M.O. 581 AIR MINISTRY

METEOROLOGICAL OFFICE

THE METEOROLOGICAL MAGAZINE

VOL. 83, No. 988, OCTOBER 1954

A KATA-FRONT OF NOTABLE STRUCTURE

By M. K. MILES, M.Sc.

A cold front which crossed England on July 6, 1953, seems worthy of attention on account of the way in which warm and very dry air came in at medium levels ahead of the surface front.

At 0200 G.M.T., when the surface front was near the Isle of Man lying approximately north-east to south-west, the Liverpool radio-sonde observation showed very dry air above a weak inversion at 650 mb. Below, the air was fairly moist with a very steep humidity lapse near 650 mb. The Hemsby 0200 observation showed fairly moist air at all levels, with a slight increase of humidity above 700 mb. (see Figs. 1 and 2).

At 1400 when the surface front was lying from the Wash to Pembroke (see Fig. 3) the Crawley radio-sonde observation showed a similar structure, moist air to 750 mb. and then a very rapid decrease of humidity. The temperature of the very dry air was in both cases the same or a little higher than that of the moist air at Hemsby.

The rear edge of the rain belt (about 100 miles wide) was at least 100 miles ahead of the surface front at 0200, and, later, clearances occurred as much as 150 miles ahead. At some places rain began again, but at no time was there rain nearer than 100 miles to the front.

The vertical structure of the atmosphere near the front may be represented schematically as in Fig. 4. The boundary of the dry air must be supposed to slope upwards nearly vertically just east of Liverpool since Hemsby showed no sign of it, and in the moderate rain reported at Manchester at 0100 saturated air must have reached to 500 mb. at least. This nearly vertical boundary appears to have been nearly parallel to the surface front since it can be assumed almost coincident with the back edge of the rain area. The wind field at 600 mb. is consistent with this inference. The fluctuation of the edge of the rain belt may indicate that there was some oscillation of this boundary.

The components of the winds normal to the surface front indicate relative forward motions of about 7 kt. at 600 mb. and 19 kt. at 500 mb. at Liverpool, but at Hemsby the air was moving slower than the front up to 400 mb. Over-running is shown at Aldergrove, beginning at 700 mb. and increasing with height. It is also noteworthy that a wind veer occurred at 700 mb. and above before the passage of the surface front at Liverpool, Hemsby and Crawley.

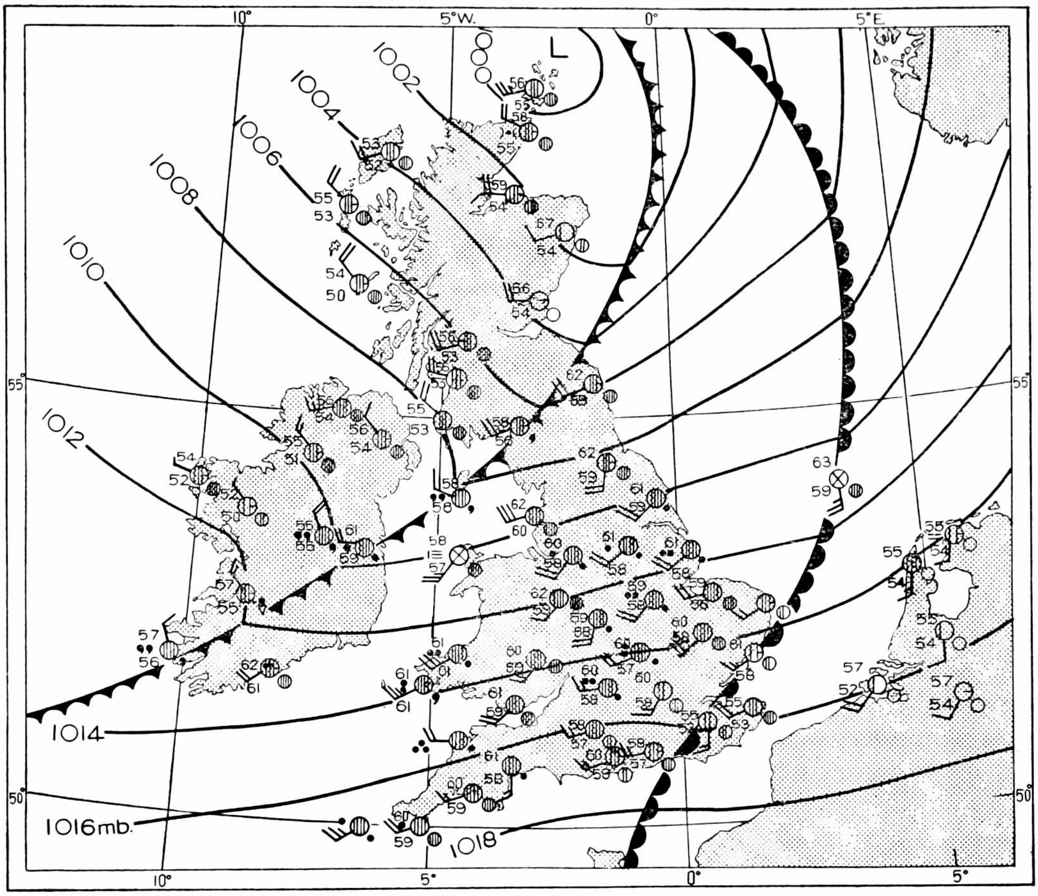


FIG. I—SYNOPTIC CHART, 0200 G.M.T., JULY 6, 1953

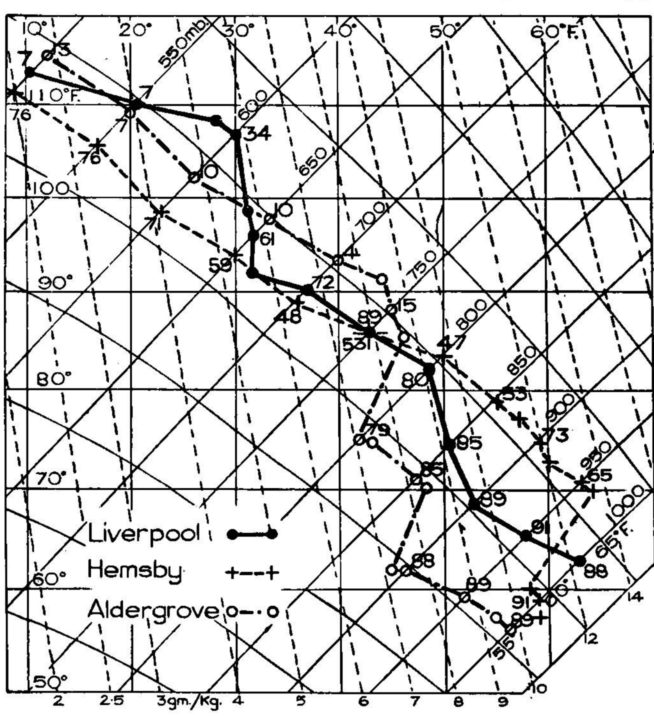


FIG. 2—TEPHIGRAM OF RADIO-SONDE ASCENTS, 0200 G.M.T., JULY 6, 1953
The figures at the side of the curves give the observed relative humidity.

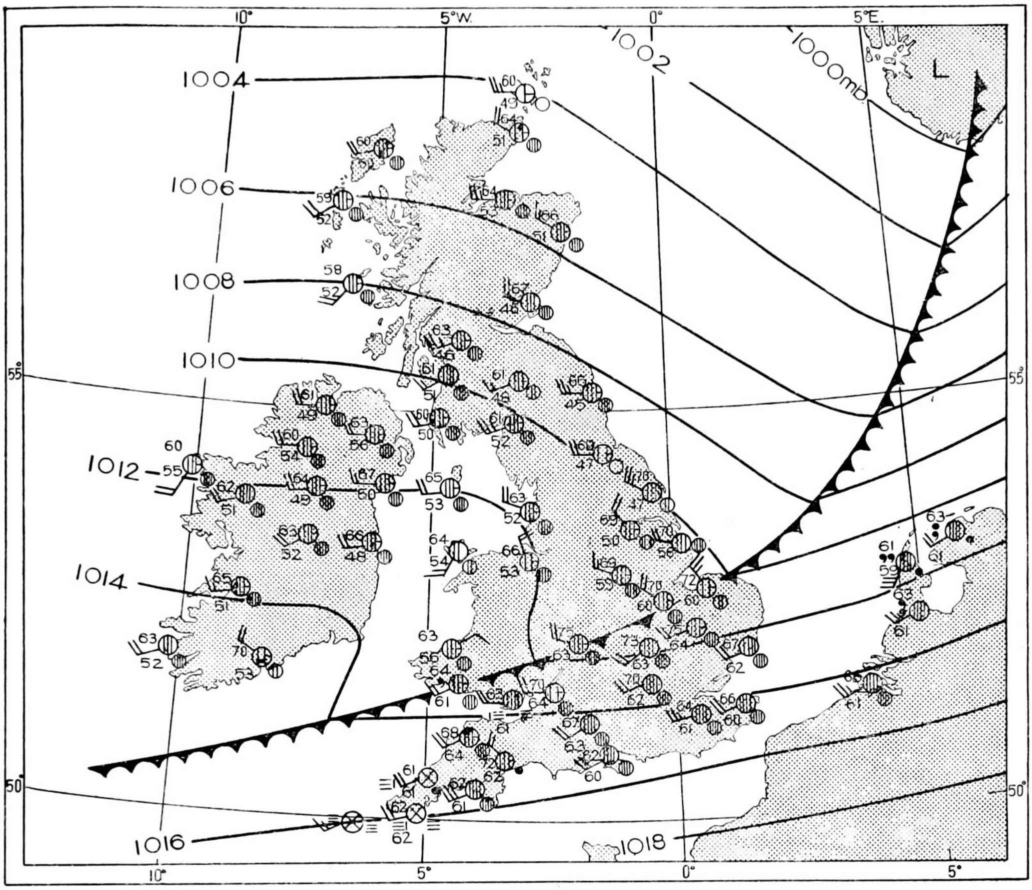


FIG. 3—SYNOPTIC CHART, 1400 G.M.T., JULY 6, 1953

The wind and temperature distributions at Aldergrove are typical of those behind kata-fronts as found by Sansom[1]. The Liverpool sounding was not typical for places 100 miles ahead, where Sansom usually found moist air. However, it is quite common for rain to cease for distances of up to 50 miles ahead of kata-fronts, and in these cases it may be presumed that drier air is coming in aloft ahead of the surface cold air. This case, then, may be thought of as an extreme example of this forward over-running.

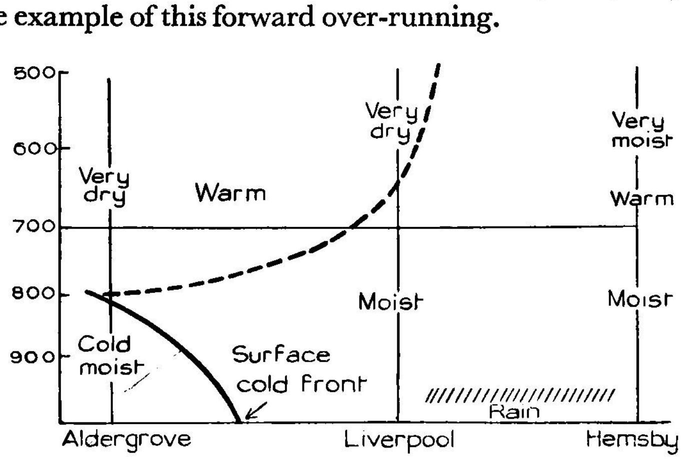


FIG. 4—SCHEMATIC STRUCTURE OF THE COLD FRONT
0200 G.M.T., July 6, 1953

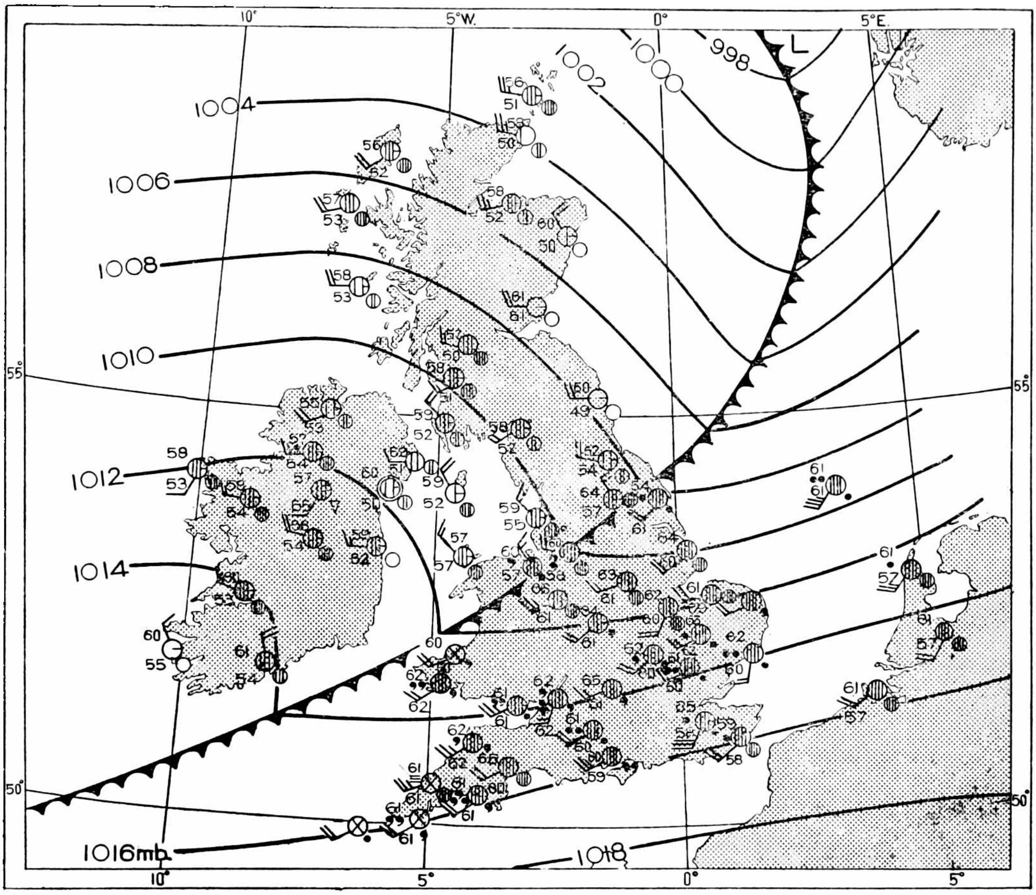


FIG. 5—SYNOPTIC CHART, 0800 G.M.T., JULY 6, 1953

It is interesting to notice that this front was very well defined at the surface. The dew points on the two sides differed by 8–10°F., wind veers of about 90° occurred and there was a sharp isobaric trough (see Fig. 5). This has enabled the estimates of wind normal to the front to be made with some confidence, but the chief interest of the situation lies in the apparent dissociation of this well marked surface front from events in the upper air. All the dynamical activity occurred about 100 miles ahead of it, i.e. the change in the field of vertical motion indicated by the cessation of rain and the humidity change, and this was approximately associated with the wind veer above 700 mb. noted above. The isobaric structure at the surface can be accounted for by the hydrostatic effect of a wedge of air about 5°F. colder and reaching a maximum depth of about 6,000 ft., and this the upper air ascents show to have actually existed.

Two interesting questions then remain. What controls the dynamical aspect of the front as opposed to the hydrostatic? How are we to classify this warm but dry air that lies above, and goes forward more or less independently of, the shallow cold wedge?

It is suggested that here it was the advance of an intensifying trough, little more than 30° of longitude to the west, that affected the dynamics of the front. The relevant flow pattern can be seen clearly on the 300-mb. chart for 0200 G.M.T. (Fig. 6). The contour ridge up wind from this frontal trough over the British Isles is little more than 15° of longitude away. With the prevailing flow

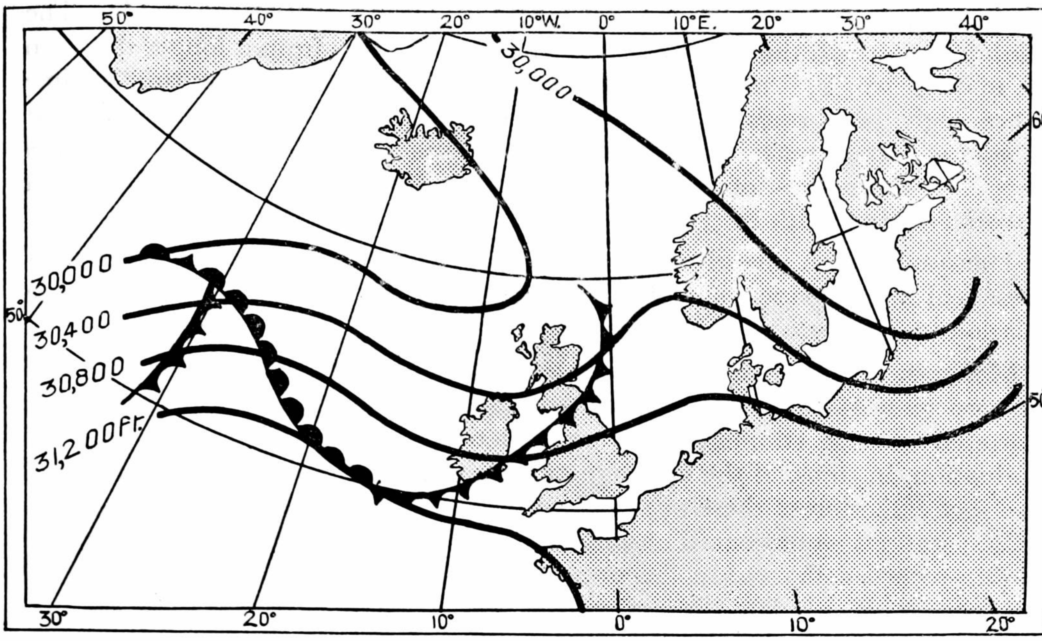


FIG. 6—300-MB. CONTOURS, 0200 G.M.T., JULY 6, 1953

The surface frontal system is indicated by the usual symbols.

(106 kt. at 300 mb. at ocean weather station J) this short wave-length implies considerable ageostrophic motion causing an acceleration and perhaps a weakening of the down-wind trough. At lower levels where the zonal flow is less there would be less or even no acceleration and the upper trough would thus get ahead of the surface front. The acceleration (and weakening) of the upper trough would probably be accompanied by dynamical warming of the southern and western parts of the associated thermal trough[2]. This would lead to the existence behind the upper trough line of dry subsided air, and this, it is suggested, is the air encountered above 650 mb. at Liverpool at 0200 and above 700 mb. at Crawley at 1400. The dry air should on this hypothesis be classified as subsided cold air—a description consistent with the low wet-bulb potential temperatures observed.

REFERENCE

1. SANSOM, H.; A study of cold fronts over the British Isles. *Quart. J. R. met. Soc., London*, **77**, 1951, p. 96.
2. MILES, M. K.; Influence of a quasi-stationary long-wave pattern on small-scale thermal features (in the press).

ONE ASPECT OF THE PATTERN OF RAINFALL

By A. B. THOMSON, M.A.

A glance at the appropriate tables in the annual volumes of *British Rainfall* shows that, if a reasonably long period is taken, rain anywhere in the British Isles falls at a mean rate (i.e. total amount divided by its duration) which is very nearly constant, a fact which is not as well known amongst meteorologists as it deserves to be. To give one example; in 1951, 66·74 in. of rain fell during the 12 months at Eskdalemuir (Dumfriesshire) in 1,380 hr. The corresponding figures for Mildenhall (Suffolk) were 26·63 in. in 581 hr. The respective mean rates of rainfall were 0·048 and 0·046 in./hr. The popular belief that rainfall is more intense in the western Highlands of Scotland, say, than in the drier areas of the east is not supported by the mean-intensity records available. The truth is that much the greater part of the excess results from a longer duration or, in other words, it merely rains longer in the Highlands. From time to time exceedingly high rates of rainfall do, of course, occur and, being of great economic importance, receive considerable space in the volumes of *British Rainfall.* They are infrequent, however, and will not appreciably affect statistics dealing with the general distribution pattern of rainfall.

The results of an investigation into one aspect of the question of "pattern" is presented in this paper, namely the incidence of amount of rain in an hour in relation to locality, season and total rainfall.

Method.—Tables in an article on the distribution of rainfall in the *Meteorological Magazine*[1] showed the constancy of distribution over four widely scattered coastal stations. The construction of these tables involved the evaluation, in steps, of the duration of rates of rainfall greater than r mm./hr., and any extension of these tables to cover a period of several years at suitably chosen stations would entail an immense expenditure of time in the evaluation of rain-recorder charts. In the present investigation the more easily obtained number, N, of tabulated hours with r mm. or more has been used. Within limits, a statistical relationship between N, r and R (the total rainfall) can be found.

Data.—For each of the stations listed in Table I the number, N, was ascertained for various values of r, and the ratio R/N calculated, R being the total monthly or annual rainfall recorded in millimetres. It was not felt justifiable to evaluate monthly values of R/N for a period of less than 5 yr. except for $r \geqslant 0 \cdot 1$ mm./hr. The results are set out in Tables II and III.

Conclusions.—For periods of 5–6 yr. there is good agreement in the monthly ratios up to $r \geqslant 2$ mm./hr. or $r \geqslant 3$ mm./hr., and in the annual ratios up to $r \geqslant 4$ mm./hr. At Leuchars and Valentia the annual ratios for $r \geqslant 5$, 6,

TABLE I—OBSERVED TOTAL NUMBER OF TABULAR HOURS WITH r OR MORE MILLIMETRES OF RAIN

Station	Period	r or more millimetres of rain 0·1	1·0	2·0	3·0	4·0	5·0	6·0	7·0	Total recorded rainfall
		number of hours								mm.
Wick	1948–52	6,644	1,274	368	130	50	28	14	10	4,039·5
Leuchars	1936–40, 1945–52	13,085	2,818	971	407	202	105	56	38	9,074·8
Glasgow, Renfrew	1948–52	6,914	1,726	582	235	107	51	36	19	5,157·6*
Prestwick	1947–52	7,467	1,765	607	242	120	54	27	11	5,403·3†
Valentia	1922–37	29,004	7,226	2,912	1,334	630	337	175	101	22,726·0
Orkney, Grimsetter	1951	1,675	326	84	27	10	5	4	0	1,023·1
Aberdeen, Dyce	1951	1,292	314	114	53	27	18	10	7	977·2
Edinburgh, Turnhouse	1951	1,063	270	95	32	19	11	6	4	797·4
West Freugh	1951	1,276	351	122	52	22	6	4	0	997·9
Eskdalemuir	1935	1,826	520	192	81	39	22	9	5	1,523·6
Kew	1935	870	204	85	34	15	7	4	1	651·9

* Excluding January and February 1948.

† Excluding February and March 1947 and December 1950.

TABLE II—MONTHLY VALUES OF R/N

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
						$r \geqslant 0{\cdot}1$ mm./hr.							
Wick	0·6	0·5	0·7	0·5	0·5	0·6	0·7	0·9	0·6	0·6	0·6	0·6	0·6
Leuchars	0·6	0·6	0·6	0·5	0·7	0·6	0·9	0·9	0·9	0·7	0·7	0·6	0·7
Renfrew	0·7	0·7	0·6	0·7	0·7	0·7	0·8	0·9	0·9	0·8	0·7	0·7	0·7
Prestwick	0·6	0·6	0·6	0·7	0·7	0·7	0·8	1·0	0·9	0·8	0·7	0·6	0·7
Valentia	0·9	0·7	0·7	0·7	0·7	0·8	0·8	0·8	0·8	0·7	0·8	0·8	0·8
Grimsetter	0·6	0·5	0·6	0·6	0·3	0·5	0·7	0·7	0·4	0·6	0·7	0·6	0·6
Dyce...	0·7	0·7	0·5	0·5	0·5	0·7	1·2	0·8	0·6	0·8	1·2	0·8	0·8
Turnhouse	0·8	0·6	0·6	0·6	1·0	0·9	1·0	1·1	0·4	0·4	0·8	0·6	0·8
West Freugh ...	0·7	0·5	0·7	0·6	0·9	0·7	0·7	0·9	0·8	0·6	1·0	0·9	0·8
Eskdalemuir ...	0·6	0·9	0·6	1·0	1·0	0·8	0·6	1·1	1·1	0·9	0·8	0·5	0·8
Kew	0·4	0·7	0·4	0·7	0·6	0·8	2·1*	1·3	0·8	0·7	0·8	0·5	0·7
						$r \geqslant 1{\cdot}0$ mm./hr.							
Wick	3·1	2·5	2·9	3·7	3·3	3·2	3·3	3·3	3·4	3·4	3·0	3·6	3·2
Leuchars	3·1	3·4	3·3	3·6	2·9	3·6	3·2	3·2	3·5	3·2	2·9	3·4	3·2
Renfrew	2·7	3·1	2·7	3·7	2·8	3·2	3·1	3·2	3·2	2·8	2·9	2·9	3·0
Prestwick	3·0	3·2	2·8	3·0	3·0	3·1	3·3	3·5	2·9	3·3	2·8	3·1	3·1
Valentia	3·1	3·0	3·1	3·1	3·0	3·3	3·2	3·3	3·2	3·1	3·2	3·2	3·1
						$r \geqslant 2{\cdot}0$ mm./hr.							
Wick	11·8	16·1	12·5	8·4	15·2	10·6	10·2	8·1	11·5	11·8	14·2	11·8	11·0
Leuchars	10·9	19·5	12·6	13·5	8·3	10·1	7·4	7·2	9·0	7·9	8·1	13·3	9·3
Renfrew	9·8	10·0	11·6	12·9	10·0	9·1	7·1	8·3	7·5	7·7	9·4	8·8	8·9
Prestwick	10·2	11·4	13·8	12·6	9·2	8·1	8·1	7·3	6·8	8·8	7·7	10·5	8·9
Valentia	7·5	8·1	8·3	8·6	8·4	8·4	6·8	7·9	7·7	8·3	7·7	7·3	7·8
						$r \geqslant 3{\cdot}0$ mm./hr.							
Leuchars	35·7	71·6	29·9	30·3	25·3	22·8	14·2	11·6	14·3	16·1	29·0	58·2	22·3
Valentia	16·6	18·3	20·1	20·9	24·5	15·5	14·6	14·5	18·2	18·5	15·1	16·0	17·0
						$r \geqslant 4{\cdot}0$ mm./hr.							
Leuchars	99·1	214·8	209·4	72·8	44·6	61·5	25·1	22·6	23·9	39·1	73·7	106·8	44·9
Valentia	31·7	46·4	43·4	60·0	55·0	32·8	27·4	26·2	36·2	40·6	33·6	36·7	36·1

* A fall of 21·4 mm. in one hour accounted for more than half the month's total rainfall.

7 mm./hr. compare not unsatisfactorily. The monthly figures indicate a seasonal variation at some of the stations, but whether this and the high values of $r \geqslant 2, 3, 4$ mm./hr. at Wick and Grimsetter are real is not certain.

The formula (by least squares),

$$\frac{R}{N} = 0{\cdot}291 \times 10^{1{\cdot}063\sqrt{r}}$$

or

$$\log \frac{R}{N} = 1{\cdot}063\,\sqrt{(r)} - 0{\cdot}536,$$

where R and r are in millimetres, gives a reasonably good fit to the observed Valentia data up to $r \geqslant 5$ mm./hr. or $r \geqslant 6$ mm./hr. (see Table III). The

TABLE III—ANNUAL VALUES OF R/N

	r or more millimetres of rain							
	0·1	1·0	2·0	3·0	4·0	5·0	6·0	7·0
Wick	0·6	3·2	11·0	31·1	80·8	...	...	...
Leuchars ...	0·7	3·2	9·3	22·3	44·9	86·4	162·1	238·8
Renfrew ...	0·7	3·0	8·9	22·1	48·2	...	...	...
Prestwick ...	0·7	3·1	8·9	22·3	45·0	...	...	...
Valentia ...	0·8	3·1	7·8	17·0	36·1	67·4	130·0	227·0
Grimsetter ...	0·6	3·1	12·2	36·9	102·3	...	...	...
Dyce	0·8	3·1	8·7	18·4	36·2	...	...	...
Turnhouse ...	0·8	3·0	8·4	24·9	42·0	...	...	...
West Freugh ...	0·8	2·8	8·2	19·2	45·4	...	...	...
Eskdalemuir ...	0·8	2·9	7·9	18·8	39·1	...	...	...
Kew	0·7	3·2	7·7	19·2	43·5	...	...	...
Theoretical R/N, Valentia	0·6	3·4	8·9	20·2	38·9	69·3	116·7	189·1

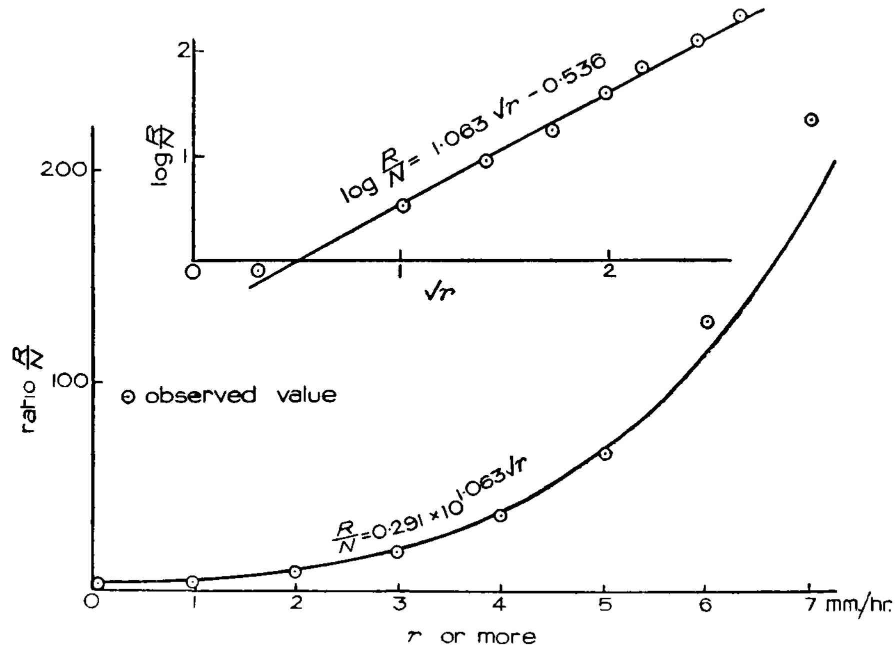


FIG. 1—HOURLY RAINFALL AT VALENTIA, 1922–37

theoretical curves for Valentia are shown on Fig. 1. If this formula holds for all stations in the British Isles, then the total rainfall, R, will determine the number of tabular hours, N, on which not less than r mm. of rain will fall.

Reference was made above to the small variation over the British Isles of the mean rate of rainfall, i.e. the ratio of total rainfall to the actual time during which it rains is nearly constant. Table II shows that at all the stations the number of tabular hours in which rain falls (0·1 mm. or more) is very nearly $1\frac{1}{3}$ times the total rainfall measured in millimetres.

A similar relationship between R/N and $\sqrt{r}$ seems to hold at Poona. Table IV was compiled from data published by Narasimhan and Zafar[2] for the 10-yr. period 1930–39.

TABLE IV—MEAN NUMBER OF HOURS, N, A YEAR WITH r IN. (OR MM.) OR MORE RAIN AT POONA, 1930–39

Mean annual rainfall 27·7 in. (703·6 mm.)

r in. or more	0·01	0·06	0·11	0·16	0·21	0·26	0·31	0·36	0·41	0·46	0·51
r mm. or more	0·25	1·52	2·79	4·06	5·33	6·60	7·87	9·14	10·41	11·68	12·95
N (hr.)	443·5	109·5	59·8	40·1	28·4	22·1	17·7	14·0	10·3	8·5	6·9
Observed R/N	1·6	6·4	11·8	17·6	24·9	31·9	39·9	51·0	68·3	83·0	102·3
Theoretical R/N	2·0	5·3	9·5	14·8	21·8	30·7	41·9	55·7	72·5	93·3	118·3

The observed values of R/N, and the theoretical values calculated from the formula (by least squares) connecting N, R and r (R and r in millimetres),

namely $$\frac{R}{N} = 1{\cdot}05 \times 10^{0{\cdot}57\sqrt{r}}$$

or $$\log\frac{R}{N} = 0{\cdot}02 + 0{\cdot}57\sqrt{r},$$

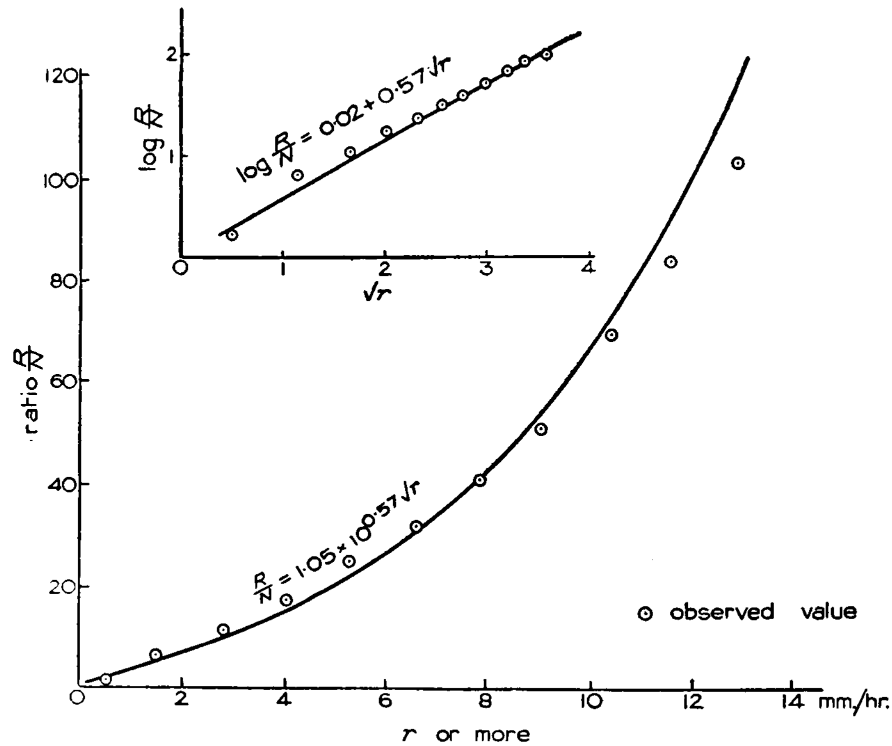


FIG. 2—HOURLY RAINFALL AT POONA, 1930–39

are appended to Table IV and the theoretical curves for Poona are shown in Fig. 2.

REFERENCES

1. MCCONALOGUE, D. J.; On the distribution of rainfall rates at some coastal stations in the British Isles. *Met. Mag., London,* **82,** 1953, p. 304.

2. NARASIMHAN, V. L., and ZAFAR, M.; An analysis of the hourly rainfall records at Poona. *Sci. Notes met. Dep. India, Simla,* **9,** No. 110, 1947, p. 93.

SURFACE TEMPERATURE AND VAPOUR PRESSURE AT LONDON AIRPORT

By N. E. DAVIS, M.A.

Surface temperature.—Statistics relating to the mean daily maximum and minimum temperature for each month are available for most weather observing stations together with the highest and lowest recorded. In addition, values may be given of the mean monthly maximum and minimum, i.e. the highest (or lowest) in any particular month averaged for that month over a number of years. At observatories values of the means for each hour for each month are also published. However such statistics in no way fully describe the variation of temperature at a place. Curves showing the diurnal variation of hourly mean temperature and the diurnal variation of standard deviation about the hourly means give a much better representation of the temperature régime at a place, a representation which, although not entirely complete, is sufficient for most purposes and allows adequate comparison of the temperature at different places.

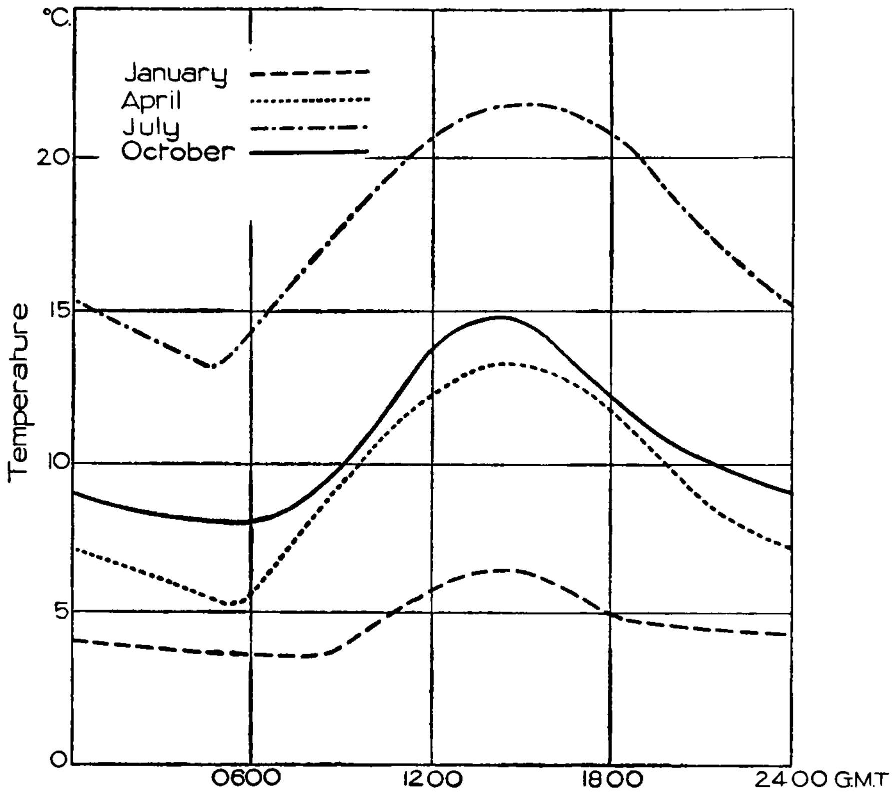


FIG. I—DIURNAL VARIATION OF TEMPERATURE AT LONDON AIRPORT

A curve showing the diurnal variation of hourly mean temperature may be constructed by taking the mean for each hour or as many hours as are available over a particular month for a number of years and drawing a smooth curve through the values so obtained. The temperature at any particular time of day however varies from day to day, and this may be shown by calculation of the standard deviation of the temperature about its mean for a particular hour for a particular month. The values thus calculated vary from hour to hour and may be presented by means of a curve drawn through the values.

At London Airport the diurnal curves of mean temperature for the four months January, April, July and October are given in Fig. 1 and the diurnal curves of standard deviation for the same months are given in Fig. 2. These curves are derived from observations of temperature at the main observing hours, 0000, 0300, 0600, 0900, 1200, 1500, 1800 and 2100 G.M.T. over the five years 1947–51, inclusive. Means and standard deviations for each of these hours for each month were calculated separately and smooth curves were drawn through the calculated values.

The most remarkable feature of these two sets of curves is that although the diurnal curve of mean temperature is at a much higher average level in July than it is in January, the standard deviation curves show little annual variation in general level. The prime reason for this is that the polar front is active over Great Britain throughout the year—in no month does one air mass predominate to the exclusion of the others. The reason for the standard deviation at night

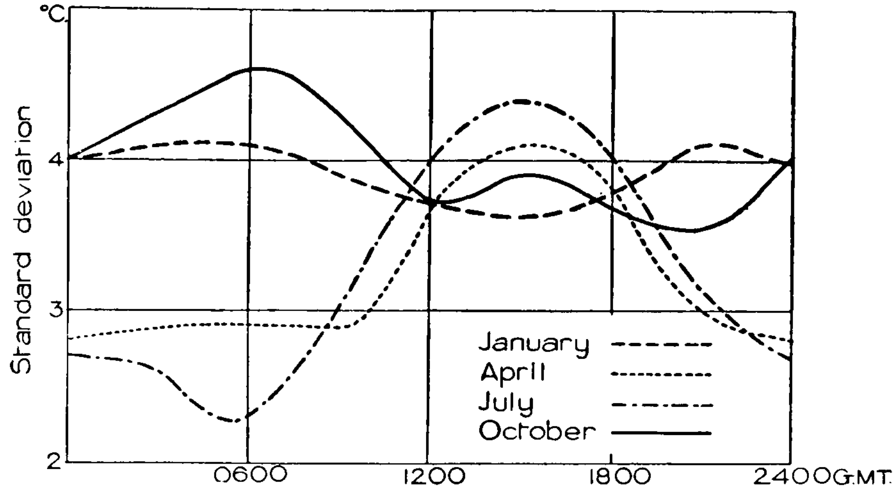


FIG. 2—DIURNAL VARIATION OF THE STANDARD DEVIATION OF TEMPERATURE AT LONDON AIRPORT

being greater in January and October than in April and July will become apparent after discussion of the shapes of the individual curves.

The significant features of the individual curves are as follows:—

In January:

(*a*) the small diurnal range of temperature

(*b*) the maximum standard deviation at about the time of minimum temperature and a minimum standard deviation at about the time of maximum temperature

(*c*) the small fall of temperature during the night hours.

In April:

(*a*) a greater diurnal range of temperature compared with January

(*b*) a maximum standard deviation at the time of maximum temperature.

In July:

(*a*) a maximum diurnal range

(*b*) a maximum standard deviation at about the time of maximum temperature and a minimum at about the time of minimum temperature

(*c*) the time of maximum temperature delayed until 1500 or 1600.

In October:

(*a*) a smaller diurnal variation of temperature than in April but still more than in January

(*b*) a maximum standard deviation at the time of minimum temperature and a secondary maximum at the time of maximum temperature

(*c*) a slow rise of temperature after sunrise.

These features are to be explained in the main by consideration of the amounts of cloud or fog normally associated with each type of air mass, the velocity of the wind and the amount of insolation. Average day-time cloud cover does not vary much from month to month, averaging about 6 oktas throughout the year. Hence the diurnal range of temperature which depends on the amount of incoming radiation should be greatest in July and least in January, while that of April should be greater than that of October. Over the period under consideration 1947–51, however, April was probably rather less cloudy than usual so that the diurnal variation was rather larger than one would expect.

In any type of air mass except with E. and SE. winds the temperature at London Airport tends to approach the temperature of the surrounding seas by day or night whenever there is sufficient cloud cover to keep incoming or outgoing radiation to a minimum or sufficient surface wind, and consequent turbulence, near the ground to minimize the effects of radiation. With E. or SE. winds, owing to the shorter sea track, the air tends to retain the temperature characteristic of its continental source. Hence at London Airport the larger departures of temperature from the sea temperature will normally occur when skies are clear, so that the diurnal variation of the standard deviation of temperature for the most part depends on the relative frequency at various times of day of such clear skies.

In January the least cloudy skies are associated for the most part with polar westerlies and north-westerlies in which the sky tends to clear at night, the wind tends to drop and consequently low temperatures occur. During the day, however, the increased surface wind and cloudiness normally associated with polar westerlies and north-westerlies tends to raise the temperature towards the sea temperature. Hence the spread of temperature, and consequently the standard deviation will be a maximum during the latter part of the night.

In April, clear skies tend to be associated with warm S. and SE. types of weather by day resulting in the occurrence of some high day temperatures whilst the cool W. and NW. types tend to be cloudy so that the greatest spread of temperature and consequently the maximum standard deviation occurs at the time of maximum temperature.

In July cool air masses are cloudy while warm air masses have clearer skies so that insolation results in the greatest spread of temperature and consequently the maximum standard deviation occurs at about the time of maximum temperature.

October shows the characteristics of both July and January. There is still sufficient heating in the afternoon to cause a maximum of standard deviation to occur then. On the other hand warm air masses are very cloudy or foggy at night so that as in January there is a maximum of standard deviation at the time of minimum temperature.

From the foregoing it will be seen that the reason why the standard deviation of temperature at London Airport at night in January and October is greater than in April and July is that the cool air masses in January and October tend to have clearer skies resulting in radiational cooling spreading the difference in temperature between the air masses. In April and July, however, the cool air masses tend to be cloudy so that radiational cooling reduces the difference in temperature between the air masses.

The above paragraphs give only a broad outline of the weather at London Airport in so far as it is necessary to explain the general features of the standard-deviation curves. A discussion of the more detailed shape of the curves would require a much closer description of the weather at London Airport.

The remaining significant features of the diurnal variation of mean temperature curves are explained briefly in the following. The small fall of temperature during the night hours in January is due to the greater frequency of cloudy warm air masses in which temperature at night falls less quickly than on clear nights, and may even rise slightly. In the mean this largely compensates for the more rapid fall of temperature on the clear nights. In July the time of maximum is delayed until well into the afternoon by reason of the length of day and the small difference in the sun's elevation between noon and 1600. In October the mornings are frequently foggy so that there is a slow rise of temperature after sunrise until the fog clears.

The two sets of curves are typical of a maritime temperate climate in which an occasional continental type of climate does occur—but infrequently. Similar curves apply to most places in north-west Europe but with increasing diurnal range of temperature and increasing standard deviation as the frequency of the continental type increases.

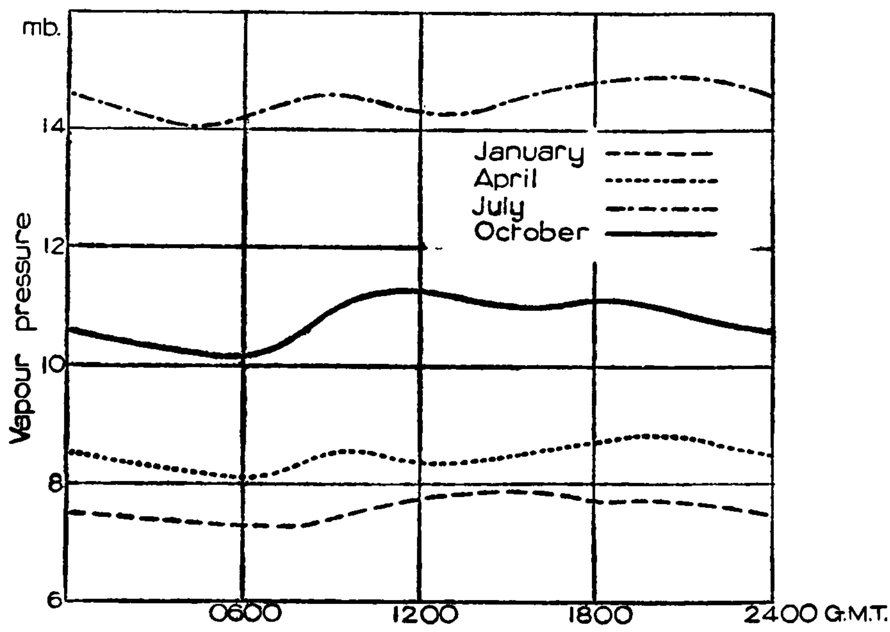


FIG. 3—DIURNAL VARIATION OF VAPOUR PRESSURE AT LONDON AIRPORT

Vapour pressure.—Fig. 3 shows the diurnal variation of vapour pressure at London Airport obtained in a similar manner to the diurnal curve of mean temperature. As would be expected in a place not far from the sea in any direction, the vapour pressure shows very little diurnal variation. All four months show a minimum around sunrise. January shows a maximum in the middle of the afternoon while the other months show maxima some time in the morning and some time after sunset with a secondary minimum in the afternoon.

The minimum at sunrise (the time of minimum temperature) is due to stabilization of the lowest layers by cooling and the deposition of moisture as dew. When the sun rises the dew is re-evaporated into the air and mixing takes place with the layers immediately above causing a rise in vapour pressure. As the morning progresses temperature rises further and convection sets in causing a fall in vapour pressure as moisture is carried upwards until a balance is struck between fresh moist air arriving from the sea and the ability of convection to carry it up. Convection dies down towards sunset but moist air is still arriving from the sea so that vapour pressure rises again as the moisture is concentrated in the lowest layers. This process continues after sunset until falling temperature produces an inversion in the lowest layers with a consequent dropping off of wind speed and the deposition of moisture as dew.

In January, however, the diurnal rise of temperature is insufficient to start convection, and there is frequently an increase of absolute humidity upwards from the surface. Furthermore the ground is frequently saturated so that, all in all, the air near the ground tends to remain saturated in spite of the diurnal rise of temperature, and consequently the vapour-pressure curve has a single maximum in the late afternoon.

In October the mornings are frequently foggy with a consequent inversion of absolute humidity so that the rise in vapour pressure in the morning is greater than in the other months.

The curves for April and July in Fig. 3 are typical of most maritime temperate situations, but the range of diurnal variation tends to increase with increasing distance from the sea provided the climate still remains to some extent maritime.

Application.—The curves in Figs. 1, 2 and 3 are of considerable use to the planners of aircraft operations. In general, the higher the temperature and to a less extent the higher the absolute humidity the greater the length of runway required by an aircraft to take off with a given weight or alternatively the less weight that can be lifted with a given length of runway. With the diurnal curves of temperature and standard deviation it is possible, assuming that the temperature distribution for a particular hour is normal, to calculate the frequency with which a certain temperature is exceeded at any particular time of day, and consequently the frequency with which a given weight cannot be lifted. While this question is only of academic interest at London Airport because of the length of the runways, at some overseas airfields the economic operation of an aircraft may be severely restricted, and, however inconvenient it may be, it may be essential to plan operations so that take-offs occur only in the early morning at the coolest time of day.

The assumption that the temperature distribution for a particular hour is normal may not be true for certain places at certain times of the year and certain hours of the day. The distribution may exhibit a skewness due to the presence of a long tail of high or low values or to the suppression of the normal tail of high or low values. A skew distribution due to the presence of a long tail of high or low values is most probable at those hours at which the standard deviation is a maximum, and a skewness due to the suppression of the normal tail of high or low values is most probable at those hours at which the standard deviation is a minimum. The general climatic features of a place indicate which way the distribution is skew, whether it is the high or low values which are affected, so that allowance can be made when using the curves in the manner described above. At London Airport slight skewness occurs in the early hours in January owing to a long tail of low values, and rather more skewness in the afternoon in January owing to the suppression of high values. In other months the skewness is insignificant.

USE OF "FACSIMILE" FOR METEOROLOGICAL TRANSMISSIONS

By C. V. OCKENDEN, B.Sc.

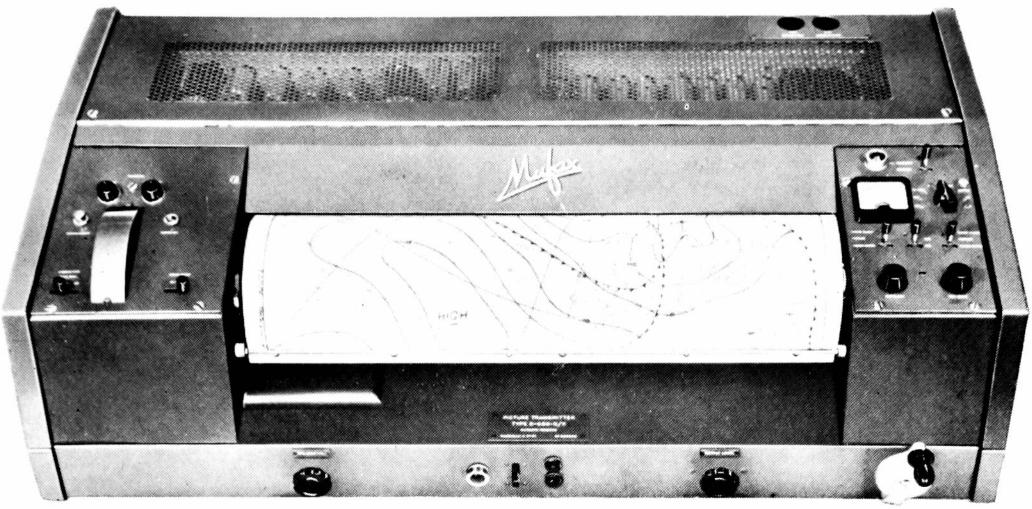
A recent survey showed that about 400,000 five-figure groups are handled daily by the meteorological communications centre at Dunstable, and the great volume of traffic continues to grow. The demand by forecasters is for more data to be received more speedily to meet the requirements of aviation in these days of aircraft flying at ever increasing heights and speeds. The problem of transmitting from Dunstable all the basic and derived information which is required by the many meteorological stations in the British Isles becomes more acute with the passage of time. Basically there are only two land-line teleprinter channels over which information can be broadcast from Dunstable; one of these can only operate for 45 minutes in each hour because it has to be used for the collection of hourly reports, and the other only serves a relatively small number of main centres. Whilst the volume of data has increased, the channels available for their rapid dissemination have remained as they were at the end of the last war. The provision of another meteorological teleprinter channel to all stations would solve one problem, but create another in that more personnel would be required at stations to plot the additional data so that they can be used by the forecasters. Over the past 18 months tests have been in progress in the Meteorological Office on the development of transmissions by "facsimile" apparatus since it appears possible that this technique might be extended to provide an answer to the problem of supplying the needed additional data without the necessity for employing additional personnel.

At a meeting in April 1953 of the World Meteorological Organization Commission for Synoptic Meteorology it was agreed that "facsimile is an extremely effective means of communication for meteorology, permitting, even in its present stage of development, improvement in meteorological services, complete accuracy of material transmitted, and a certain amount of economy". The purpose of this article is to give the reader a general background without entering into detailed technicalities.

The possibilities of making use of the technique of photo-telegraphy or facsimile transmissions for meteorological purposes have been realized for the last quarter of a century. In 1929 the Commission for Synoptic Weather Information of the International Meteorological Organization examined pictures of charts, plain-language forecasts and messages in figure codes which had been received by picture telegraphy, and set up a Sub-Commission to "consider the best method of utilizing wireless pictures in synoptic meteorology and of keeping the Commission informed of the progress made in different countries in the development of this system".

At about the same time, the Meteorological Office made trials of transmitting simple weather charts by radio from Cardington to an airship in flight by using the Fultograph process. The same system was also used by the British Broadcasting Corporation which included weather charts in its broadcasts from Daventry. Judged by today's standards the picture was crude and small and took a relatively long time to send. Reproductions of material actually transmitted are contained in Watson Watt's Symons Memorial Lecture[1] delivered to the Royal Meteorological Society on March 20, 1929. With the disbandment of the Airship Section of the Meteorological Office transmissions ceased, and meteorologists waited for better apparatus to be produced giving larger pictures, better definition and greater speed. The wait was to be a long one. On the one hand, manufacturers naturally concentrated their energies towards the development of apparatus best suited to the financially more important needs of radio and cable companies and newspaper concerns where large size was not as necessary as quality. On the other hand meteorologists did not press for equipment, probably because the teleprinter was being introduced on a large scale and largely satisfied the requirement for greater speed in the exchange of meteorological information as compared with hand-morse transmissions necessitating the employment of wireless operators. So it was that, until the Second World War 1939–1945, there was no progress to report on the application of facsimile to meteorology. During the war, however, large numbers of facsimile "transceivers" were used by American weather services, and several long-distance circuits were successfully operated. The apparatus enabled pictures 12 in. × 18 in. to be transmitted in about 20 min.

After the war, the Meteorological Office arranged for five United States "transceivers" to be lent for trials which were made by land-line between Dunstable, Transport Command, Lyneham and Victory House. The experiments had to be curtailed because the period of loan was terminated before expectation, but the general feeling was that the Meteorological Office would be well advised to wait a little longer for further technical improvements to be made before embarking on any large-scale scheme of facsimile working. Attention was therefore directed to producing a specification for a recorder which would satisfy the requirements of the average outstation and at the same time be capable of being developed without too long a delay. Up to this time all facsimile recorders used in meteorological offices had been of the drum type, requiring an operator to unload and load the machine after the receipt of each individual picture. The new specification called for a continuous-paper recorder so that the received chart could be seen as it was produced inch-by-inch, and could be simply torn off after completion just as one tears off data from a teleprinter for the forecaster's use. It was also demanded that the recorder should be compact, easy to maintain by unskilled personnel, quiet in operation, operate at more than one speed, give good definition and be capable of handling charts up to 18 in. × 22 in. in size. It was realized that there was a most important international aspect—for example, stations in the United Kingdom would wish to be able to intercept meteorological charts broadcast by radio from transmitters in the United States and from any which might be set up in European countries in the future. The matter was therefore brought up at the meeting of the European Sub-Commission for Weather Transmissions held in Stockholm in 1949, and an agreed list of desiderata was prepared, taking into consideration the opinions of technicians in the field of facsimile. It will be realized that many compromises have to be made in designing a recorder best suited to any particular purpose. If the meteorologist wants apparatus which will enable a very small symbol on a detailed working chart to be clearly recognizable in all circumstances he must be prepared to accept a longer time for the transmission of the chart, because of limitations of "band width" of communications channels. If he wants to be able to send a very large chart, the manufacturer's costs may rise out of all proportion so that few services would be able to purchase the apparatus in large quantity. The best compromise seemed to call for a definition of about 100 lines/in. and a picture width of about 18 in. The product of the diameter of the drum and the number of lines scanned per

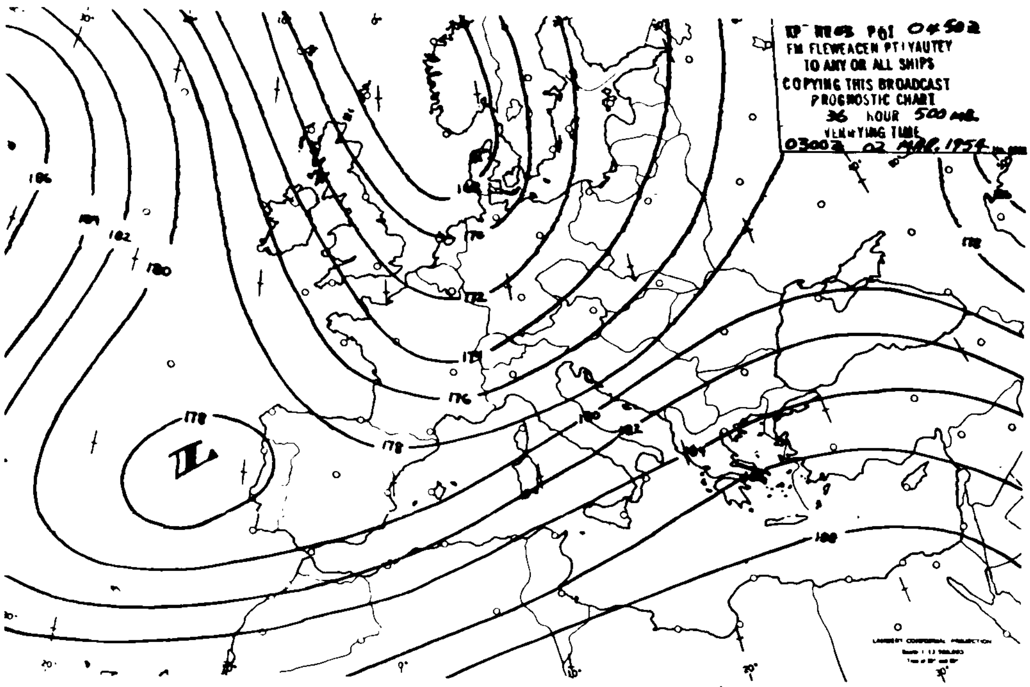


18-IN. CHART TRANSMITTER

18-IN. CHART RECORDER

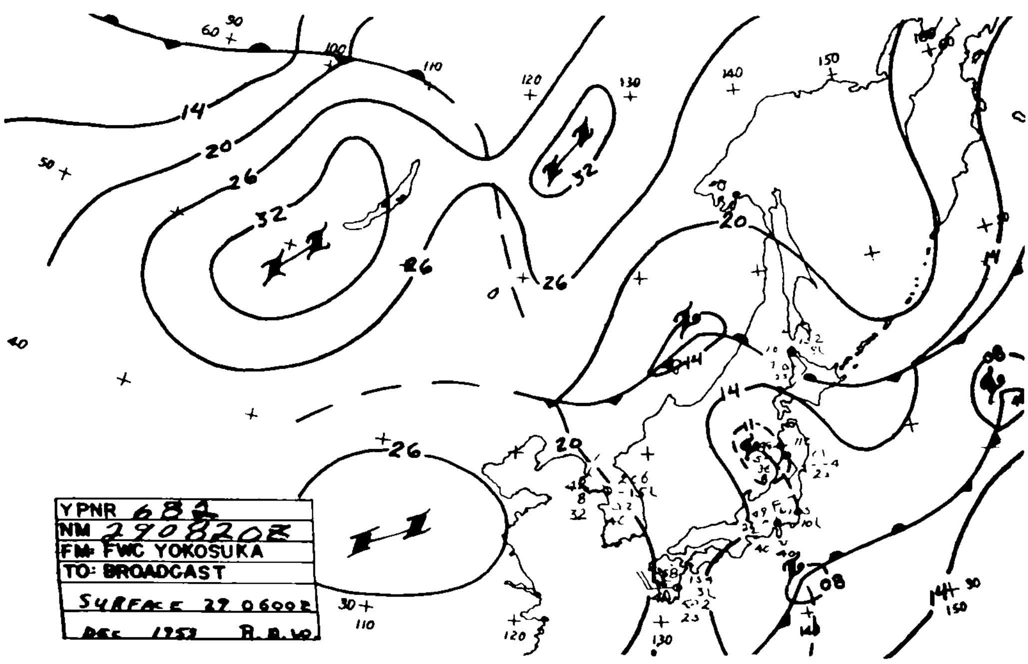
Photographs reproduced by courtesy of Muirhead & Co., Ltd.

FACSIMILE APPARATUS FOR TRANSMITTING CHARTS
BY RADIO OR LAND-LINE
(see p. 303)



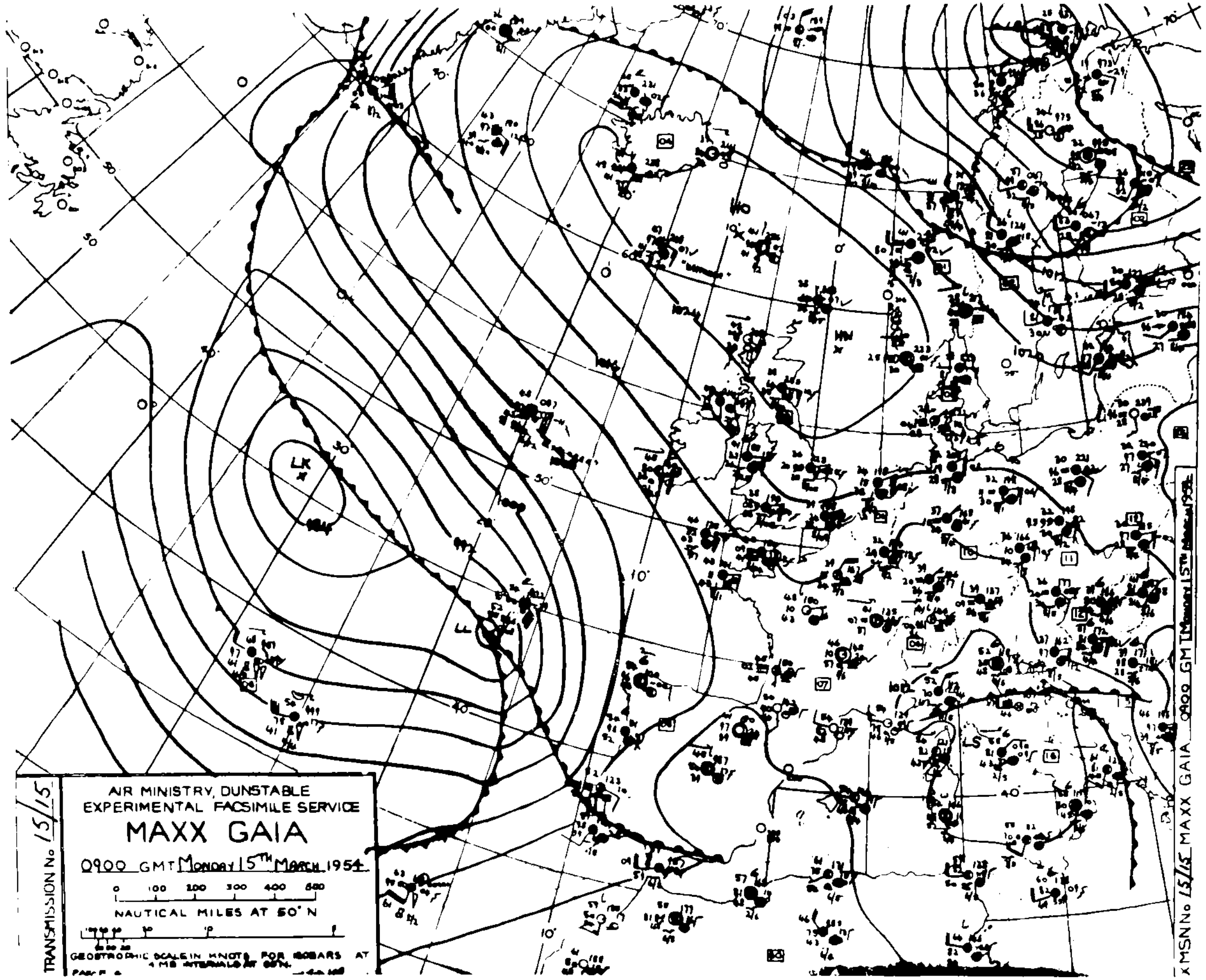
FORECAST UPPER AIR CHART AT 500 MB., 0300 G.M.T., MARCH 2, 1954

This is a quarter-scale reproduction of a chart received at Dunstable, 0505 G.M.T., March 1, 1954, by direct interception of Port Lyautey (U.S. Navy) radio-facsimile broadcast



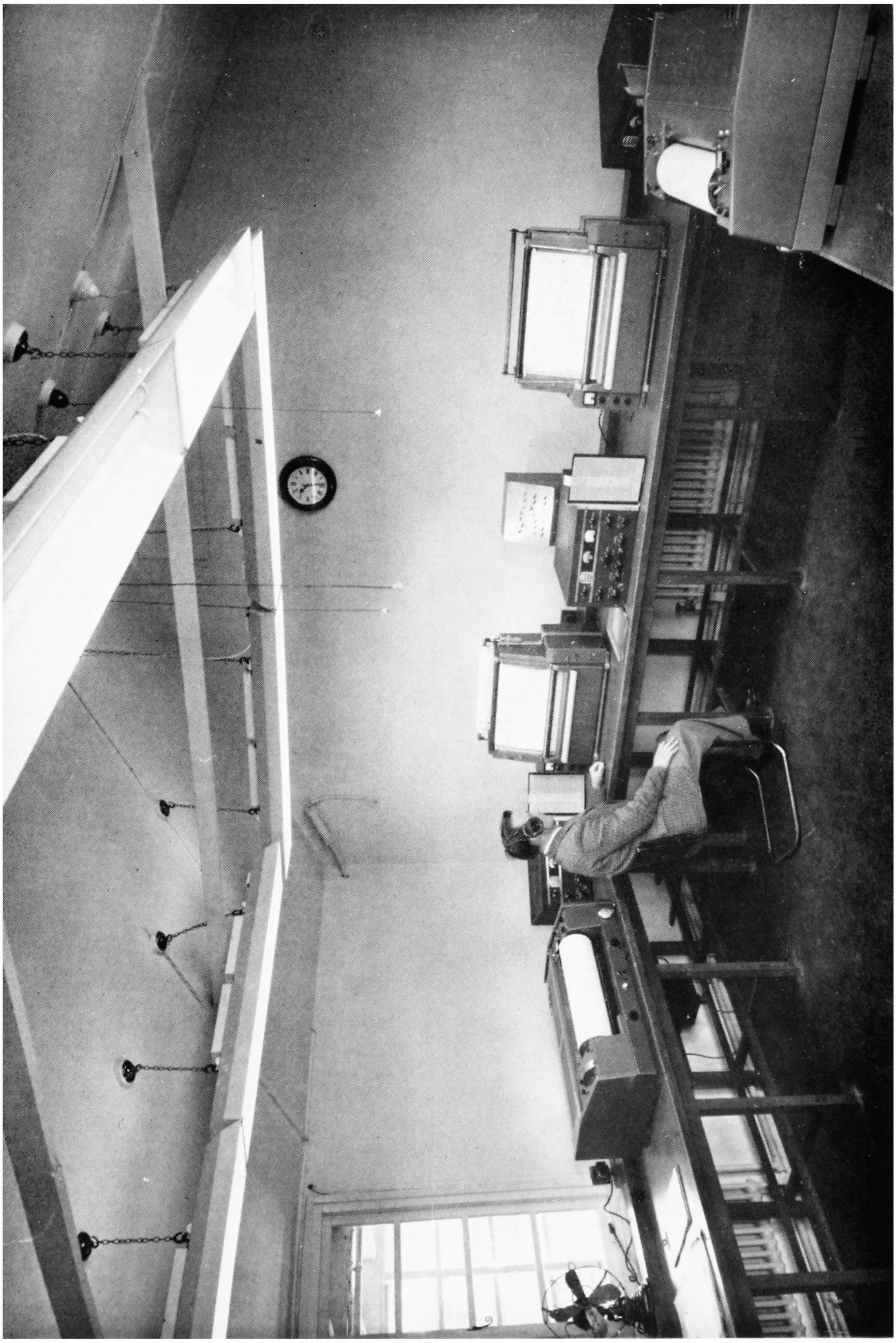
SURFACE CHART, 0600 G.M.T., DECEMBER 29, 1953

This is a quarter-scale reproduction of a chart received at Dunstable, 0955 G.M.T., December 29, 1953, by direct interception of Yokosuka (U.S. Navy) radio-facsimile broadcast on 9,427 Kc./sec.



SURFACE CHART, 0900 G.M.T., MARCH 15, 1954

This chart was received at Dunstable on a recorder monitoring the radio-facsimile broadcast



FACSIMILE TRANSMITTING AND RECORDING ROOM,
CENTRAL FORECASTING OFFICE, DUNSTABLE

unit length is known as the index of co-operation, and in the case of most facsimile apparatus used for meteorological transmissions at the present time this index has the value 576 (96 lines/in. and 6 in. drum diameter). In order to secure successful inter-working without distortion it is necessary that the index of co-operation, the direction of scan and the speed of rotation of the transmitter drum and the drum (or other scanning device such as a helix) of the receiver shall be identical.

The latest type of meteorological facsimile transmitter as installed in the Central Forecasting Office at Dunstable is illustrated in the photograph facing the top of p. 304. The chart to be transmitted is wrapped round a horizontal drum 22 in. long and 6 in. diameter which is rotated by a synchronous hysteresis motor supplied with 1,000 c./sec. by a valve-maintained tuning fork. At the same time a spot of light is caused to traverse the surface of the drum parallel to the drum spindle. Thus the chart is scanned in the form of a spiral. The image of the illuminated portion of the chart is arranged to fall on to a photo-multiplier cell which passes a current proportional to the illumination. This current is amplified and converted to either an amplitude-modulated signal or a frequency-modulated subcarrier, according to the transmission system used. Provision is made for transmitting a phasing signal to start the chart recorder in the correct relative position. The drum can be caused to rotate at speeds of either 30, 60, or 120 rev./min. selected by a switch.

The 18-in. continuously operating recorder is illustrated in the photograph facing the bottom of p. 304. For the past year recorders have been in operation at four selected outstations whilst two are available at Dunstable for monitoring transmissions and for receiving foreign facsimile broadcasts. The recorder produces a continuous record 18·75 in. wide on electro-sensitive paper which is supplied in 100-ft. rolls, sufficient for operation at normal speed for over 30 hr. The roll is contained in a substantially air-tight compartment in the bottom front part of the machine. The paper is drawn at constant speed between a stainless steel writing-edge and a rotating helix. A current, controlled by the received signal, passing through the paper at the point of contact causes the dissociation of the electrolyte and a ferric salt reacts with a colour-forming substance in the paper to give a black colouration. The record is permanent if dried thoroughly before storing, though the paper itself may deteriorate over a period of years. The rotation of the helix and movement of the paper together cause the point of contact to traverse the paper in a series of horizontal lines. The paper advances at 96 lines/in., each line taking 1 sec. to trace at normal speed (corresponding to the rotational speed of the drum at the transmitting station). The helix and paper-feed rollers are driven by a hysteresis motor supplied with 1,000 c./sec. derived from a high-stability valve-maintained tuning fork and power amplifier. The paper passes up over the "lectern" in front of the recorder and the forecaster therefore sees the chart as it is built up. A chart 18 in. × 22 in. can be transmitted in about 17 min. at the higher speed available, or a chart 18 in. × 11 in. can be sent in 8½ min. The system can be operated either over a radio link or a good-quality land-line. Radio interference causes dark lines across a chart which spoil its appearance but do not cause a great loss in intelligibility unless very severe; in fact, a chart received by radio may still be perfectly usable to the meteorologist in propagation conditions which would cause so much "garbling" on a radio-teleprinter channel that no map could be plotted. Looking to the future it seems highly probable that the meteorological services of many countries will make simultaneous facsimile broadcasts by land-line to many subsidiary stations which can be conveniently and economically served in this way, and by radio for reception by the more remote stations and ships at sea. A photograph of the facsimile room at the Central Forecasting Office, Dunstable is shown facing p. 305.

The exchange of meteorological information by facsimile is most useful in the case of "processed" information such as baratic, prebaratic, contour and prontour charts for widely separated regions. The present method involves selecting points on curves, coding the positions of the selected points, sending lengthy messages by teleprinter or wireless telegraphy, decoding and plotting and joining the points by lines. Not only is this laborious, but the chart prepared by the recipient is liable to differ from the original to such an extent that derived information, e.g. upper wind speed and direction may be in error to a dangerous degree. The day is probably not far distant when charts prepared by analysts at main centres in different regions of the world will be exchanged by radio point-to-point or broadcast facsimile transmissions, to facilitate the preparation of charts covering a whole hemisphere. The individual regional analyses would of course be based on considerably more detailed information than could be transmitted or used by other regions in the limited time available. At the present time about a dozen radio-facsimile meteorological broadcasts are made from widely scattered centres in the northern hemisphere, including, for example, Dunstable, New York, Washington and Tokyo. A very extensive land-line facsimile network exists in the United States, and within recent months a coast-to-coast Weatherfax network has been established in Canada using apparatus manufactured in the United Kingdom. The network involves the employment of a score or so of transmitters (at regional stations) and over 100 recorders which are fully automatic. A description of the way in which stations will receive facsimile transmissions of weather information from the Central Analysis Office at Dorval, Quebec and from the District Aviation Forecast Offices is given in Circular 2337 of the Canadian Department of Transport, Meteorological Division[2].

Apart from the role which meteorological facsimile broadcasts will undoubtedly play in the world-wide exchange of basic charts, it will be readily appreciated that the technique might well be employed at a main airport where many operating companies could be served with a local broadcast of meteorological information comprising a selection of simplified actual and prognostic charts to keep aircrews and operations staff in touch with the development of the synoptic situation. Where several companies operate a frequent service over the same air route, pictorial flight forecasts could be transmitted on a routine basis. Such local broadcasts would reduce the number of telephone calls and personal inquiries which tend to disrupt the work of a forecasting office. It would also be practicable for one office at a main airport to prepare cross-section charts for a particular route or routes, and issue them by facsimile to other departure airfields. In the future there might be a requirement for a special broadcast service from the Central Forecasting Office, the contents and schedule being designed to benefit small airfields without meteorological offices, gliding clubs, yachting clubs, port organizations, etc. Such a broadcast might be of value to universities and various industrial concerns and public utilities whose activities are directly affected by the weather.

Facsimile transmission programme

Frequencies: 2655, 3143 and 4780 Kc./sec. *Items broadcast:* Monday–Friday 1–26
Saturday 1–15 Winter
1–16 Summer

	Transmission time	Transmission speed		Fax chart
	G.M.T.	rev./min.		
1	0100	120	Prontours 700 mb.	F3
2	0115	120	Prontours 500 mb.	F3
3	0130	120	Pre-thickness chart	F3
4	0145	120	Prontours 300 mb.	F3
5	0200	120	Prontours 200 mb.	F3
6	0215	120	Prontours 100 mb.	F3
7	0430	120	Prebaratic 2400	F3
8	0445	60	British winds } Upper air stations* ...	F6
9	0510	60	British tephigrams } Upper air stations* ...	F2
10	0550	60	0300 1/10,000,000 chart, plotted and analysed ...	F4
11	0650	60	0600 1/2,000,000 chart, plotted only	F1
12	0750	60	0700 1/2,000,000 chart, plotted only	F1
13	0850	60	0800 1/2,000,000 chart, plotted only	F1
14	0950	60	0900 1/2,000,000 chart, plotted only	F1
15	1045	120	Prebaratic 0600	F3
16	1145	60	0900 1/10,000,000 chart, plotted and analysed ...	F4
17	1230	120	Prontours 700 mb.	F3
18	1245	120	Prontours 500 mb.	F3
19	1300	120	Pre-thickness chart	F3
20	1315	120	Prontours 300 mb.	F3
21	1330	120	Prontours 200 mb.	F3
22	1345	120	Prontours 100 mb.	F3
23	1400	60	1300 1/2,000,000 chart, plotted only	F1
24	1630	120	Prebaratic 1200	F3
25	1645	60	British winds } Upper air stations* ...	F6
26	1710	60	British tephigrams } Upper air stations* ...	F2

* *List of upper air stations:* Lerwick, Stornoway, Leuchars, Fazakerley, Hemsby, Crawley, Camborne, Aldergrove, Valentia, ocean weather stations I and J.

Details of the radio transmission which is at present being made from Dunstable on a frequency of 4780 Kc./sec. are given above and some examples of charts intercepted at and transmitted from Dunstable in recent months are reproduced in the photographs in the centre of this Magazine.

REFERENCES

1. WATSON WATT, R. A.; Weather and wireless. *Quart. J. R. met. Soc., London*, **55**, 1929, p. 273.
2. Toronto, Department of Transport, Meteorological Division. Faxpro: Procedure manual of the Canadian Weatherfax system. *Circ. met. Div. Dep. Transp., Toronto*, No. 2337, 1953.

LOCAL DEGREE-DAY VARIATIONS IN THE READING AREA

By M. PARRY, M.Sc.

It is well established that the heat requirement of a building depends partly on the outside temperature, and Dufton[1] has prepared a map showing the variation of mean daily temperature conditions over Great Britain in terms of accumulated temperatures, in degree-days below a base of 60°F. (the outside temperature below which indoor heating is considered necessary). Although it has been recognized that quite local variations in degree-day values occur and may be significant[2], there can as yet be little precise information as to the magnitude of these local differences, as few investigations of local climates have been undertaken in this country.

A study of this kind has been carried out recently in and around Reading, and the data obtained include values of degree-days (base 60°F.) over a 12-month period at 10 stations sited so as to yield temperature records representative of different facets of the area. The values were calculated day by day (60° minus the mean temperature) and summed for the whole period. These annual degree-day totals are mapped against a background of the relief of the district and the built-up area (Fig. 1); the height of each station, the kind of exposure, and the degree-day totals, expressed as percentages of that at the University station, are given in Table I.

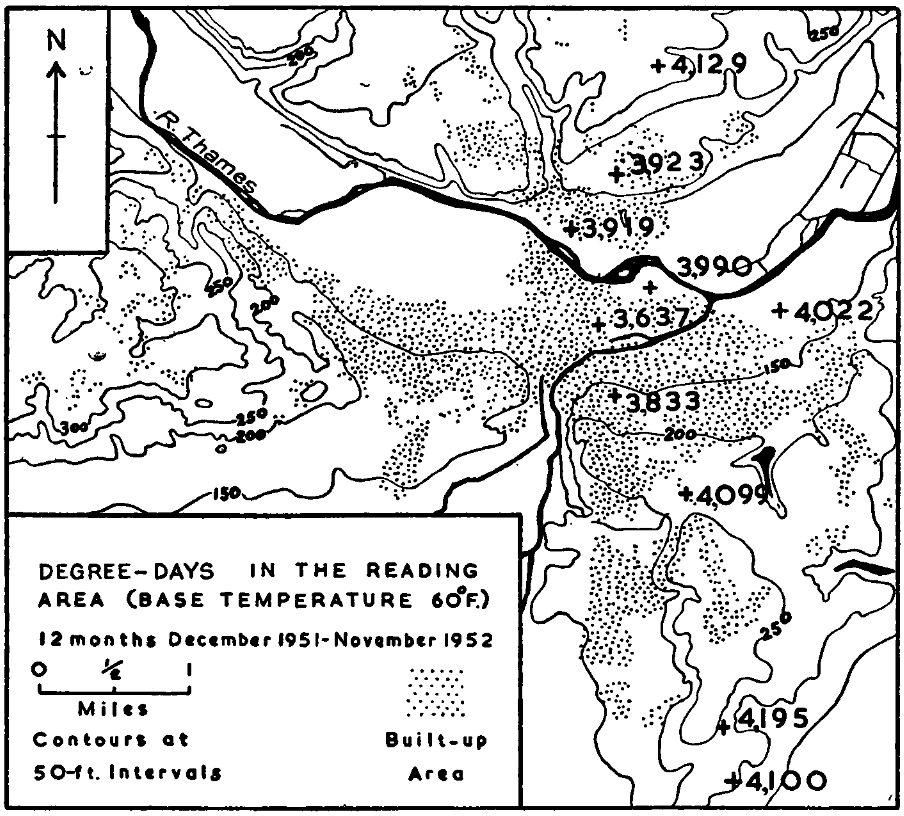


FIG. 1

The records at two stations, Forbury Gardens and Queen Anne's School, include a few interpolated values; elsewhere, the records are continuous over the period. The Forbury Gardens station is over-sheltered in some directions, and its annual degree-day total may be considered too low in comparison with those at the other stations, where conditions of exposure, while varying, nevertheless conform to official requirements.

TABLE I—DEGREE-DAYS IN THE READING AREA

12-month period, December 1951-November 1952
Base of 60°F.

	University	Shinfield	Seed Trial Grounds	Caversham Park	St. Patrick's Hall	Lower Caversham	King's Meadow	Forbury Gardens	Shinfield Green	Queen Anne's School
Height above M.S.L. (ft.)	152	200	141	274	230	125	120	143	248	178
Exposure	Urban	Open	Open	Open	Suburban	Urban	Open	Urban	Open	Suburban
Degree-days ...	3,833	4,100	4,022	4,129	4,099	3,919	3,990	3,637	4,195	3,923
Degree-days as percentage of University values	100	107	105	108	107	102	104	95	109	102

If the Forbury Gardens value is increased to, say, 98 per cent. of the University value, then the magnitude of local variation of degree-days in the Reading area is of the order of 10 per cent. Of this about 5 per cent. seems due to difference in elevation (compare King's Meadow and Caversham Park or Shinfield Green), and the other 5 per cent. to the difference between sheltered (urban) and open exposures (compare University and Seed Trial Grounds). A favourable exposure on a south-facing terrace seems responsible for the relatively low value at Queen Anne's School.

Of the stations used in the investigation, three are permanent auxiliary climatological stations. Table II shows the mean annual degree-day totals—calculated by the simplest method[2]—for a 12-yr. period during which contemporaneous records are available from all three stations. The differences are of the same order as those obtained for the 12-month period.

TABLE II—MEAN DEGREE-DAY TOTALS
12-yr. period, 1940–51

	University	Shinfield	Seed Trial Grounds
Degree-days	3,588	3,789	3,771
Degree-days as percentage of University values	100	106	105

From a comparison of totals for the 12-month period at stations of similar exposures but at different heights, it seems that the effect of increasing altitude is to augment the annual degree-day values, on the average, by 100 units in about 90 ft. Over a long period, assuming the mean daily temperature to be below the base of 60°F. for 10 months of the year, and the usual average fall of temperature of 1° in 300 ft., the expected increase of annual degree-day values with increasing elevation would be about 100 units every 100 ft. This was, in fact, broadly the conclusion reached by Dufton[1], after examining degree-day variations on the macroclimatic scale over the period 1881–1915.

The range of elevation between highest and lowest stations in the Reading area is relatively small (154 ft.), and the urban warmth due to a mainly residential and light-industrial town of moderate size (some 120,000 people), a fairly clean atmosphere, and a relatively open pattern away from the centre, is not strongly marked. Local variations of degree-day totals of more than 10 per cent. are clearly to be expected with more closely built-up towns and in sites of more pronounced relief contrasts.

REFERENCES

1. DUFTON, A. F.; Degree-days. *J. Instn Heat. Vent. Engrs, London,* **2,** 1934, p. 83.
2. London, Ministry of Works. Post-war building studies No. 19. Heating and ventilation of dwellings. By the Building Research Board, Department of Scientific and Industrial Research. London, 1945.

METEOROLOGICAL RESEARCH COMMITTEE

The 31st meeting of the Synoptic and Dynamical Sub-Committee of the Meteorological Research Committee was held on June 24, 1954.

Numerical forecasting was the subject of two reports both by Mr. F. H. Bushby and Miss M. K. Hinds[1,2]. The Committee also discussed future development and research in the application of numerical methods. Two other papers dealt with high-level turbulence. The first by Mr. G. A. Corby[3] dealt with the air flow over mountains, the second by Mr. D. C. E. Jones[4] discussed the exceptionally severe high-level clear-air turbulence on April 14, 1954. Other papers considered by the Committee included one by Mr. J. K. Bannon[5] on the variation of temperature in the lower stratosphere above Larkhill and Lerwick and one by Mr. D. H. Johnson[6] on the diurnal and semi-diurnal oscillations of the lower stratosphere.

ABSTRACTS

1. BUSHBY, F. H. and HINDS, M. K.; The electronic computation of two series of 1000-mb., 500-mb., and 1000–500-mb.-thickness forecast charts by application of the Sawyer-Bushby two-parameter baroclinic model. *Met. Res. Pap., London,* No. 841, S.C.II/162, 1953.

2. BUSHBY, F. H. and HINDS, M. K.; A preliminary report on ten computed sets of forecasts based on the Sawyer and Bushby two-parameter atmospheric model. *Met. Res. Pap., London,* No. 863, S.C.II/169, 1954.

The Sawyer-Bushby model of the atmosphere is set out in a form suitable for machine computation of the height and thickness of pressure levels. The technique of computation is described and the results of two trials are shown in numerous charts. They gave a fair representation of the motion of the real atmosphere for a 24-hr. period. In the second paper ten 12-hr. and 24-hr. forecasts of 1000-mb. and 500-mb. contours and 1000–500-mb. thickness over the North Atlantic and western Europe were computed on the Sawyer-Bushby model using 1-hr. steps. Machine time was 8½ min./step. Actual and forecast charts are shown, and each case is discussed and compared with conventional forecasts. Correlation coefficients between actual and forecast 24-hr. changes are tabulated. Correlation is good; on the whole the conventional forecasts showed up better, but this was mainly due to neglect of heating of cold air over Atlantic in winter, over-estimation of contour heights in anticyclones, and small area of grid.

3. CORBY, G. A.; The air flow over mountains: a report on the state of current knowledge. *Met. Res. Pap., London,* No. 842, S.C.II/163, 1953.

In Part I of this exhaustive report the observational evidence of air flow over mountains, notably lee waves, is summarized. It includes mountain clouds, especially stationary lenticular clouds and rotors, and experiences of pilots of gliders and powered aircraft. Part II summarizes (with standardized notation), discusses and generalizes the theoretical studies of Queney, Lyra and Scorer; fundamental importance is attributed to the magnitude l^2. The various assumptions involved in the theories are reviewed. In Part III model experiments by Abe, Long and others, including the Gibraltar investigation, are critically discussed. Part IV takes up the gliding studies of Förchgott in mountain regions and his consistent theories of types of flow. Finally applications to aviation forecasting and criteria of safety heights are considered.

4. JONES, D. C. E.; Note on exceptionally severe clear-air turbulence and other phenomena on April 14, 1954. *Met. Res. Pap., London,* No. 868, S.C.II/172, 1954.

Turbulence, severe enough to turn aircraft upside down, was met at 40,000 ft. in a strong NW. current near Edinburgh; it ceased below 38,000 ft. It was in the upper troposphere in pronounced vertical and horizontal wind shear on the warm side of the jet stream above the axis. On the same day many standing waves were reported at 4,500–18,000 ft. over England.

5. BANNON, J. K.; Variation of temperature in the lower stratosphere above Larkhill and Lerwick. *Met. Res. Pap., London,* No. 860, S.C.II/167, 1954.

Correlation coefficients of temperature at 150 mb., 100 mb. and 60 mb. with height of 300-mb. surface and with tropopause pressure, based on all available data, are tabulated separately for day and night. Those with H_{300} are negative, those with P_T positive; in both cases magnitude decreases to less than a half between 150 mb. and 60 mb. The decrease is greatest in January and April and least in October, and may be related to annual variation of ozone.

6. JOHNSON, D. H.; Diurnal and semi-diurnal oscillations of the lower stratosphere. *Met. Res. Pap., London,* No. 861, S.C.II/168, 1954.

Changes of wind in 6 hr. at 100 mb. over Great Britain in 1950–51 show significant variations which are similar in each month. These are analysed harmonically; the mean amplitude of the diurnal component is 0·54 kt. from S. and 0·51 kt. from E.; semi-diurnal 0·67 kt. from S. and 0·51 kt. from E.; both give elliptical paths (diurnal NW. at 0000; semi-diurnal NE. at 0900 and 2100). The variations are attributed to solar tides.

ROYAL METEOROLOGICAL SOCIETY

Visit to the National Institute of Oceanography

This year, the summer meeting of the Royal Meteorological Society was held on July 7 in the very pleasant surroundings of the National Institute of Oceanography at Wormley near Godalming in Surrey. The Society was invited by the Director, Dr. G. E. R. Deacon, to walk freely through the building, inspecting the instruments and specimens displayed.

The instruments and appliances included plankton nets, water-sampling bottles, a reversing thermometer (to measure the temperature of the sea at various depths), a sensitive resistance thermometer and a float salinity meter.

Ocean currents are reported from many light-vessels round the British Isles but experiments are also being made with drift cards—prepaid postcards in double plastic envelopes which are dropped by aircraft about every ten miles along a course some 500 miles west of the British Isles. After two or three months the cards reach the sea-shore and many are found and forwarded to the Institute. During May and June this year winds have been sufficiently often from W. and N. for some of these cards, despite the North Atlantic Drift, to travel east-south-eastwards towards Ireland.

Much of oceanography has to do with waves and several wave recorders were displayed including one like that installed in O.W.S. *Weather Explorer*. Owing to her size waves exceeding 50 ft. in height cannot be recorded on this ship (traces were shown of such waves) but comparison with a similar recorder aboard R.R.S. *Discovery II* showed the records to be reliable up to that value.

Much of the mathematical analysis in oceanography is done by machines, of which the outstanding examples were an automatic curve-follower, a harmonic analyser, and a photo-electric correlation meter.

Because it seems to be of particular interest to meteorologists the correlation meter will be described here. Two curves formed by the dividing lines between black areas and white areas are rapidly scanned by similar narrow lines of light. The amount of light reflected from each line by the curves is picked up on the same photo-electric cell; the output from this cell is squared electronically and then smoothed. Therefore the recorded deflexion is proportional to the sums of the squares of the ordinate of each curve plus a component proportional to the correlation coefficient [$\sum (a + b)^2 = \sum a^2 + \sum b^2 + 2\sum ab$]. The mean squares of the ordinates of each curve can be obtained by masking each line of light out in turn and therefore the resulting record can be calibrated. Separation of the two lines of light can be varied at a constant slow rate so that the recorder draws a "cross-correlogram". For autocorrelation the lines of light both scan the same curve and the resulting record is therefore a correlogram of which the initial peak, when the lines are coincident, is equal to unity.

Among the specimens of marine life displayed were plankton, whale food, squid and even two small foetal specimens of whales; especially interesting were small portions of a huge rock of ambergris weighing several hundredweight when it was taken from the inside of a whale.

The final item on the programme before tea in the canteen was the showing of films made on board R.R.S. *Discovery II* before the war.

LETTERS TO THE EDITOR

Dust clouds in the stratosphere

Dust clouds in the stratosphere during July 1953 after a volcanic eruption in Alaska, as reported in the April 1954 issue of the *Meteorological Magazine*[1], may provide the explanation of an abnormal darkness of the earth's shadow observed during the total eclipse of the moon of July 26, 1953.

According to observations made at Mount Stromlo[2] and reported in the French bulletin *Documentation des Observateurs* of January 1954 the optical density in green light near the centre of the shadow was about 6·0 (or 15 magnitudes), as against 4·8 only (12 magnitudes) during the preceding eclipse of January 29, 1953. This latter value is about normal for the phase of the solar cycle last year. Further, dark nuclei were observed in the intermediate parts of the shadow, some 25′ or 30′ from the centre (radius of shadow: 45′), as might be projected by clouds at abnormally high altitude above the equatorial regions of the earth.

Such evidence led to the following conclusions:

The unexpected appearance of a dark eclipse near the end of a (solar) cycle suggests the presence in the atmosphere of an abnormal source of absorption: perhaps the sequel of recent volcanic eruptions in Alaska? If such is the case we should witness a repetition of phenomena such as followed the great eruption of Mount Katmai in 1912 and pyrheliometer records should show it.[2]

The report of a volcanic eruption in Alaska on July 9 and observations of extensive high-altitude dust clouds over Great Britain and western Europe during the last week of July and first week of August would seem to agree with this hypothesis. Since, however, near mid eclipse (July 26, 1220 G.M.T.) the terminator of the earth[3] followed roughly the Asian and American shores of the Pacific (including Alaska), the extreme South Atlantic and the Indian Ocean, the darkness of the eclipsed moon requires extensive pollution of the atmosphere over most of those areas as well.

Thus additional observations of dust clouds in late July 1953 could have been made elsewhere, and a check on solar radiation records in widely separated stations during the same period would also be of interest.

G. DE VAUCOULEURS

Commonwealth Observatory, Mount Stromlo, Canberra,
June 18, 1954

REFERENCES

1. JACOBS, L.; Dust clouds in the stratosphere. *Met. Mag., London,* **83,** 1954, p. 115.
2. VAUCOULEURS G. DE; L'éclipse totale de lune du 26 juillet 1953. *Docum. Observateurs, Paris,* **7,** 1954, Fasc. 3. (where other references are given).
3. BOUSKA, J. and LINK, F.; Ephéméride détaillée des éclipses de lune de 1953. *Bull. astr. Insts. Csl., Praha,* **3,** 1952, p. 79.

[Following the publication of my article, to which G. de Vaucouleurs refers, F. Volz of the Institute of Meteorology and Geophysics, Mainz University, Germany, sent me a copy of his paper, shortly to be published in the *Meteorologische Rundschau,* on the long streaks of thin, high-level dust cloud seen and photographed from the ground at Mainz on July 24–26, 1953. From the observed slight easterly drift of the cloud he estimates the height as 22 Km. or above against the 15 Km. in the observations I described, and he suggests that the high cloud seen over Mainz was possibly a second layer resulting from the Alaskan volcanic eruption. Volz commented on a marked weakening of the sun's radiation by the dust cloud on the morning of July 24.

Because of the thinness of the dust layers it was only possible to see them from the ground at twilight (apart from the morning of July 24 at Mainz) and observers in other parts of the world may not have noticed them at these times. Even observations by high-flying aircraft were difficult as the cloud had to be observed obliquely. It is not therefore surprising that no observations have been received from the areas listed by G. de Vaucouleurs.—L. JACOBS.]

Wet-bulb temperatures in Aden

A note appeared in the *Meteorological Magazine* for February 1954 on high wet-bulb temperatures in Aden. The month of June 1953 was regarded by residents in Aden as the most uncomfortable experienced for 20 years.

The unpleasant conditions were due to the wet-bulb temperature remaining high for long periods. June 1954, although not pleasant, was probably one of the most comfortable on record, and it is of interest to compare the conditions experienced this June with those of June 1953. The mean daily wet-bulb temperature for June 1954 was 79·8°F. which is 2°F. lower than last year. The mean daily relative humidity was 63 per cent. in June 1954 compared with 67 per cent. in June 1953.

The table below shows clearly why June 1954 was more comfortable than June 1953.

TABLE I—FREQUENCY OF OCCASIONS OF HIGH WET-BULB TEMPERATURE AT ADEN

	Occasions of wet-bulb temperature					
	$\geqslant$82°F.	$\geqslant$83°F.	$\geqslant$84°F.	$\geqslant$85°F.	$\geqslant$86°F.	$\geqslant$87°F.
			number of hours			
June 1953 ...	387	249	146	55	10	1
June 1954 ...	164	65	6	1	0	0

C. C. NEWMAN

Aden, July 7, 1954

Forecasting temperature at 6,000 ft. for transatlantic flights

For transatlantic flights forecast values of wind and temperature are supplied for every 5° in longitude of the route for the heights, 6,000, 10,000 and 18,000 ft. They are derived, according to the time of take-off, from the appropriate set, one surface and two upper air, of composite forecast charts. Winds at the higher levels are taken directly from the 700-mb. and 500-mb. charts while the winds at 6,000 ft. are obtained by a vector interpolation between the 700-mb. and surface charts.

Values of the temperature at 10,000 and 18,000 ft. are readily obtained from the forecast upper air charts. But forecast charts for 800 mb. (approximately 6,000 ft. above the surface or 1000-mb. chart) are not normally constructed. Therefore, after some consideration, it was decided that an attempt should be made to relate the temperature at 6,000 ft. to the 1000–700-mb. thickness. Accordingly, a number of standardized curves with a saturated adiabatic lapse rate were constructed between 1000 and 700 mb., and the temperature at 800 mb. was read off the curves in each case. The results are given in Table I.

TABLE I

1,000–700-mb. thickness (ft.)	9,000	9,100	9,200	9,300	9,400	9,500	9,600	9,700	9,800	9,900	10,000
Temperature at 800 mb. (°C.)	−13	−10	−7	−4	−1	+2	+5	+8	+11	+14	+17

The obvious objection to using a table such as this for forecasting is the assumption of a particular lapse rate. As a first approach to estimating how serious this error was likely to be, a comparison was made, for some 200 occasions during March and April 1953, between the actual temperature at 800 mb. and that derived from Table I using the ascents from the Atlantic ocean weather ships. A wide variety of both weather types and actual temperatures was included in this series. The mean algebraic error was found to be less than 0·1°C. It was found that 65 per cent. of the observations were within an error of ±1°C., 92 per cent. within ±2°C., and 99 per cent. within ±3°C.

The distribution showed no obviously irregular features and the root-mean-square error was 1·5°C.

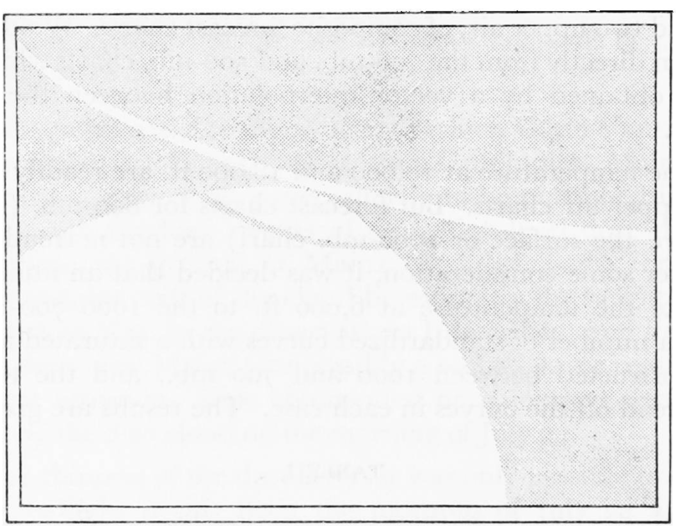
Thus the method can be used in a similar fashion to many other forecasting techniques; it provides a rapid answer which may be adjusted in the light of other information. It substitutes a known random error for one arising from the otherwise inevitable bias towards the latest actual value. The method has been in use at London Airport since June 1953 with satisfactory results.

R. H. ELDRIDGE

London Airport, February 26, 1954

Contrails and distrails

On re-reading the letter on contrails and distrails from Mr. R. A. S. Ratcliffe on p. 152 of the May 1954 issue of the *Meteorological Magazine* I am prompted to remind observers of these phenomena of the great care needed before it is safe to base any theories on the formation of distrails, for the following reason. If an aircraft flying just above cirrus cloud when the sun is fairly high, makes a contrail, the shadow of the contrail appears on the cirrus cloud and obviously the colour of the shadow is approximately the same colour as the sky which illuminates it; if the cirrus is in bands the effect at first glance may resemble contrails and distrails, but this is erroneous.



I was fortunate in observing recently against blue sky a contrail made by an aircraft flying appreciably above a sheet of cirrus cloud, half covering the sky, and seeing at the same time the shadow of the contrail which appeared as a long blue streak across the cloud. Before I could get a camera with an appropriate filter set for taking a photograph, a matter of a minute or so, the shadow had moved off the edge of the cloud sheet and there was nothing to record photographically, although the occurrence indicated an appreciable change of wind between the cirrus cloud and the level of the contrail. A sketch of the contrail and its shadow is illustrated above.

R. M. POULTER

Stanmore, July 29, 1954

REVIEWS

The physics of the stratosphere. By R. M. Goody. *Cambridge monographs on physics.* 8¾ in. × 5¼ in., pp. 187, *Illus.*, Cambridge University Press, Cambridge, 1954. Price: 25*s*.

So much has been written recently on rival systems of nomenclature for the upper layers of our atmosphere that it is as well to make clear at the outset just what Dr. Goody's book is about. He takes the word "stratosphere", as advocated by Flohn and Penndorf[1], to apply to the layers bounded below by the tropopause and above by the temperature minimum at 70–80 Km., which he designates the stratopause. We may be glad, if only on grounds of euphony, that he has not adopted Chapman's[2] more detailed proposals, but it is a pity that we have now yet another word "stratopause" with two meanings, for in Chapman's scheme it is applied to the ill defined level at the base of the layer heated by ozone absorption.

The interlinked phenomena of temperature, composition, radiation transfer, and air movement in this region form Dr. Goody's subject; in particular he is concerned with the application of "fairly straightforward physical methods" to their measurement and explanation. He claims to write not so much for meteorologists as for physicists, and appears to find much less difficulty than does the reviewer in drawing the distinction between these two classes of reader. It is true that the book contains no treatment of atmospheric dynamics, very little climatology, and less about the weather. But it is concerned with the physics of part of the atmosphere, and atmospheric physics, its methods no less than its results, is meteorology; those who practise it are meteorologists, whether they like the word or not. However, once the professing meteorologist has digested the patronizing remarks on the dust-jacket, which include the information "that he should find it profitable to see how the broad features of part of the atmosphere can be understood in terms of relatively simple physical concepts", he can settle down to enjoy a very good book.

The opening chapter is mainly devoted to a description of the "tools of research"—manned and free balloons and rockets. The second chapter, on temperature, deals with direct measurements by radio-sonde, the use of sound propagation and meteor observations, the several methods using rockets, and the possibilities of spectroscopy and of the observation of scattered light. Composition is next discussed, the topics ranging from frost-point hygrometers to the mass spectrometry of samples collected by rocket. Ozone has a chapter to itself, the longest in the book, and, in accordance with the general plan, the methods of measurement of amount, distribution, and temperature, and the background of photochemical theory, receive much more attention than the correlation with weather and atmospheric movement. Fifteen pages suffice for the discussion of winds and turbulence. The final chapter, on radiation, presents some necessary elements of the theory of molecular spectra and radiative transfer and ends with a discussion of radiative equilibrium temperatures.

Dr. Goody is at pains throughout to ensure that the physical principles underlying the methods he describes are understood, but the calls he makes on his readers in the process vary greatly from chapter to chapter. The superficial description of the determination of temperature structure from sound-ranging observations is easy to read but not very satisfying; the treatment of radiative transfer in the final chapter demands concentration and rewards it. Dr. Goody's own work in this sphere has been on subjects treated in his "Ozone" and "Radiation" sections, and as would be expected these chapters are the best in the book. The latter, especially, must be commended, for no other treatment of the fundamental problems of infra-red radiation in the atmosphere comes to mind which so successfully meets the conflicting claims of clarity, rigour, and conciseness.

The book ends with a four-page bibliography which has clearly been chosen with some care to cover the very early history and the latest work. This is a most valuable feature, but some meteorologists will regret that the selection has excluded such names as W. H. Dines and C. J. P. Cave from both bibliography and index.

It remains to be said that the production of the book conforms to the highest modern standards; so, unfortunately, does its price.

G. D. ROBINSON

REFERENCES

1. FLOHN, H., and PENNDORF, R.; The stratification of the atmosphere. *Bull. Amer. met. Soc., Lancaster Pa.*, **31**, 1950, p. 71 and p. 126.
2. CHAPMAN, S.; Upper atmospheric nomenclature. *J. geophys. Res., Baltimore*, **55**, 1950, p. 395 and *Bull. Amer. met. Soc., Lancaster Pa.*, **31**, 1950, p. 288 and *J. atmos. terr. Phys., London*, **1**, 1951, p. 121.

Meteorological instruments. 3rd edn, revised. By W. E. K. Middleton and A. F. Spilhaus. 10 in. × 6¾ in., xii + 286, *Illus.*, Toronto University Press (London: Geoffrey Cumberlege), 1953. Price: 92*s*. 0*d*. or $11.50.

This, the third edition of *Meteorological instruments*, has been revised by Prof. A. F. Spilhaus, Dean of the Institute of Technology, University of Minnesota. The text of the second edition has been changed into American forms ("endeavour" changed to "endeavor", "metres" to "meters", "apart from" to "aside from", etc.) and a few new sections have been added or existing sections enlarged. Practically no other change was found necessary; this is mainly due to the fact that, on the whole, surface meteorological instruments in use today are very little different from those in use in 1941, when the first edition was published; but it is evidence also of the thoroughness with which Mr. Middleton prepared the original editions. There are a few comparatively recent minor developments which might have been included in the third edition but are not, for example a simple time-marking device developed, I believe, in Germany, and several new types of pen. But lucid accounts are given of the important developments which have taken place in electronic devices for upper air sounding, thunderstorm location, etc., as well as of modern instruments for use on aircraft.

In the earlier editions descriptions of instruments for the measurement of the electrical and optical state of the atmosphere, of radiation instruments, and of instruments for the study of atmospheric pollution were all omitted on the grounds that "only a small minority of meteorologists ever have occasion to operate such instruments". With the exception of the Robitzsch actinograph and of the Eppley pyrheliometer descriptions of all these instruments are still omitted. But most meteorologists nowadays, at some time or other, have occasion to use instruments for the measurement of the optical properties of the atmosphere—or else to use data obtained by the use of these instruments; their continued exclusion can hardly be justified on these grounds. And, in these days of "smog", many would like to see pollution instruments described also.

The only other serious criticism that can be made concerns those sections in which are discussed the desirable performance characteristics of meteorological instruments. In these sections no consideration is given to the use to which the observations are to be put; the authors are influenced only by what present instruments and techniques are capable of. For example, on p. 63, we find in adjacent paragraphs a statement that the soil temperature at a depth greater than 4 ft. should be measured to an accuracy of 0·02°F., and a statement that sea-surface temperatures should be measured to an accuracy of 1·0°F. The first of these is clearly based on the fact that the temperature at a depth of 4 ft. is very steady and could be measured to the accuracy specified; the second on the supposed fact that the difficulty of measuring sea-surface temperature using present techniques is such that the readings can hardly be relied upon to better than 1°F. It is difficult to imagine of what use to a meteorologist would be an accuracy of measurement of soil temperatures, at a depth of greater than 4ft., of 0·02°F.; on the other hand there are many meteorologists who regard an accuracy of 1°F. in the measurement of sea-surface temperature as not good enough.

Another example of rather a different nature arises where the desirable lag coefficient of thermometers used for measuring air temperature are being discussed. The authors present a graph showing temperature measurements made using a rapid thermometer. From this graph it is deduced that the lag of an air-temperature thermometer should be at least 30 sec. The deduction is completely fallacious. If the graph is analysed one finds, as one would expect, that fluctuations of all periods are present; and that the amplitude of fluctuations of period about 30 sec. is roughly 0·8° of period 2 min. about 1·1° and of period 10 min. about 1·0°. It is not possible to analyse for fluctuations longer than 10 min. or shorter than 30 sec., but certainly there is here no evidence on which to select 30 sec. as about the right lag for a thermometer. On the same graph is superimposed what purports to be a record obtained from a thermometer with a lag of 240 sec. It is not. In places the trace is actually going down whilst the air temperature is above the indicated temperature; and a little arithmetic is sufficient to show that a thermometer with a lag of 240 sec. would show very much larger fluctuations than are indicated here.

The desirable accuracy and lag coefficient of meteorological instruments is a matter of some importance; but it is not one which can be decided by a study of the records obtained from one station. The frequency of observations and the distances apart of stations as well as the use which is to be made of the data must also be considered.

The book is well produced and should be studied by all who make or use meteorological observations.

R. FRITH

ERRATUM

August 1954, PAGE 234, line 26; *for* "to be 3 m.p.h. and 1·5 m.p.h. respectively" *read* "to be 1·5 m.p.h. and 3 m.p.h. respectively".

BOOKS RECEIVED

The ice ages. By E. J. Öpik. *Irish astr. J., Armagh,* **2,** 1952, pp. 71–84, *Illus.*

On the causes of palaeoclimatic variations and of the ice ages in particular. By E. J. Öpik. *J. Glaciol., London,* **2,** 1953, pp. 213–218.

A climatological and astronomical interpretation of the ice ages and of the past variations of terrestrial climate. By E. J. Öpik. *Contr. Armagh Obs., Armagh,* No. 9, 1953, pp. 79, *Illus.* Price 10*s.* 6*d.*

Convective transfer in the problem of climate. By E. J. Öpik. *Geophys. Bull., Dublin,* No. 8, pp. 16, 1953. Price 3*s.* 6*d.*

Resumen de Labores, Año 1953. No. 2, 10 in. × 7½ in., pp. 30, *Illus.*, Universidad Mayor de San Andres, Laboratorio de Física Cósmica, La Paz, Bolivia, 1954.

New relations between the mean monthly air temperatures. By J. Xanthakis. 9½in. × 6¾ in., pp. 48, *Illus.*, University of Thessaloniki, Department of Astronomy, 1953.

Harmonic analysis of the tides at Bakar. By M. Kasumović. *Rad. geofiz. Inst., Zagreb,* Ser. III, Br. 1, pp. 9, University of Zagreb, 1952.

METEOROLOGICAL OFFICE NEWS

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

London B.Sc. (General): Second Class Honours in pure and applied mathematics and physics, G. S. Smith.

London B.Sc. (Special): Pass in pure and applied mathematics, Miss J. Portnall.

Intermediate B.Sc.: physics, J. N. Brand.

General Certificate of Education (Advanced Level): pure and applied mathematics and physics, K. Bruley, E. J. Butler, J. W. Davies, D. L. Jones; physics, C. Alderson, Miss P. D. Elcock (with distinction); pure mathematics, C. E. Wood.

Ocean weather ships.—The following extracts from the Master's report, *Weather Observer*, Voyage 56, shows that life aboard a weather ship has its moments of variety:—

July 15. An aircraft from R.A.F. Station Topcliffe circled the ship and dropped mail. The aircrew were unable to see the ship owing to low cloud and fog. We told the pilot to drop the mail as he passed overhead. We were able to see far enough to see the canister hit the water and recover it.

During the voyage a darts and also a cribbage competition was held between the Messes. These were enjoyed by everyone, and other competitions have been arranged for the next voyage. During the lay-up a cricket match was arranged with "our" school, but unfortunately it was cancelled owing to rain; a football match with them is to be arranged later. The highlight of the voyage was when the ship's "dog" gave birth to seven bonnie pups—all are doing well.

WEATHER OF AUGUST 1954

The mean pressure for the month was noteworthy for the fact that it was below normal over an extensive area including Europe, the North Atlantic and most of the United States. The difference from normal was not very great, being generally between 1 and 4 mb. The lowest mean pressure in the region, 1006 mb., occurred just south of Iceland and also over Scandinavia; the highest mean pressure, 1023 mb., was at the Azores. The mean pressure over central and west Europe was very uniform varying only between 1013 and 1015 mb.

Mean temperature in the west and south of Europe was generally 2–4°F. below normal, but over Scandinavia it was 1–2°F. above normal. Over most of the United States, especially the southern half, mean temperature was above normal.

In the British Isles the weather of August was similar to that of the preceding two months and maintained the character of this summer as combining low temperature with a general deficiency of sunshine. Over most of England and Wales and south Scotland there was also more than average rainfall but the distribution was rather variable owing to heavy local falls of rain, associated at times with the rather frequent thunderstorms. The weather in most parts was again dominated by frequent and active depressions.

From the 1st to the 3rd a depression moved from the Atlantic to the northern North Sea and on the 4th a secondary disturbance moved northward to affect southern districts of the British Isles. Troughs to a new Atlantic depression moved across the country on the 5th and subsequently a complex low-pressure system covered the British Isles. On the 9th another small but active depression moved quickly north-east along the English Channel to become slow moving over the North Sea on the 10th. Periods of rain and frequent showers occurred but there were long sunny periods in some places; for example, Leuchars in Fifeshire recorded 13·7 hr. on the 4th and 12·5 hr. on the 7th. Local thunderstorms occurred on most days and rainfall was heavy at times and daily totals of more than 1 in. were recorded at a number of places, notably in Wales on the 1st and in Kent and Sussex on the 9th (3·16 in. at Swansea Waterworks, Brecknockshire and 2·55 in. at Ystalyfera, Glamorgan on the 1st). Strong westerly winds prevailed along the south coast on the 7th. Temperature rose to 70°F. or above in southern England during the first few days; 78°F. was reached in Kent on the 3rd, 80°F. at Camden Square, London, on the 4th, and 78°F. in Dorset on the 5th, but from then until towards the end of the month temperature was for the most part below the August average. A weak ridge of high pressure moved in over the British Isles on the 11th; it was followed on the 12th by a trough of low pressure and on the 15th and 16th by another ridge. Changeable weather occurred over this period, with rain in most areas, heavy at times, with thunderstorms in places but also with sunny periods; Bidston near Liverpool, with 2·36 in. on the 15th, had its heaviest daily rainfall ever recorded in 88 years of observation. On the 17th and 18th a deepening depression from the Atlantic moved eastward across Ireland and northern England giving heavy rain in England and Wales and southern Scotland on the 17th (3·25 in. at Blaenau Festiniog, Merionethshire, 2·12 in. at Uswayford, Northumberland and 2·09 in. at Wet Sleddale, Westmorland). On the 18th an intense ridge of high pressure developed from the Azores towards Scandinavia and maintained fine weather for a few days over much of Scotland, Ireland and parts of western England and Wales. The depression, however, became slow moving in the North Sea on the 19th and then began to move slowly south-west. It was replaced by another system which settled down as a complex depression over the southern North Sea and gave rise to a period of dull rainy weather over eastern districts of England, which gradually extended to much of Scotland, Wales and western England and did not finally clear up until the 25th. During this period there was some very cool weather; on the 19th, Kew, with a maximum of only 57°F., had its coolest August day since 1931. Thunderstorms with heavy local rain were frequent in England (2·08 in. at Halifax Waterworks on the 20th, 3·1 in., most of which fell in 1 hr., at Freshwater, Isle of Wight on the 21st, 2·00 in. at Guisborough, Yorkshire on the 22nd). Morning fog caused some dislocation of road, rail and air traffic in London and the Home Counties on the 22nd. Considerable sunshine occurred in some north-western and western areas during this period; Stornoway recorded 14 hr. on the 16th and over 12 hr. were recorded in parts of south-west England on the 23rd. On the 25th a ridge from the Azores anticyclone spread over the British Isles. It subsequently moved slowly southward into France but southern England had mostly fine weather with considerable sunshine and temperature once more rose into the seventies; on the 31st, 80°F. was reached at a number of places in south-east and east England and locally in the Midlands and 81°F. at Camden Square and Benson, near Oxford. A maximum of 75°F. was registered at Dyce near Aberdeen on the 25th. Scotland, Northern Ireland and, to a less extent, Wales and northern England had mostly cloudy weather with rain or drizzle at times. South-westerly gales occurred in north and west Scotland on the 30th.

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 ...	81	36	−2·3	140	+3	73
Scotland	75	28	−1·5	103	+1	77
Northern Ireland ...	71	38	−1·9	74	−2	87

RAINFALL OF AUGUST 1954

Great Britain and Northern Ireland

County	Station	In.	Per cent. of Av.	County	Station	In.	Per cent. of Av.
London	Camden Square	3·41	154	*Glam.*	Cardiff, Penylan	3·96	94
Kent	Dover	3·37	146	*Pemb.*	Tenby	3·82	101
„	Edenbridge, Falconhurst	3·15	120	*Radnor*	Tyrmynydd	5·91	110
Sussex	Compton, Compton Ho.	3·31	107	*Mont.*	Lake Vyrnwy	4·77	89
„	Worthing, Beach Ho. Pk.	2·73	121	*Mer.*	Blaenau Festiniog	13·55	121
Hants.	Ventnor Park	3·99	196	„	Aberdovey	4·79	108
„	Southampton, East Pk.	3·78	144	*Carn.*	Llandudno	3·09	110
„	South Farnborough	3·04	137	*Angl.*	Llanerchymedd	3·97	110
Herts.	Royston, Therfield Rec.	3·12	121	*I. Man*	Douglas, Borough Cem.	4·64	122
Bucks.	Slough, Upton	3·01	139	*Wigtown*	Newton Stewart	4·56	109
Oxford	Oxford, Radcliffe	3·16	139	*Dumf.*	Dumfries, Crichton R.I.	4·18	103
N'hants.	Wellingboro' Swanspool	3·48	146	„	Eskdalemuir Obsy.	5·84	113
Essex	Shoeburyness	3·97	224	*Roxb.*	Crailing	6·45	219
„	Dovercourt	3·05	170	*Peebles*	Stobo Castle	5·14	144
Suffolk	Lowestoft Sec. School	4·88	222	*Berwick*	Marchmont House	6·13	185
„	Bury St. Ed., Westley H.	4·37	168	*E. Loth.*	North Berwick Res.	5·28	167
Norfolk	Sandringham Ho. Gdns.	4·97	184	*Midl'n.*	Edinburgh, Blackf'd. H.	5·33	166
Wilts.	Aldbourne	3·35	126	*Lanark*	Hamilton W. W., T'nhill	4·67	137
Dorset	Creech Grange	3·47	121	*Ayr*	Colmonell, Knockdolian	4·37	109
„	Beaminster, East St.	3·55	113	„	Glen Afton, Ayr San.	5·45	101
Devon	Teignmouth, Den Gdns.	2·24	99	*Renfrew.*	Greenock, Prospect Hill	5·14	100
„	Ilfracombe	3·55	99	*Bute*	Rothesay, Ardencraig	5·79	119
„	Princetown	6·95	102	*Argyll*	Morven, Drimnin	4·20	80
Cornwall	Bude, School House	2·76	98	„	Poltalloch	4·99	102
„	Penzance, Morrab Gdns.	1·74	55	„	Inveraray Castle	6·44	98
„	St. Austell	2·80	77	„	Islay, Eallabus	4·12	94
„	Scilly, Tresco Abbey	1·55	56	„	Tiree	3·20	76
Somerset	Taunton	2·31	97	*Kinross*	Loch Leven Sluice	3·31	86
Glos.	Cirencester	3·63	121	*Fife*	Leuchars Airfield	2·45	80
Salop	Church Stretton	5·11	153	*Perth*	Loch Dhu	6·66	99
„	Shrewsbury, Monkmore	3·68	133	„	Crieff, Strathearn Hyd.	4·11	98
Worcs.	Malvern, Free Library	4·06	140	„	Pitlochry, Fincastle	3·12	88
Warwick	Birmingham, Edgbaston	4·15	153	*Angus*	Montrose, Sunnyside	2·66	95
Leics.	Thornton Reservoir	4·54	162	*Aberd.*	Braemar	2·88	84
Lincs.	Boston, Skirbeck	3·58	150	„	Dyce, Craibstone	3·06	101
„	Skegness, Marine Gdns.	3·72	152	„	New Deer School House	2·50	84
Notts.	Mansfield, Carr Bank	4·12	148	*Moray*	Gordon Castle	3·01	95
Derby	Buxton, Terrace Slopes	5·70	130	*Nairn*	Nairn, Achareidh	2·22	91
Ches.	Bidston Observatory	5·32	173	*Inverness*	Loch Ness, Garthbeg	3·03	93
„	Manchester, Ringway	5·03	153	„	Glenquoich	7·31	89
Lancs.	Stonyhurst College	7·51	148	„	Fort William, Teviot	5·92	95
„	Squires Gate	4·31	126	„	Skye, Broadford	5·68	88
Yorks.	Wakefield, Clarence Pk.	5·88	226	„	Skye, Duntuilm	4·33	97
„	Hull, Pearson Park	6·20	213	*R. & C.*	Tain, Mayfield	2·22	82
„	Felixkirk, Mt. St. John	6·05	212	„	Inverbroom, Glackour	2·31	55
„	York Museum	7·18	285	„	Achnashellach	4·31	68
„	Scarborough	4·38	158	*Suth.*	Lochinver, Bank Ho.	3·00	90
„	Middlesbrough	4·55	166	*Caith.*	Wick Airfield	2·35	85
„	Baldersdale, Hury Res.	5·20	157	*Shetland*	Lerwick Observatory	2·69	89
Norl'd.	Newcastle, Leazes Pk.	5·62	199	*Ferm.*	Crom Castle	3·36	81
„	Bellingham, High Green	4·53	128	*Armagh*	Armagh Observatory	2·26	62
„	Lilburn Tower Gdns.	6·21	220	*Down*	Seaforde	2·86	76
Cumb.	Geltsdale	6·08	148	*Antrim*	Aldergrove Airfield	2·20	61
„	Keswick, High Hill	5·87	112	„	Ballymena, Harryville	2·38	56
„	Ravenglass, The Grove	5·07	111	*L'derry*	Garvagh, Moneydig	3·16	81
Mon.	A'gavenny, Plâs Derwen	3·70	112	„	Londonderry, Creggan	4·45	96
Glam.	Ystalyfera, Wern House	7·49	121	*Tyrone*	Omagh, Edenfel	3·40	80

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

Wt-34. K16.