 0000 January 1 to 1200 GMT January 5, No. 3 covering the period 0000 January 6 to 1200 January 10 and so on, with overlapping pentads such as No. 2, which covers the period 1200 January 3 to 0000 January 8. This gives 145 values for each complete year and these values for both levels in 1962 are shown in Figure 2. As an indication of the variation of the ETW, the range of extreme values at 300 mb in each pentad is also shown in Figure 2. This range is the difference between the most favourable and the least favourable ETW in the pentad.

Over this period there is no consistent pattern from year to year, three years' data being insufficient to give a climatological pattern. Certain points, however, do emerge from the figure and from Tables I, II and VII. The ETW has its lowest negative mean value in the spring of each year, and spring is the only season of the year in which positive ETW's show in the pentads of each year. In each year summer has the lowest value for standard deviation of ETW and this is shown also in the low ranges of pentad extremes in the lower part of Figure 2. The extreme range of February 1962 can be seen in the pentad pattern with the steady decrease in headwind during the last fortnight of the month.

As can be seen from Figure 2 the patterns for 500 mb and 300 mb are very similar in shape and the ETW's of the two levels were correlated for the period January 1961 to June 1962. The correlation coefficient was found to be 0.94 and the regression equations are:

$$C_3 = 1.22C_5 - 7.2 \text{ knots} \qquad \ldots (1)$$
$$C_5 = 0.72C_3 + 2.3 \text{ knots} \qquad \ldots (2)$$

where C_3 denotes ETW at 300 mb and C_5 denotes ETW at 500 mb.

The ETW's are predominantly negative and the equations indicate that the ETW at 300 mb is usually less favourable than that at 500 mb. Although on individual occasions this may not be the case (as shown by the extreme values in Table VII), it generally is the case with the smoothed values of the pentads. Equation (1) can be compared with that given in WMO *Technical Note* No. 35[5] for comparison between wind speeds at 500 mb (V_{500}) and at 300 mb (V_{300}) for three stations in America in a single month:

$$V_{300} = 1.16V_{500} + 13.5 \text{ knots.}$$

The relationship of the ETW's is shown as a correlation surface in Figure 3 with the regression lines superimposed, line A corresponding to equation (1) and line B to equation (2). X is the point given by the means at the two levels: –36 kt at 300 mb and –24 kt at 500 mb. The regression lines can be used to give an estimate of the ETW at one level when the ETW at the other level is known, e.g. if the ETW at 500 mb is –50 kt, then, using line B, the expected value at 300 mb is –73 kt. Similarly if the value at 300 mb is –90 kt, then, by using line A, the value at 500 mb is found to be –68 kt.

Conclusions.—

(i) The mean error at 500 mb for the period was 0.3 with a standard deviation from actual of 9.0 kt, the corresponding values at 300 mb were 0.7 and 12.0 kt.

(ii) The correlation coefficients between forecast and actual ETW's were 0.88 and 0.85 at 500 mb and 300 mb respectively.

(iii) The mean ETW was about –25 kt at 500 mb and about –35 kt at 300 mb.

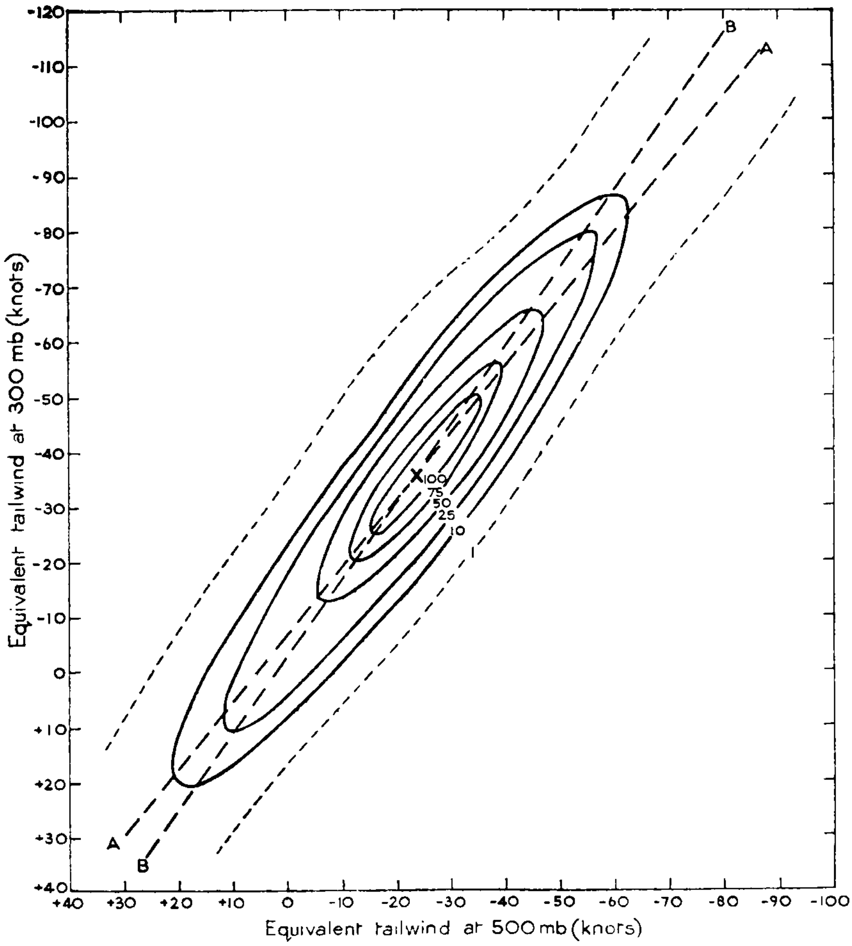

FIGURE 3—CORRELATION SURFACE OF EQUIVALENT TAILWINDS AT 500 MB WITH EQUIVALENT TAILWINDS AT 300 MB

X Mean ETW at each level.
A Regression line for 300 mb from 500 mb corresponding to equation (1).
B Regression line for 500 mb from 300 mb corresponding to equation (2).

The figure labelling each contour gives the actual number of observations contained in a cell representing 10 knots at 500 mb by 10 knots at 300 mb.

(iv) Spring was the only season in each year showing positive ETW in a five-day period.

(v) Given an ETW at either 500 mb or 300 mb, the ETW at the other level can be found simply and with a fair degree of accuracy.

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551.521.18:551.521.31:551.571.36

METEOROLOGICAL CONDITIONS ALLOWING A RARE OBSERVATION OF 24-MICRON SOLAR RADIATION NEAR SEA LEVEL

By G. B. HOIDALE
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Summary.—Atmospheric transmission of solar radiation of 24-μ (micron) wavelength was observed at a sea-level site in Death Valley National Monument, California, U.S.A., on 15 March 1963. The atmospheric environment which allowed this transmission is briefly described. Analysis of surface and upper air pressure–moisture patterns, and space and time cross-sections, leads to the conclusion that the observed transmission was permitted by a column of extremely dry and cold air passing over the Death Valley site during the afternoon of 15 March.

Introduction.—In support of a project designed to examine theoretically and experimentally the effects of the earth's atmosphere on the transmission of 20-μ to 40-μ solar radiation, field data were taken at 34 metres below sea level in Death Valley National Monument, California (36°30′N, 116°53′W) from 8 March 1963 to 24 March 1963. The transmission measurements were taken with a heliostat and a Perkin-Elmer Model 112U spectrophotometer. During the afternooon of 15 March, transmission of solar radiation up to 24.4μ was observed.

The occurrence of 24.4-μ transmission, coupled with a mid-afternoon increase of transmission with increasing optical air mass, led to an analysis of the atmospheric environment which could have allowed this transmission.

Observed transmission.—The sky over Death Valley on the morning of the observation was overcast, affording little hope that the spectrometer would 'see' the sun at all that day. However, the stratocumulus clouds began to dissipate shortly after 2100 GMT (1300 Pacific Standard Time, PST). Rapid clearing ensued and by 2345 GMT (1545 PST) the sky was cloudless.

With clouds still capping the mountains to the east and west, the first transmission run, between 2130 GMT (1330 PST) and 2200 GMT (1400 PST), showed the atmosphere as presenting a window for solar radiation of 24-μ wavelength. The following transmission run, 2200 GMT (1400 PST) to 2230 GMT (1430 PST), showed an increase in transmission, though scattered clouds were still topping the surrounding peaks. In subsequent runs, the transmission diminished as expected as a result of the rapidly increasing number of optical air masses through which the radiation had to penetrate.

At the time of the aforementioned transmission runs, the transmission at 24.4 μ and its subsequent increase were attributed to dry air passing over the site. The decreased number of water molecules would thus reduce the probability of the pure rotational absorption of radiation of this wavelength by the triatomic water molecules. The surmise of dry air passing over the site was supported by three contemporaneous observations: (*a*) rapid clearing of the clouds, (*b*) the particularly deep blue hue of the sky, and (*c*) the mean mixing ratio at the surface during the afternoon which was about one half of the lowest mean mixing ratio observed at the site during each of the preceding four days.

Synoptic surface pattern.—To illustrate the pressure and frontal pattern existing over the Death Valley area on 14 and 15 March, a sequence of synoptic surface charts is shown in Figures 1(*a*)–(*d*). The 1500 GMT map for 14 March (Figure 1(*a*)) shows a cold front across the north-western corner of California. Skies over Death Valley at that time were clear, except for a trace of thin cirrus cloud. The front passed over the site that afternoon to the accompaniment of sustained 20-knot winds, blowing dust, and scattered puffs of cumulus clouds.

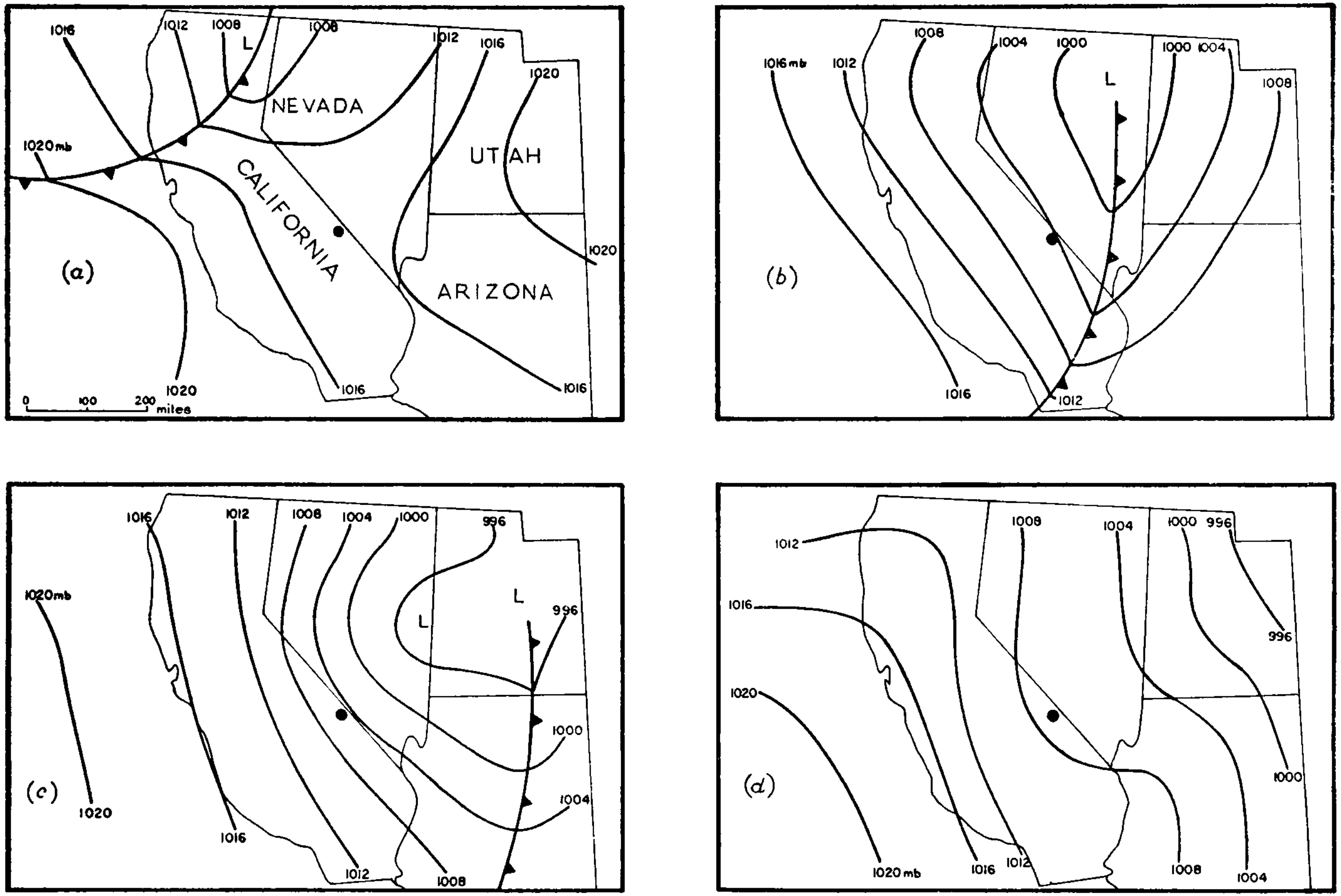

FIGURE 1—SYNOPTIC SURFACE CHARTS

(*a*) 1500 GMT on 14 March 1963 (*b*) 0300 GMT on 15 March 1963
(*c*) 1500 GMT on 15 March 1963 (*d*) 0000 GMT on 16 March 1963

The state boundaries and coastline are shown as feint lines, and the four states of California, Nevada, Utah and Arizona are named in Figure 1(*a*). The position where the field data were taken is marked by a large dot.

By 0300 GMT, the cold front extended along a line from Ely, Nevada, through Las Vegas, Nevada, and on out over the Pacific Ocean across San Diego (Figure 1(*b*)). (Note the secondary trough oriented east–west across northern Nevada and California.) By sunrise on 15 March, the surface cold front had progressed to central Arizona and the secondary trough to central Nevada (Figure 1(*c*)). By the afternoon of interest, the front had moved out of the four-state area (Figure 1(*d*)) and the secondary trough to a position directly over Death Valley.

Upper air.—Analysis of relevant upper air data substantiated the original conclusion that a pronounced drying of the atmosphere had occurred over the site on the afternoon of 15 March. Examination of the 500 millibar surface, as analysed in Figures 2(*a*), (*b*) reveals a pocket of dry air situated to the west of the Death Valley site at 1200 GMT (Figure 2(*a*)). Twelve hours later, the same pocket was centred over the site (Figure 2(*b*)), which corresponds well with the peak transmission observed at 2215 GMT.

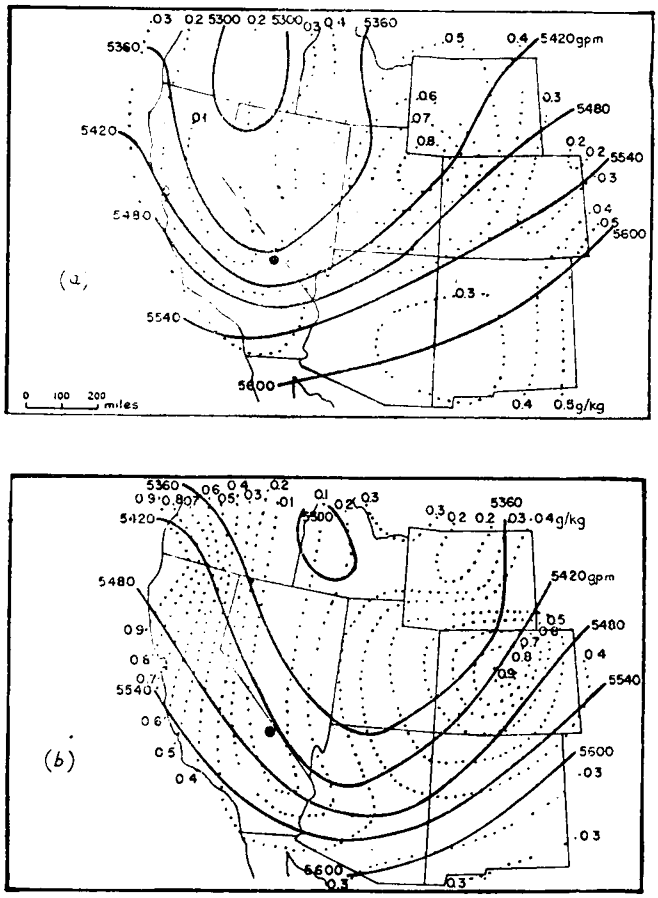

FIGURE 2—500 MILLIBAR ANALYSES

(*a*) 1200 GMT on 15 March 1963 (*b*) 0000 GMT on 16 March 1963
——— 500 mb contours (gpm), ····· mixing ratio (g/kg).

The state boundaries and coastline are shown as feint lines, and the four states of California, Nevada, Utah and Arizona are named in Figure 1(*a*) (see page 78). The position where the field data were taken is marked by a large dot.

Vertical cross-sections of potential temperature and mixing ratio revealed an eastward progressing, dry, cold column of air. Figure 3 shows the vertical cross-section near the time of observed maximum transmission.

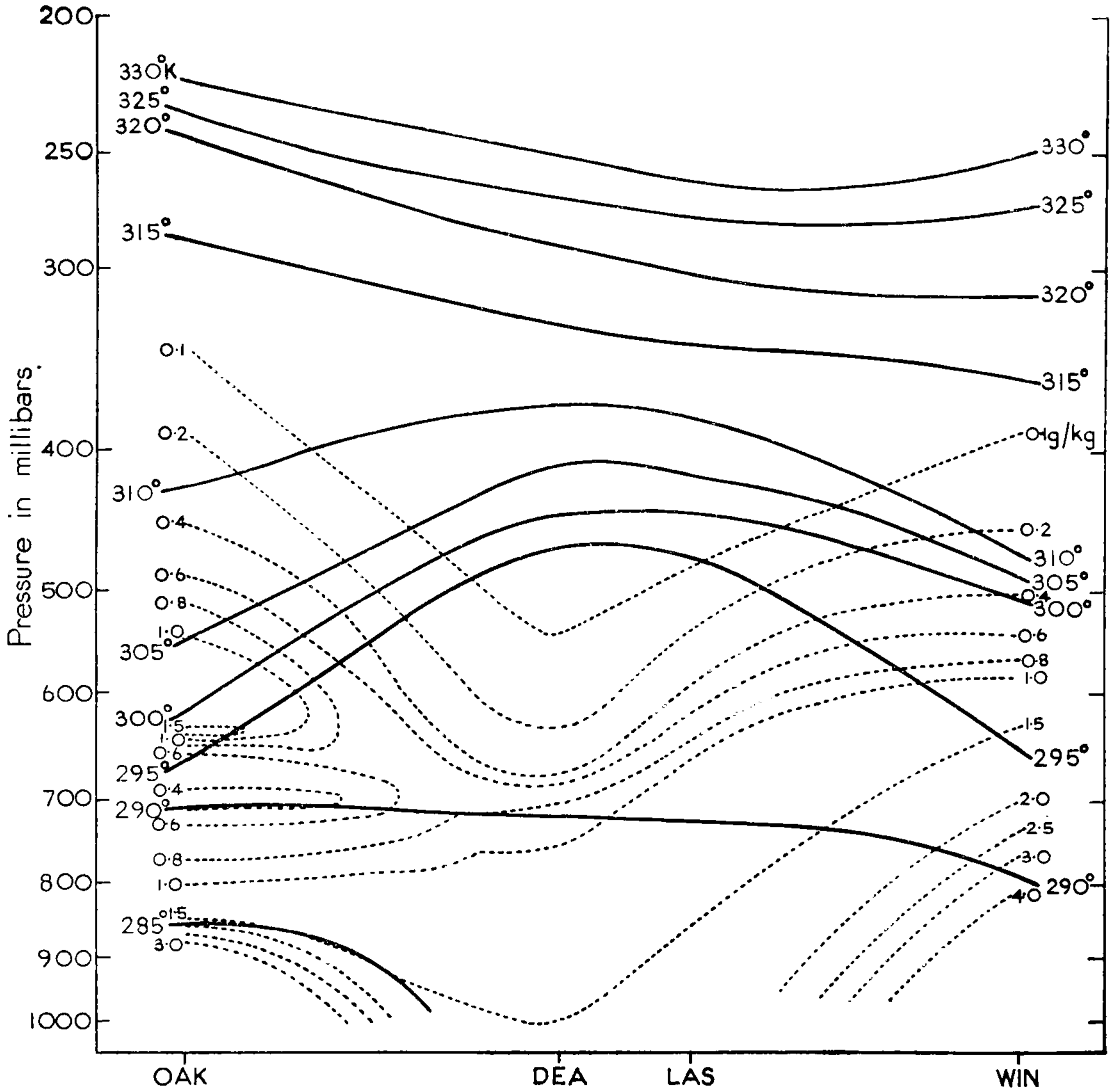

FIGURE 3—VERTICAL CROSS-SECTION OF POTENTIAL TEMPERATURE AND MIXING RATIO FROM OAKLAND, CALIFORNIA, TO WINSLOW, ARIZONA, AT 0000 GMT ON 16 MARCH 1963

——— Potential temperature (°K), ····· mixing ratio (g/kg).

OAK = Oakland, California, (6m above MSL), DEA = Death Valley, California, (34 m below MSL), LAS = Las Vegas, Nevada, (664m above MSL), WIN = Winslow, Arizona, (1505 m above MSL). Oakland is about 660miles from Winslow.

The cross-section is drawn in an approximate west-north-west to east-south-east direction.

Conclusion.—The resultant picture is of a column of very dry air, extending from a surface secondary trough to 350 millibars, moving across the Death Valley site during the afternoon of the 15th. The initial break-up of the clouds signalled the passage of the surface trough over the site. The influx of drier air continued until mid-afternoon when the peak transmission of 24.4 μ was observed.

Thus, on occasion, the earth's atmosphere is dry enough to allow solar radiation up to at least 24 μ to reach sea level, even at latitudes as low as 36°N.

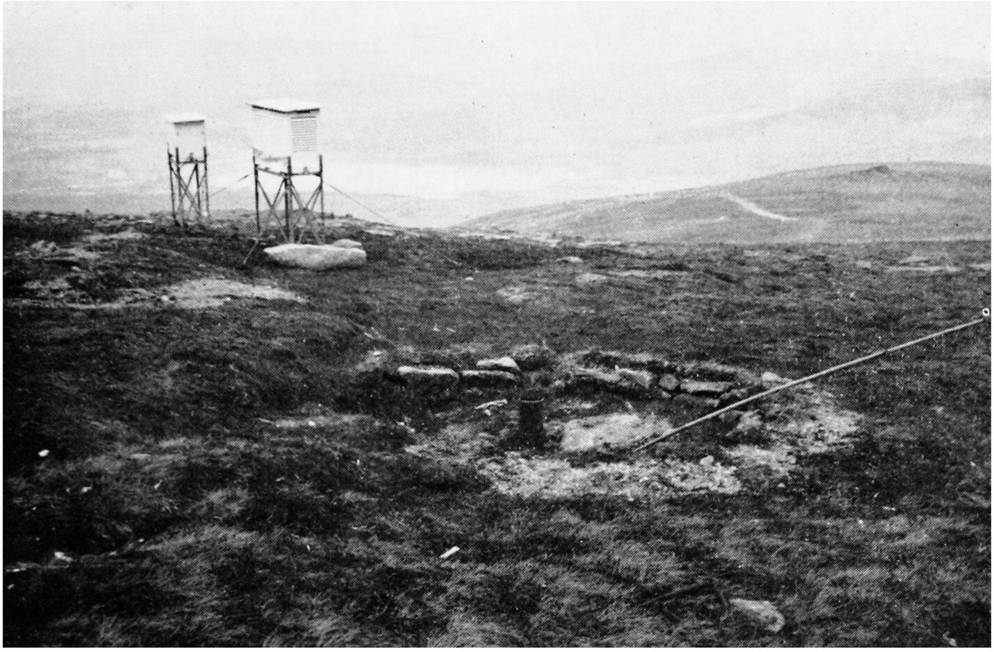

PLATE I—THERMOMETER SCREENS AND RAIN-GAUGE AT THE CAIRNGORM STATION

The cane in the foreground is placed vertically in the ground when snow is lying to indicate to skiers the position of the rain-gauge (see page 84).

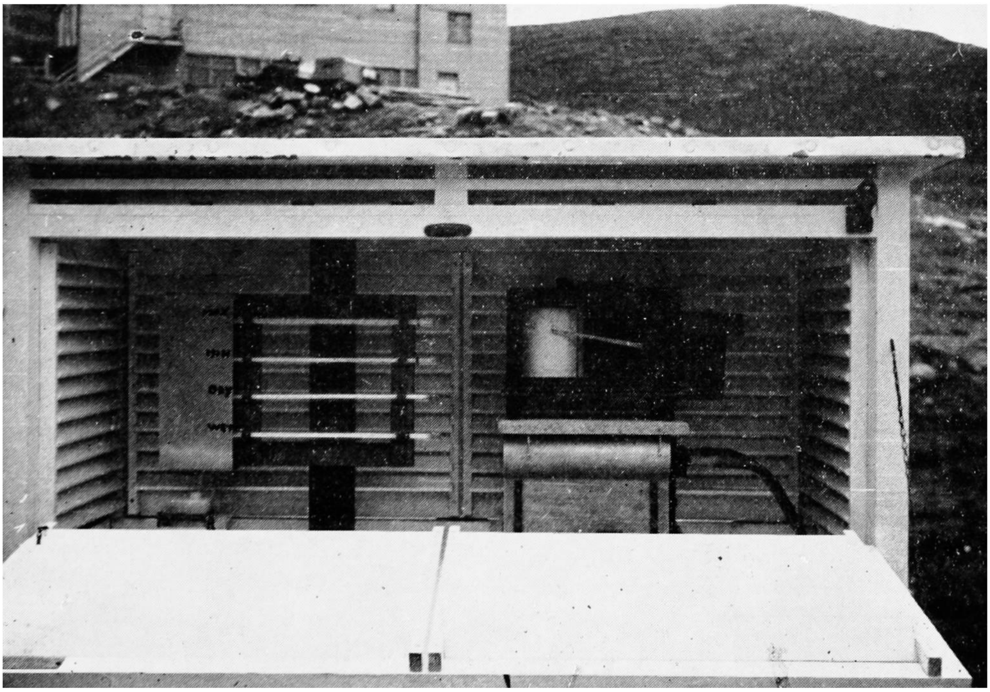

PLATE II—INSTRUMENTS IN THE THERMOMETER SCREEN AT COIRE CAS SHIELING STATION

The hair hygrograph can be seen on the right-hand side above the mercury-in-steel thermograph (see page 84).

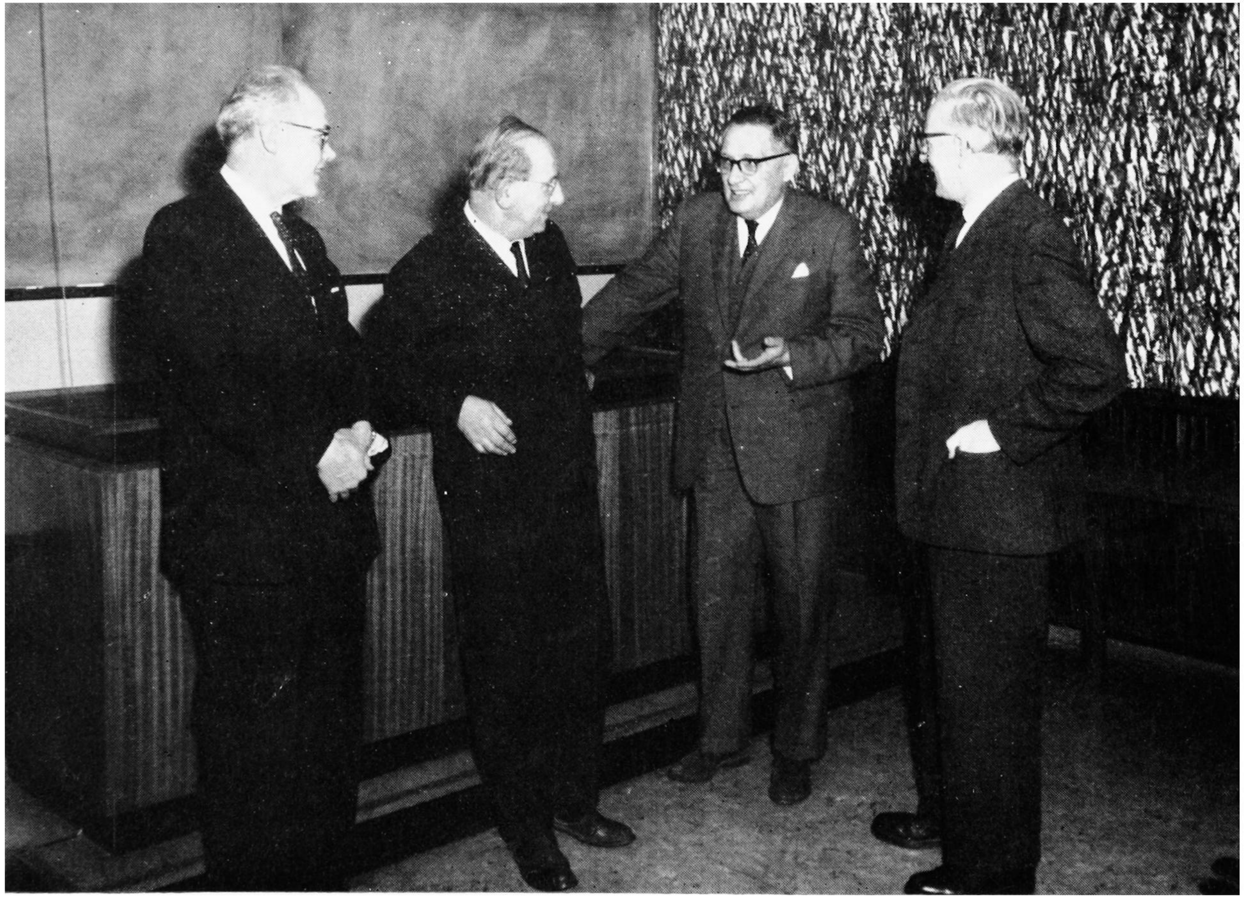

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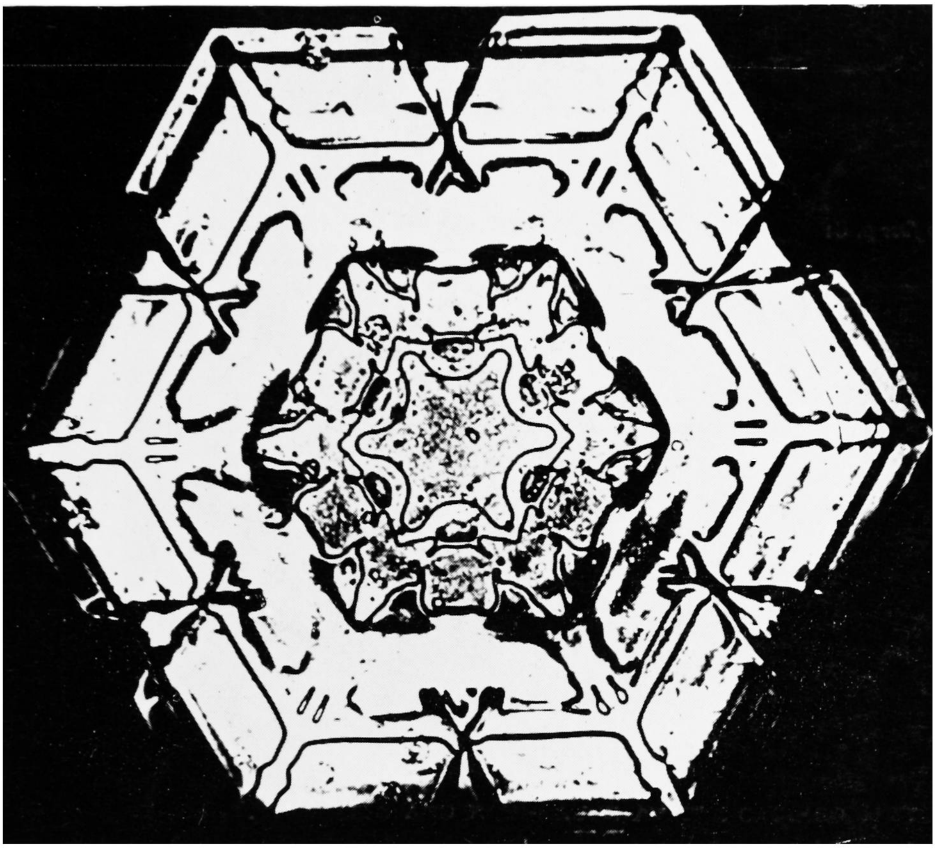
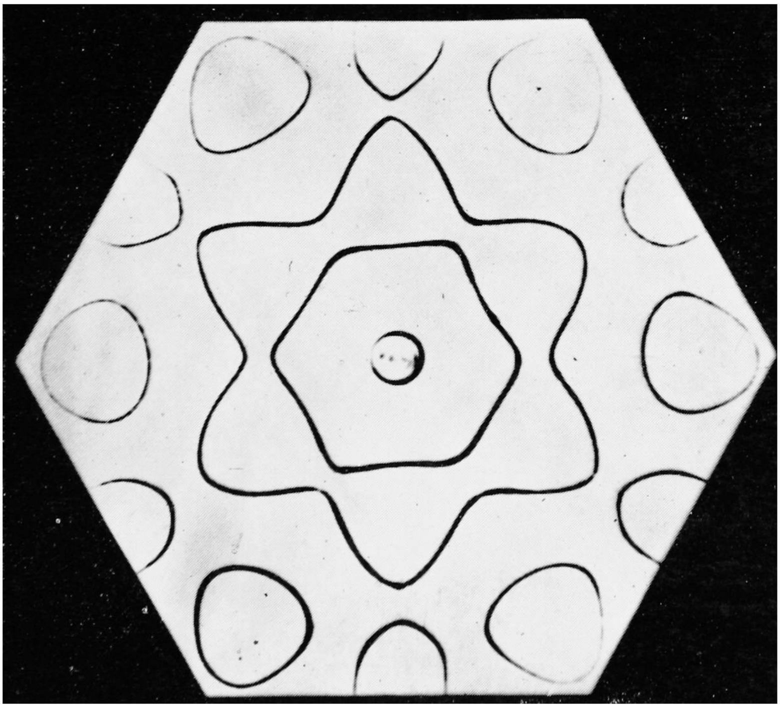
PLATE III—THE DIRECTOR-GENERAL TALKING TO PROFESSOR TOLANSKY BEFORE THE LECTURE AT BRACKNELL ON 19 NOVEMBER 1964

Left to right: Dr. R. C. Sutcliffe, F.R.S., Professor S. Tolansky, F.R.S., the Director-General, Sir Graham Sutton, F.R.S., and Dr. A. C. Best (see page 94).



Photograph by courtesy of McGraw-Hill Publishing Co. Ltd.

(*a*)



Photograph by Professor S. Tolansky, F.R.S.

(*b*)

PLATE IV—PHOTOGRAPHS OF AN ICE CRYSTAL (*a*) AND A VIBRATING PLATE (*b*) DEMONSTRATING FINE-SCALE CURVILINEAR SYMMETRY

See page 95.

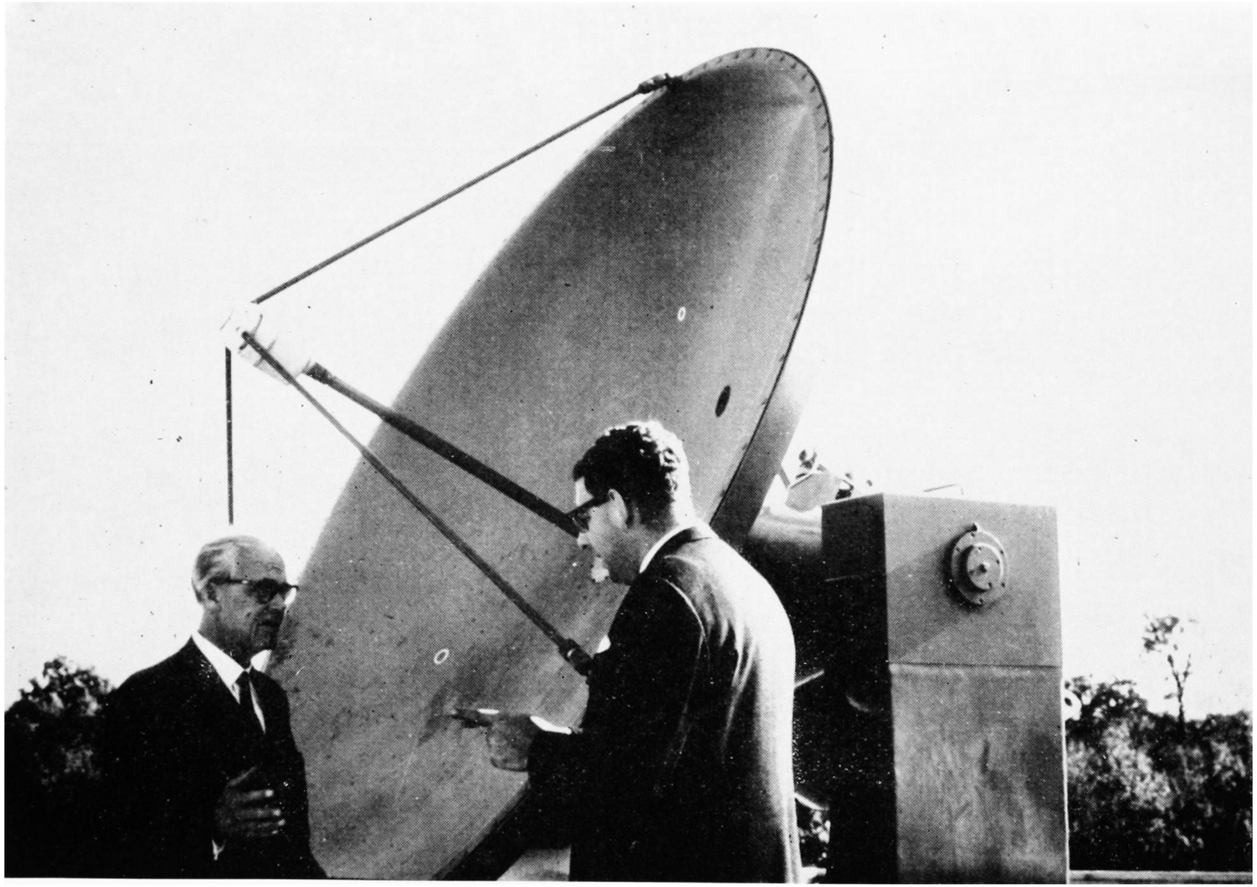


PLATE V—NEW METEOROLOGICAL OFFICE WIND-FINDING RADAR AT CRAWLEY

Dr. R. C. Sutcliffe, F.R.S., is seen talking to Mr. P. R. Max, General Manager of the Radar Division of Cossor Electronics Ltd. (see page 95).

551.571.36(41/42):551.589.1

THE INCIDENCE OF LOW RELATIVE HUMIDITY IN THE BRITISH ISLES

By F. H. W. GREEN
The Nature Conservancy

Introduction.—It has become clear that occasions of relative humidity below 20 per cent are not nearly as rare in the British Isles as would appear from references in earlier meteorological literature. Hawke,[1,2] in particular, drew attention to the incidence of low humidity and subsequent references include notes by Needham,[3] Green[4,5,6] and Smith.[7] Since both low relative humidity and violent changes in humidity are detrimental to plants and animals, it was felt that a preliminary survey of recent occurrences would be useful.

Achnagoichan autographic readings.—Since May 1956 a thermo-hygrograph has been functioning most of the time in a standard screen at Achnagoichan (1000 ft above MSL) in Strathspey. The records of this instrument from May 1956 to October 1964 were used as a rough guide to the number of days of very low humidity during this period and an analysis is shown in Table I. The number of days when the record showed a relative humidity of 30 per cent or less was 109 with a large monthly frequency in April, May and June. There were 10 days with humidity below 20 per cent and 2 below 10 per cent.

TABLE I—MONTHLY FREQUENCY OF DAYS OF LOW HUMIDITY AT ACHNAGOICHAN, MAY 1956–OCTOBER 1964

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
30 per cent and below	1	6	7	15	26	29	5	8	5	4	0	3	109
20 per cent and below	0	2	1	2	3	1	1	0	0	0	0	0	10
10 per cent and below	0	0	0	0	0	2	0	0	0	0	0	0	2
Cases unrelated to diurnal rise in temperature	0	2	4	0	0	1	0	0	1	2	0	3	13

The totals for individual years would be misleading, owing to interruptions, but 1959 had by far the greatest number of days (32) with relative humidity below 30 per cent.

The great majority of the occasions were days of warm, dry weather with clear skies, when the diurnal temperature range was considerable, and the fall in humidity corresponded with the daily rise in temperature. On a few occasions, mostly in winter and early spring, the low humidity was not readily correlated with a diurnal rise in temperature.

Discussion of particular occasions.—A special examination was made of a few of the more important occasions, including some which were not indicated by the Achnagoichan hygrograph, but mainly those where the Achnagiochan humidity was below 20 per cent or was not readily correlated with a diurnal rise in temperature.

March 1959.—On 1 March 1959, the hygrograph trace at Achnagiochan went down well below 20 per cent a little before midday. The fall did correspond to some extent with a rise in temperature, but it had begun before the rise started, and in fact the temperature fell about 4°F at one stage during the fall in humidity. Relative humidity had been fairly low since 24 February, since when both it and the temperature had shown considerable short-period oscillations, although the total range of temperature over the period barely exceeded 10°F.

During this period there were strong south-westerly winds and a series of depressions moved in a north-eastward direction, with several associated fronts crossing the British Isles. The contrast between the air-mass characteristics on each side of the fronts was not very great. After the passage of a front on 28 February the gradient slackened considerably and by the morning of 1 March winds were light and variable over most of Britain. Pressure was high over central Europe. Inspection of the *Daily Weather Report** (*DWR*) revealed no records of particularly low humidities, the lowest noted in fact being at Malin Head and Wick at 1200 GMT where the humidities were just above 60 per cent.

June 1959.—June 21, 1959, was one day of a series of warm, sunny days, remarkable only in that the relative humidity recorded on the hygrograph fell as low as 10 per cent, with a temperature of 70°F. The accuracy of the hygrograph at this time may be doubted, but there can be no doubt at all that the relative humidity did reach an unusually low level, and that it rose to 84 per cent between about 1500 GMT on 21 June and 0300 GMT on 22 June. In the *DWR* however only Renfrew (21 per cent) and Prestwick (31 per cent) at 1200, and Silloth (36 per cent) at 1800 had unusually low humidities. The airflow was from the south-east, and these stations were in the lee of hills. There was an anticyclone over Scandinavia, as Hawke[1] found to be usual in cases of low humidity, and pressure was low to the west of the British Isles with a front moving in from the Atlantic.

October 1959.—In the week commencing 5 October 1959, there was fine sunny weather with considerable diurnal temperature range and corresponding humidity variation. During the night of 9–10 October however, the temperature fell only a few degrees, but the humidity fell instead of rising and continued to fall to a minimum of 20 per cent at about 1500 GMT on the 10th while at the same time the temperature was rising. The only remarkably low humidities noted at *DWR* stations occurred at 1200 GMT on the 9th and were as follows:

Kew	30 per cent	Ross-on-Wye	36 per cent
Gatwick	31 per cent	Manchester	29 per cent

London (Heathrow) Airport 30 per cent

Again there was a south-westerly airstream between an anticyclone and a depression.

May 1960.—In the week commencing 9 May 1960, there was a centre of high pressure over the Norwegian coast and a depression to the south-west of Ireland. On the 1200 GMT chart for 12 May, a trough on an instability line was shown lying across England and Ireland from south-east to north-west. Some fairly low humidities occurred north-east of this trough, where the isobars could locally have been divergent, but no *DWR* station showed any unusual humidity that day, whereas Achnagoichan had a relative humidity of less than 40 per cent over most of the period from 0900 on the 12th to 1600 on the 13th, after which the humidity rose very steeply indeed, presumably with the passage of the trough.

*London, Meteorological Office. *Daily Weather Report*. Relative humidities for *DWR* stations were calculated from the temperatures and dew-points which are given in whole figures.

Among the *DWR* stations, only Prestwick revealed a relative humidity below 40 per cent, 38 per cent being recorded at 1200 GMT on the 11th. The Achnagoichan records showed a very remarkable drop in humidity for about two hours between about midnight and 0200 on the 11th. The humidity fell suddenly from 80 to 40 per cent and equally suddenly climbed again, possibly suggesting the presence of a layer of subsiding air: the thermograph trace was slowly falling at the time.

March 1961.—At the beginning of March 1961 an anticyclone was centred over the north of France with a complex low-pressure system to the north and north-west of the British Isles. The pressure gradient was steepest between the Faeroes and the south of Scotland. The Achnagoichan hygrograph trace moved erratically, and often quite out of phase with the thermograph, the lowest relative humidity reading being about 26 per cent during the afternoon of 5 March. Among the *DWR* stations however, a really noteworthy low humidity was observed only at Boscombe Down, where the dew-point was 21°F and relative humidity 28 per cent.

February 1962.—On several days running in the week commencing 19 February 1962, there were fine sunny conditions and on 22 February the reading of the Achnagoichan hygrograph dropped to 20 per cent. No remarkably low humidities occurred at any of the *DWR* stations during this period of easterly airflow between a Scandinavian anticyclone and a depression just west of Portugal. As would be expected, humidities were lower inland and on the west coast, but none were as low as 40 per cent.

March 1962.—On 7 March 1962 there were strong south-south-easterly winds between an anticyclone over north Germany and a deep complex depression west of the British Isles. Relative humidity at Achnagoichan fell during the morning from over 70 per cent to less than 30. This was in itself not very unusual, but the slow rise that followed was rather remarkable—humidity only began to climb quickly at about 0800 GMT the next morning, reaching over 80 per cent by midday on the 8th. Inspection of the *DWR* revealed the following occurrences of relative humidity of 40 per cent or below:

1200 GMT on 7 March, Valley	35 per cent
1800 GMT on 7 March, Hurn	35 per cent
1800 GMT on 7 March, Aberporth	35 per cent
1800 GMT on 7 March, Ross-on-Wye	31 per cent
1800 GMT on 7 March, Benbecula	34 per cent
0000 GMT on 8 March, Heathrow	34 per cent

The tendency for low relative humidities to occur in lee situations was evident, but the occurrences at Hurn and Benbecula were rather surprising.

December 1962.—The very remarkable case of 3 and 5 December 1962 has been recorded in the *Meteorological Magazine*.[8] The instrumental records show that at least in several places in the Cairngorm region, and on the Westmorland Fells at Moor House, the air must have been very nearly 'bone dry'. Since it was quite cold at the time, a number of very low dew-points were recorded. It is worth noting that since daily instrumental records were begun at Moor House in 1952 only once before had anything really comparable occurred. This was in March 1953 and the occurrence was described by Green.[4]

February and March 1963.—After the extremely cold spell of the winter of 1962–63 came to an end in the last days of February, there was a week in which unusually low humidities occurred in many parts of the British Isles. As shown by the Achnagoichan hygrograph, humidity fell well below 50 per cent during the morning of 26 February and did not rise above 70 per cent until 3 March. Mr. and Mrs. R. M. Murray, who run the climatological station at Prabost, Isle of Skye, drew attention to the reading of 12 per cent from their instruments at about noon on 28 February. The daily reports (0000, 0600, 1200, 1800 GMT) of all 55 stations in the *DWR* were then examined and it was found that several cases of low humidity occurred during the period 0600 February 26 to 0000 March 3.

TABLE II—NUMBER OF OCCURRENCES OF LOW RELATIVE HUMIDITY AT *DWR* STATIONS BETWEEN 0600 GMT 26 FEBRUARY AND 0000 GMT 3 MARCH 1963

	Time (GMT)	40 per cent or below	20 per cent or below		Time (GMT)	40 per cent or below	20 per cent or below
26 Feb.	0600	2	0	1 Mar.	0000	2	1
	1200	9	2		0600	1	0
	1800	2	1		1200	9	1
27 Feb.	0000	0	0		1800	1	1
	0600	2	0	2 Mar.	0000	0	0
	1200	8	2		0600	0	0
	1800	4	0		1200	6	1
28 Feb.	0000	2	1		1800	2	0
	0600	1	1	3 Mar.	0000	1	0
	1200	6	1				
	1800	3	0				

The *DWR* stations which exhibited relative humidities of 40 per cent or below, and the number of occurrences, at the four standard observation times over this period were as follows:

Cape Wrath	15	Stornoway	3
Aberporth	7	Kew	3
Carlisle	6	Eskdalemuir	2
Manchester	5	Squires Gate	2
Prestwick	5	Chivenor	2
Renfrew	4	Elmdon	1
Valley	4	Heathrow	1

The distribution of these places and occurrences is interesting. Three-quarters of the occurrences were at stations in the lee of hills in the south-south-easterly airstream, and most of the remainder were at urban sites. A few of the climatological station observations made at 0900 GMT were investigated and showed the same pattern.

September 1963.—At Achnagoichan, the occurrence of low humidity on 15 September 1963 looked at first sight like a simple case associated with diurnal rise in temperature, but closer inspection showed that the humidity fell rapidly about two hours before the temperature began to rise. The traces from the mercury-in-steel thermograph at the newly-established stations of Cairngorm (Plate I) and Coire Cas Shieling (Plate II) (3575 ft and 2500 ft above MSL respectively) confirmed this and showed that the significant change there began at about midnight. The 0900 GMT readings at Coire Cas were:

Dry bulb	Wet bulb	Vapour pressure	Relative humidity	Dew-point
63.9°F	45.6°F	2.3 mb	11 per cent	9°F

The autographic records indicate that this humidity was the lowest reached and suggest that the relative humidity was as low as 17 per cent at 0200 GMT. A sharp rise in humidity began about 1100 GMT; this was shortly before the time when it had first begun to drop steeply at Achnagoichan. The Cairngorm thermogram trace agreed closely with that at Coire Cas, the lowest humidities being approximately as follows:

Time (GMT)	Dry bulb	Wet bulb	Vapour pressure	Relative humidity	Dew-point
0500	54°F	38.5°F	1.0 mb	7 per cent	–8°F
0900	59°F	42°F	1.5 mb	9 per cent	0°F
1215	56°F	40°F	1.3 mb	8 per cent	–3°F

A study of the *DWR* revealed widespread low humidities from the 13th to the 17th, but nothing remarkable. The only cases of relative humidity below 40 per cent were at Dyce at 1200 GMT on the 13th with 38 per cent and at Tynemouth at 1800 GMT on the 15th with 37 per cent.

Through most of the period exhibiting these very low humidities, depressions were passing from west to east, to the north of Scotland and pressure was high to the south with a notably slack pressure gradient in between. Some of the low humidities occurred within this area of nearly calm conditions, and under cloudless skies, but in the north and east of Scotland on 15 September surface winds were fairly strong.

Notable stratification in the upper air over Scotland was indicated by the cloud structure. The 1130 GMT radiosonde ascent from Shanwell showed marked stratification in the same air mass, and showed in particular a very dry layer, with relative humidity about 23 per cent at 850 mb, corresponding roughly with the height of Cairngorm. The wind direction was between about 240° and 260° at all levels, and the speed only varied between about 40 and 50 kt up to the tropopause, which was a double one above Shanwell. At the Coire Cas Shieling the surface wind at 0900 GMT was estimated as Beaufort force 5 (about 18 kt).

The *Daily Aerological Record* shows that a layer (or layers) of low humidity extended from Ocean Weather Station J (52°30′N 20°W) eastwards right across the British Isles.

This particular occurrence of low humidity therefore seems to have been associated with a very stable air mass in which there had presumably been considerable subsidence. The episode came to an end with the passage southwards over the country of a front.

January 1964.—On 18 January 1964, the synoptic situation was again that of a very pronounced anticyclone over Scandinavia, with a deep depression west of the British Isles. The isobars were divergent over Scotland. At the Coire Cas Shieling (approximately 2500 ft above MSL), according to traces on the mercury-in-steel thermograph, the humidity began to fall during the afternoon of 17 January, and gradually reached its lowest at about 0900 GMT on the 18th. It remained at about this level until mid-afternoon, after which it gradually increased and then steadied at about 83 per cent by approximately 2100 GMT. At 0900 GMT on the 18th the dry-bulb thermometer read 48.1°F and the wet-bulb 36.1°F. A comparison of the humidities according to these two readings and to the (uncorrected) thermograph trace is as follows:

	Dry bulb	Wet bulb	Vapour pressure	Relative humidity	Dew-point
Thermometers	48.1°F	36.1°F	1.8 mb	16 per cent	4°F
Thermograph	47.0°F	34.5°F	1.2 mb	11 per cent	–5°F

At Achnagoichan (about 6 miles to the west-north-west of Coire Cas and only 1000 ft above MSL) the hygrograph and thermograph agreed well with the thermometer readings at 0900 GMT. The humidity values can therefore be quoted with reasonable accuracy in the table below, which shows that the lowest hygrograph reading of 30 per cent occurred at 1100 GMT:

	Time (GMT)	Dry bulb	Wet bulb	Vapour pressure	Relative humidity	Dew-point
Achnagoichan	0900	37.7°F	31.5°F	3.5 mb	45 per cent	18°F
	1100	40°F	32°F	2.4 mb	30 per cent	12°F

Inspection of the 0900 GMT readings on 18 January at various other stations in the vicinity revealed only Glenmore Lodge with a relative humidity as low as 40 per cent, and a dew-point of 5°F, but the hygrograph trace went down to 12 per cent about 1400 GMT—having been as low as 29 per cent at 1500 on the previous day with a rise to not more than 65 per cent in between. Hourly readings at Kinloss showed humidities of 40 per cent or below at 1400, 1500, 1600, 1800 and 1900 GMT. Three-hourly readings at Cape Wrath revealed 40 per cent or less from 0000 to 1800 GMT. The low humidities at Cape Wrath had begun during the night of 16–17th and the very low reading of 12 per cent and dew-point –0.4°F was recorded at 1200 GMT on the 17th. There was a calm with a clear sky nearly all the time.

A study of the six-hourly readings of the *DWR* stations revealed no other occurrences of relative humidity 40 per cent or less.

March 1964.—This occasion characterized by low, but not remarkably low, humidities was distinguished by its striking effects on pine foliage and certain other phenomena. There were southerly winds almost continuously at gale force for nearly a week from 14 March. The winds were accompanied intermittently by snowfall sufficient to cause heavy drifting in Perthshire and parts of Strathspey. With air temperature above freezing-point and wet-bulb temperature below, a good deal of freezing was caused during the process of evaporation. Ice formed where water drained over rocks although the air temperatures were above freezing-point, and there were remarkable 'trailers' of frozen snow on the lee side of trees and other obstructions. A little later on, the browning of the needles on the windward sides of pine trees became most conspicuous; isolated trees were completely browned on this side as were the corresponding sides of tree crowns protruding from dense stands and plantations. It is considered that this was a desiccating effect caused by simultaneous transpiration and freezing; cell destruction may have aggravated the damage.

October 1964.—Finally a striking case recorded at the Coire Cas Shieling and Cairngorm on 4 October 1964 must be mentioned. Hair hygrograph charts at both stations recorded a fall to 8 per cent humidity. The sequence of events was as follows.

Humidity began to fall suddenly at both stations just before 0000 GMT on the 4th and there were violent fluctuations between about 60 and 80 per cent for the next two hours. After this the humidity at the upper station (Cairngorm) showed a steady but rapid fall to about 20 per cent by 0400 GMT on the 4th, and a slower, fairly steady fall after that to the minimum of just under 8 per cent soon after 1000 GMT. The humidity at the lower station (Shieling) showed a very similar trace, except that two or three violent fluctuations occurred on the descending curve; the minimum of 8 per cent was reached at 1000 GMT. At the lower station, humidity rose quickly after this to about 30 per cent, at which level it remained, with minor fluctuations, until about 2300. Then there was a fairly rapid rise to about 90 per cent by 0300 GMT on the 5th. At the upper station the rise was more gradual, until about 0000 GMT on the 5th, after which it rose at the same time and rate as at the lower station. The accuracy of the hygrograph at the Shieling was confirmed by the mercury-in-steel thermograph trace and by the dry-bulb (54.1°F) and wet-bulb (39.9°F) temperatures read at 0930 GMT on the 4th which gave a relative humidity of 14 per cent—almost exactly as shown on the hygrograph at that time.

The synoptic situation was again a south-easterly airstream, with an elongated anticyclone stretching north-west and south-east from a centre over the western Baltic, but no humidities in the least remarkable were recorded that day at *DWR* stations or even on the hygrograph at Achnagoichan, only a few miles away. Subsidence thus seemed to affect the surface air conditions only on high ground.

Conclusions.—An examination of all the occurrences of low humidity here discussed shows that in the majority of cases the most noteworthy low humidities were recorded in the lee of hills, and most of the remainder tended to be at the places furthest away from the upwind coast. Achnagoichan is a good 'indicator station' because it is both inland and surrounded by hills on all sides. A few stations, such as Manchester, regularly reporting low humidity are in urban 'heat islands'.

The small number of reported occurrences at high-level stations is almost entirely due to the absence of such stations from the *DWR*, but the records from Moor House, Cairngorm and other high-altitude stations indicate that these are at least as susceptible to low humidities as are lee stations, to the extent that one may reasonably conclude that really exceptional widespread low humidities occur when large-scale subsidence and föhn effects coincide. Diurnal heating often plays a part in summer occasions, but only in enhancing these effects.

The records from the new Cairngorm and Coire Cas stations show that low humidities must frequently occur at high level when they do not occur at lower stations. Thus in the autumn of 1964, there was not only the occurrence on 4 October, but the relative humidity fell to 18 per cent about 2300 GMT on the night of 23–24 September, and to 20 per cent about the same time on the night of 21–22 October. There was also a sudden short-lived drop to 36 per cent about 0600 GMT on 6 October. At no other place have remarkably low humidities been noticed on these dates.

From the ecological point of view, the most significant occasions are when the freezing threshold is involved. With air temperature above freezing-point and wet-bulb temperatures below, ice can be formed as evaporation takes place and vegetation can be frost damaged. The evidence suggests that high-level and lee sites are most susceptible to this damage which occurs mainly in the month of March. The effect of soil temperatures being below freezing-point is comparable to that of wet-bulb temperatures below freezing, and it has been noted that heather 'frosting' is correlated with high daytime evaporation coinciding with freezing temperatures in the root zone.

Hawke[1] pointed out that the lowest humidities tend to occur, not in summer, but in spring and that the most usual synoptic conditions at the time is high pressure over Scandinavia; the present investigation amply supports his contention, although it demonstrates that there are exceptions to this rule.

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551.501.71:551.510.41:551.510.534:061.3

THE OZONE SYMPOSIUM AT ALBUQUERQUE—1964

The International Ozone Commission (a Commission of the International Association of Meteorology and Atmospheric Physics) holds a symposium every two or three years, traditionally at a place where important work on ozone is being carried out. This year the Commission were the guests of the University of New Mexico, at Albuquerque—the home of Professor V. Regener, and the birthplace of the chemiluminescent ozonesonde.

Most of the participants came from the North American continent but there were also meteorologists present from Australia, France, Germany, India, Japan, Norway, Sweden and the United Kingdom. It was a hard-working week, with no 'time-off' during 'working hours'; but there was, inevitably, a 'banquet'; there was also a pleasant evening excursion for dinner at 10,000 ft on the top of a nearby mountain (Albuquerque itself is at 6000 ft) and a most enjoyable all-day excursion on the Saturday.

During the symposium some 60 papers were read with, on the whole, adequate time for discussion. The following notes do not pretend to be comprehensive.

The Dobson ozone spectrophotometer.—This is still the main source of ozone data. It is mostly used to measure 'total ozone' but, given suitable conditions (clear sky for several hours), it can be used to get information about the vertical distribution of ozone—using the so-called Umkehr effect. As an instrument for measuring total ozone it is capable of quite high accuracy (5 per cent or better) but depends upon a knowledge of the solar spectrum, and of the ozone absorption coefficients at the several wavelengths involved. Papers were presented which demonstrated that absorption coefficients given in the World Meteorological Organization manual for the instrument must be wrong—in some cases by 5 per cent or more (leading to errors of the same sort in deduced ozone amounts). Existing laboratory measurements of these absorption coefficients relate for the most part to 'room' temperatures; it is in the extrapolation to the low temperatures of the high atmosphere that the difficulty lies. The Commission stressed the need for laboratory determination at these low temparatures.

The Dobson spectrophotometer can be an absolute instrument since the constants of the instrument can be determined *in situ.* However, the determination of the constants can be carried out accurately only at stations in low latitudes and when skies are clear; even then a fairly intensive observational programme is required. In practice most new instruments are calibrated against a 'standard'—in Europe either No. 1 which is held by Dr. Dobson, or No. 2 which is held by the Meteorological Office, Bracknell—and subsequent instrumental drift is monitored by means of 'standard lamp' techniques. The 'standard lamp' techniques used are known to be unreliable and several papers were presented discussing, but not really resolving, the problems.

The accuracy of vertical distributions deduced from Umkehr observations was severely questioned in two papers (Bibby, United Kingdom and Mateer, U.S.A.). There was agreement that the height of the 'centre of gravity' of the ozone layer could be accurately determined and that if the ozone distribution was known up to some height, e.g. from a balloon sounding, then a mean concentration over the next 5 km or so could be assessed with reasonable accuracy. Considerable doubt was expressed, however, about whether the observations could give anything more of value. On the other hand it was remarked that charts of ozone distributions, based solely on Umkehr, seemed to be self-consistent and 'sensible' and therefore, it was suggested, of value. It was this consideration that led the Ozone Commission to accept an offer from Dr. Godson, on behalf of the Canadian meteorological service, to process Umkehr data, for inclusion in the Canadian ozone publication, using a computer technique developed by Dr. Dütsch.

(The Dütsch programme, or any similar programme, produces from a set of Umkehr results a vertical ozone distribution which, all agree, is likely to be significantly different from the true distribution. But, if the reduction technique is fixed, the distribution obtained is unique and does, of course, depend upon the actual ozone distribution. Therefore if the total ozone distribution varies systematically with time and position it is not especially surprising that the 'Dütsch' distributions also vary systematically. The 'Dütsch' vertical distributions will usually be wrong: the question is whether, bearing in mind the uses to which they are put, the results can be seriously misleading. There were no reasoned arguments on this subject, one way or the other.)

Ozone in polar regions.—Wardle (Cambridge University) described a stellar spectrophotometer (developed with the help of a grant from the Meteorological Office) primarily for use in the Arctic. Ozone measurements were made at Resolute Bay (74°N) from 13 December 1963 to 20 March 1964. The measurements indicate a more-or-less steady rise of 250 Dobson units in total ozone during this period from about 300 to about 550 units, with a scatter about this rise of ±50 units. During February and early March large erratic variations in total ozone over periods of a few hours were recorded. For example on 2 March the amount fell from 524 units at 0720 GMT to 425 at 1015 GMT.

Aldaz (University of New Mexico), reporting on ozone observations in Antarctica, tentatively reported that he found no accumulation of total ozone during the winter and that large changes in the thermal structure of the stratosphere did not seem to be accompanied by large changes in the shape of the vertical ozone profile. (The first of these conclusions appears to differ from Wardle's findings in the Arctic.)

Ozonesondes.—Various types of ozonesonde were described—both optical and chemical. Optical sondes have the advantage that they provide information about ozone above the sonde ceiling but reduction of results is laborious and the accuracy is low. The Regener chemiluminescent sonde has the advantage of very fast response (so fast that it was suggested it could be used in effectively free fall after ejection from a rocket at 60 km) but it seemed to be agreed that the Brewer type was rather easier to use.

A new chemical sonde, using carbon–iodine, was also described.

Rocket soundings.—Two papers described rocket techniques. In the first, ultra-violet radiation from the sun was monitored during the ascent of the rocket, using optical filters to isolate four wavelength regions each about 50 Ångströms (Å) wide. Eight flights had been made. From the first seven, for one reason or another, no results had been obtained. The last had only then just been fired. The results, we were told, 'look good' but they had not been analysed.

In the second, ultra-violet light from the night airglow was monitored in two wave bands—2400 to 2800 and 2400 to 3000 Å—again using optical filters. Only one rocket had been launched. This had been intended to make astronomical observations but, owing to a malfunction of the rocket, the astronomical experiment failed and, by an accident, it was possible to determine instead a vertical ozone distribution. Results from this experiment are given in a later section.

Chemical and photochemical processes in the atmosphere.—The chemical and photochemical processes responsible for the formation and destruction of ozone were considered in a number of papers. It was apparent that present estimates of photochemical equilibrium amounts may be seriously in error because of

(i) a lack of knowledge of the solar spectrum (it was stated by one speaker that an accuracy of better than one part in 1000 was needed!);
(ii) neglect of certain reactions (one speaker regarded X-ray radiation as important);
(iii) uncertainty about certain rate constants and absorption coefficients.

Brewer (Toronto University), who has been measuring solar intensity at 2100 Å (a weak 'window' in which radiation penetrates to below 15 km), stated that his measurements showed that present figures for the solar intensity and for the oxygen absorption coefficient at this wavelength are in error by 25 per cent or even more.

Two papers were presented which suggested that ozone is destroyed by dust at high levels. A persistent dip which had been noted over Boulder, Colorado, at 50 mb over a four-week period from 9 March to 10 April 1964, was, it was suggested, caused by a layer of volcanic dust at that level.

Ozone in the troposphere.—A few papers discussed the measurements of ozone near the ground and the destruction and creation processes in the troposphere. The role of thunderstorms seemed to be regarded as small but reports of ozone in ice caves had led one experimenter to try to produce ozone by shaking ice cubes in a tumbler. He reported that he had succeeded.

Ozone above 30 km.—The only measurements of ozone at levels above balloon ceiling (apart from Umkehr) were the night airglow rocket results. The ozone concentration measured at 60–65 km was, as anticipated from theoretical considerations, some 10 times the supposed day-time equilibrium values.

The '26'-month period.—More evidence was produced indicating the presence of an approximate 2-year periodicity in total ozone. Godson (Canada) presented a preliminary report on 'an extensive program of generalized harmonic analysis of hundreds of series of solar and geophysical parameters'. He reported that he frequently found a double peak, corresponding to periods of about 22 and 26 months and pointed out that the beat frequencies of oscillations of period 1 year and 11 years have periods of 22 and 26.4 months. He stated that he found these two frequencies, for example, in an analysis of upper air temperatures over Crawley, at all levels between 200 and 60 mb.

Lindzen (Harvard University) reported on an investigation on the interaction between photochemical processes and radiative equilibrium, and of both with hydrodynamics. His thesis seemed to be that a change in ozone concentration would result in a change in the radiative equilibrium temperature and this, in turn, in a change in the ozone photochemical equilibrium. He concluded that the consequence of a perturbation could be an oscillation rather than a simple decay.

Lindzen then extended the same sort of study to a well-defined hydrodynamical problem—the vertical propagation of a wave symmetric about the equator and about the earth's axis. He concluded: "A dispersion relation is obtained which describes a wave similar, with respect to phase speed and relative amplitudes of velocities and temperatures, to the observed 26-month oscillation".

The sunspot cycle.—Willett (Meteorological Department, Massachusetts Institute of Technology) returned to the attack and produced further evidence, which struck many as convincing, for his correlation between total ozone and the sunspot cycle.

Sekihara (Meteorological Research Institute, Tokyo) reported on efforts to detect a direct solar relationship with ozone by looking for correlations between ozone and geomagnetic disturbances. He found a rather complex correlation pattern and suggested that perhaps X-rays were destroying ozone.

The general circulation.—Many papers dealt with ozone either as a tracer or as a parameter in determining the general circulation. In a report of an analysis of the first year's operation of the U.S.A. 11-station ozonesonde chain (extending from the Canal Zone in the south to Thule, in Greenland, in the north) Hering and Borden (Air Force Cambridge Research Laboratories, Massachusetts) conclude: "Composite analysis of the distribution of ozone and potential vorticity during the winter and spring months indicates that mixing in the meridional plane in the lower stratosphere occurs predominantly along surfaces which slope downwards by approximately 5 km from 30°N to 60°N. Comparison with the mean slope of the isentropic surfaces confirms the results of studies showing that the lower stratosphere is a region of northward, counter-gradient, heat flux and a region in which kinetic energy is converted into potential energy".

Several other speakers, notably Reed (University of Washington) discussed the counter-gradient flux of ozone (which can occur if there is a sloping 'preferential surface' of mixing) and stressed the importance of this in any study of the distribution of ozone.

R. FRITH

REVIEWS

The mechanics of aerosols, by N. A. Fuchs (translated from the Russian by R. E. Daisley and M. Fuchs). 10¼ in × 7 in, pp. xiv + 408, *illus.*, Pergamon Press Ltd., Headington Hill Hall, Oxford, 1964. Price: £6.

To those active in the field of aerosol science the work of N. A. Fuchs has been known for a long time and the publication of an English translation of his book will be a welcome event. The Russian edition appeared in 1955 and was followed in 1961 by an addendum written specially to bring the work up to date (i.e. to 1960) for translation into English.

According to Webster's Dictionary an aerosol is 'a suspension of ultramicroscopic solid or liquid particles in air or gas' and according to Green and Lane in their book on particulate clouds the term was coined near the end of the First World War to represent the aerial counterpart of a hydrosol or liquid colloidal suspension. Not surprisingly the term has come to be used in a looser sense than originally intended and in the present book the term encompasses particles of radii in the range 10^{-7} to 10^{-1} cm, well outside the range of 10^{-5} to 10^{-4} normally associated with ultramicroscopy.

As the author explains at the outset his aim is to review and critically examine all theoretical and experimental work on the motion of particles under the action of external forces, also taking into account where necessary the effect of the interaction of the particles themselves. This aim is achieved under the following broad headings: physical classification (size distribution, structure); motion of various kinds (steady rectilinear, non-uniform rectilinear, curvilinear); diffusion and deposition by Brownian motion and by forced convection and turbulence; coagulation; detachment by wind action; fluidization of powders. There are nearly 900 references to original papers and other books.

To the physicist concerned with one aspect or another of particle physics, in laboratory work and in industrial processes, there is no doubt that the book will be a valuable reference volume and an authoritative guide. For the meteorologist in particular there are two specific applications, namely in the microphysics of clouds and in the dispersion of particulate material in the atmosphere. The chapter on coagulation devotes about 10 pages to reviewing the work on the collision and coagulation of droplets as a result of their relative motion, and this chapter includes leading contributions made in the U.K. up to 1960. The chapter on convective and turbulent diffusion runs to nearly 40 pages, of which the last 15 pages are specifically devoted to the movement of aerosols in the atmosphere, and much of the remainder, in dealing with flow in pipes and ducts, is also relevant to the atmospheric problem. The classical milestones in the treatment of diffusion in this country are given proper place but, surprisingly in the circumstances, there is no reference to work which has emanated from Moscow on atmospheric diffusion, notably that of Monin, which is well known here. Otherwise the treatment is reasonably up to date and comprehensive for 1960, and it is noteworthy that important issues such as the distinction between Eulerian and Lagrangian properties, and between the spread of a cluster of particles and that of a continuous release of particles, are well recognized. To those concerned with the latest development of the science of turbulence and diffusion some differences of view will inevitably occur. For example, on a purely formal matter, the author's first reference to a Lagrangian system (p. 258) will not be acceptable to fluid dynamicists!

Again, but in a more important practical matter, the second item in the author's summary (p. 283) of requirements for further progress in problems of atmospheric diffusion shows an unawareness of what can be achieved by reasonable adaptation of the statistical theory of turbulence.

Those responsible for the translation and editing thereof are to be warmly congratulated. It is only in very occasional places that a choice of word or phrase betrays the work as a translation. There are very few misprints and omissions. The tables and diagrams are excellent and here the only improvement which this reviewer would request is the inclusion, with the table or diagram, of a reference to the source of the data. The printing and binding are also of high quality and altogether the book can be highly recommended.

F. PASQUILL

The structure of atmospheric turbulence, by J. L. Lumley and H. A. Panofsky. $9\frac{1}{4}$ in × 6 in, pp. xi + 239, *illus.*, John Wiley & Sons, Glen House, Stag Place, London, S.W.1., 1964. Price: 72*s*.

The study of atmospheric turbulence in the lower atmosphere has developed considerably in the last decade and the classic work of the early 1950's, Sutton's *Micrometeorology*, which largely encompassed the whole subject in a single book, would now if written with the same comprehensiveness fill several volumes.

The arrival on the scene of Lumley and Panofsky's book is therefore very welcome and it takes its rightful place on the shelf beside Priestley's *Turbulent Transfer in the Lower Atmosphere* and Pasquill's *Atmospheric Diffusion*, to form a trio of books which go a long way to spanning, with an up-to-date account, the subjects of atmospheric turbulence and transfer processes.

Lumley and Panofsky purposed to summarize the basic characteristics of turbulence of meteorological interest as derived from the hydrodynamical equations and to bring up to date the observational data including recent Russian observations. They have succeeded admirably. Just under half the book deals with the statistical description of turbulence in terms of the now familiar covariances, correlations and spectra and the many subtle related problems and connexions between them. These were dealt with to some extent in Pasquill's book, of course, but on comparison one is constantly struck with the complementary nature of the two accounts. Pasquill was concerned with diffusion of smoke and particles and was therefore writing with the practical meteorologist, rather than the mathematician, in mind. It was none the worse for that. Now Lumley and Panofsky have produced this rather more academic account which the theoretician is bound to appreciate; it is thorough and detailed and should be particularly valuable in the Universities.

The second part of the book deals with the observational material, beginning with the profiles of temperature and wind close to the ground. Convection is briefly dealt with, being in a sense an addendum to Priestley's book in the light of more recent observations and the development of Monin and Obukhov's similarity theory. Then comes a chapter on the magnitude of turbulent fluctuations followed finally by an account of spectra and the scales of atmospheric turbulence. Both these chapters are full of very useful material and although some duplication is inevitable they provide a welcome expansion of the sections in Pasquill's book on these topics.

At the end of the book are two short appendices in the form of glossaries. The first expounds three meteorological terms (lapse rate, the perfect-gas law and Coriolis force) and is of doubtful value in a book of this calibre; the second discusses certain mathematical methods and terms and is of rather more significance.

The book is well written, the diagrams are well drawn and clearly reproduced and the whole production of the book is such that it is a pleasure to use and to read. A very useful list of references is not least of its potential uses to serious students and workers in this field. Very many problems remain to be solved—many of them of fundamental nature—along the way to understanding turbulence, but Lumley and Panofsky have here laid an important milestone.

F. B. SMITH

NOTES AND NEWS

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Address by Professor S. Tolansky, F.R.S.

Pursuing his policy of inviting distinguished speakers from other realms of science, the Director-General invited Professor S. Tolansky of the Royal Holloway College, University of London, to lecture at Bracknell on 19 November 1964 (see Plate III). Professor Tolansky is a world authority on the structure of diamonds and has developed to a fine art the technique of multiple-beam interferometry for the examination of surfaces. The keen pleasure the speaker obviously derived from his subject was infectious and made this a most enjoyable address.

To examine the microtopography of a surface, Professor Tolansky uses the interference fringes set up in monochromatic light by multiple reflections between a semi-silvered (that is, partly transmitting but largely reflecting) plane glass surface and a similarly treated surface of the object to be examined, set a small distance apart and at a small angle to each other. The distance apart of the interference fringes can be controlled by the angle between the surfaces but the fringes themselves are height contours of the surface examined provided the reference glass surface is smooth. The difference in height of neighbouring contours is only half a wavelength of the light used (i.e. about 2500 Ångströms (Å) or a quarter of a micron). The fringes can be made very sharp and Professor Tolansky estimated that steps on the surface of no more than 2 Å could be detected and displayed, a distance comparable with molecular diameters. The magnification obtained in this one dimension (perpendicular to the surface) therefore is very much greater than can be obtained by any other means. In the other two dimensions, in the plane of the surface, the magnification is that of the microscope used to examine the fringes.

Slides were shown of the spiral growth of crystals and of the application of this technique for the examination of surface microstructure during hardness tests. An interesting aeronautical development was the use of multiple-beam interferometry to display and measure the damage caused to metal and perspex surfaces by high-speed impact of single raindrops. Specimens of the material to be tested were shot from an airgun at speeds of up to 800 mph at a drop of known size suspended on a fine fibre. These studies revealed that the damage caused by raindrops increased very considerably with speed of impact, the damage being proportional to the eighth power of the speed for speeds between 500 and 1000 mph.

Turning next to ice crystal growth, Professor Tolansky remarked on the extraordinary symmetry revealed by photographs of individual ice crystals. Not only was there the overall symmetry of the familiar hexagonal growth but even to the finest details was this symmetry preserved. Professor Tolansky maintained by analogy with the complex but symmetrical patterns of vibration observable on a metal plate in various modes of vibration (see Plate IV*), that the exceptional symmetry of the ice crystal could only be explained on the assumption that the crystal was vibrating during growth. On this theory, applicable only to growth of ice crystals by diffusion while falling freely, water molecules would attach themselves preferentially to the nodes of vibration, where there was no motion, rather than to the oscillating antinodes. The theory is a difficult one to test experimentally, and highly symmetrical crystals may themselves be very rare, but we are far from knowing the reasons for crystal growth habits of ice and Professor Tolansky's theory must clearly be taken into account.

R. F. JONES

551.508.57

New Meteorological Office wind-finding radar

On 13 October 1964 a demonstration of the new Meteorological Office wind-finding radar was given at the upper air station at Crawley, Sussex, to inaugurate the equipment (Plate V). The demonstration was attended by the Director-General and members of the directorate of the Meteorological Office, together with senior officers from the Ministry of Aviation and Messrs. Cossor Electronics Ltd., the manufacturers.

The new radar, the first of its kind to be accepted by the Meteorological Office, is known as the Cossor 353D and complies with a Meteorological Office specification calling for a range of operation of 200 km together with enhanced accuracy to permit the satisfactory determination of upper winds at this long range. There are no height limitations, as such, to the operation of the wind-finding system, and the range of 200 km will ensure that virtually all wind-finding balloons will remain within the field of the radar while ascending to 100,000 ft, whatever the prevailing wind speed.

The radar, which will be styled the 'Meteorological Office Wind-Finding Radar Type 4' (MOWFR 4) has a number of features, novel in British wind-finding equipment. The aerial system can be remotely controlled from an optical director for the initial location of the balloon and radar target by visual means, and there is a system for acquisition by radar when the balloon is obscured by fog or low cloud. The balloon, once so located, will subsequently be followed automatically for the remainder of the flight.

Observations of range, elevation and azimuthal bearing are provided at intervals which may be varied from 1 minute to 15 seconds, the dials indicating these values being held stationary during the period of reading.

Steps are now being taken to secure equipment which will present these values in printed tabular form, as a step towards the possible automatic computation of the wind measurement itself.

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*BENTLEY, W. A. and HUMPHREYS, W. J.; Snow crystals. New York, McGraw-Hill Book Co., inc., 1931.

The radar equipment is built into the existing offices of the station thus providing considerably improved operating conditions compared with those of the previously trailer-mounted radar. In all, 11 of this type of Cossor radar are on order, for use at both home and overseas upper air stations.

A. L. MAIDENS

OBITUARY

Mr. John Wemyss Reid.—It is with deep regret that we report the death on 9 October 1964, at the early age of 29, of John Reid, Scientific Assistant. His many friends and colleagues will remember him not only for his conscientious work, but for his cheery disposition and unfailing ability to instil humour into the daily round.

John Reid joined the Meteorological Office in August 1954 and accepted a permanent appointment early in 1959. When he came to Preston from Eskmeals towards the end of 1957, he had already experienced a wide variety of work, including radiosonde duties, at a number of outstations. Apart from a short detachment to Blackpool, his home town, he remained until 1961 at the Main Meteorological Office at the Air Traffic Control Centre, Preston, from where he volunteered for overseas service. After an exhaustive medical examination he was pronounced fit for Germany and was posted to Wildenrath in June 1961. Here he was joined by his family and apart from one spell in hospital successfully completed his tour of duty.

He returned to Blackpool in June 1964 with high hopes for the future, and made plans for a new house which was still under construction at the time of his untimely decease. It is a great tribute to his indomitable courage that he fought on for many weeks after the doctors had given up all hope.

Our heartfelt sympathy goes to his widow and two young daughters.

H.T.D.H.

OFFICIAL PUBLICATION

GEOPHYSICAL MEMOIRS

No. 108—*Gales in Yorkshire in February* 1962, by C. J. M. Aanensen, M.Sc.

Geophysical Memoirs No. 108 deals primarily with the gale of 16 February 1962 which produced great damage in the Sheffield area in particular, and on the eastern slopes of the Pennines in general. Descriptions are given of the damage to buildings in Sheffield and to trees in north-east England. The synoptic situation which produced the gale is investigated and a survey of the pressure and wind fields on both a synoptic and meso-scale is followed by consideration of lee-wave phenomena. Calculation on a two-dimensional basis of the standing resonant lee-wave pattern gives an explanation of the gale. A calculation for 12 February 1962 also shows why a similar synoptic pattern on that occasion was not accompanied by severe gale damage. The similarity with occasions of previous westerly gales in Sheffield and possible frequency of such gales is discussed.

CORRIGENDUM

Meteorological Magazine, December 1964, p. 359, Table I; for "Height of freezing-level above the ground (gpm)" read "Height of freezing-level above the ground (mb)."