

METEOROLOGICAL OFFICE

THE METEOROLOGICAL MAGAZINE

VOL. 89, No. 1,053, APRIL 1960

HIGH ATMOSPHERE RESEARCH IN THE METEOROLOGICAL OFFICE

By the DIRECTOR-GENERAL

Meteorologists like to think that "the sky is the limit", but their upward ambitions, until recently, have been determined by the fact that balloons carrying instruments cannot ascend beyond about 50 kilometres. The position has changed in the last few years. The rate of development of the rocket as a geophysical tool has exceeded all expectations and artificial satellites are in orbit around the Earth. The old limits of accessibility no longer apply.

The Meteorological Office has kept well in the fore of high atmosphere research by means of the Meteorological Research Flight. This unique unit has added greatly to the stockpile of knowledge of the physical properties of the upper air and the structure of clouds. But aircraft capable of acting as flying laboratories are even more limited than balloons in the heights attained, and it has been evident for some time that meteorology must turn its attention to the rocket as a routine sounding device if the supply of data is to match the demands of the theoreticians.

It has therefore been decided to create within the Meteorological Office a new Assistant Directorate to deal with the problems of the high atmosphere. In meteorology the adjective "high" must be interpreted according to the facilities available at any given time. At the beginning of the century, when Teisserenc de Bort discovered the stratosphere, the "high atmosphere" extended only a few kilometres above the tropopause. Today, we may pause at about 100 kilometres, the level at which dissociation becomes significant and the stratosphere (if the name can still be used) merges into the ionosphere.

The decision to regard, for the time being, 100 kilometres as the "top" of the meteorologists' atmosphere does not, of course, imply that meteorology ceases at this level, but merely that this is a convenient height for the separation of techniques. In the mid-latitudes there is little change in mean temperature from the tropopause to about 20 kilometres, but above this height temperature increases to a maximum of about 20°C at 50 kilometres, followed by a fall to a second minimum of about -80°C at 80 kilometres, after which there is another rise. The lowest appreciable ionization in the atmosphere, the D-layer, lies

between 70 and 90 kilometres, and the base of the all-important E-layer is between 100 and 120 kilometres. The E-region and above are regularly explored by radio waves, but the atmosphere between 30 and 100 kilometres is something of a no-man's-land, inaccessible to balloons except in its lowest 20 kilometres and too low for ionospheric techniques, except in its upper layers. This part of the atmosphere is of considerable interest to meteorologists if only for the reason that ozone reaches its maximum concentration between 20 and 40 kilometres. It is certain that regular measurements of wind, pressure, temperature, density and ozone concentration between 30 and 100 kilometres would be especially valuable in studies of the general circulation of the atmosphere.

In general terms the task of the new unit is to extend our knowledge of the movements, physical state and composition of the Earth's atmosphere up to about 100 kilometres. The measurements will be made by instruments carried by large balloons, rockets and, it is hoped, artificial satellites. The rocket work is planned on two main lines: (i) with "large" rockets, such as Skylark and, (ii) with specially designed "small" rockets capable of carrying an instrumented telemetering head to about 60 kilometres. In the field of satellite observations the Office has begun a design study for an experiment to determine the vertical distribution of atmospheric ozone by means of the solar spectrum in the ultra-violet and visible ozone bands at satellite sunrise and sunset. The same instruments will probably allow determination of the total ozone content over the sunlit Earth by examination of the albedo in the same absorption bands. It is planned to complete this instrument in time for its inclusion in the second United States-British "Scout" satellite.

The problems of instrumentation involved in this work are both difficult and fascinating, but observations are but means to an end. In the planning of the staff, provision has been made for theoretical studies of the data obtained both in this country and abroad, as they become available.

Although the creation of the new unit involves many novel concepts, in another sense it is simply a logical continuation of the exploration of the atmosphere which began with kites and the Dines balloon-meteorograph and received its greatest impetus to date with the development of the radio-sonde and radar-wind equipment. To the vast majority of meteorologists, rockets and satellites are unknown tools, but their potentiality is evident. It is to be hoped that the coming generation of meteorologists will discover in their results as great an inspiration and as valuable an aid towards the understanding of the ways of the atmosphere as our generation found in the radio-sonde and radar-wind soundings.

RAPID SPREAD OF LINCOLNSHIRE FOG DURING A FEBRUARY AFTERNOON

By T. A. M. BRADBURY

Forecasting the behaviour of fog during the winter months is often complicated by factors which cannot readily be assessed at short notice. On 17 February 1959 there occurred an unusually rapid spread of fog just after the period of maximum insolation. Since this early spread of fog was not generally expected, an account of developments may be of interest.

The general synoptic situation at 1200 G.M.T. on 17 February is shown in Figure 1. A large well established anticyclone was centred over Belgium, and there was a very slack gradient over most of England. Fog had been widespread and dense over central and south-east England during the night. This fog continued to spread after dawn and a shallow layer of fog reached Lincolnshire and south Yorkshire by mid-morning.

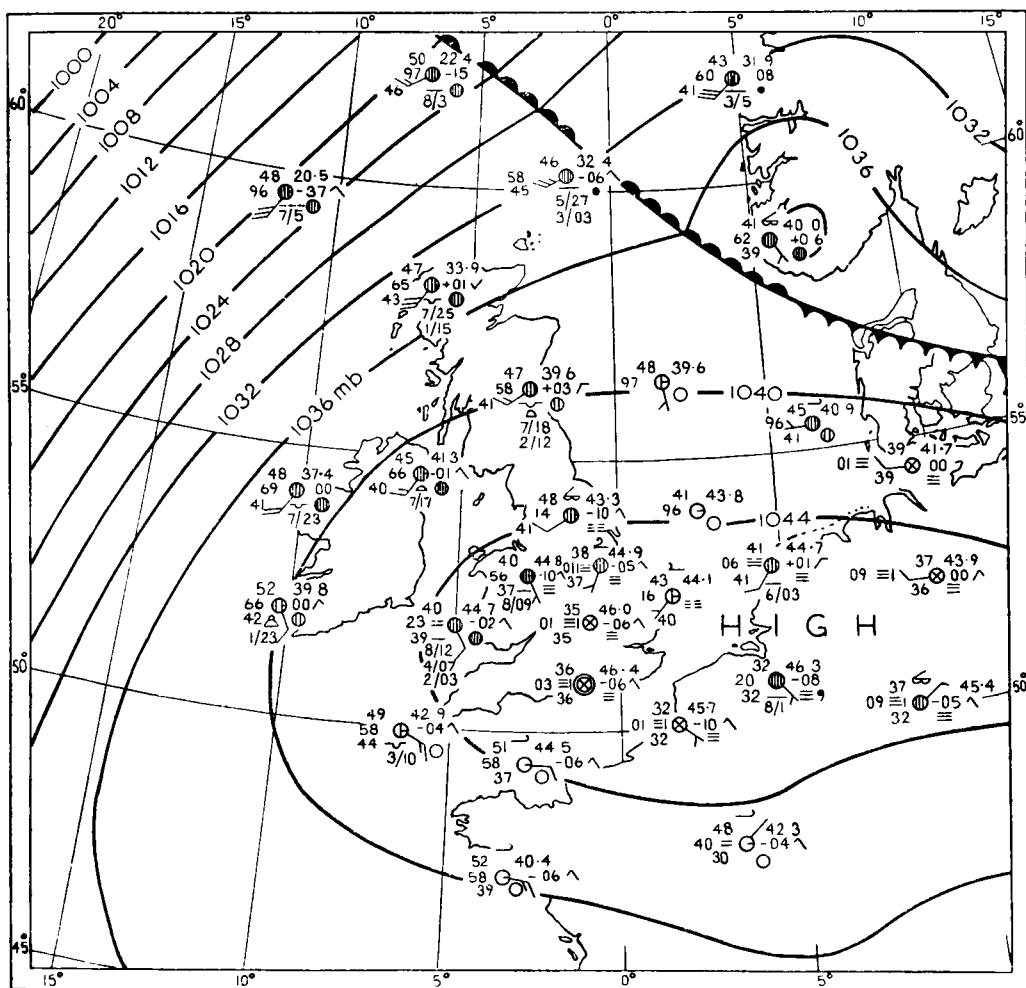


FIGURE 1—SYNOPTIC CHART FOR 1200 G.M.T. 17 FEBRUARY 1959

Over Lincolnshire where it was practically cloudless the temperature rose to 50°F. in several places; this was sufficient to raise the level of the inversion enough for the smoke haze to clear and allow the visibility to reach three miles around Finningley. Further south the thick smoke haze persisted and the dispersal of water fog did not result in such a marked improvement in visibility. By 1400 G.M.T. the fog had cleared from most Lincolnshire airfields, and temperatures were rising rapidly in all except the persistently foggy areas along the Trent valley near and above Newark. At first the rise of temperature suggested that the fog would be slow to return in the evening, and a clear afternoon appeared probable. However, within half an hour the fog had begun to spread again, and within three hours it had advanced across all the inland airfields in Lincolnshire.

Isochrones of the advancing fog bank are shown in Figure 2. The surface wind speed and direction at the time of onset of fog have been plotted against the stations. The movement of this fog was first noticeable at Cottesmore, which had been clear of fog during the morning. The development can be summarized as follows:

1330 G.M.T., the fog began to lift out of the broad valley to the west of Cottesmore, and a freshening wind began to carry the fog across the airfield, although not actually over the meteorological office. The wind increased from 7 knots at 1250 G.M.T. to 12 knots at 1405 G.M.T., when the fog had lifted to stratus at 300 feet. (A similar increase of wind occurred at Syerston where fog persisted all day.)

1423 G.M.T., fog began to thicken again at Swinderby.

1437 G.M.T., fog returned to Cranwell. The anemograph recorded a gust to 13 knots just before 1500 G.M.T.

1447 G.M.T., fog rolled across Waddington.

1533 G.M.T., fog bank reached Scampton, and the surface wind increased to 15 knots temporarily.

1550 G.M.T., fog reached Hemswell, where the Air Traffic Control Officer reported that the wind had increased to 15 knots and the visibility dropped to only 25 yards.

1607 G.M.T., Coningsby reported visibility reduced by smoke to 700 yards, followed at 1636 G.M.T. by stratus, base 300 feet.

1657 G.M.T., fog reached Binbrook.

1654 G.M.T., Finningley surface wind backed to 140 degrees 9 knots, smoke haze rolled in from the south-east and by 1700 G.M.T. the visibility was reduced to 440 yards.

1708 G.M.T., Lindholme visibility deteriorated from 2,200 to 770 yards and between 1700 and 1800 G.M.T. the wind backed from 180 degrees to 140 degrees.

There is little doubt that the cold surface air advanced as a distinct line which progressed at about ten or twelve knots. An aircraft observed this advancing line of fog between Waddington and Scampton just after 1500 G.M.T. The existence of a bank of fog was confirmed by an aircraft from Lindholme which reported fog lying east of Lindholme, but remarked that near Finningley the bank had the appearance of thick smoke.

This line was in effect a very shallow "front". As it progressed it was accompanied by a wind shift which brought the wind from a direction at right-angles to the line of the "front". At stations where the "front" passed during the period of maximum temperatures there was a marked increase of wind accompanied by a sharp fall of temperature. This was most marked at Scampton and Hemswell where the arrival of the fog bank was accompanied by an increase of wind to 15 knots for a short time. At Finningley and Coningsby, where the advancing "front" approached from the south-east and the west respectively, the first indication of a change seems to have been the arrival of thick smoke haze. This suggests a wedge of cold air penetrating beneath the warm air, with a concentration of smoke trapped beneath the resulting inversion.

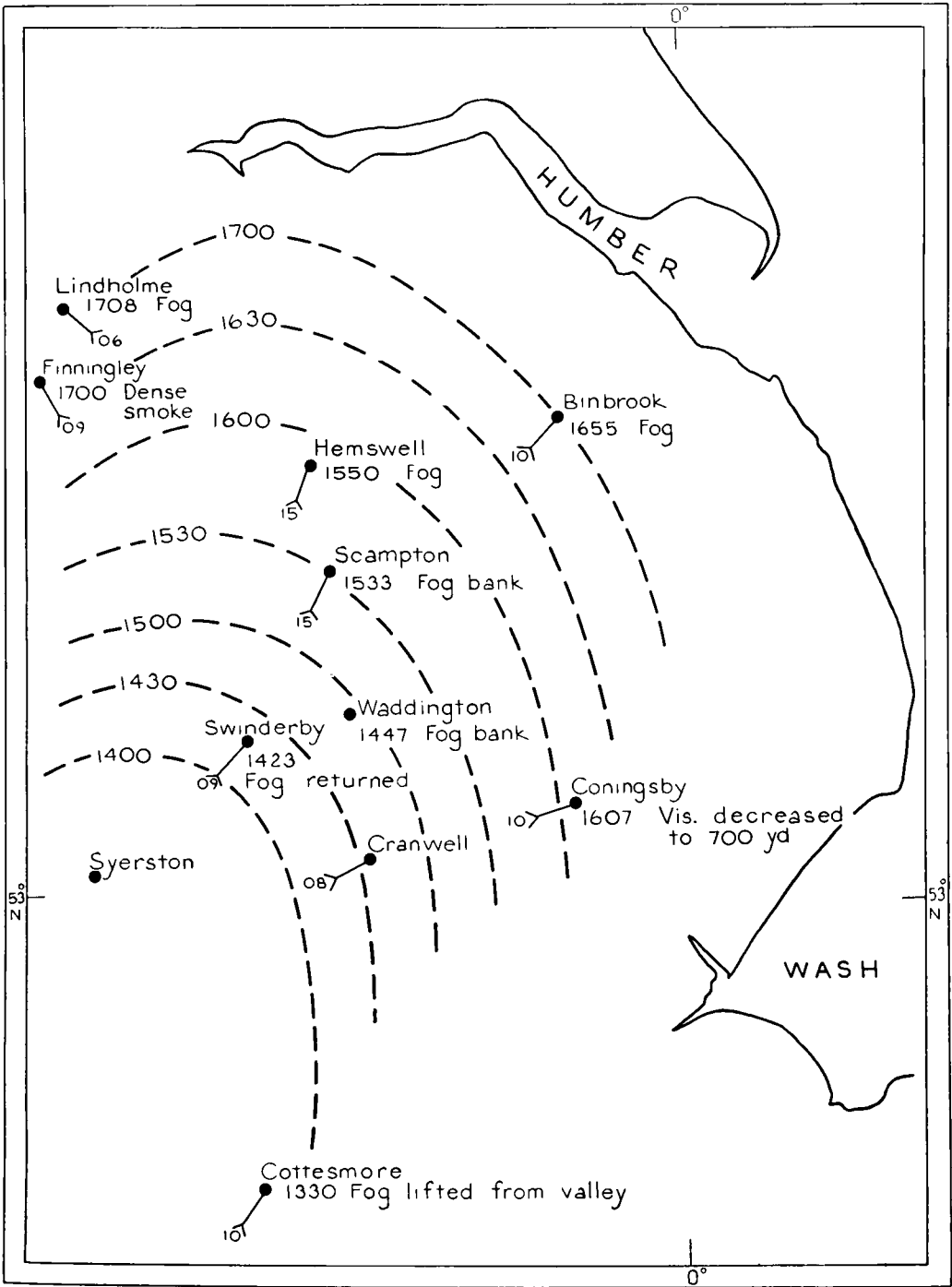


FIGURE 2—ISOCHRONES SHOWING MOVEMENT OF FOG, 17 FEBRUARY 1959
All times are G.M.T.; wind arrows refer to time of onset of fog.

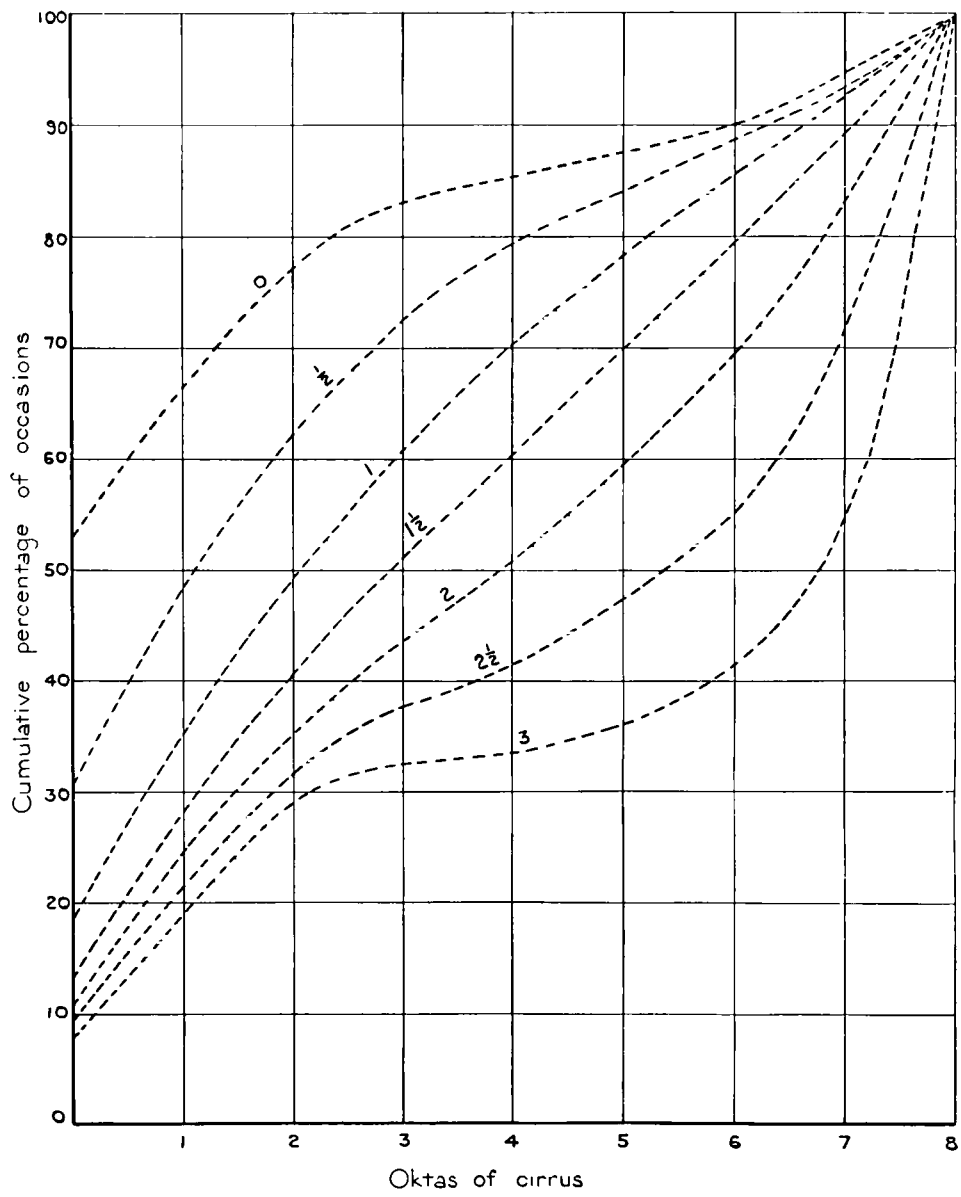


FIGURE 1—CUMULATIVE PERCENTAGE OF CIRRUS AMOUNTS FOR
FORECAST “SCORES” 0, $\frac{1}{2}$, 1, $1\frac{1}{2}$, 2, $2\frac{1}{2}$ AND 3
(see p. 102)

This "front" had several similarities with a sea-breeze front, and it is suggested that its movement may have been caused by a similar mechanism, which in this case was started by the temperature contrast of about 13°F . between the warm sunny area covering north Lincolnshire and south Yorkshire, and the cold fog-bound region of the Midlands.

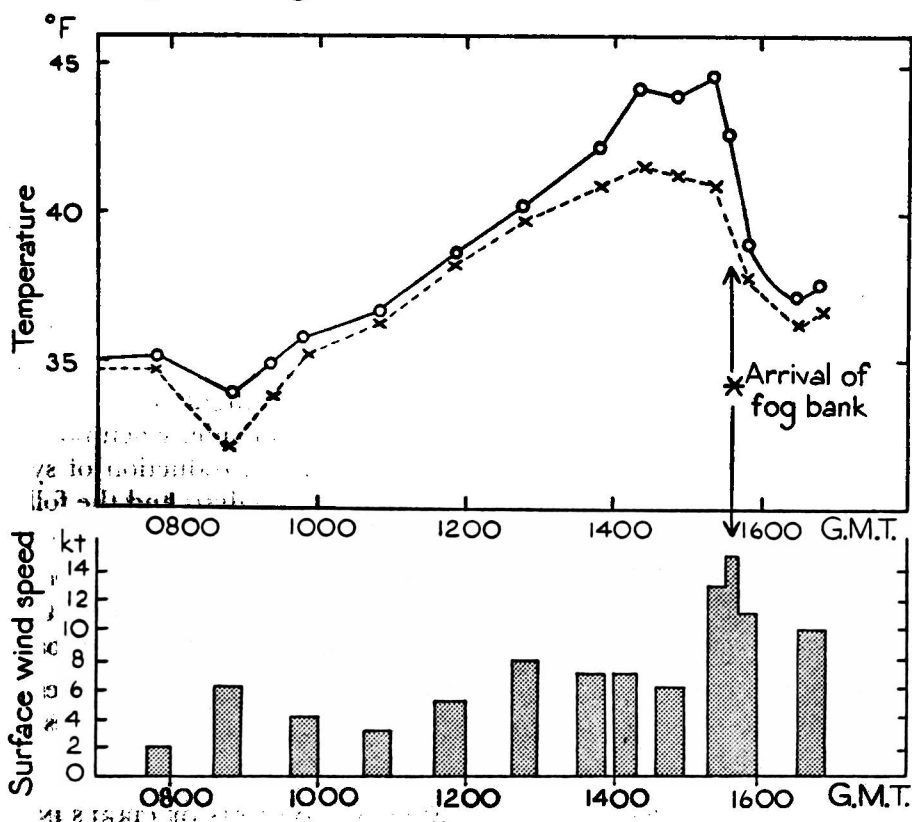


FIGURE 3—VARIATION OF TEMPERATURE AT SCAMPTON, 17 FEBRUARY 1959

A rapid onset of fog during winter afternoons is not without precedent in this area, but there is a natural inclination to assume that once the sun has dispersed the fog the rising temperatures will prevent return of fog until after sunset. The developments on 17 February 1959 indicate that relatively high afternoon temperatures may possibly result in a large-scale movement of surface air which will transport fog for distances of 30 miles during the afternoon.

A NOTE ON CIRRUS FORECASTING

By F. SINGLETON, B.Sc., D.I.C. and B. G. WALES-SMITH

Introduction.—An objective technique for forecasting cirrus for periods 6–9 hours and 24–36 hours ahead has been suggested by James¹ and has also been discussed in detail at a Meteorological Office Monday evening discussion in November 1958.² The method described was to answer as many questions as possible from a list of thirteen for the short-range forecast, and six for the longer period. In this note it is suggested, as a result of a practical trial, that three of James' questions not only provide a good basis for a "cirrus" or "no-cirrus" forecast, but also may be used to obtain an indication of the expected high-cloud cover.

The three criteria are as follows:

- (i) Is the forecast area in or just to the rear of a ridge in the 200-millibar contour pattern?
- (ii) Is the forecast area on the anticyclonic side of a 200-millibar jet stream and within 300 miles of the jet axis?
- (iii) Is the forecast area up to 300 miles ahead of a surface warm front or occlusion?

A trial of the proposed method.—Following a preliminary trial of 50 days during the latter half of 1957, 214 days during 1958 were selected. The number of days chosen during 1958 was determined by the availability of high-cloud observations. On each of the 264 days a mark (0, $\frac{1}{2}$ or 1) was given for each of the above questions according to whether the answer was “no”, “uncertain” or “yes” respectively. The area considered was England and Wales south of 53°N and the period 0600–1200 G.M.T.

The total “score” obtained was compared with the average amount of cirrus reported by the Farnborough morning reconnaissance flight (0815–0900 local time) or, in the event of there being no flight, use was made, when possible, of surface synoptic observations. In order to avoid the introduction of synoptic forecasting errors, the midnight 200-millibar contour analysis and the following 0600 G.M.T. surface chart were used to obtain the score.

James used the 300-millibar chart but the 200-millibar chart was used in this analysis since, in the forecast room where the “scores” were obtained, the only constant-pressure surface to be analysed as a routine is that at 200 millibars.

Results of the trial.—For the complete trial of 264 days the “scores” were 0– $\frac{1}{2}$ on 104 days, 1–1 $\frac{1}{2}$ on 106 days and 2–3 inclusive on 54 days. The results are presented in Table I.

TABLE I—NUMBER OF OCCASIONS WHEN AVERAGE AMOUNTS OF CIRRUS IN THE RANGES SHOWN CORRESPONDED TO “SCORES” 0– $\frac{1}{2}$, 1–1 $\frac{1}{2}$ AND 2–3

“Score”	Average amount of cirrus (oktas)				Total
	0	1–3 <i>number of occasions</i>	4–6	7–8	
0– $\frac{1}{2}$	45	36	12	11	104
1–1 $\frac{1}{2}$	16	43	30	17	106
2–3	5	15	10	24	54
Total	66	94	52	52	264

Figure 1, which was derived from Table I, shows observations of average cirrus amounts (expressed as cumulative percentages) as a function of the “score”. As there were insufficient data to prepare Figure 1 directly from the observations, use was made of an intermediate diagram on which isopleths were drawn relating cumulative percentages of amounts of cirrus to the scores $\frac{1}{4}$, 1 $\frac{1}{4}$ and 2 $\frac{1}{2}$, from which Figure 1 was then obtained by means of graphical interpolation. Figure 2, also derived from the intermediate diagram, indicates the optimum amount of high cloud to be forecast for any given “score”. The points plotted in Figure 2 are the amounts of cirrus at the 50 per cent (cumulative) value for “scores” $\frac{1}{4}$, 1 $\frac{1}{4}$ and 2 $\frac{1}{2}$.

Preparing a forecast.—After having obtained a “score” relevant to the area and period of the forecast, inspection of Figure 2 should give the most likely amount of cirrus. If, as is usual and preferable, an expected range of cirrus is

required, then the isopleth corresponding to the “score” on Figure 1 will give the most probable range of cirrus amounts for varying degrees of confidence. For example, with a score of $\frac{1}{2}$ the most likely amount of cirrus is 1 okta; a forecast

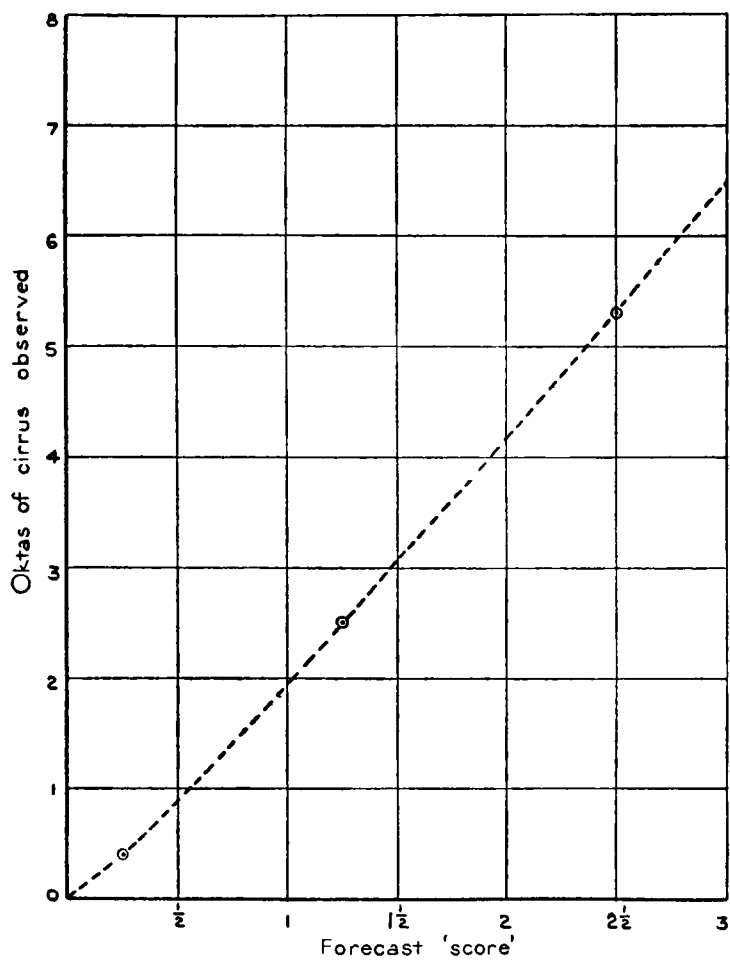


FIGURE 2—AVERAGE AMOUNTS OF CIRRUS OBSERVED PLOTTED AGAINST FORECAST “SCORE”

range of 1–2 oktas will be correct on $62 - 48 = 14$ per cent of occasions, 0–2 oktas will be correct on 62 per cent of occasions and 0–3 oktas will be correct on 72·5 per cent of occasions. Further examples are shown in Table II.

TABLE II—OPTIMUM AMOUNTS OF CIRRUS TO FORECAST FOR “SCORES” 0–3 AND EXAMPLES OF EXPECTED PERCENTAGE OF CORRECT FORECASTS

“Score”	Optimum amount <i>oktas</i>	Correct forecasts	
		<i>range in oktas</i>	<i>per cent</i>
0	0	0–1	66
$\frac{1}{2}$	1	0–2	62
1	2	0–3	61
$1\frac{1}{2}$	3	0–3	50
2	4	0–4	51
		2–7	48
$2\frac{1}{2}$	5	5–8	53
3	6–7	6–8	59

The results as shown in Table II indicate that for scores of 0–1 and $2\frac{1}{2}$ –3, forecasts such as 0–2 oktas in the first instance or 5–7 oktas and 6–8 oktas in the

second would be quite satisfactory, but that for scores $1\frac{1}{2}$ or 2, on the other hand, such a precise forecast would not be possible. In the last case the best indication would probably be of the form "amounts of cirrus varying from 2-6 oktas".

It is suggested that the forecaster could use Figures 1 and 2 in conjunction with any other questions outlined by James that could easily be answered. The results of these other questions could then enable a decision to be made between, for example, 2-7 oktas or 0-4 oktas cirrus for a "score" of 2.

Validity of the results

(a) *Representativeness of the data used.*—Murgatroyd and Goldsmith³ have presented data relating to the occurrence of cirrus cloud over southern England from 1949-54, these are shown in Table III.

TABLE III—OBSERVATIONS OF HIGH CLOUD OVER SOUTHERN ENGLAND³

							Percentage number of occasions
High cloud in immediate vicinity	...	...	...	...	...	...	47
High cloud visible in the distance	...	...	...	...	...	...	28
No high cloud	...	...	...	...	...	...	25

Total number of observations = 290

Figure 3 shows, for purposes of comparison, the observations of average amounts of cirrus on the 264 days of the present investigation, expressed as cumulative percentages. These agree favourably with Table III as regards percentage occasions of "cirrus" and "no-cirrus", otherwise comparison cannot easily be made. If, however, the phrase "high cloud visible in the distance" is translated to mean 1-2 oktas and "high cloud in the immediate vicinity" to mean 2-8 oktas, then the two distributions are broadly similar.

(b) *The case of convective cirrus.*—It is to be expected from the nature of the criteria employed that they would not be adequate for forecasting convective cirrus. Moreover, the observations are probably biased towards an unrepresentatively small amount of anvil cirrus because they were made between 0800 G.M.T. and 0900 G.M.T. On three occasions, however, the reconnaissance flight reported "1 okta anvil cirrus"; these corresponded to "scores" of 0, 0 and 1. It is probable, moreover, that convective cirrus was present on other days but was not readily identifiable as such and hence no conclusions may be drawn as to the validity or otherwise of the technique as regards convective cirrus.

Conclusions.—The above investigation shows that there exists an objective technique for forecasting amounts of cirrus as far ahead as a satisfactory synoptic forecast can be made. It is not proposed that the other criteria used by James should be ignored; as suggested in the above text they may be used to advantage as may also, of course, the forecaster's personal experiences of individual synoptic situations.

Acknowledgement.—To Mr. D. J. Smith, who assisted with the calculations and preparation of the diagrams.

REFERENCES

1. JAMES, D. G.; Forecasting cirrus cloud over the British Isles. *Prof. Notes Met. Off., London*, No. 123, 1957.
2. London, Meteorological Office; Forecasting cirrus (Meteorological Office discussion). *Met. Mag., London*, **88**, p. 74.
3. MURGATROYD, R. J., and GOLDSMITH, P.; High cloud over southern England. *Prof. Notes Met. Off., London*, No. 119, 1956.

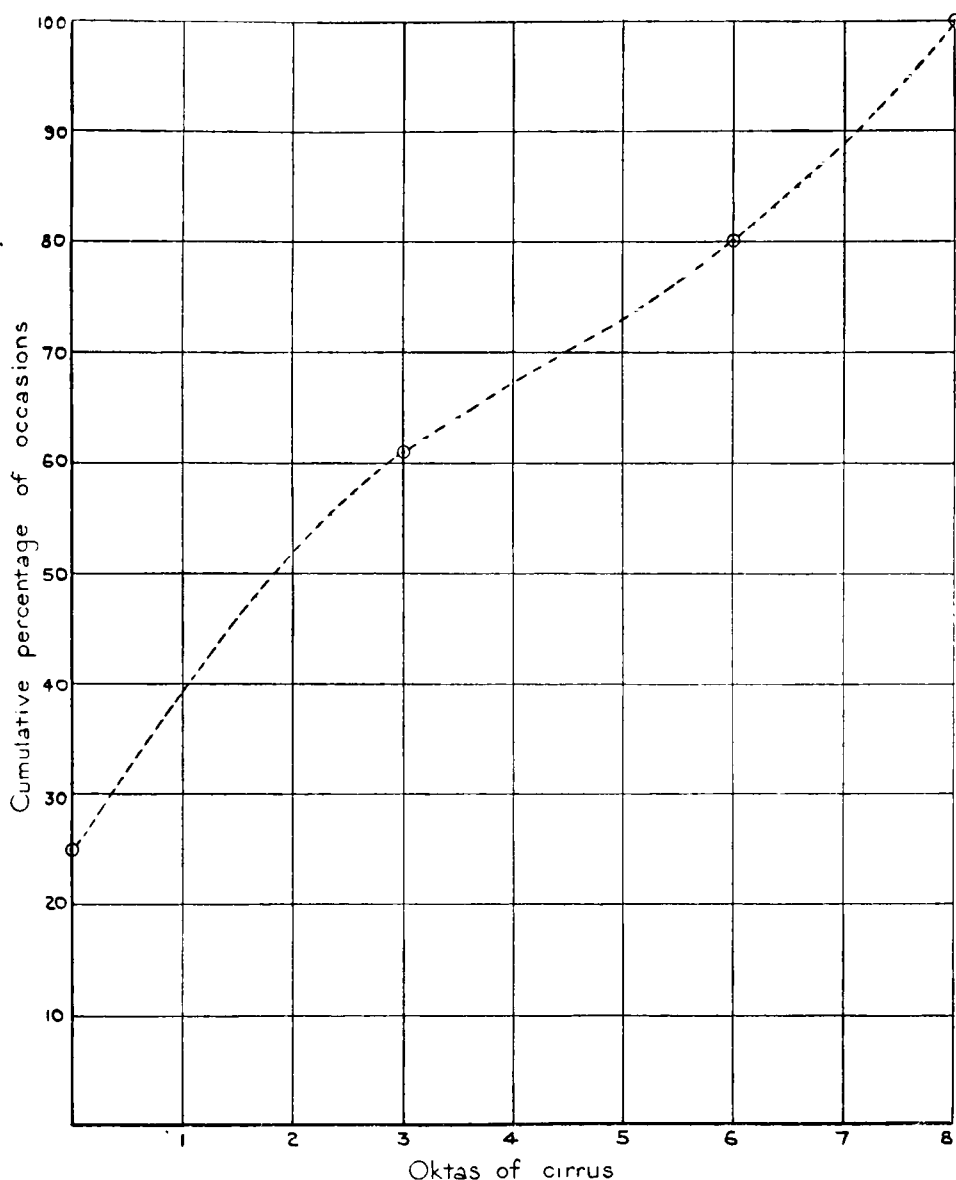


FIGURE 3—AMOUNTS OF CIRRUS OBSERVED, EXPRESSED AS A CUMULATIVE PERCENTAGE

DRY SPELLS OF THREE DAYS OR MORE AT LONDON FROM MAY TO OCTOBER

By C. A. S. LOWNDES

Introduction.—This work was undertaken to provide a background to the problem of forecasting dry spells at London, on which it is hoped to publish a further paper shortly. For the purpose of this investigation, a dry spell was defined as a period of three or more consecutive days at Kew with no precipitation other than a trace of dew. Tabulations of the total daily rainfall from 0000 G.M.T. to 2400 G.M.T. at Kew Observatory were used to extract the dates of the beginning and end of periods with not more than a trace recorded. The weather records for Kew in the *Daily Weather Reports* were then examined and

any day during these periods with precipitation other than dew recorded in the Beaufort Letters was discarded and the dry-spell periods amended accordingly. The spells were extracted for the periods 1931 to 1939 and 1943 to 1958, a total of 25 years. The years 1940 to 1942 were not included because of the lack of synoptic data over the Atlantic and Europe. The investigation was restricted to the six months from May to October, the period when the Central Forecasting Office provides warnings of dry spells of three days or more for the benefit of farmers. The spells occurring in each month were listed separately. Where a spell extended from one month to another, it was included in the month which contained the greater part of it.

The frequency of dry spells of three days or more.—There were 244 spells during the whole period, giving an average of 1·6 spells per month.

TABLE I—AVERAGE NUMBER OF SPELLS FOR EACH MONTH

May	June	July	August	September	October
1·9	1·6	1·8	1·8	1·3	1·4

Table I shows the average number of spells for each individual month, ranging from 1·9 in May to 1·3 in September. Each of the six months, however, was without dry spells in a number of years. Table II shows the number of months with no dry spells, ranging from two for August to seven for September. Roughly one in four Septembers and one in five Octobers had no dry spell of three days or more.

TABLE II—NUMBER OF MONTHS WITH NO DRY SPELLS (IN 25 YEARS)

May	June	July	August	September	October
3	3	3	2	7	5

If we consider the number of months with no dry spells of four days or more we obtain Table III. Roughly one in three Septembers and Octobers had no dry spells of four days or more.

TABLE III—NUMBER OF MONTHS WITH NO DRY SPELLS OF FOUR DAYS OR MORE (IN 25 YEARS)

May	June	July	August	September	October
3	3	5	5	10	10

Of the 36 cases, 12 occurred in three particular years, that is, 1932, 1936 and 1946. The months were May, July, September and October, 1932; June, July and September, 1936; May, June, August, September and October, 1946. The suggestion of a seasonal persistence of type is not borne out by an inspection of the intervening months of 1932 and 1936. In July 1946 there were dry spells of three, four and seven days.

The frequency of each length of spell is shown in Figure 1. Of the spells 28 per cent were of three days and 22 per cent of four days, so that half the spells were of three or four days duration. Spells of three to seven days made up 84 per cent of the total. Of the remainder 12 per cent were of 8 to 11 days and 4 per cent were 12 days or more in length; the longest spell lasted 19 days.

The probability of a dry spell continuing.—The probability of the day after a three-day spell being dry is $175/244 = 0\cdot72$ where 175 is the number of

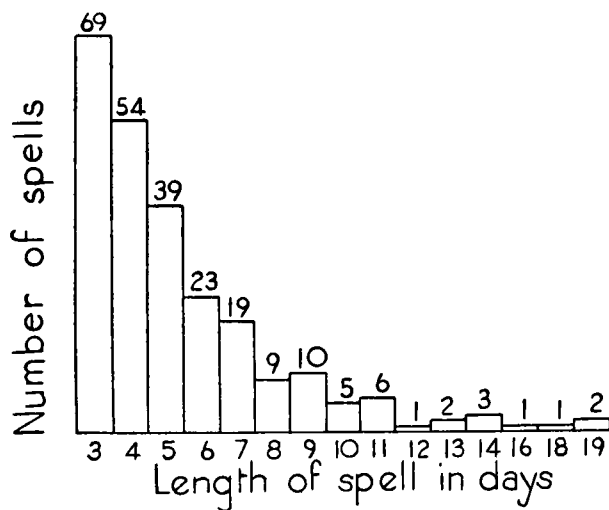


FIGURE 1—FREQUENCY OF EACH LENGTH OF SPELL, MAY TO OCTOBER
Total number of spells = 244

spells lasting four days or more and 244 the number of spells of three days or more. The probability after a four-day spell is 0·69 and after a five-day spell 0·68. It is clear that values of probability calculated for the longer spells would be rather erratic owing to the liability of large percentage errors in the small frequency values. To avoid this, the frequency was plotted against the length of spell, a best fitting curve drawn through the points and the frequency corresponding to each length of spell read off from the curve.

TABLE IV—THE PROBABILITY OF A DRY DAY AFTER DIFFERENT NUMBERS OF SUCCESSIVE DRY DAYS

		Number of dry days									
		3	4	5	6	7	8	9	10	11	12
		<i>probability</i>									
Kew (25 years)	...	0·72	0·69	0·68	0·69	0·72	0·73	0·73	0·73	0·75	0·75

Table IV shows the probability values calculated from the frequencies obtained in this way. The probability of a dry day after spells of from 3 to 12 days is roughly constant at about 0·7. There is, however, a fairly steady increase in probability between 5 and 11 days from 0·68 to 0·75.

Newnham¹ calculated probabilities for a 10-year period at Kew (1901–10), and a 27-year period at Greenwich (1887–1913). The data were extracted from all months of the year and a dry day was defined simply as one with less than 0·01 inch of precipitation. The smaller frequency values were smoothed by means of the formula $B = (a + 2b + c)/4$.

TABLE V—THE PROBABILITY OF A DRY DAY AFTER DIFFERENT NUMBERS OF SUCCESSIVE DRY DAYS

	Number of dry days											
	1	2	3	4	5	6	7	8	9	10	11	12
	<i>probability</i>											
Kew (10 years)	0·55	0·66	0·64	0·68	0·74	0·73	0·73	0·78				
Greenwich (27 years)	0·57	0·66	0·72	0·73	0·73	0·72	0·73	0·74	0·78	0·80	0·82	0·82
Kew (25 years)			0·72	0·69	0·68	0·69	0·72	0·73	0·73	0·73	0·75	0·75

Table V shows the probabilities calculated by Newnham and also those shown in Table IV. Newnham shows that there is a rapid increase in probability from about 0.55 after one day to about 0.65 after two days. His figures for the longer spells are in reasonable agreement with those in Table IV but are mainly rather higher. A possible explanation of this may lie in his use of a less severe criterion for a dry day, resulting in spells of length up to 23 days at Kew and 30 days at Greenwich. The probability of a further three dry days following spells of from three to ten days is roughly $(0.7)^3$ or about 0.35.

The synoptic types associated with dry spells at London.—A short description of the synoptic type in the region of the British Isles was written for each spell. In nearly all cases this involved a description of the position, movement or formation of the anticyclone or ridge with which the dry spell was associated. The types were then classified according to the region from which the high or ridge moved towards the British Isles or in which the high was situated, often with a ridge extending to the British Isles. The regions are shown in Figure 2. For example, highs moving from the south-west or ridges extending

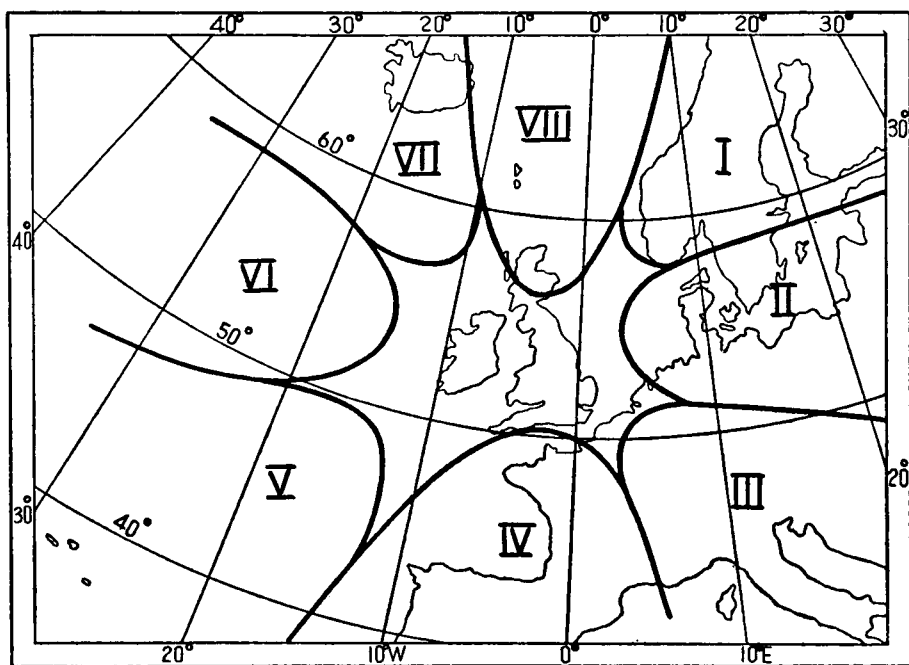


FIGURE 2—THE REGIONS USED IN THE CLASSIFICATION OF SYNOPTIC TYPES

from highs situated to the south-west were classed as Type V; highs as Type VH and ridges as Type VR. A type which began with a ridge extending from the south-west from which a high then developed or broke away was classed as Type VRH. The complete classification is shown in Table VI, together with the number of spells associated with each type. For the purpose of this table, if a spell was made up of more than one type, it was grouped under the type which predominated.

The most striking feature of the table is the high proportion of spells (62 per cent) associated with high pressure to the south-west of the British Isles (Type V). Of these, 70 spells were associated with highs which moved from the south-west

TABLE VI—CLASSIFICATION OF SYNOPTIC TYPES (MAY TO OCTOBER)

Total number of spells = 244

Synoptic type	Class	Number of spells
Ridge from Scandinavia extended { over British Isles ... to east of British Isles ...	IR ₁ IR ₂	4 3 } 7
High over Scandinavia	IH	5
Ridge from east extended { over British Isles ... over southern British Isles ... to south of British Isles ...	IIR ₁ IIR ₂ IIR ₃	6 1 3 } 10
High to east of British Isles	IIH	2
Ridge from high to SE extended over British Isles	IIIR	—
High over Continent	IIIH	6
High to south of British Isles	IVH	2
High moved from south to Norwegian Sea { across British Isles east of British Isles	IVH ₁ IVH ₂	3 1 } 7
High moved from region of Spain, south of British Isles to eastern Europe	IVH ₃	1
Ridge from SW extended { to west of British Isles ... over British Isles ... over southern British Isles ... to south of British Isles ...	VR ₁ VR ₂ VR ₃ VR ₄	— 16 8 16 } 40
Ridge from SW extended over British Isles, then high formed over British Isles and moved	VRH ₁ VRH ₂ VRH ₃ VRH ₄ VRH ₅	2 3 2 5 3 } 42
Ridge from SW extended to south of British Isles, then high formed to south or SE of British Isles and persisted or moved east ...	VRH ₆	27
High moved from SW { to a position west or NW of British Isles west of British Isles to Norwegian Sea ...	VH ₁ VH ₂	7 2 } 70
High moved from SW over British Isles { to Norwegian Sea ... to Scandinavia ... to North Sea ... to Continent ... then to west ...	VH ₃ VH ₄ VH ₅ VH ₆ VH ₇	3 9 10 14 3 } 70
High moved from SW, south of British Isles, to Continent ...	VH ₈	22
Mobile ridge moved from west across British Isles	VIR ₁	1
Blocking ridge, or col, associated with high to south, moved from west across British Isles	VIR ₂	7
Ridge from west extended over British Isles	VIR ₃	—
High moved from west, north of British Isles { to Norwegian Sea (or over N. Scotland)	VIH ₁ VIH ₂	2 1 } 18
High moved from west across British Isles { to Scandinavia ... to North Sea ... to Continent ... to SW approaches ...	VIH ₃ VIH ₄ VIH ₅ VIH ₆	1 6 6 2 } 18
Ridge from NW extended over British Isles	VIIR	4
High to NW	VIIH	2
High moved from NW { west of British Isles to SW approaches ... west of British Isles to Continent ... to British Isles ... across British Isles to Continent ...	VIIH ₁ VIIH ₂ VIIH ₃ VIIH ₄	1 2 — 4 } 9
Ridge from north extended { over British Isles ... east of British Isles ...	VIIIR ₁ VIIIR ₂	4 4 } 8

TABLE VI—CLASSIFICATION OF SYNOPTIC TYPES (MAY TO OCTOBER) *contd.*

Synoptic type	Class	Number of spells
High to north of British Isles or over Scotland (low to south of British Isles)	VIIIH	5
High moved from Norwegian Sea, east of British Isles, to Continent	VIIIH ₁	2 } 7
Shallow low over Continent and British Isles	IX	1

to the west of, across, or to the south of the country (Type VH); 42 were initially associated with a ridge from the south-west extending over (or to the south of) the British Isles with a high soon forming over (or to the south of) the country and persisting or moving east (Type VRH); 40 were associated with ridges which extended from the south-west over or to the south of the British Isles (Type VR).

Some 11 per cent of the spells were associated with high pressure to the west of the British Isles (Type VI). Of these, 18 spells were caused by highs which moved from the west over or to the north of the country (Type VIH) and seven by blocking ridges, or cols, which moved slowly across the country from the west (Type VIR₂). Of the remaining spells, six per cent were associated with high pressure to the north (Type VIII) and five per cent with high pressure to the north-west (Type VII), to the north-east (Type I) and to the east (Type II).

TABLE VII—THE PERCENTAGE OF SPELLS IN EACH MONTH ASSOCIATED WITH

Synoptic type	EACH CLASS OF SYNOPTIC TYPE				September	October
	May	June	July <i>percentage number of spells</i>	August <i>percentage number of spells</i>		
I (NE)	4	5	2	2	3	14
II (E)	4	0	2	2	9	14
III (SE)	0	8	2	0	0	5
IV (S)	9	0	2	0	3	3
V (SW)	55	64	80	78	50	39
VI (W)	9	10	10	11	16	11
VII (NW)	9	5	0	2	6	11
VIII (N)	10	8	0	5	13	3
IX	0	0	2	0	0	0
			<i>total number of spells</i>			
	47	39	45	45	32	36

Table VII shows the number of spells in each month which were associated with each class of synoptic type, expressed as a percentage of the total number of spells in each month. The percentage of Type V increases from 55 in May to 80 in July and then falls abruptly to 50 in September, reaching a minimum of 39 in October. Types I and II show mainly small values, but both reach a maximum of 14 per cent in October. Types III and IV show values of below 10 per cent in all months. The percentage of Type VI remains fairly constant at about 10 per cent, with a maximum of 16 per cent in September. Type VII shows mainly below 10 per cent with a minimum in July. Type VIII has values mainly below 10 per cent, with a minimum in July and a maximum of 13 per cent in September.

The long-period variation of the synoptic types associated with dry spells at London.—The percentage of spells associated with each synoptic type for the three eight-year periods, 1932–39, 1943–50 and 1951–58, is shown in Table VIII, together with the values for the 25-year period 1931–58.

The percentage of Type V spells was about 10 per cent lower in the period 1943-50 than in the other two periods. This difference was mainly associated with Type VH₈ which caused ten spells in 1932-39 and 1951-58 and only one spell in 1943-50. The percentage of Type V and VI spells rose from about 70 per cent in the two earlier periods to over 80 per cent in 1951-58.

TABLE VIII—THE PERCENTAGE OF SPELLS ASSOCIATED WITH EACH SYNOPTIC TYPE FOR DIFFERENT PERIODS

Type	1932-39	1943-50	1951-58	1931-58
	<i>percentage</i>		<i>number of spells</i>	
I	7	7	1	5
II	3	7	7	5
III	1	3	1	2
IV	1	5	1	3
V	65	56	68	62
VI	7	13	14	11
VII	6	4	4	5
VIII	9	5	4	6
IX	1	0	0	1
	<i>total number of spells</i>			
	86	73	73	244

The make-up of the longer spells.—The spells of seven days or more are generally made up of a number of different types, with Type V predominating. In 85 per cent of the cases Type V is associated, at least partly, with the spell. For the months May to August the figure is 93 per cent. Table IX shows the number of spells in each month partly or wholly associated with Type V.

TABLE IX—THE MAKE-UP OF SPELLS OF SEVEN DAYS OR MORE

Month	Total number of spells	Number of spells associated with Type V
May	9	8
June	12	11
July	7	7
August	16	14
September	6	4
October	9	5
Total	59	49

Conclusion.—About 30 per cent of the dry spells at London lasted only three days. In such cases, in order to achieve a forecast of three dry days, an indication must be obtained about 24 hours in advance. Some 60 per cent of the spells were associated with high pressure to the south-west of the British Isles (Type V) and this figure showed no significant variation over the 25-year period. In July and August about 80 per cent were Type V spells. The percentage of spells associated with high pressure to the west (Type VI) remained fairly constant at about 10 per cent in all months. The spells which lasted for seven days or more were associated with Type V, at least partly, in 85 per cent of the cases.

It seems clear that the problem of forecasting dry spells of three days or more at London is in the main that of forecasting Type V and VI spells, particularly in high summer.

REFERENCE

1. NEWNHAM, E. V.; The persistence of wet and dry weather. *Quart J. R. met. Soc., London*, **42**, 1916, p. 153.

METEOROLOGICAL OFFICE DISCUSSION

Forecasting for public services

The Meteorological Office discussion held at the Royal Society of Arts on Monday, 21 December 1959 on "Forecasting for public services" was, as pointed out by the Director-General in introducing the opening speakers, somewhat less technical than most such gatherings but nevertheless it produced a lively debate.

Mr. N. B. Marshall, the first speaker, pointed out that most forecasting, and indeed other activities of the Office, had for many years been directed towards the service of aviation and that, in this field, a high level of accuracy and precision had been attained, while close liaison with "customers", Royal Air Force officers, airline captains, controllers, etc., had been kept through the use of a common meteorological language. Since pilots and operations officers had, before being licensed, been trained and examined by Meteorological Office staff there was a mutual understanding which made communication with them much easier than might be expected. In our dealings with public utilities, industry, the Press, broadcasting producers and others, however, we have often found, through our inability to talk the same way, a lack of understanding on both sides. Nevertheless, the need for accurate advice on weather and climate was apparent and there was little doubt that whenever meteorologists had taken the trouble to learn something of the problems of the customer the effort had been amply repaid.

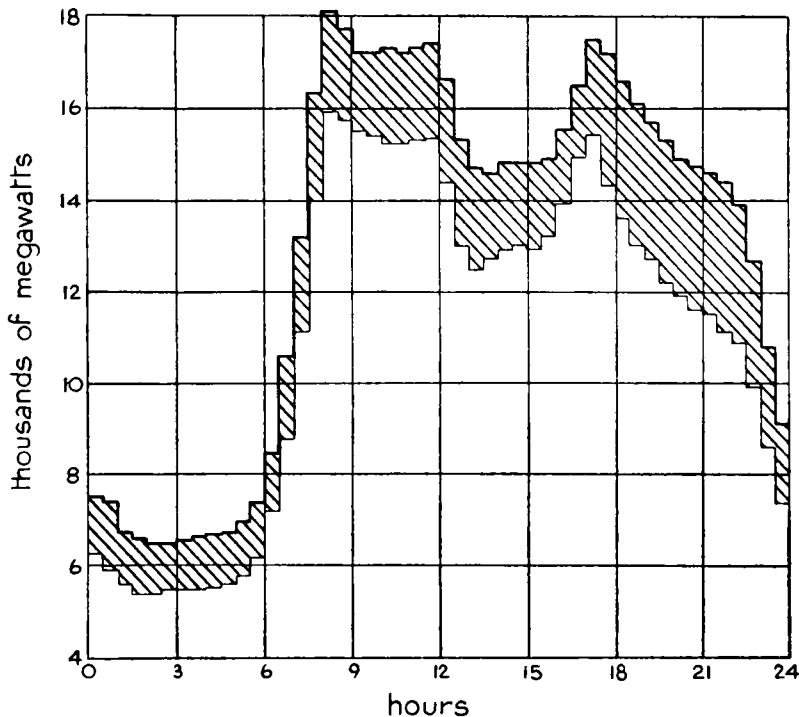


FIGURE 1—DAILY CURVES OF NATIONAL ELECTRICITY LOAD

The thin and thick lines refer to 26 January and 2 February 1956 respectively.

				Time (hours)		
				0830	1200	1730
				Average temperature (°F)		
Thursday, 26 January 1956	...	...	...	36	39	42
Thursday, 2 February 1956	...	...	...	22	24	20

By courtesy of the Central Electricity Generating Board

The opener then mentioned the case of a constructional engineer who had, over a three-week period of possible night frosts earlier in the year, obtained from the London Forecasting Office each afternoon, free of charge, an assurance that the temperature would not fall below 32°F, thereby saving £300 worth of de-icing chemical a night. This engineer, however, really wanted forecasts of the weather a week ahead all over the country and had estimated that with an accuracy little better than chance his organization could save £2 millions a year by suitable deployment of its considerable labour force.

Mr. Marshall then dealt, in some detail, with the weather problems of three major users of Meteorological Office services, talking first on the Central Electricity Generating Board. After a brief mention of the organization of that authority the speaker went on to show, with the aid of slides, the effects of weather on electricity demand. He quoted two Thursdays early in 1956: 26 January was cloudy with a moderate south-westerly wind and 2 February cold under the influence of an anticyclone; the mean difference in temperature over the country being of the order of 14°F and the difference in load approximately 2,000 megawatts. Ignoring other parameters it might be inferred that 1°F over England and Wales is equivalent to 140 megawatts, roughly the output of two smaller power stations.

Attention was called to the peak hours of 0900 (the maximum), 1200 and 1800 and to the fact that the evening peak could be as late as 2100 in the

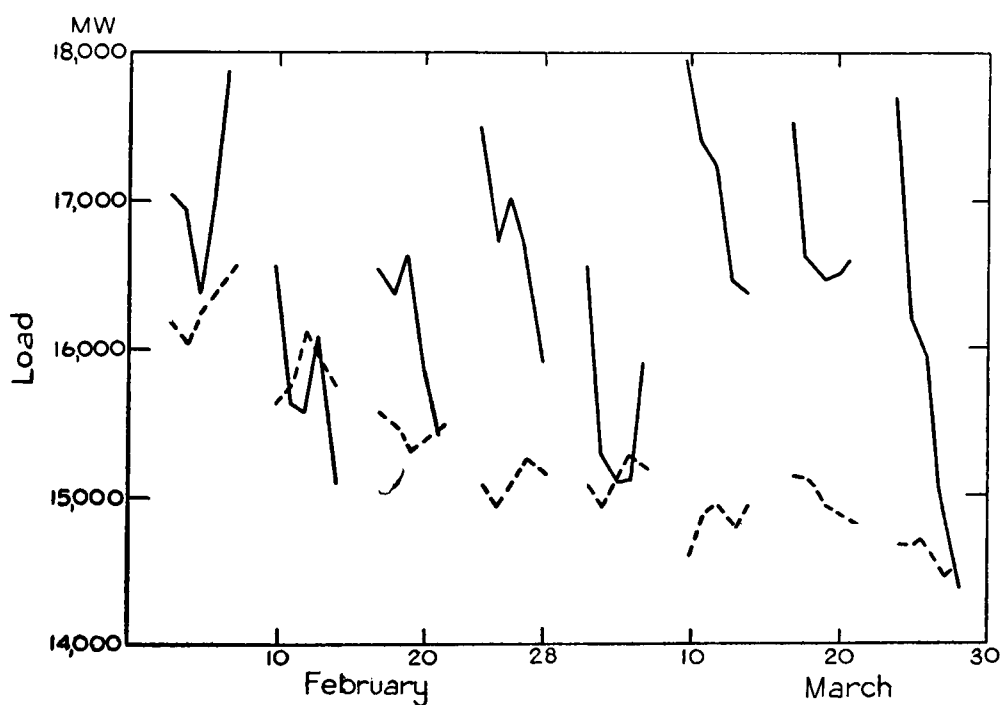


FIGURE 2—PEAK ELECTRICITY DEMANDS FOR 0900 HOURS, FEBRUARY–MARCH 1958, ON WEEKDAYS

— actual demands --- loads adjusted to normal weather
By courtesy of the Central Electricity Generating Board

summer. Next was shown a curve illustrating the 0900-hour loads on working days during February and March 1958, together with a derived curve showing the theoretical load, had no weather factor been included.

After explaining the variations in the basic equation which Dr. Davies, late of C.E.G.B., had used to produce working tables, Mr. Marshall then dealt with the relative effects of cloud cover, visibility, precipitation and wind and pointed out that these could have even more effect on demand than temperature (to which public reaction seemed to be nearly a day (22 hours) in arrears). Mention was made, however, of the extreme sensitivity of the public on spring and autumn evenings to temperatures about 57°F.

At the request of C.E.G.B. the opener then referred to the dual effect of thunderstorms on electricity control. The greater vulnerability to lightning strikes of the 275,000-volt cables was mentioned and also the economic factor in taking these particular high tension links, even temporarily, out of service. At one time the increased cost of producing electricity in the south instead of importing it from the Midlands or north of England worked out at approximately £200 an hour and even this year the cost of taking out a cable at Bolton was as high as £109 an hour. It was essential therefore that forecasters should not hesitate to cancel a thunderstorm warning as soon as it was reasonably safe to do so. The embarrassing sudden increase in demand was then demonstrated in the case of dark cumulonimbus clouds spreading over London during a

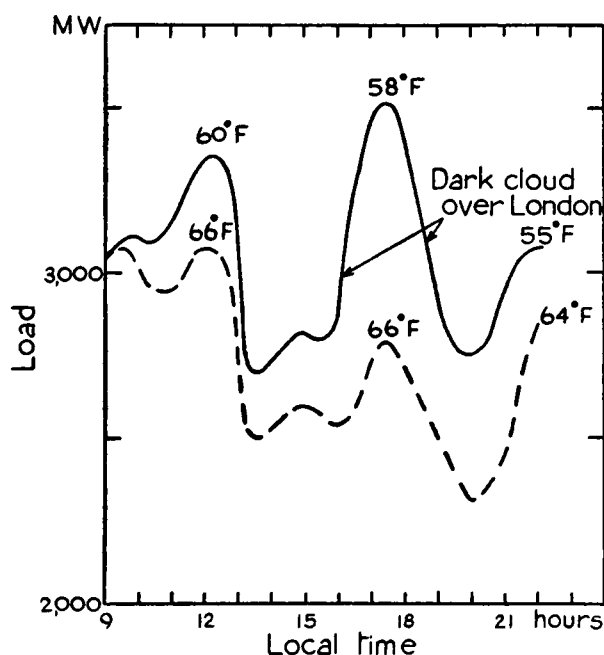


FIGURE 3—ELECTRICITY LOAD FOR THE LONDON AREA, 16–17 JULY 1958

— 16 July 1958 --- 17 July 1958
By courtesy of the Central Electricity Generating Board

summer afternoon in 1958. Whereas the “temperature” effect for a 6°F difference amounted to about 200 megawatts (7 per cent of the total), that solely due to the sudden diminution of daylight illumination was probably of the order of 500 megawatts (equal to the output of one of the largest atomic energy power stations). The seriousness of this was increased by the fact that the incidence of a high lightning risk precluded the import of power from outside the London area.

Turning next to the gas industry, Mr. Marshall quoted from the speech of the Chairman of the Gas Council, Sir Harold Smith, to the Institution of Gas Engineers in November in which he stated that "we are now too dependent on the weather. A month or two of fine weather upsets our balance sheet and we must not allow that to continue." He went on to explain that whereas at one time the major part of the peak load of gas could have been taken from storage in gas-holders, improved methods of control, made possible by use of accurate routine weather forecasts, made it feasible to operate with only about 40 per cent of the peak load in holders. The difference in potential storage space represented a saving, in steel alone, of quite staggering amounts of capital outlay.

Various curves were then shown, demonstrating the variations in load during the day, the week and throughout a winter month. Gas, being less used for lighting than for heating, was more in demand at midday though, as with electricity, there was the lag in response to temperature changes of almost a day. The curious anomaly that the Bracknell district showed a marked increase in demand on Friday evenings was noted with some amusement by those in the audience affected by the approaching move of Headquarters Branches. Temperature-consumption diagrams were then discussed and the idea of an "effective temperature", the mean of a "forecast" and the "seasonal" temperature, developed.

It was pointed out that although the North Thames Gas Board (one of the largest in the world) made no allowance for any weather factor apart from temperature, in other, more rural, areas the effect of wind was significant, the Eastern Board reckoning an increase of one in the Beaufort scale to be the equivalent of 1°F in the case of north-easterlies.

Mention was made of the various methods of gas manufacture, of the relative cheapness but lack of control of vertical retorts used for producing the basic supply of gas and of the corresponding expense coupled with ease of management of horizontal retorts. It was the latter type which were used for the "weather" component of the load. The accuracy of temperature estimates was therefore of considerable economic importance to the industry.

The opener then presented some maps and diagrams prepared by Mr. Richards, the Chief Physicist of the London Transport Executive, in connexion with an investigation into RAILICE problems. Night minimum temperatures were taken during the 1958-59 winter at 40 exposed stations on the London Underground system and a surprisingly wide spread of temperatures was disclosed. Never was the range less than 6°F on any one night, deviations of $12-15^{\circ}\text{F}$ were common and on one occasion there was a difference of as much as 21°F between the extreme minima. The conclusions from the results showed, *inter alia*, that the late Dr. Farquharson had advised well in recommending Queensbury as an "average" station but that Wembley Central might be even better, and that certain stations were notably "cold" and others relatively "warm". As a result of these, the London Transport Executive had, as an economy move, decided to withhold de-icing precautions on lines through "warm" stations whenever only a "small" risk was forecast by Dunstable. It was emphasized that, apart from the cost of de-icing fluid and of its application to conductor rails, the interference with routine maintenance work whenever an icing risk was forecast was a serious item in "Underground" operations. A plea was made for geographical precision at almost a "micro" level in all RAILICE warnings.

Mr. Marshall concluded by mentioning that he had purposely dealt only with these chargeable services and that following speakers would discuss the supply of free meteorological information to the public at large.

Mr. D. Hamilton, the second opener, dealt specifically with public services hitherto provided by the aviation meteorological office at Renfrew Airport. Pointing out that a 25-mile circle included many points of scenic and historic interest he emphasized the fact that only a small proportion of weather inquiries were concerned with Glasgow itself.

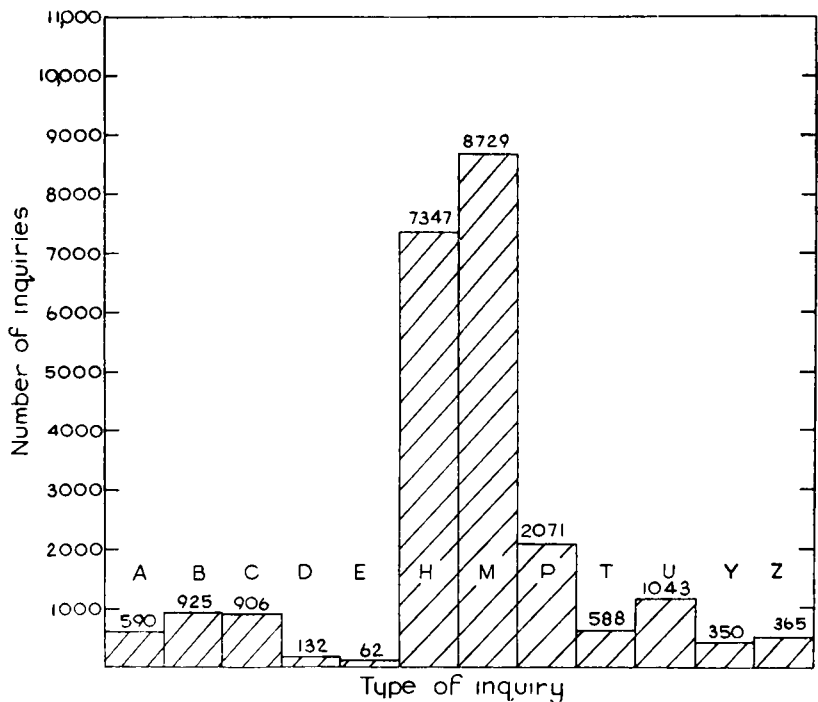


FIGURE 4— **Types of Inquiry at Speke, November 1957–October 1958.**

- A, agriculture, farming, market gardening.
- B, building and maintenance of outdoor installations.
- C, commercial, industrial or manufacturing activities.
- D, displays in the open including public functions such as fêtes and sporting events which constitute public spectacles.
- E, educational (for example, to assist in writing essays) or scientific.
- H, holidays, hobbies, picnics and personal sport excluding yachting and sailing.
- M, marine, including shipping, yachting and sailing.
- P, press or other information centres.
- T, transport by road.
- U, utilities, such as gas companies, electricity authorities, public corporations, railways.
- Y, miscellaneous, purpose known.
- Z, purpose not known.

He then went on to analyse in detail the histograms of public service telephone calls during the twelve months from November 1957–October 1958 which showed that most inquiries emanated from holidaymakers of various kinds. Marine inquiries totalled only 2,249, a relatively unimportant fraction of the whole. The speaker put this down to the comparatively sheltered nature of the Clyde and contrasted it with the Mersey from which, over the same period, 8,729 inquiries were received by Speke.

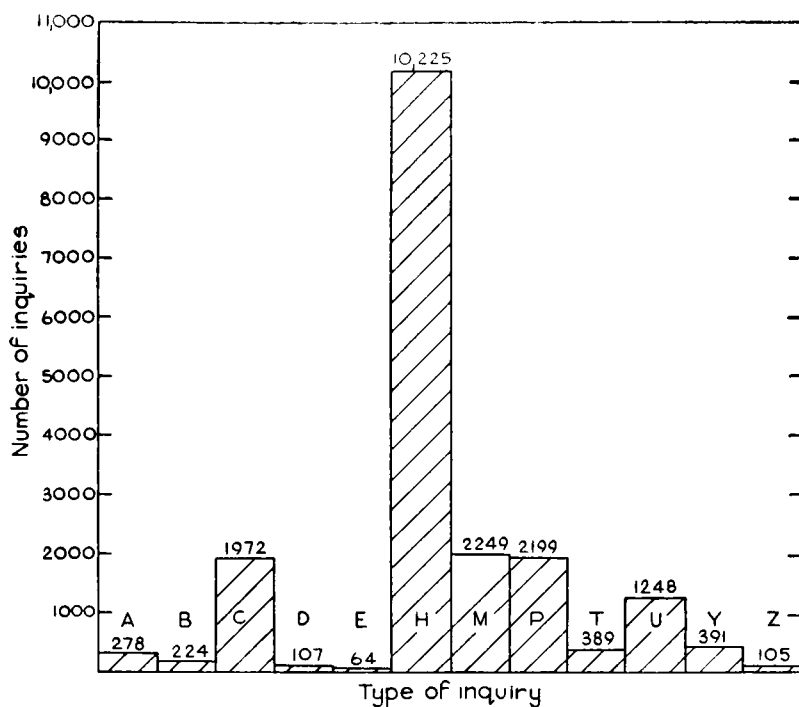


FIGURE 5— **Types of inquiry at Renfrew, November 1957–October 1958.**

Referring again to the Renfrew chart, Mr. Hamilton commented on the relatively few agricultural and building inquiries during the year under examination and suggested that the winter 1958–59 with its persistent fog and frost would have told a different tale. Road transport inquiries were similarly affected. He thought that those making commercial, industrial or manufacturing inquiries knew exactly what they wanted and appreciated the forecasting problems involved.

Mr. Hamilton went on to tell of the happy relationship of Renfrew with the Glasgow Press and how there had been a steady improvement in punctiliousness in reporting weather information.

TABLE I—MONTHLY FIGURES OF INQUIRIES AT RENFREW

	Type of inquiry									
	A	B	C	D	E	H	M	P	T	U
	number									
1957										
November	0	4	91	2	4	207	101	114	3	25
December	4	30	127	2	1	281	154	169	56	64
1958										
January	7	57	176	3	5	365	191	307	105	74
February	4	43	162	1	4	314	124	147	58	80
March	4	41	276	4	9	346	195	200	43	144
April	4	10	259	4	7	483	145	219	20	127
May	19	9	240	8	5	1028	238	176	14	123
June	16	10	166	66	5	1325	285	160	26	117
July	128	4	133	7	11	2009	210	297	27	119
August	48	5	97	4	10	2249	210	151	22	153
September	39	4	119	2	2	1238	235	169	13	109
October	5	7	126	4	1	380	161	90	2	113

Some interesting conclusions followed from a study of monthly figures (see Table I) with an expected maximum for agriculture in July, for building in

the winter months and peaks in July and August which cover the Glasgow and Paisley "fairs". That catastrophic weather makes good headlines is borne out by January figures for press inquiries.

A study of the figures for the Glasgow Automatic Telephone Weather Service showed that, after the initial surge of spring 1957, the frequencies of calls generally agree with those made by telephone to Renfrew. The different peak month of June corresponded with the incidence of a large number of out-of-door functions in the city and its immediate environs, these activities taking place before the holiday exodus further afield which would provoke more specialized questions.

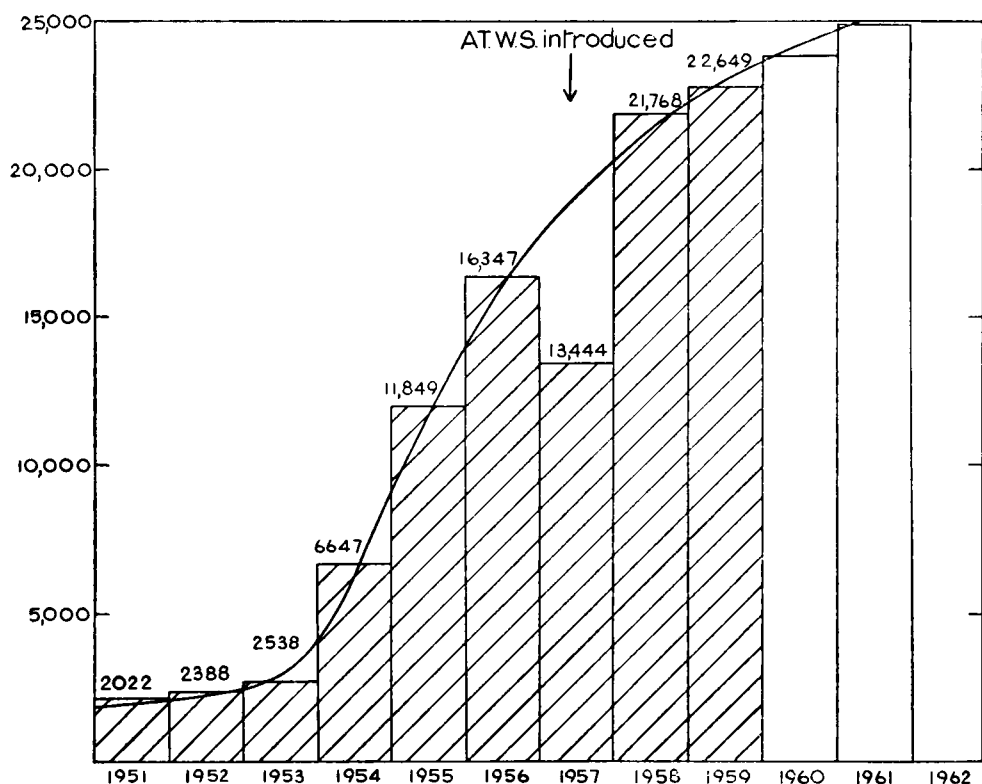


FIGURE 6—ANNUAL TOTALS OF TELEPHONE CALLS TO RENFREW

Mr. Hamilton then discussed the importance of accurate forecasting to the British Aluminium Company and to a sheep-farmer having to move his flocks by boat. He concluded by showing a slide (Figure 6) illustrating the growth in the number of public inquiries and urged that although the problems involved might seem faint and far off compared with the nearer and noisier demands of aviation, they must be dealt with carefully and considerately. Accuracy is important but not always attainable. Courtesy should always be available.

Mr. Sharp dealt with our services in Wales in a general way so that the various types of service could be discussed with a view to their improvement or development. He stressed the need to make a close study of the public so that the most effective service could be provided. He showed that the concentration of population in Glamorgan and Monmouth was so great that it would be most appropriate to have a service to Wales centred in Cardiff. This would

serve the million and a half people of these two counties almost directly and the further million people in Wales rather more remotely.

He then briefly referred to the synoptic network and suggested that the four auxiliary inland reporting stations covering the 8,000 square miles of Wales were not adequate for the type of development he envisaged.

Mr. Sharp then showed a table classifying meteorological services into three types: macro, meso and micro. A macro service dealt with a large percentage of the population daily; a meso service was a service on a much smaller scale than this, catering daily for less than one per cent of the population. It could never be developed into a macro service but it was too large to be handled by micro facilities. The micro service was a service to individuals, either because they telephoned us or we telephoned them on an organized basis. Despite its small numbers it could be important.

Table II shows these services with the number of people using them daily in Wales. The percentages are of the adult population of Wales, except for the Cardiff Automatic Telephone Weather Service (A.T.W.S.), where the percentage is that of the adults of Cardiff and District.

TABLE II—SERVICES TO THE PUBLIC WITH THE NUMBER OF PEOPLE USING THEM EACH DAY

MACRO SERVICES							<i>number</i>	<i>percentage</i>
Morning newspapers							2,000,000	100
Radio	{	8 a.m.	...	...	...	...	220,000	11
		1 p.m.	...	...	...	...	160,000	8
		6 p.m.	...	...	...	...	60,000	3
Television	{	B.B.C.	6 p.m.	...	...	...	200,000	10
		Commercial	6 p.m.	...	...	...	200,000	10
MESO SERVICES								
Cardiff A.T.W.S.							400-800	0·2
On exceptional days							1,500	0·5
MICRO SERVICES								
Rhoose 343, Cardiff Airport (restricted hours)							2-12	
Gas boards								
Warnings services: collieries; railways; councils and some private firms.								

Mr. Sharp then went on to say that it would be appropriate to discuss each of these services with a view to improvement either in accuracy or presentation and also to consider their development. Instead of doing this he would make three suggestions, one for improving the accuracy, one for improving the presentation of a certain service and one as a contribution to development. Accuracy was a very elusive quality and very difficult to improve. He would like to suggest that two senior forecasters should be continuously on duty at Dunstable and that the continuous interchange of ideas resulting would lead to perhaps a ten per cent increase in the accuracy of forecasts.

He then dealt with the presentation in newspapers which were our most powerful means of communication. Some newspapers provided an excellent service, printing exactly what we gave them. Others compressed two or three hundred words into two or three. These papers were giving no service to their readers and did us a great disservice. They should be pressed to do better. A third type of paper spent much time, effort and space in producing a visual presentation fitting our forecasts, as supplied, to a forecast chart also supplied by us. Their efforts varied but as one paper fitted the 3 p.m. forecast, another the 9 p.m. forecast to the same forecast chart the results could be ludicrous.

One day an enterprising newspaper might try to fit our third midnight forecast once again to the same forecast chart. Mr. Sharp thought that if a visual presentation was required it would be best for the Meteorological Office to produce it.

Finally Mr. Sharp suggested that the best service to develop was the Automatic Telephone Weather Service, and to have such a service in every town. The area of the forecast would be restricted to perhaps 5 to 10 miles' radius and the period also restricted to perhaps 15 hours. It would be a great mistake to develop this service as a young brother to the newspapers or radio. It had its own particular qualities and we should strive for accuracy and simplicity by the restrictions suggested. This Mr. Sharp thought was what the public wanted.

He concluded by saying that the service should be provided free to the General Post Office, that they should take their profit and be very welcome to it, but that in exchange we should have the service developed along the lines we wanted.

Mr. T. L. Hunt, speaking from the floor, referred to the pioneer work of the West German Meteorological Service in attaching staff to fishing fleets in order to provide up-to-date information to mariners. He also asked for many more synoptic observations. He pointed out in particular their absence from east Lancashire and the West Riding of Yorkshire, much of which areas are thickly populated to considerable heights. Quite severe weather could exist there unreported and thus unconsidered.

The phrase "snow on high ground" was not precise enough as a forecast for these areas where it could mean snow affecting only the hill farmers or, on the other hand, hundreds of thousands of people. He asked for closer collaboration with the police and the Automobile Association whose weather reporting facilities could fill large blanks in our network.

Mr. G. J. Jefferson called attention to the fact that in the 5.55 p.m. B.B.C. broadcasts the part of the forecast most needed by the listeners, that is, that for the following day, was likely, necessarily, to be the least reliable, a weakness not shared by those transmitted at 6.55 a.m., 7.55 a.m. and at 12.55 p.m. He suggested that perhaps the extended use of the word "outlook" might create the right impression.

Mr. J. H. Brazell mentioned the up-to-date visibility information received at the London Forecasting Office from the Automobile Association and stressed its value. He thought that the Office should move in the direction of greater regionalization.

Mr. N. Bradbury asked whether telephone subscribers were satisfied with the format and accuracy of the forecasts available on the A.T.W.S., while *Mr. S. P. Peters* wished to know whether the G.P.O. continued to discourage frequent changes of forecasts. Mr. Marshall replied that in the absence of criticism and in view of the continued and growing popularity of the A.T.W.S. no steps had been taken to obtain consumer reaction from the public. The G.P.O. were, within their own staff limitations, most co-operative in making the A.T.W.S. an up-to-the-minute service.

Replying to *Mr. T. L. Hunt*, *Mr. R. K. Pilsbury* pointed out that the working group of the synoptic network was always open to accept suggestions for extra

observations whenever a demand was made, but that teleprinter schedules were already saturated.

Mr. H. H. Lamb thought that there were many potential clients whose lives or livelihoods were peculiarly vulnerable to weather conditions and who would, rather than wait for the perhaps unlikely time when three-day to seven-day forecasts became available, prefer to hear a discussion of the existing *Gross-wetterlage* and its most likely alternative lines of development over the coming days.

Commander C. E. N. Frankcom related how a Swansea shipowner had indicated his gratification at the meteorological information received by telephone and suggested that the scheme by which prebaratic maps and forecasts on properly prepared forms were issued by the London Forecasting Office to all captains leaving London River might be extended to other ports, especially if a weather centre were reasonably near. He also wondered whether shipowners would be prepared to install facsimile equipment for the reception of charts by wireless telegraphy.

Mr. C. J. Boyden, replying to *Mr. G. J. Jefferson*, stated that the audience for the 5.55 p.m. B.B.C. sound broadcast was relatively small and that therefore the Office rather concentrated on the television presentation at 6.07 p.m., when the right degree of confidence could be given by the weatherman. He did not think that *Mr. Sharp's* suggestion for two senior forecasters to be on duty at the Central Forecasting Office very practicable. He went on to point out that, at a recent meeting with the Press at which the supply of meteorological information was discussed generally, a plea was made that forecasts should be published as issued. There seemed little hope, however, of any change in the method of presentation by those newspapers favouring a highly condensed forecast. He also deprecated the use by the B.B.C. of "tabloid" forecasts in their news bulletins.

Dr. D. G. James complained that on many occasions forecasts occupied less than half of the available broadcast time on B.B.C. sound.

Mr. A. G. Matthewman wondered whether one of the two senior forecasters asked for by *Mr. Sharp* might not profitably provide a day-to-day quasi-statistical aid to his partners' more synoptic approach to the forecast problem.

Sir Graham Sutton thanked the various speakers for an enjoyable discussion and referred to attempts to obtain more broadcasting time from the B.B.C. and of prolonged efforts to regain Airmet. Technical difficulties seemed to be almost insurmountable. He thought that successful long-range forecasting, on which our work so far had been an act of faith, would be of immense value to the public. The real solution to this difficult problem lies in a fuller understanding of the general circulation.

Nevertheless, in spite of disappointments, the Meteorological Office is making a valuable contribution to the welfare of our country and we should be proud of it.

Communicated since the discussion

Mr. Boyden, referring to *Dr. James's* remarks, says that "The facts are not as given. The allotted time for the main land-area forecasts on B.B.C. sound radio is four minutes (not five, as is often supposed), and this allows for a broadcast of 480 words. It is rare for the number to be substantially below this. A broadcast may finish early because it is read too fast or, at 1255 or 1755 hours, because one regional forecast is inevitably shorter than another."

LETTERS TO THE EDITOR

The maximum temperature of cumulonimbus tops associated with thunderstorms

I have read with interest the report of the discussion meeting on hail.¹

Had I been able to attend the meeting, I would have expressed my doubt whether it is still justified to suggest that a storm with echo tops at the -30°C level was only marginally giving thunder because the warmest temperature at cloud tops associated with thunder, so far reported, was close to -30°C . From thunderstorm studies in the Netherlands an increasing amount of evidence is becoming available, which suggests that thunder and lightning may occur in clouds, the growth of which is arrested by inversions or thick stable layers where the temperatures are well above even -20°C .

In the period 1952 to 1955 inclusive there were 25 cases of thunder and lightning observed during periods in which inversions or thick stable layers, often accompanied by a considerable wind-shear, inhibited the growth of cumuliform clouds above levels where the temperature was above -20°C . In five cases these levels were likely to lie between the isotherms of -10°C and -16°C . It is hoped to publish this material in due course.

Apart from this suggestive evidence, direct observational evidence of thunder and lightning from a cumulonimbus only 10,000 feet thick and with a temperature of -16°C at its top, was obtained recently.

On 5 November 1959 at 1500 G.M.T. an aircraft flying over the Rotterdam area reported cumulonimbus with tops at 12,000 feet (-16°C). Thunder was reported shortly before 1500 G.M.T. at the airfield, Zestienhoven near Rotterdam. This observation was confirmed by a volunteer thunderstorm observer in Rotterdam. Close thunder and lightning was also reported shortly after 1500 G.M.T. by observers 10 and 20 kilometres to the south-south-west of Rotterdam. The highest cumulonimbus tops reported on this day were at 12,000 feet. There were no reports of higher clouds.

The cumulonimbus clouds developed in a maritime polar airstream behind a small depression, which moved over the Netherlands during the early morning. The convective condensation level, computed from representative surface observations was at 2200 feet (940 millibars, temperature 3.5°C). Aircraft reported the cloud base at 2000 feet.

It seems to me that the occurrence of lightning and thunder in cumulonimbus clouds is related to the vertical distribution of updraught velocity, and to the distribution of liquid and solid precipitation in the cloud, rather than to the cloud-top temperature or depth of the cloud above the 0°C level.

De Bilt, January 1960

P. J. FETERIS

Reply by R. F. Jones

In the paper Mr. Harper referred to in his report of the discussion,² I showed that the temperature at the top of most thunderstorm clouds was probably below about -30°C and, with more certainty, that if the radar echo-top temperature was below -40°C the echo would be from a thunderstorm. I did, however, draw particular attention to a thunderstorm occasion when the cloud-top temperature was certainly no lower than -14°C . The last sentence

of my paper read "Infrequently, large numbers of ice crystals may exist at higher temperatures than -40°F —as the remains, for example, of previous frontal activity—and the introduction of supercooled raindrops into such a volume may explain the exceptional thunderstorms with a relatively high echo-top temperature and relatively low echo intensity." I look upon the cloud-top temperature in thunderstorm clouds as being important only as an indicator of the probability of there being large numbers of ice crystals there. I still think there may be some truth in the sentence quoted and it is not at all at variance with Mr. Feteris's beliefs or, I think, with his interesting observations.

REFERENCES

1. London, Meteorological Office; Meteorological Office discussion—Hail. *Met. Mag.*, London **88**, 1959, p. 178
2. JONES, R. F.; The temperatures at the tops of radar echoes associated with various cloud systems. *Quart. J. R. met. Soc.*, London, **76**, 1950, p. 312.

Wet-bulb higher than dry-bulb temperature

Mr. S. M. Ross's letter to the Editor of the *Meteorological Magazine* published in the November 1959 issue, prompts me to put on record what appears to be a good example of a wet-bulb reading a degree higher than the dry-bulb reading. This occurred at Achnagoichan, Strathspey, Inverness-shire (1000 feet O.D.), at 0900 G.M.T. on 14 January 1960. As in the case of Mr. Gold's observations, referred to in the editorial comment on Mr. Ross's letter, the temperature was not much below freezing point, the readings being: dry bulb 28.9°F ; wet bulb 29.9°F . The readings were carefully checked by the observer, Mr. A. MacDonald, and the hygrograph pen in the same screen was at its highest position on the chart (that is, apparently reading 100 per cent) for a short period. There had been, on the previous two days, slight falls of snow. At the time of observation it was still lying, and there was a patchy cold mist at levels below about 1500 feet O.D.

F. H. W. GREEN

The Nature Conservancy, Speyside Research Station, Achantoul, Aviemore, Inverness-shire

[The area was at the time in a north-easterly airstream between a wedge of high pressure extending from Greenland to central Norway and depressions over France and Germany.

Dr. J. Pepper points out that this phenomenon occurs frequently at the Antarctic bases of the Falkland Islands Dependencies Survey. In August 1950 at Argentine Islands the ice bulb was at a higher temperature than the dry bulb at 1200 G.M.T. on 17 occasions out of 31 and the means of dry-bulb and ice-bulb temperature for the month were 1.5°F and 1.6°F respectively.¹

In some copies of the *Meteorological Magazine* for November 1959 the suffix *i* is missing from one of the two *Eis* in the formula in the note on this subject on page 315.

REFERENCE

1. PEPPER, J.; Meteorology of the Falkland Islands and Dependencies, 1944–1950. London, 1954, p. 65.

Ed. M.M.]

NOTES AND NEWS

Funnel cloud at Chester, 28 July 1959

A well developed habit of looking up to the sky whenever I open the door to the garden rewarded me well on 28 July 1959. About half a mile away was a developing funnel cloud, and with a camera that has been loaded for nearly twelve years for just such an occasion, I managed to get the accompanying photographs.

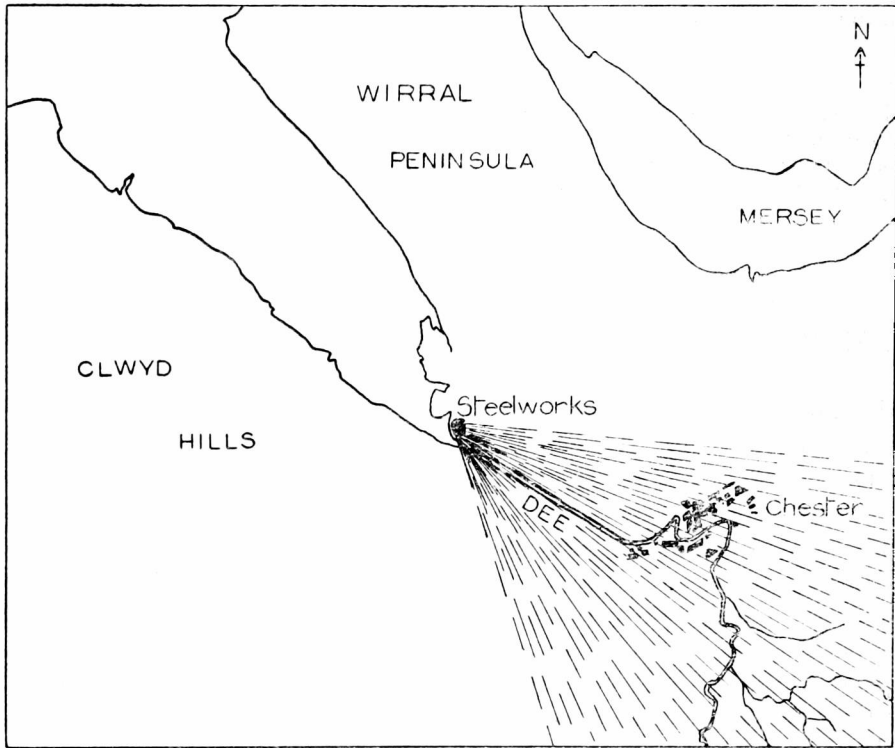


FIGURE I—MAP SHOWING CHESTER AND THE DEE ESTUARY

The shaded area is the zone of new cumulonimbus development.

The funnel was first seen at 1140 G.M.T. hanging from the north-westerly edge of a developing cumulus cloud that was moving to the east over Chester from the Dee estuary area. Initially it was thin and tenuous but by 1145 G.M.T. (Plate II) it had thickened and extended downwards. The view shown in Plate III, however, was the most interesting as the funnel was then very close and betrayed some odd antics. Its smooth column, every few seconds, threw out fringes of tiny cloudlets at high speed and then drew them in again. A part of this fringe was visible in the original photograph and may be detectable about the centre of the column in Plate III.

By 1150 G.M.T. the fringe development ceased to be drawn in and the whole column became ragged and shorter. It continued to send out, however, very thin finger-like miniature funnel clouds periodically from the shrinking tip, and it was still obviously rotating, though very much slower, as the fragmented edges could be seen circling the stumpy column (Plate IV). About 1155 G.M.T. a very rapid collapse took place, the upper part near the parent cloud dissolving away and the remaining tongue becoming a fragment. Although I was not able



Photograph by M. H. O. Hoddinott

PLATE I



Photograph by M. H. O. Hoddinott

PLATE II

FUNNEL CLOUD AT CHESTER, 28 JULY 1959



Photograph by M. H. O. Hoddinott

PLATE III



Photograph by M. H. O. Hoddinott

PLATE IV

FUNNEL CLOUD AT CHESTER, 28 JULY 1959

to see the lowest end at maximum development, another witness confirmed that the tip did not reach to the ground at any time.

There are two points about this very ordinary funnel cloud that I feel may be worth mentioning as they link up with other development observed previously in the same area.

Although I have lived in the same house for thirty years and "sky-watched" for nearly twenty years, 1958 and 1959 are the first times that I have seen funnel clouds. This fact in itself may be a coincidence but it is very significant that since 1955 this area about the Dee estuary has been the source of considerable convectional energy since a local steelworks started up two large new coke-quenching plants. Under suitable conditions of instability it is now possible to trace back the "new" cumulonimbus and cumulus development to the leeward of these works. Furthermore, the relative "smallness" of the parent cloud (it was only worth calling a large cumulus) and the complete absence of any subsequent precipitation or thunder compared with other showers in the area, seems to suggest to me that this funnel was the by-product of a small but intense convection current. Although I have not yet obtained any data to confirm this fact I feel confident in expecting the locally renowned "dry zone" to the lee of the Welsh Hills to disappear due to a man-made change in climate.

M. H. O. HODDINOTT

OBITUARY

Mr. Edward Theodore Young-Evans.—It is with deep regret that we learn of the death on 27 February of Mr. E. T. Young-Evans, Senior Scientific Assistant, at the age of 57.

He joined the Office as an Observer in 1935 and his earlier years were spent at Shoeburyness and Larkhill; tours of duty at Gibraltar and in Egypt followed. After short spells in Headquarters at Dunstable and Harrow, he was engaged upon administrative duties at H.Q. Transport Command, Upavon for 10 years; at the time of his death he was serving at Porton.

"Y-E", as he was affectionately and universally known, was the most helpful of colleagues and the friendliest of men, ever ready to give a practical helping hand or wise advice, such advice was often emphasized from his unending fund of stories, always amusing and never ironic. His latter years had been marred by ill-health, but he bore his afflictions with courage and optimism to the end. He died, as he would have wished, in harness.

He is survived by a widow, and two sons, to whom the sympathy of all who knew him is extended.

HONOUR

Professor H. Amorim Ferreira, Director of the National Meteorological Service of Portugal, has been appointed by Her Majesty the Queen a Commander of the Order of the British Empire for services over many years on behalf of the British-Portuguese connexion.

Professor Ferreira is well known among meteorologists for his scientific work and his long experience in international collaboration. He was for many years a member of the Executive Committee of the World Meteorological Organization, and also Vice-President of the Organization.

We extend our hearty congratulations also to Professor Ferreira on his election as President of the Section for Sciences of the Academy of Sciences of Lisbon.

METEOROLOGICAL OFFICE NEWS

Retirement.—The Director-General records his appreciation of the service of:

Mr. H. E. Forster, M.B.E., Senior Experimental Officer, who retired on 19 February 1960. He joined the Office as a Technical Assistant in April 1920 after service during the First World War in the Royal Air Force Meteorological Service. Apart from a period from 1925 to 1929 in the Instrument Division at Headquarters, his service has been spent at aviation outstations including tours of duty in Gibraltar and Germany. From 1951 until his retirement he served at Uxbridge. He was appointed a Member of the Most Excellent Order of the British Empire (Military Division) in 1943 and was mentioned in despatches in 1945.

REVIEW

The great tide. The story of the 1953 flood disaster in Essex. By Hilda Grieve. 10 in. \times 7½ in., pp. 883, *illus.* The County Council of Essex, County Hall, Chelmsford, 1959. Price: 30s.

A letter from the Lord Mayor of London in *The Times* of 4 February 1953 began with the words "I doubt if in the past century so much devastation and misery has ever fallen on our country in 48 hours in peace-time as that which has taken place during the past weekend". It was in this way that he introduced his appeal for victims of the floods of the night of 31 January, when many hundreds of people in eastern England and the Low Countries lost their lives. When one reads a full account of that catastrophe and the race to renew the barricades before the peak spring tides, it seems remarkable that the Essex County Council at its meeting on 3 March, less than five weeks after the sea broke through, decided to record in book form the complete story of the disaster to Essex and the steps taken to deal with it. *The great tide*, published six years later, is that story.

The author is described as a senior assistant archivist in the Essex Record Office. Her book is a monumental achievement. It contains nearly 900 pages of information which is mostly factual and impressively detailed, yet one is never far from an atmosphere of drama and tension. Some of the material is inevitably of only local concern, yet there is probably something on every page to interest the general reader.

The battle against the sea has gone on for centuries, and there is good evidence that over the last 2,000 years some of south-eastern England has been lost to the sea. A rise in sea level there may well have begun with the last ice age, and is ascribed partly to a tilting of Great Britain (a rise in Scotland and a sinking in the south) and partly to an increase in the volume of water resulting from the progressive melting of ice. It has been estimated that during the last 100 years the rise of the mean sea level off south-east England has averaged nearly an inch in 10 years. With safety margins of only a few feet this is a far from negligible amount in the planning of defences.

It is surprising to learn that Essex has more than 300 miles of man-made defences. For centuries the cost of their maintenance was borne by those who were in greatest danger from flooding, and there were no substantial government grants until after the Second World War. A make-do-and-mend policy has produced defences which were far from ineffective, but once or twice in a generation Essex has suffered floods of some magnitude, and each was a spur to more concerted effort in establishing adequate countermeasures.

Many of us remember the floods of 6–7 January 1928, though not so much because of widespread damage as because fourteen people were drowned in basement houses in west London. Subsequently an investigation of North Sea surges was undertaken by the Meteorological Office and the Liverpool Observatory and Tidal Institute. This resulted in the institution of a scheme whereby the Meteorological Office issued warnings through New Scotland Yard on the basis of the onset of a strong north-westerly wind, which has the effect of forcing the water southwards and giving it an unbalanced motion to the right of the general flow. Somewhat surprisingly this association between very high tides and wind was reported as far back as 1800 by Graeme Spence, head maritime surveyor to the Admiralty.

It was during Friday, 30 January 1953 (Douglas¹), that a depression moving north-east off Scotland began to turn south-eastwards towards the North Sea. The following morning Scotland experienced the strongest winds ever recorded there. By the time the depression had passed, thousands of acres of forest had suffered severe damage and over a quarter of the fishing fleet was lost. Throughout the weekend the news of these happenings overshadowed the greater tragedy that came to south-eastern England on the Saturday night. People on the Essex coast who noticed that the high tide hardly ebbed at all may have been thinking not of their own danger but of the tragedies such as that of the motor-vessel *Princess Victoria*, lost in the Irish Sea.

Attack by the sea, as by an army, may be violent and unexpected. Survivors of the advance are probably isolated and without means of warning others. Elsewhere the sea creeps in quickly: there was the occupant of a bungalow who thought he was looking out on a wonderful night frost until a floating dustbin banged against the wall. It seems that, for at least 18 hours after the break-through was complete, even the people of Essex had little knowledge of the true extent of the disaster which had taken the lives of 119 of them. The story is one of confusion and uncertainty, which seem inevitable however adequate the warning system, but equally it is a story of initiative and improvisation.

Three months afterwards the Waverley Committee was appointed with wide responsibility both for planning a flood-warning system and for advising on protective measures. Warnings are originated nowadays by Admiralty Hydrographic Officers stationed at the Central Forecasting Office, Dunstable. On the basis of meteorological advice and of reports from tide-gauge stations they issue such information as is necessary to authorities with special responsibilities in the event of flooding of eastern coastal areas of England.

The great tide is published by the Essex County Council at a modest price. The quality of production is outstandingly high.

REFERENCE

1. DOUGLAS, C. K. M.; Gale of 31 January 1953. *Met. Mag., London*, **82**, 1953, p. 97.

C. J. BOYDEN

OFFICIAL PUBLICATIONS

The following publications have recently been issued:

METEOROLOGICAL REPORTS

No. 21—Synoptic evolution of 500-millibar flow patterns. By C. V. Smith, M.A., B.Sc.

The common modes of evolution of some characteristic flow patterns at 500 millibars are examined. The approach is primarily descriptive and the behaviour of troughs and ridges, "blocks" and "jets" is discussed with the aid of sequences of 500-millibar charts. Where possible, criteria are presented to distinguish between the probable alternative evolutions. The relation between 500-millibar and surface synoptic features is treated briefly in an appendix.

No. 22—Aviation meteorology of the West Indies.

This introduction to the weather of the West Indies is intended primarily as practical guidance for pilots and forecasters, but it also suggests some problems for research workers.

The first half of the report deals with techniques used by forecasters in the West Indies and also with the main synoptic phenomena of the area—the intertropical front, easterly waves, hurricanes, cold fronts and shear lines. The second part deals with particular aspects of rainfall, visibility, cloud, wind, pressure, temperature, humidity, sea and swell in relation to the general pattern of West Indian weather.

PROFESSIONAL NOTES

No. 124—The preparation of statistical wind forecasts and an assessment of their accuracy in comparison with forecasts made by synoptic techniques. By C. S. Durst, B.A. and D. H. Johnson, M.Sc.

The principles and practice of forecasting upper winds by linear regression equations are discussed. An account is given of the accuracy achieved by the statistical technique and by the current synoptic method during trials held for the first four months of 1955. The use of the statistical approach in deciding the effect on forecast accuracy of changing the distribution of observing stations is illustrated.