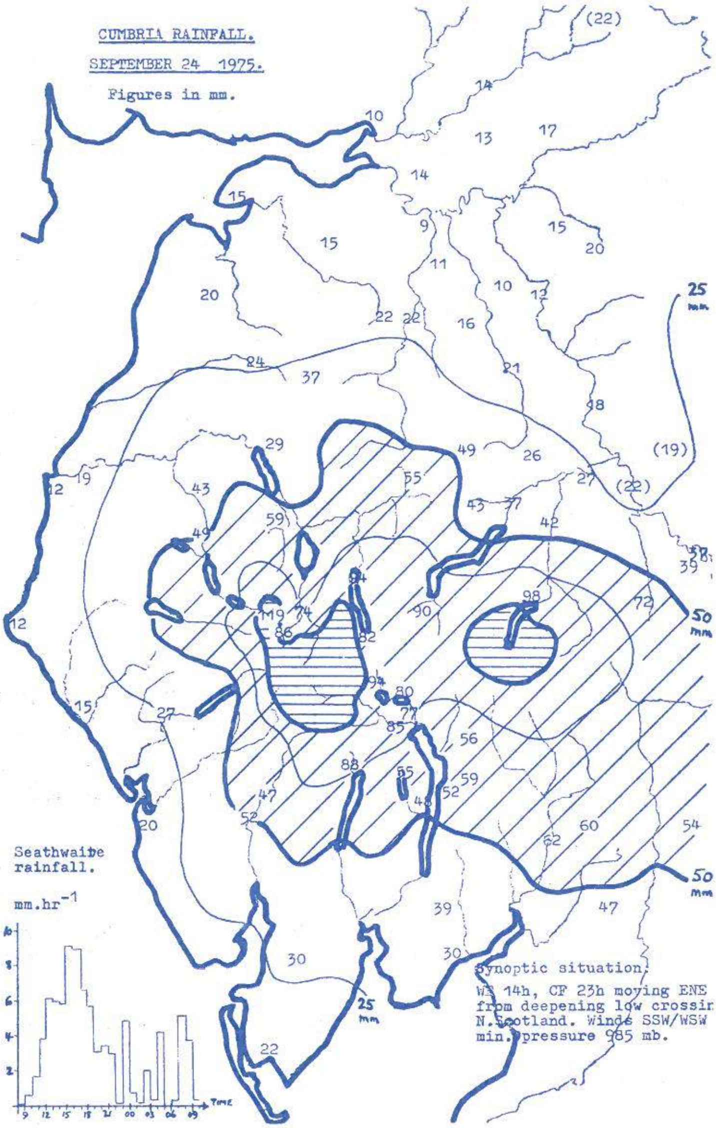
The JOURNAL of METEOROLOGY



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Edited by Dr. G. T. Meaden, Cockhill House, Trowbridge, BA14 9BG, England.

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JOURNAL OF METEOROLOGY

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THE ANTICYCLONIC WINTER OF 1975-76

By A. H. PERRY
Department of Geography, University College Swansea

Long spells of a particular weather type, followed by an abrupt change to an entirely different type which then persists, have been a feature of the circulation in many recent years, and was again notable during the last winter, December 1975–February 1976. The synoptic type near the British Isles was persistently anticyclonic, but the dominant position of the anticyclone varied during the course of the winter. The series of long settled spells which developed may be summarised as follows:

1) From 3 December 1975 until Christmas, pressure was high to the west and south-west. Short, cold, northerly and north-westerly outbreaks were repeatedly terminated by warm air of Atlantic origin which flowed around the northern side of the high behind generally weak frontal systems moving southeast across the country. Mean pressure during December was 20 mb above normal west of Ireland.

2) From late December to 22 January the main anticyclone was to the south of Britain, over Biscay and western Europe. Mean temperatures were 6–7°C and the weather was as mild as in January 1975. On 11 January pressure reached 1045 mb near 45°N 15°W; this was probably the highest January reading in this part of the eastern Atlantic since January 1949 when pressure exceeded 1050 mb near 50°N 30°W.

3) From 23 January to 6 February and again from 15–19 February the main anticyclone lay over Scandinavia and eastern Europe and a very cold E. or S.E. flow affected the British Isles, the Low Countries and France. This spell provided the 'cold filling to the mild sandwich', and gave the coldest weather generally since the cold snap of late-January 1972. Most places had a little snow but amounts were mostly not large.

4) During the last half of February there was a tendency for the high pressure over Europe to become part of an east-west anticyclonic belt extending well into Asia; at the same time the anticyclone forming the western part of this belt took up a more southerly position over France and western Europe. At this time, pressure was unusually high just north of the Black Sea. The British Isles was flooded with mild, maritime tropical air on the northern side of the anticyclonic belt. Maximum temperatures reached 16.6°C at Aberdeen on the 25th, the highest February temperature on record there, and similar high temperatures occurred in the lee of the Pennines near Doncaster.

Not only was the weather remarkably dry, except for parts of the north-west, but most of the precipitation fell on very few days. Thus, in December, 50–70% of the total fell on the 1st at many stations, and in January in southern England, where totals for the month were less than 15 mm in places, some stations had half their month's total on the 4th. The few unsettled intervals were, however, extremely stormy, especially on the 2/3 and 20 January. Much of southern England had less than half the normal winter rainfall, and the winter of 1975–76 has been one of the six driest on record. Dryness combined with mildness is very unusual in winter. This very dry winter follows a dry summer and a dry autumn (despite September 1975 being wetter than normal). These three seasons have only been as dry as this (tercile 1) in 1962–63, 1933–34 and 1904–05. With the exception of September 1975, pressure has been above normal over the British Isles in every month since the spring of 1975, March 1976 included.

Third of a Series

RECORDING HAMPSTEAD'S WEATHER

By R. A. TYSSEN-GEE
Hon. Meteorologist, Hampstead Scientific Society
238 Finchley Road, London N.W.3

Abstract: Weather records have been kept at the observatory in Hampstead under the authority of two observers, Eric L. Hawke from 1910 until June 1965 and myself since then. The observatory station is close to the Whitestone Pond, the highest point in London, 137 metres above sea level. Some earlier records are available taken at various sites nearby.

The Hampstead Scientific Society was founded in 1899 mainly to study astronomy, science in general and natural history and a photographic section soon followed. A site was sought for an observatory to house a 10½ inch reflecting telescope, and, through the persistence of Mr. C. O. Bartrum, who was honorary secretary, the observatory was set up on the Metropolitan Water Board's reservoir in 1906. At the suggestion of Dr. H. R. Mill, a famous meteorologist, the weather station was established by it at the end of 1909. Eric L. Hawke, a schoolboy of 17, was appointed honorary meteorologist, a job he carried out for 55½ years until ill health forced his retirement. The readings have been made by Water Board employees, or Turncocks to give them their official title. At the beginning readings were made twice daily, and Hawke summarised the figures and continued to do this after he had left Hampstead. He first moved to Rickmansworth, where he found the famous frost hollow, and later moved to Dagnall, high on the Chilterns, where he investigated snow, and then moved to Tring where he lived until his death in November 1967. He was extremely keen on the subject and was honorary secretary of the Royal Meteorological Society for 20 years. He seldom took a holiday and was most careful with his observations and summaries. On Hawke's retirement I took over, having had three years in the Meteorological Office during the war including a year in Iceland which gave me useful experience. The readings are now made once daily and in 66 years not many have been missed. Air raids during the war, thefts of thermometers and occasional sickness meant that a few readings had to be estimated with the help of the Meteorological Office at Bracknell.

Another of our well known meteorologists was L. C. W. Bonacina twice vice-president of the Royal Meteorological Society. He contributed many

articles to ***Weather*** and other journals. He estimated the visibility over London for a ten-year period and the results were published in the April 1960 edition of ***Weather*** which I refer to later on. He died in July 1975 aged 94.

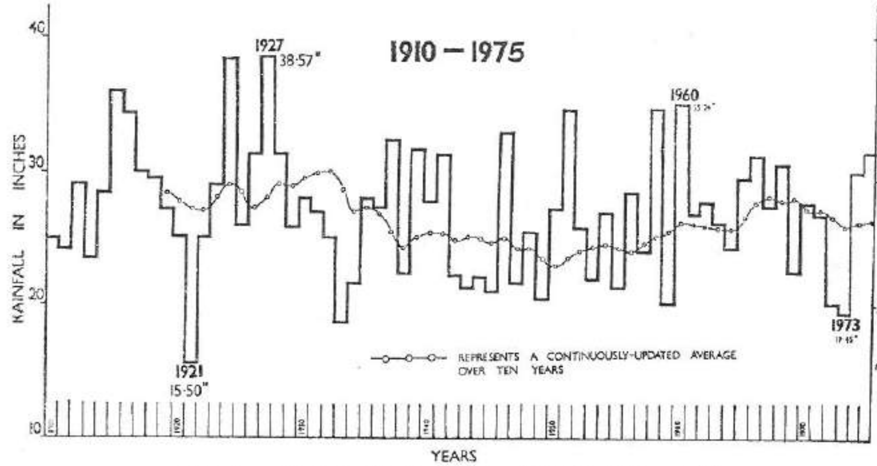

Fig. 1. Hampstead observatory rainfall, 1910—1975.

Some temperature records. With a height of 137 metres above sea level, coupled with the proximity of Hampstead Heath mainly to the north and north-east, Hampstead has a rather cooler climate than most London stations. On average it is about 0.6°C cooler than Kew which is just above sea level. In the early days all readings were made with Fahrenheit thermometers, maxima and minima being rounded up or down to the nearest whole degree. A change to the Celsius scale was made in 1968 since when maxima and minima have been read to the nearest 0.1°C. Early readings have been converted to Celsius to the nearest tenth of a degree but inevitably there may be errors of ± 0.2 to 0.3°C. With a hill-top site the minima are not exceptionally low and no frost has been reported after May 17 and it has occurred only once in September. At Rickmansworth (Herts) it has been recorded at times in every month of the year. Although records started at the present site in 1910, there are a few earlier records from sites nearby. The following figures have been deduced for the period 1900–1911: Greenwich maximum 37.7°C, minimum —11.1: Hampstead maximum 34.5, minimum —10.1.[1]

Since 1910, the highest temperature at Hampstead has been 34.5°C recorded on 9 August 1911 which was probably the hottest day of the present century. The reading was almost as high in 1932. A reading of 90.0°F (32.2°C) is recorded in about one year in five. The lowest maximum in any year was 24.4°C in 1931. The average mean temperature is 9.7°C with extremes of 11.0°C in 1921 and 1949 and 8.3°C in 1917. July 1921 was the hottest month with an average of 19.6°C.

The lowest reading was −12.8°C on 15 February 1929 and the coldest month January 1963 with a mean temperature of -2.5°C. In 1917, described as the year without a spring, cold conditions persisted until April, resulting in a temperature below freezing point all day on 5 April. The latest spring frost was on 17 May 1935. This bitter spell occurred a few days after a heat wave which coincided with King George V's jubilee (6 May et seq). The earliest autumn frost was in September 1919 when 0°C was recorded, the only occasion when this has happened in September.

Our knowledge of visibility in the summer evenings is due to Mr. Bonacina who kept daily records for ten years from 1950–1959 from May to August by looking across London and using a code which he devised. Code 1 indicated that the Dome of St. Pauls, nearly 8 kilometres away was invisible while the maximum code 5 signalled that the North Downs scarp, about 30 km distant, was visible in detail. He found that the visibility improved as the summer progressed but there was little difference between July and August. Code 5 was recorded on 92 occasions in August, almost 30% of the evenings, compared with 32 in May. The cool, rainy summer of 1958 gave the maximum number of code 5 readings, 41 out of 123 days or exactly one in three.[2]

Sunshine has been measured regularly but unfortunately the site at Hampstead is not quite perfect and on clear evenings from early May until mid-August the sun is cut off by a building so that rather more than an hour's sunshine may be lost at the summer solstice. Despite this, Hampstead, even though it has a higher precipitation than Kew and some other low stations, has a good sunshine record. The average for the 66 years is 1477.3 hours with a maximum of 1847.5 in 1949 and a minimum of 1239.3 in 1936. The highest monthly total, recorded in July 1911, was 321.3 hours, while the lowest was 7.6 hours in December 1956. The maximum for any one day was 15.2 hours in June 1965.

The Clean Air Act seems to have improved the winter sunshine, which is not surprising, and possibly the replacement of steam engines by diesel engines has also helped because Euston, King's Cross and St. Pancras are to the south-east 5 km away. In the months from October to March the average for the last 10 years shows an increase in all cases except January which is fractionally lower. February and November show record maxima of 106.7 hours in 1970 and 100.7 hours in 1971 respectively.

Rainfall since 1910. At this hill-top site, rainfall is rather heavier than at Kew or Greenwich and the average annual fall since 1910 has been 691 mm. The Barnet-Elstree ridge to the north, which is some 10–15 metres higher is a little wetter. The three wettest years of Hampstead were 1927 with 960 mm, 1924 with 957, and 1915 with 910. By far the driest was 1921, possibly the driest calendar year for a century, which produced 394 mm, but in the twelve months ended 31 March 1973 it was only 392 mm. The next two driest calendar years were 1933 with 473 mm and 1973 with 493 mm. H. H. Lamb in a lecture at the Royal Geographical Society remarked that throughout Europe, from Kiev to Greenland, the weather has been drier since 1931 and the Hampstead figures support his view. The wettest year since then has been 1960 with 895 mm. No subsequent decade has been as wet as 1921–1930 despite the drought of its first year. The highest monthly total was 193 mm in July 1924 and the minimum 2.3 mm in April 1912 and September 1959. November is the wettest month, despite having only 30 days, the average rainfall in that month being 70 mm followed by July with 66.8 mm. The

number of hours of rain has also been recorded though unfortunately some years are missing. The maximum for any year was 723 hours in 1960 and the lowest was 347 in 1949. Unfortunately no figures are available for 1921 or 1973. If we take a further look at the monthly figures we find that the November average is 60 hours and the July average only 30, despite the fact that its rainfall is only 10% less, showing that summer rainfall is usually more intense with more frequent thunderstorms.

Up to August 1975 the maximum rainfall in any one day was 69.1 mm which fell during the night of 9/10 July 1923; there was lightning all night over a wide area making it a brilliant sight. This record was broken on 14 August 1975 when a deluge lasting 2 hours and 40 minutes struck Hampstead at about 1715 B.S.T. finishing shortly before sunset. The rainfall for the 24 hours to 9 a.m. on 15 August was 170.8 mm nearly all of which fell in this great storm. It is described in the *Journal of Meteorology*[3] and *Weather*[6].

TABLE 1: Hampstead Weather Records

	Mean Max	Mean Min	Max	Min	Av Rain	Rain Days	Max in day	Year	Av Sun
Jan	6.0	0.8	13.9	—12.2	60.0	17.5	29.3	1918	40.6
Feb	6.6	1.0	17.2	—12.8	45.2	14.4	25.4	1926	60.7
Mar	9.3	2.1	22.8	—8.9	44.2	13.9	24.2	1916	110.5
April	12.4	4.0	27.2	—5.6	49.6	14.3	42.6	1919	149.0
May	16.5	7.2	30.6	—1.7	51.3	13.0	44.6	1926	198.5
June	19.4	9.9	33.4	1.7	50.0	11.9	40.5	1917 1941	208.0
July	20.9	11.9	33.9	5.0	64.0	12.9	69.1	1923	190.1
Aug	20.7	11.9	34.5	5.0	65.2	14.0	170.8	1975	177.1
Sept	18.1	9.9	33.9	0.0	60.0	13.0	51.6	1921	145.4
Oct	13.7	6.9	28.9	—3.3	62.0	14.5	41.3	1939	102.6
Nov	9.1	3.4	20.6	—6.1	71.6	16.6	29.2	1963	56.2
Dec	6.8	1.9	15.0	—8.3	63.6	17.6	41.6	1927	38.6
Year	13.3	5.9	34.5	—12.8	686.7	173.6	170.8	1975	1477.3

When studying figures over 66 years some interesting facts emerge. Apart from the lower rainfall since 1931, October has become much drier since 1961. Since then only four Octobers out of 14 have been wetter than average and the mean has been 45.2 mm, only 69% of the previous average.

Another curiosity is the dryness of every September which finishes with a nine; the six out of 66 Septembers include the four driest, while the other two are well below average. Driest of all was in 1959 with 2.3 mm on 2 days; second driest was 1969 (7.4 mm on 9 days); third driest was 1929 (8.4 mm on 2 days); and fourth driest 1949 (9.4 mm on 6 days). 1939 was 15th driest (33.0 mm on 9 days), and 1919 23rd driest (39.4 mm on 11 days) (the 66-year average for September is 60.0 mm on 13 days).

Rainfall before 1910. Quite a lot is known about Hampstead's rainfall before the observatory station was opened as there were several raingauges nearby, mostly within 1–2 kilometres of the present site. This information has been collected by Hawke.[1] One was in Finchley Road and in 1860 the heavy total of 878 mm was measured. At Squires Mount, 20 metres below the Hampstead Heath summit, records were kept from 1862–1910. The wettest year was 1903 with 943 mm and the driest 1898 with 435 mm. Six years had falls of over 760 mm and in six cases the fall was under 508 mm. It is clear that there were some very wet and dry periods over this half century. Both 1872 and 1878 were exceptionally wet, the former having been the wettest on record for the country as a whole and, in the last 3 months, 356 mm fell at Rosslyn House, about half the average annual rainfall. This was just exceeded by a 3-month period in 1924. In 1878, when the annual total was about 990 mm at Haverstock Hill, no less than 118 mm fell between 5 p.m. on 10 April and noon on 11 April causing considerable flooding. The police had to wade through 110 cm of water to rescue a number of children trapped near Tally Ho corner about 5 km away.[4] On this occasion there was over 50 mm of rain over the whole of London and some neighbouring counties. Another heavy storm occurred on 23 June of the same year and 83 mm was measured by G. J. Symons in 1½ hours at Camden Square, 4 km from the Hampstead observatory.[5] A year with two such heavy storms must be very rare. One of the most remarkable droughts was in 1893 when only 59 mm fell in the 4 months ending 30 June at Rosslyn House while February 1891 was, so far as I know, the only month with no rain at all.[1] This was the year of the great snow storms in Devon and Cornwall in March, but London was not affected very much. It is a pity that the observatory station had not been opened earlier to record some of these interesting dry and wet spells as well as the low temperatures that were a common feature of many of the 19th century winters.

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24 SEPTEMBER 1975: CUMBRIA'S WETTEST DAY FOR THREE YEARS

By P. R. CUTFORTH
31 Campbell Road, Edinburgh

Most of the features usually associated with a wet day in the Lake District were present on 24 September: a deepening depression was moving north-east across North Scotland and its associated fronts were separated by a very wide warm sector in which the wind was from the south-south-west (Fig. 1).

An area of central Lakeland, about 40 km by 25 km, received rainfall in excess of 75 mm. The highest total for the period ending 09h on the 25th was at Honister Pass (119 mm) but it is probable that the Styehead gauges some 5 km to the south received at least 140 mm. Seathwaite in Borrowdale lies between Honister and Styehead but is much lower than either. The autographic record for Seathwaite (Fig. 2) shows that most of the rain fell between 12 h and 19 h, before the warm front and in the warm sector.

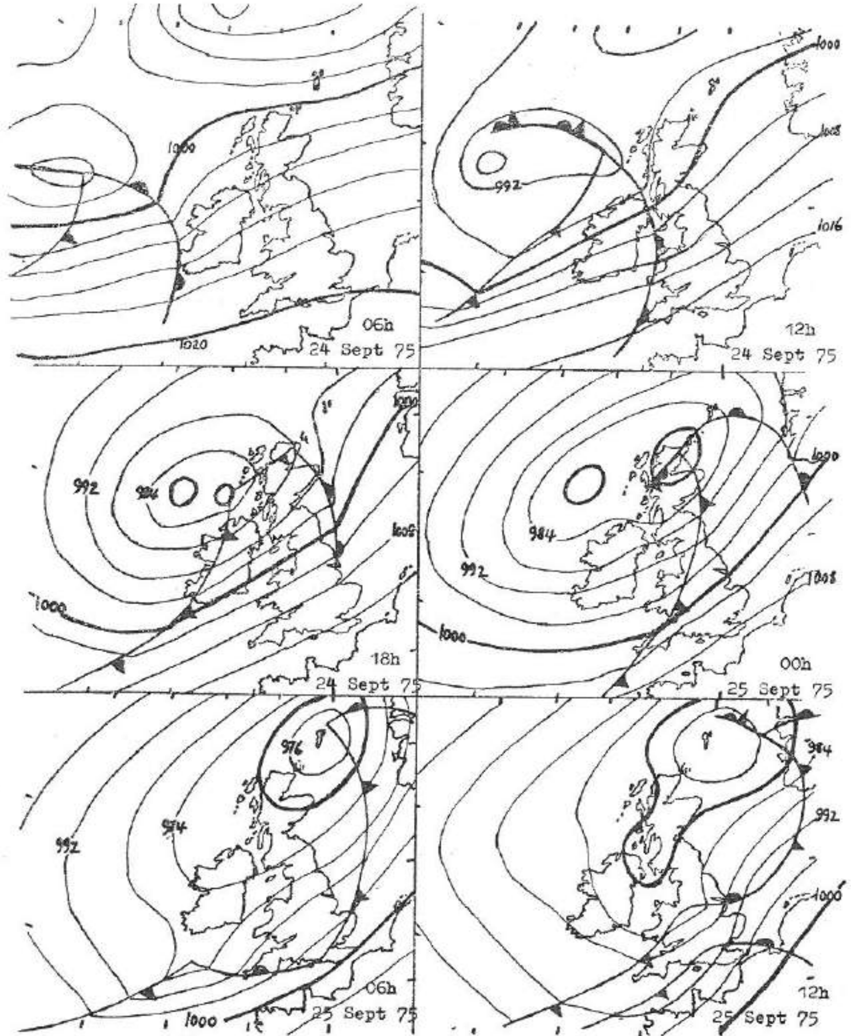

Fig. 1 Synoptic charts for 24-25 September 1975

Rainfall after the passage of the cold front was more showery although heavy at times. The 24-hour total at Seathwaite Farm was 86 mm.

The rainfall distribution map (front cover illustration) shows that the Solway and lower Eden Valley received less that 15 mm, a contrast which is usual in orographic falls of this kind and which is often even more marked.

Thermograph traces from Honister (Fig. 2) indicate that, at least at the surface, the cold front brought little change of temperature but the change to showery weather coincided with the passage of the cold front, presumably due to changes in the upper air. It is also likely that the cold front would show as a change of slope in the pressure graph but without barograph records I could not confirm this.

This rainfall is by no means exceptional for Cumbria but in the Central Lake District this was the wettest rainfall day since 9 November 1972 when Honister recorded 172 mm.

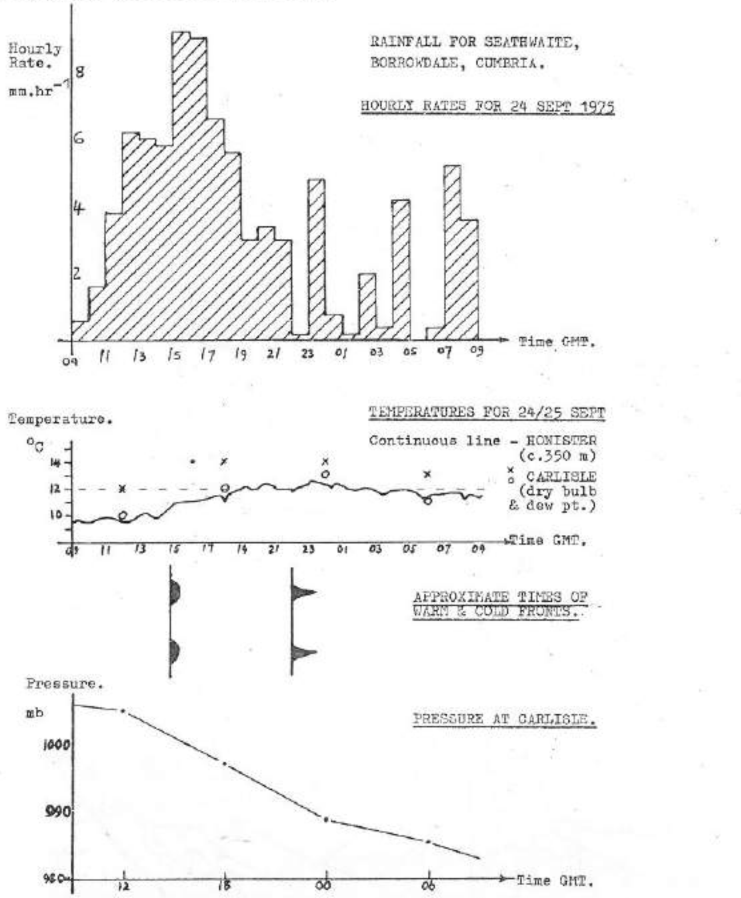

Fig. 2

TWO OBSERVATIONS OF THE PARRY ARC, AND OTHER HALOES

By R. WHITE

Department of Mathematics and Statistics, City of London Polytechnic.

Abstract: Two recent observations of the type I Parry arc are described. One is shown to be an unusual observation in which only the Parry arc and the 22° halo were present, with no superior tangential arc.

Since I reported[1] my four previous observations of the Parry arc, I have seen it on two further occasions. All six observations have been of type I Parry arcs[2 3], and were made at Woodford Green, Essex.

THE OBSERVATIONS OF 8 SEPTEMBER 1975

The first observation was made at 1530 GMT on 8 September 1975. Two arcs, A and B (as shown in Fig. 1) were seen. The broken line indicates the edge of the cirrus sheet producing the haloes. There was some other cirrus around, but it was thinner and not producing significant haloes at the time of observation.

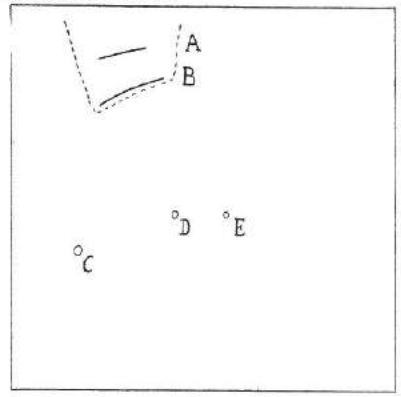

Fig. 1. Halo phenomena of 8 September 1975 at Woodford Green, Essex.

The arc A was narrow (perhaps ½° broad) and rainbow-coloured with red below. The arc B was broader and less well-coloured, though the red below was clear. Although this arc followed the edge of the cloud sheet, I believe the true form of the arc is as shown. Proximity to the edge of a cloud sheet might distort a locus of maximum intensity, but would not greatly affect a locus of constant colour.

Unfortunately I did not note the relative position of the sun to the arcs during the short time that they were visible. The inclination of A to the horizontal was very slight, and another point not known with absolute certainty is whether the sense of inclination was as shown, or the opposite. Certainly A was the type I Parry arc, but B would be interpreted as the superior tangential arc for solar position C, or the 22° halo for solar positions D and E. I shall outline below my reasons for preferring the latter interpretation.

Also seen on 8 September were all parts of the circumference of the 22° halo (although not simultaneously), a superior tangential arc of 22° showing the second degree of development[4], an inferior arc in the first degree of development, and Lowitz arcs in the first degree of development.

THE OBSERVATIONS OF 15 OCTOBER 1975

The second Parry arc observation was made at 1343 GMT on 15 October. Three oktas of ragged cirrus was in the east, but although this cloud had at times come close to the sun, it did not produce any haloes. The phenomena to be described were produced by a much smaller area of cirrus, whose apparent motion was along the solar vertical from the south. This cirrus consisted of a small area of tenuous *fallstreifen* (dimensions about 3°), almost exactly on the solar vertical, with a more uniform but more tenuous area (dimensions about 10°) below and to the left. The latter was so tenuous as to be hardly visible when not producing haloes.

In the first phase a superior tangential arc (second degree of development) was produced in the *fallstreifen*. As the cloud moved up, the tangent arc (almost attaining the third degree of development) and the Parry arc were seen in the area of uniform cirrus. The Parry arc was again about ½° broad with even more brilliant spectral colours than on 8 September. The superior tangential arc was of similar width and colouration to the Parry arc.

The third phase came at most one minute later, with the appearance of a brilliantly coloured fragment of a circumzenithal arc in the *fallstreifen*. Subsequently, both the circumzenithal arc and the supralateral tangential arc of 46° were seen in the uniform cirrus. Both arcs were 1 to 2° broad with fine rainbow colours.

At 1430 the ragged cirrus produced a portion of a 22° halo between 'half past two' and 'half past three'[4]. The 22° halo (12 o'clock to half past one) was seen again at 1450, with a weak right hand parhelion.

INTERPRETATION OF THE OBSERVATIONS

The solar elevations in the two cases were about 26½° and 27° respectively, so all the arcs should have the same form in both cases. This fortunate coincidence allows me to make a positive identification of the arc B in Fig. 1. Whatever assumptions I make about the solar position in Fig. 1 (even considering positions other than those shown) it is impossible to identify B with the superior tangent arc seen on 15 October. Thus, it is certain that the 8 September observation was of a 22° halo and a type I Parry arc only, which is a most unusual, if not unique, observation. It indicates the presence of a crystal population with three degrees of rotational freedom (producing the 22° halo), and a population with one degree of rotational freedom (producing the type I Parry arc), but no significant population with two degrees of rotational freedom (such as would produce the superior tangential arc). If the solar position were E, rather than D, though, a poorly-developed tangent arc might have escaped attention.

The only controversial point connected with the observations of 15 October concerns the fact that I have claimed an observation of a supralateral tangential arc of 46°, when an alternative interpretation as a 46° halo might seem equally plausible. (At a solar elevation of 27°, the halo of 46° and the circumzenithal arc are only 1° apart, by ready reference to Mr Goldie's 'Graphical Guide'[3]. The arcs on this occasion were sufficiently broad to obliterate a gap so small).

The observation of a superior tangent arc of 22° and a Parry arc indicates the presence of crystal populations with two degrees of rotational freedom, and one, respectively. The absence of a 22° halo indicates the lack of a population with three degrees of rotational freedom. Thus, an interpretation of the observation as a 46° halo, would require the conveniently-timed, sudden appearance of a crystal population with three degrees of rotational freedom. By contrast, the supralateral arc of 46° and the superior arc of 22° can be produced by the same population.

Other recent observations of Parry arcs

A 'second order' (*sic*: presumably type II) Parry arc was seen by F. Nieuwenhuys[5] at the Hague on 20 August 1975. On 24 September 1975, at the Hague, the Parry arc was seen at 1430[6]. A lunar Parry arc was seen from Hoogeven on 18 November 1957[7], surely a unique observation.

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(More recently, at 1015 GMT on 2 March 1976, the editor saw from Trowbridge a Parry arc at the same time as a large section of a circumscribed halo).

TORNADOES IN MEDIAEVAL BRITAIN

By M. W. ROWE

Lillington, Leamington Spa, Warwickshire

Abstract: Mediaeval chronicles describe 21 tornadoes in Britain prior to the year 1500. Although the meanings of some of the accounts appear unclear at first sight, the features reported can nearly always be explained by reference to modern tornado cases.

Although the list of tornadoes given by Brooks[1] includes two from as far back as 1729 and 1638, and Manley[2] (quoting Stow's Chronicle) describes a case at Nottingham in 1558, these are by no means the earliest British examples known. Lane[3] mentions two which occurred in 1091 and 1140. It seems that he was quoting from the well-known compilation of Britton[4], which contains descriptions of no fewer than 21 certain, or highly probable, tornadoes (though Britton nowhere uses this word). In the present article quotations are from Britton unless the name of the chronicler is cited, in which case they are my own translation from the original Latin text.

THE EARLIEST TORNADOES

The first undoubted tornado occurred in London on Friday, 17 October, 1091 (23 October, N.S.), although there are one or two earlier reports of storms which may have included a tornado (Meaden[5]). This 'violent whirlwind', as Florence of Worcester[6] calls it, killed two men, as well as allegedly demolishing 600 houses and a number of churches.

The next example, on 19 May (N.S.) 1141 at Wellesbourne, Warwickshire (misdated 1140 by Britton)[7] hurled the church roof across the river Avon, and damaged almost 50 houses according to John of Worcester.

DAMAGE AND CASUALTIES

In all, 14 of the 21 tornadoes are reported as damaging buildings, including mills, churches and houses. In general, only the more severe tornadoes are likely to have been recorded by the few chroniclers of those times, so that it is not surprising that several of the accounts mention human casualties. The London tornado of 1091 killed two people; in 1165 the inhabitants of a mill on the Severn perished; and in the Pillerton case of 1222 eight people were crushed by a falling house. Collapsing buildings also killed a number of people in the tornado of 1291, while in 1402 at Danbury, Essex, a man was injured by a 'devil'. Birds and animals were destroyed in 1234 and 1246 (in the latter case probably by giant hail) and crops in 1234, 1262 and 1271.

The most characteristic damage reported in the mediaeval tornadoes was the uprooting of large numbers of trees, which was specifically mentioned in 10 of the 21 cases. Three of these are particularly interesting as they relate to the twisting of the trunks. This is a characteristic effect of tornadoes, caused by large differences in wind speed between points only a few metres apart. In 1205 'several trees were torn up by the roots and carried away, some were twisted like ropes, and some were manifestly broken across the middle'. The 1246 tornado 'twisted oaks', while at Cowick in 1323 an oak was 'twisted in two at the middle, and another cloven from the top downwards'.

SUCTION EFFECTS

Three of the accounts describe violent effects, which are unambiguous evidence of a tornado. At Pillerton in 1222 the 'tempest' passed over a pond and dried it up 'in the twinkling of an eye' (Roger of Wendover[9]). In 1279 'watery places became dry' and 'men were carried away in the clouds'. It is certain that a powerful tornado could carry a man a considerable distance, even in Britain. On 5 October 1851 for example, during a tornado at Limerick, a man claimed to have been 'carried by the wind across the river at a point where it is a quarter of a mile broad[10], and a child was 'carried a hundred feet and let fall' by the Nottingham tornado of 1558[2]. In the tornado of 1234 'the corn was lifted up by a blast from hell'[11].

APPEARANCE AND SOUND OF THE TORNADOES

Surprisingly few of the tornadoes are described as having a visible funnel cloud. The most unambiguous case was at St. Albans in 1251, when the brethren of the Minors, venturing outside after a thunderstorm, saw 'a torch like a kind of drawn sword, and thunder and a dreadful murmuring continued'[12]. The use of the word 'torch' probably means that the funnel resembled a column of rising smoke, a common description. Barker[13] says that the tornado at Gretton, Northants, on 26 September (N.S.) 1749 was like 'a great smoke . . . with the likeness of fire'. On 16 May (N.S.) 1752 a whirlwind in Deeping Fen, Lincs., resembled 'a pillar of smoak'[14]. As recently as 1950 those who saw the Buckinghamshire tornado of 21 May 'likened its appearance to that of fire because of the dense masses of dust which were whisked aloft' (Bonacina[15]).

The word 'murmuring', used to describe the noise of the 1251 St. Albans tornado, is very likely a mis-translation if it is a rendering of Latin 'murmur', which can mean 'roar', the probable meaning here. Similar 'fearful noises' were heard during the tornado near Scarborough in 1165, when a large 'black horse' was seen which must have been the funnel. If one imagines that the witnesses saw a black funnel making a noise like a galloping horse, surrounded by a cloud of dust and ploughing up the ground along a definite, narrow path, the description at once seems much less fantastic. Especially interesting are the 'horse's footprints', which seem to represent the cycloidal

TABLE 1: British tornadoes to the year AD 1450

Date N.S. (O.S.)	*Location*	*Weather/Damage*
1091 Oct 23 (Oct 17)	London	—/DPX
1141 May 19 (May 12)	Wellesbourne (Warks)	H/DX
1149		—/DE
1165 Aug	Scarborough (Yorks)	tlH/MP
1173 May 24 (May 17)		TLhr/E
1205 Aug 4 (Jul 28)		TLH/E
1222 Dec 7 (Nov 30)	Pillerton (Warwicks)	TL/DP
1234 Jul 23 (Jul 16)	Abbotsley (Hunts)	TLhR/ACE
1244 Jun 18 (Jun 11)		—/DE
1246 Jul 26 (Jul 19)		TLHR/ABE
1251 May 26 (May 19)	St. Albans (Herts)	TL
1257 Jan 4 (Dec 28)		TLHR
1262 Jul 1 (Jun 24)	Grimley (Worcs)	TL/BCE
1271 Jul 11 (Jul 4)		R/CE
1279 May		TL/DEP
1291 Aug 18 (Aug 11)	St. Botolph's (Norfolk)	tl/BMP
1323 Jul 2 (Jun 24)	Cowick (Yorks)	—/E
1396 Jul 3 (Jun 25)	Caynham (Yorks)	tl/X
1402 Jun 3 (May 25)	Danbury (Essex)	TL/PX
1402 Jul 3 (Jun 24)	Hereford, or Hertford	TL/X
1402 Sep 16 (Sep 7)	Wales	R

Weather: h hail, r rain, t thunder, l lightning (capitals denote intensity).
Damage: A animals killed; P people killed or injured; B buildings, D houses; M mills, and X churches damaged; E trees uprooted. (N.B. Damage caused by accompanying hail, lightning or rain is not included).

marks left by some American tornadoes (Fujita[16]). Meaden[17], independently analysing this storm, gives a similar explanation of the reported features.

Roger of Wendover[11], in his account of the tornado of 1234, describes the funnel in a passage which Britton omits: 'There were seen in the air above the angels of Satan flying about'. Probably, the 'most foul darkness' which stretched from the sky to the earth in the Wellesbourne tornado of 1141, also refers to the funnel, although it may merely mean that the sky was black down to the horizon. The funnel of the 1323 Cowick tornado was described in the phrase 'dark whirlwind'.

It is difficult to be sure of the meaning of the word 'devil' used in connection with several tornadoes. It may indicate a sighting of the funnel, or it may be an attempt to explain the unusual effects produced by the tornado. Probably the funnel is being described in the statement that 'devils in the likeness of repulsive animals fought together' in a 'horrible whirlwind' in 1149. During a thunderstorm in August 1291 'a demon . . . threw down with its talons the pillars of a certain gallery'. In 1402 a 'devil injured a man at Danbury, Essex, and the same year damage to a church at Hereford (or Hertford—Britton gives both) was attributed to the same cause.

WEATHER CONDITIONS ACCOMPANYING TORNADOES

Most of these early tornadoes were accompanied by thunderstorms, often severe. Hail was frequently reported and was sometimes of great size, causing much damage. At Wellesbourne, in the tornado of 1141, hail 'the size of pigeon's eggs' fell and killed a woman[8]. The 1246 tornado brought hail 'angular and very hard, and exceeding the size of almonds', and in 1205 the hail was 'of the bigness of goose eggs and pointed on all sides'. Bonacina[15] gives an illustration of a stone agreeing exactly with the latest description, which fell at Wingrave, Bucks, during the tornado of 21 May 1950. The largest hailstones are nearly always irregular in shape.

MONTH OF OCCURRENCE

Of the 21 pre-1500 tornadoes, all but one can be dated to the month. Of these 20 cases, as many as 16 occurred between May and August. In a list, given by Brooks[1], of more recent tornadoes (mainly after 1870) 10 out of 23 were in these four months, with another eight in October. However, an analysis of monthly tornado fequency by Lacy[18], showed that most cases occurred in the winter half-year. Lacy, using data for 1963–66, found 19 tornado-days between October and January but only seven between May and August. In earlier years it is likely that many wintertime tornadoes were missed because their effects were confused with gale damage. For this reason the recorded examples from mediaeval Britain are not a representative sample. Nevertheless, in a recent lecture Meaden discussed the distribution of as many as 738 British tornadoes, and found a very pronounced peak in the distribution for July and August[19].

There is no mention in the chronicles of dust or land-devils, although these are common phenomena, and there is only one case of probable waterspouts: in June 1233 'two huge snakes were seen by many along the coast, fiercely battling in the air, and after a long struggle one over-came the other, and drove it into the depths'[20].

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THUNDERSTORM TRACKS

By R. J. PRICHARD
Epping, Essex

In an earlier issue of this Journal (no 3), views were sought concerning the popular theory that thunderstorms tend to favour tracks along river valleys. This article is an attempt to summarise the comments which have been received. Although a few observers are quite confident that the theory is well-grounded, others are not so sure, and it is evident that the subject is complex and worthy of further close investigation by those readers interested in it.

The first difficulty one meets is due to the large number of variables involved in thunderstorm development (as in so much of meteorology). What causes storms to develop where they do? What keeps them going, or causes them to die out quickly? What makes them follow the tracks they take? The first thought of many observers would probably be that the valleys and small hills which comprise the terrain of much of the southern half of the British Isles could scarcely have a major effect on the track of a storm whose base may be at 2000 or 3000 ft (0.7 to 1 km) with tops as high as 30,000 or 40,000 ft (10 to 13 km). Storms are normally assumed to travel with the direction of the wind at about the 10,000 ft. level (3 km), so it would appear unlikely that ground which does not rise above 1,000 ft (0.3 km) could influence their movement. However, we do know that if there is a hill, or fairly short range of hills, lying perpendicular to the surface wind direction, the wind will tend to be steered around the edges of the hill. This effect must extend into the airstream above high ground as well, so that if the hill or mountain is large enough, it could, presumably, begin to affect the movement of showers and thunderstorms. However, if the mountain range is long, most of the wind must blow over the top, rather than pass around it. Additionally, when considering thunderstorms, one is dealing with unstable air which is more likely to be *lifted* by high ground than to be *steered* around it.

So our first thoughts suggest that storms are unlikely to follow river valleys in preference to any other track. We have a further problem: suppose we observe that 10 thunderstorms out of 16, say, in a certain year appear to follow the local river valley. Then before saying that the theory looks sound, we must consider the upper wind direction, and if the wind at storm level (say, 10,000 ft) was blowing along the valley anyway, nothing has been proved. In fact, thunderstorm tracks that appear to favour a S.W.–N.E. valley may do so just because that is the prevailing wind direction in this country. But why does not the storm follow the higher ground to the north-west or south-east of this valley, rather than the valley itself? Certainly, if enough storm reports were available to show that areas along the valley floor had much more frequent overhead thunder than the higher ground on either side, we would indeed have useful and thought-provoking results. If there are observers with such figures, or in a position to start recording along these lines, we would be interested to hear from them. Can a *single* observer conclusively demonstrate this though? It is not always easy to be sure, from a given observation point, in exactly which direction a storm centre lies, and how it is moving. Because thunder can be heard over a wide area, it follows that most storms that an observer sees will pass to one side or the other of him, rather than directly over him. If he has watched the storm from the moment it came into view, he may then conclude that it has been steered. This would often be a false conclusion; a co-ordinated network of observers within the storm area would appear to be needed in order to determine the exact track of the storm and to show whether topography had any effect.

If, for the sake of argument, we assume the theory to have some basis in fact, then why should it happen that storms follow such tracks? Apart from the large-scale requirements for a storm situation, a good supply of moist air and a trigger action are also needed, such as a sea-breeze front, or a convergence zone of some other nature. Although there are variations from year to year, the major thunderstorm areas in the United Kingdom are the Pennine Hills, particularly around the Peak District, and the East Midlands of England, especially from Nottingham to the western suburbs of London. The Pennines feature because of the considerable lifting they provide for moist, unstable westerly winds, while the eastern counties feature because, presumably, they heat up readily and are not prone to cooling breezes from the sea. Rivers may provide additional moisture for thunderstorm development in some cases, but in most thundery situations the air over the country is already moist anyway. Nevertheless, the rather isolated thundery outbreaks which occur on some days in the East Midlands may need moisture from a river—and perhaps the higher day-time temperatures often found in valleys—to trigger them off. Once formed, they may only be maintained with the aid of additional moisture, and hence only survive if their track is along the valley. However, it would seem to be more a case of the storm surviving because it is following the valley, rather than the valley actively steering a pre-existing storm. It is conceivable that on days of light winds and only marginal instability, such a river-valley effect could be said to operate; but it seems unlikely that it could in most other cases—and surely not when winds at storm-level are fairly strong (20 kt or more), because it is these upper winds which then dictate the storm track. Even when storms are not travelling with the 10,000 ft wind, but at an angle to it—as is the case with severe storms sometimes—the influences responsible are well above the earth's surface.

That is about as far as this subject can be taken at this stage: we hope readers will be stimulated into further studies of their own, and perhaps after the next storm season we will have further reports to digest which will add to, or diminish, the theory. I would like to thank all those who have corresponded on this subject so far; one or two readers fervently believe the theory to be true, and I am certainly in no position to say they are wrong. In particular, Mr Lisle of Worthing says that in 25 years of observing, he has become convinced that storms from the English Channel regularly split as they reach the Sussex coast and follow the valleys of the Arun and Adur, to the west and east, respectively, of Worthing. Nevertheless, as he says, it is a mystery why this should happen; do any other Sussex readers—or anyone else—have any views or observations on this?

CLIMATIC CHANGES AND OUTSTANDING SINGULARITIES IN THE LONDON AREA 1947-75: Parts 3 and 4, MARCH and APRIL

By C. R. FINCH
Motspur Park, Surrey

MARCH

This article continues the series which commenced on page 114 (*J. Met.*, no. 4) with a general introduction. The discussion for March and April follows a similar pattern. Although the variation of mean March temperature from 1841 to 1975 will not be discussed, it is important to note that the trend of the last 10 to 15 years has been quite different from that of the two preceding months. For, whereas January and February have been characterised by a large number of mild or exceptionally mild years, March has had, by contrast, a large number of cold years.

Next, considering the graph of mean maximum temperature, it is seen that the seasonal rise dating from 27 February is temporarily arrested on 3rd/4th March, whereupon it then falls slightly until the 5th. This is mainly the consequence of a sharp fall in the period 1947–1955 which weighted the 29-year mean rather heavily. The fall against the seasonal trend to a trough on the 18th was apparent in all three post-war periods, although it was absent from the longer 1871–1950 period at Kew. The warmest part of the month occurred between the 20th and 26th in all three post-war periods, and was followed by a sharp drop between the 26th and 27th in the same periods as well. However, at Kew in earlier years there was a rise of 0.3°F between these two dates. The general seasonal rise, shown as arrested on 23 March, does not recommence until 4 April.

Regarding night minimum temperature, the seasonal rise starts about 10 March which is considerably later than for the daytime maximum temperature. There is a sharply higher night minimum on 13 March, but, even so, the temperature is still only at about the mean level attained during the rest of the month. The mean maximum on 31 March over 1947–1975 was 51.4°F (10.8°C) compared with 47.0°F (8.3°C) on 1 March, whereas at night the mean minimum on 31 March was 36.4°F (2.4°C) compared with 34.8°F (1.7°C) at the start of the month.

The most frequently wet day was 29 March with measurable rainfall on 17 occasions in 29 years. This frequency is nearly twice that of the 12th, which had measurable rain only 8 times in the same interval. The wettest part of March has been between the 24th and 30th, and also around 13th/14th and 17th/19th. The first 12 days have been fairly dry and so has the time of the spring equinox from the 20th to 23rd. Changes in mean pressure correspond to the drier and wetter spells quite well, although mean pressure on the 12th has appeared a little low for such an outstandingly dry day.

APRIL

The first graph in Fig. 2 covers mean April temperature from 1841 to 1975. Although a discussion concerning any possible overall temperature trend will not be held, it is worth remarking that the main feature about recent April temperatures has been the absence of a warm April since 1961. Like March, the month of April has a temperature pattern in recent years

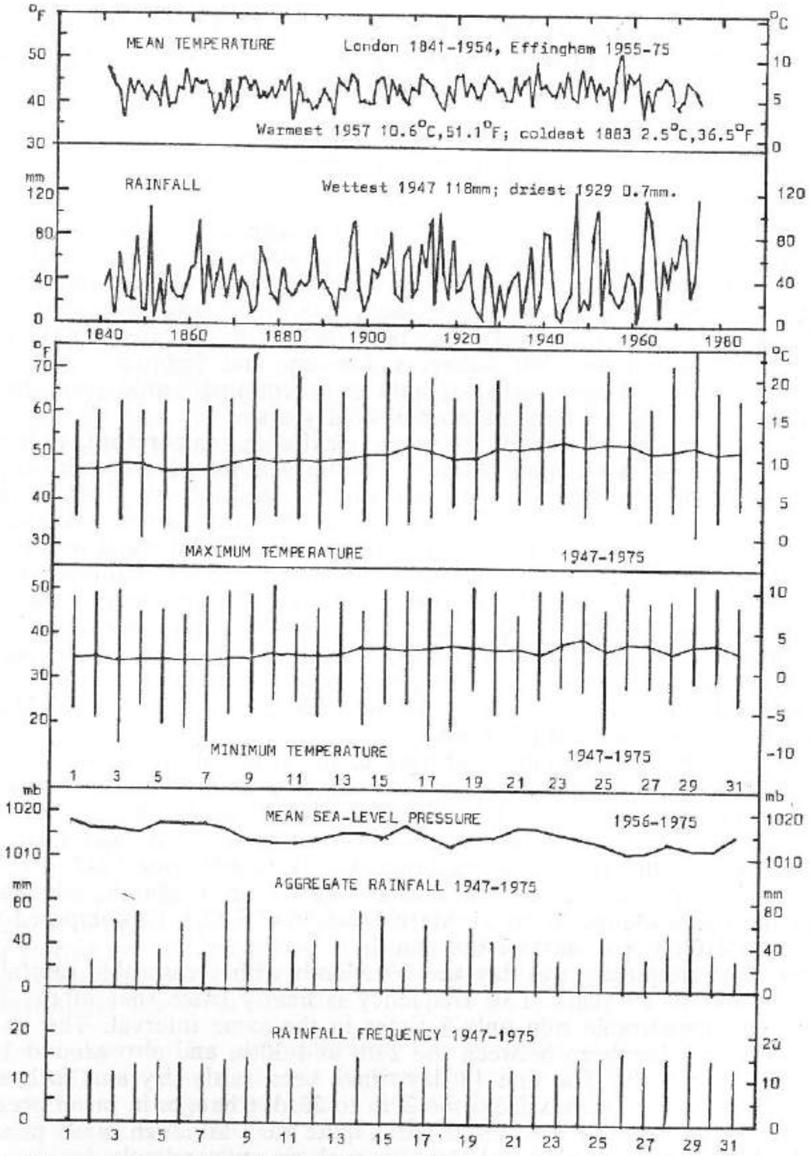

Fig. 1. Temperature and rainfall trends for March. The extreme temperatures, 1947—1975, are as follows: Maximum, highest, 74°F 23°C) 29 March 1965, lowest 31°F (—0.5°C) 4 March 1965; minimum, lowest, 15°F (—9.5°C) on 3 March 1965, highest 51°F (10.5°C) on four occasions.

with a distinct trend toward cooler springs which contrasts with the mild winters of the last few years.

The first fortnight of April over 1947–1975 has had a high number of cold

wet days, and the gain in mean daily maximum temperature has been slow until the 14th when it jumps sharply over the following two days. This singularity was marked over 1947–1955 and 1966–1975, but during the decade 1956–1965 the same sharp rise was delayed a further week. After this, the seasonal rise again slowed to virtually nothing, and was not fully

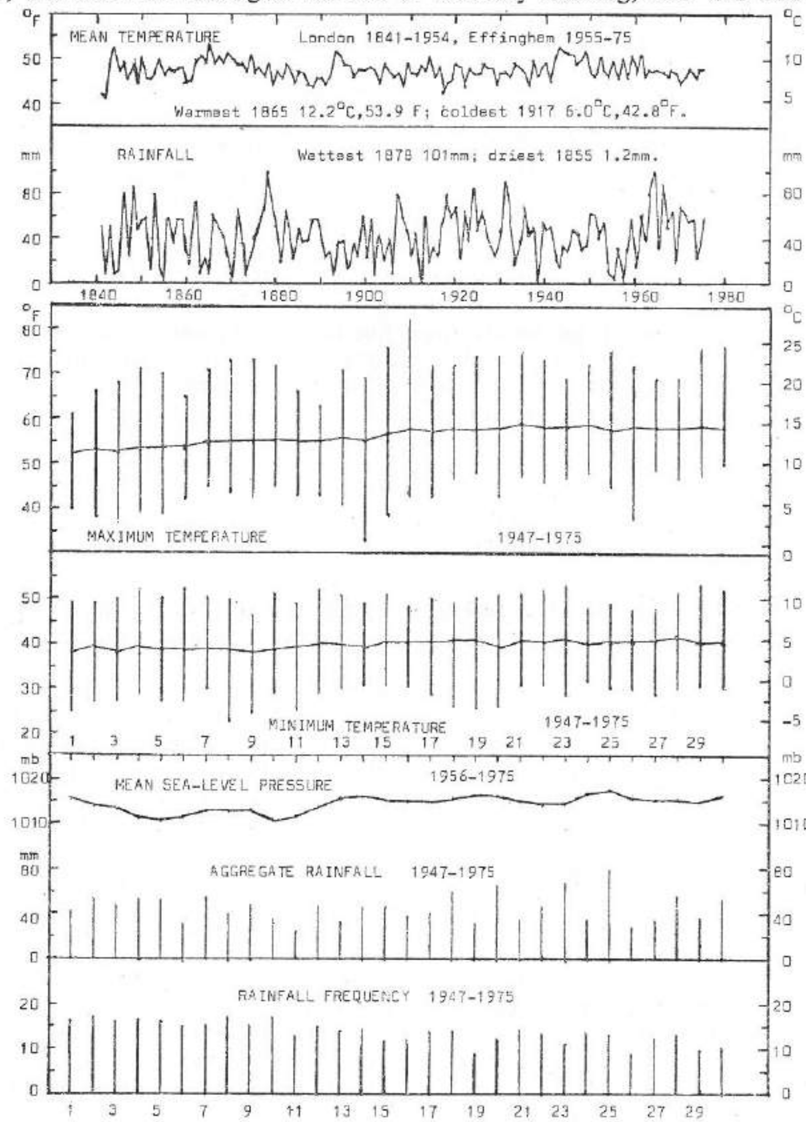

Fig. 2. Temperature and rainfall trends for April. The extreme temperatures, 1947—1975, are as follows: Maximum, highest, 82°F (28°C) 16 April 1949, lowest, 33°F (0.5°C) on 14 April 1966; minimum lowest, 23°F (—5°C) on 8 April 1968, highest, 53°F (11.5°C) on 29 April 1958.

renewed until 7 May.

At night, the feature of April has been the lack of any significant variation in mean minimum, which has kept near 4–5°C (40°F) throughout the whole month. As a result, it is not until 4 May that the seasonal rise in night minima recommences in earnest. It is true there is a small rise between the 9th and 12th, but it is only about 1°C. This trend is not dissimilar to that at Kew during 1871–1950.

The high number of wet days in the first fortnight is to be seen in the consistently high frequency of rain-days in the lowest graph; nevertheless, aggregate amounts have been on the low side, with totals not much different from those registered on less-frequently wet days later in the month. The 19th and 26th have proved to be the most frequently dry days of April, while the 2nd, 8th, and 10th share the most frequently wet position. Much of April's rainfall has come from showers, for which totals are somewhat lower than those recorded from frontal systems. It may also be noted that, during the months from November to March, rainfall from showers in the Effingham area was very small, the great majority of the rain being associated with frontal systems. In these five months showers are uncommon, the most usual variety being wintry showers in a north-easterly airstream; even then, they become very isolated southwest of London.

April mean pressure has two prominent troughs on the 5th and 10th. The sharp rise from the 10th to the 13th is also outstanding, but after this there is little variation over the remainder of the month. The peak on the 25th almost coincides with the outstandingly dry day on the 26th. The last two days of April are also relatively dry, the 30th contrasting sharply with a much higher frequency on 1 May.

RECORDING RAINGAUGE CATALOGUE FOR THE UNITED KINGDOM—IS YOURS IN IT?

A recording raingauge is one that produces a chart or tape record rather than simply storing the water and waiting for an observer. It is a vital source of historic data for those engaged in research or design in highway engineering, flood hydrology, land drainage, airport and urban studies and many other areas. It is equally important in real time for flood forecasting and water resource management. It may be complemented rather than superseded by the possible future use of radar.

The Meteorological Office operates about 100 of 1200 or so gauges in the U.K. but the rest are operated by a wide variety of organisations and there is no central agency responsible for their siting nor for the collection of data.

In 1970 the U.K. Flood Studies Team at the Institute of Hydrology began to collect and microfilm data from selected gauges. The Meteorological Office also started a large programme of automatic digitisation and chart analysis using many more gauges than had previously been studied; Dr. Peter Kelway, while at Birmingham University, continued his work on the analysis of temporal and spatial rain patterns and saw a need for full information on all gauges in the country.

These three groups have now pooled their information, Water Authorities have been consulted, and the Institute of Hydrology has produced a computerised catalogue of *all known recording raingauges in the U.K.* It gives information on location with national grid references, type dates, operating authority, film availability, data extracted etc. The full catalogue runs to 100 pages of computer listing and is available either as a full national listing or as a listing of specific hydrometric areas from the Institute of Hydrology, Crowmarsh Gifford, Wallingford, Oxon, or on microfiche which can be read on standard equipment capable of 30 × or 40 × magnification.

The problem with such a catalogue is that it can never be fully up to date. In this first version (dated February 1976) at least some reference is made to all known gauges, past or present, the aim being to encourage feedback of amending information. Could we ask that everyone who operates recording raingauges send details to *Mrs J. French, Institute of Hydrology, Crowmarsh Gifford, Wallingford, Oxon,* or check the published catalogue for their area and give details of omissions and amendments. Only in this way can we maintain this comprehensive list of all known gauges which must be of considerable value to meteorologists, hydrologists and engineers.

A NOTE ON THE COLD FRONT OF 29 FEBRUARY 1976 OVER SOUTHWEST WALES

Readers may be interested in the following comments compiled while leading a student field excursion back from Newport (Preseli, Dyfed) to Lampeter (Ceredigion, Dyfed) on 29 February 1976. The cold front in question crossed the United Kingdom during the day and produced quite severe wind damage over Humberside. The weather charts for 1200 and 1800 G.M.T. 29 February showed southwest Wales to be close to the 'tail end' of the front. Nevertheless, the front was a noticeable feature in the area, not so much as a result of the severity of the weather but by the very restricted horizontal extent of the frontal zone and the extremely ominous looking clouds associated with it.

The area had experienced for several days unusually mild and dry conditions for the time of year with relatively moist air being channelled round the western flank of a decaying anticyclone over Europe. Three of the previous four days had been generally sunny after the clearance of low overnight stratus and stratocumulus and associated hill fog and drizzle patches—a common weather feature for such a synoptic situation in the area. The day of 27th was the exception in that it remained overcast and relatively cool. Clearance of cloud during the morning of 29th was not as rapid as it had been on some of the previous days and amounts of low cloud were variable throughout the day in areas near to the Cardigan Bay coast. High and medium-level cloud, which would normally precede the arrival of the surface frontal zone, was entirely absent, even by 1530 immediately prior to the arrival of the front. The light to moderate southerly breeze picked up during the morning to become strong to gale (averaging 12 to 15 m/s on a hand anemometer) over high ground immediately south of Newport at midday, with a moderate to fresh breeze at sea level (around 8 to 10 m/s on exposed beaches at about 1400. By 1530 large amounts of 'scud' (stratus fractus) spread in beneath advancing and very black-looking cumulus near Newport. Through gaps in this cloud layer, which masked the peaks of Mynydd Caregog and Mynydd Dinas at about 300 metres, a line of massive cumulus could be seen developing over high ground in Credigion to the northeast. After a very short period of light rain observed near Cardigan around 1615, clearer weather could be seen out at sea in Cardigan Bay. During and immediately before this precipitation, light intensity was markedly reduced beneath the pall of cumulus.

The line of cloud which was all that remained of the front was certainly no more than 15 km wide, with a width of about 2 km of very low cloud significantly reducing daylight. After the line of cloud had moved inland over the Teifi valley by about 1630–1700, brighter conditions could still be observed ahead of and 'under' the cold front in the milder tropical air to the east. Simultaneously, clearance was occurring in low and medium level clouds over the coast. At this time the underside of the cloud was marked by a number of small *tuba* and an intermittent veil of *virga*. The whole cloud system looked very stormy indeed, but measurable precipitation did not generally reach the ground in the Teifi valley although a few spots of rain occurred in places over higher ground on either side of the valley. At Lampeter, where meteorological parameters are continuously monitored at St. David's University College, the passage of the front was marked by a drop in air temperature from a steady 10.0°C between 1400 and 1650 to 8.5°C by 1700, accompanied by a sudden rise in atmospheric pressure of about 1.5 mb. Soon after 1800 skies were clear of cloud, and temperatures were falling far more rapidly than during previous nights. A moderate air frost persisted from about 0330 to 0930.

Saint David's University College, Lampeter. G. N. SUMNER

THUNDERY ASPECTS OF THE COLD FRONT OF 29 FEBRUARY 1976

The cold front of 29 February was associated with a deepening depression moving northeast between Iceland and Scotland. At 1600 the front was crossing N.E. England and Wales. Two hours after affecting S.W. Wales, as described by G. N. Sumner in the preceding article, its northern flank was giving thunderstorms in the counties of Nottingham and Humberside. In the Humberside area line squall effects were reported, and it is possible that tornadic vortices developed as night was falling.

Thunder was heard at Finningley (S. Yorkshire), Newark (Notts) 1815, Cottingham 1820, Hull and Kilnsea (Humberside), and Louth (Lincolnshire) 1840. Lightning was seen at Bleasby (Notts) and Loughborough (Leics).

At Carlton, Nottingham, Mr John Osborne reported 'slight rain at 1800, and at 1815 a sudden increase of wind from force 5 to about 8 which scattered dustbin lids and other objects. Hail fell for five minutes, and then 0.5 mm rain. Sheet lightning was seen to the N.W.'

Mr Peter R. Jennings of Cottingham, North Humberside, wrote as follows:

'At Cottingham, there was a marked line squall at 1820, with heavy rain mixed with hailstones, thunder and lightning, and winds gusting to force 7, presumably on the passage of the cold front. The storm lasted for 15 minutes and gave 3.8 mm of rain. The wind veered from S.W. to N.W., and by 1900 the sky was clear; the evening remained fine and dry with a fresh wind. A rise of atmospheric pressure was first noted at 1820. Attached is an article from the *Hull Daily Mail* regarding the freak storm which caused localised damage in the docks at Hull, 6–7 km south of here'.

A 500-ton container crane was blown off its tracks at a Hull dock last night during a freak storm which swept across North Humberside. During the 15-minute electrical storm a 'wall' of rain was interspersed with lightning, thunder and high winds. Roofing on dock sheds was ripped off and caravans waiting to be exported were overturned and damaged.

The giant crane was blown 50 ft (15m) along its running track and crashed through a stopping pit containing gravel. One set of bogies came to rest about 12 ft from the end of the concrete-bounded pit. It is expected to be several days before the crane is working again. A large section of roofing from one end of No 16 shed was ripped off. Part of the flying debris smashed into an imported car which was parked with others on the opposite side of the shed. A gaping hole was left in the roof. Sheeting was also blown off Shed 15 which had its roof lifted off during a gale earlier this year. At the North Sea Ferries freight terminal on King George Dock, several caravans due to be exported were overturned and windows smashed.

Mr S. W. Andrew of Louth in Lincolnshire reported as follows:

'A thunderstorm occurred here tonight marking the passage of a vigorous cold front. The first thunder was heard at about 1840, and there were four flashes of lightning to the W. and N.W., none being nearer than 8–10 km. Immediately after one flash, the local street lights were extinguished for a couple of minutes. Regrettably, the discharges had ceased by the time the storm cell was overhead. I would think its track was from between W. and N.W. Incidentally, the temperature at 1800 was 9°C; at 1905 it had fallen to 5°C. The rainfall only amounted to 0.6 mm'.

Four hours later the cold front was reaching Holland. Mr J. J. G. de Jong (of Gorredijk, in Friesland) informed us that a thunderstorm with a dozen claps of thunder had occurred at about 2300 over the Isle of Ameland, north of Friesland. H. A. Veldman reported thunder from his station at Ten Post in the north of Holland at 2320.

G. T. MEADEN

LETTERS TO THE EDITOR

PRECIPITATION FROM SUPERCOOLED FOG

Regarding the two letters in the February issue on precipitation out of freezing fog, the following may be of interest:

On 16 December 1975 the temperature at Edgware at 0730 was —7°C. The sky was clear and there was no fog. Between 0800 and 0900 I cycled past Harrow-on-the-Hill, down Greenford Way. As I came down the long hill to Greenford itself the pavements were covered with what appeared to be a light fall of snow. In places shopkeepers were sweeping it from the pavement, and there was rime 8 mm thick on the hedges. At the bottom of the hill it was foggy. Between Greenford and Heston in the borough of Hounslow, it was foggy all the way, although not very thick, and here and there the pavements were again covered with white crystals. At one spot there were ice crystals still floating in the air.

Interestingly, the temperature at Luton airport that morning, according to London Volmet South, was +1°C, which suggests that there must have been a formidable inversion over the London basin that morning.

10, *Handel Close, Edgware, Middlesex* G. C. JACKSON

NUCLEATION OF ICE-CRYSTALS IN SUPERCOOLED FOG

I read with great interest the letter by R. G. Button 'Rapid Precipitation from Supercooled Fog' and also your own observations of this phenomenon[1]. Both observations closely parallel a recent experience of my own, detailed below.

On 15 December 1975, I was fortunate to witness ice-crystal precipitation from supercooled fog, but the observation properly starts over 12 hours before that time. At 0745 G.M.T., I was driving east along the A329 road between Wokingham and Bracknell, Berkshire. The weather was foggy, with visibility around 100 m. As the temperature was below freezing (—2°C at Easthampstead Park, 3.5 km to the south), I was on the lookout for rime building-up, and indeed a thin layer was seen on trees and bushes in the Wokingham area. When about 1 km west of Bracknell centre, I was surprised to see that all horizontal surfaces were covered with an even, white deposit a few mm thick, including the pavement and roadway, where tyre tracks and footprints were clearly visible. My first conclusion was that there had been a light overnight snowfall, but this theory was quickly dispelled as I drove around the by-pass of the New Town, because the white covering ceased as suddenly as it had begun.

Later that day, at 2155 G.M.T., I was again approaching Bracknell from the west along the same stretch of road. Visibility was poor generally, as low as 15 m near Wokingham, but as I neared Bracknell, it improved to about 200 m, and I was astonished to witness the glitter of a myriad shining motes in the headlight beam. Confirmation that the glittering particles were ice crystals was quickly obtained, as the headlights of approaching vehicles exhibited vertical pillar halo phenomena. This was also noted above the sodium street lights. By the time I reached the by-pass, the optical phenomena ceased, so that the horizontal extent of the ice-crystal precipitation in the direction of my traverse was only about 1 km. It is tempting to link this with the 'snow-covered' area observed earlier that day, the position and extent of the two events being almost identical.

On the following morning, at 0830, I again passed along the same stretch of road, and as on the previous day there was a 'snow' covering starting near the west end of the by-pass and ending about 1.5 km west of the town centre. The by-pass is within 250 m of the town centre along its entire length.

The phenomena I witnessed are interesting because they suggest that an efficient seeding agent must have been active in a very limited area that day, as ice-crystal fog is not normally observed at temperatures warmer than about —30°C[2]. The temperatures at the time have been estimated from the Easthampstead Park values, which give a minimum of —3°C for 2100 on the 14th to 0900 on 15th, and —6°C for the time between 2100 on 15th and 0000 on 16th (personal communication). This sets the probable upper limit of —3°C for activation of the seeding agent. The existence of seeding agents active at these temperatures has been known for some time[3]. It is thus reasonable to postulate that the nucleation of the supercooled fog droplets was, by virtue of its limited extent on a day of widespread supercooled fog, attributable to a locally-produced seeding agent. The source of such an agent could possibly be found on the Bracknell Industrial Estate, on whose northern boundary the observations were made.

It would be of interest to know if the observations of Button and Meaden were also taken in close proximity to sources of industrial effluent at Stratford and at Bradford-on-Avon. If this proved to be the case, then a search might be made for the chemical responsible. This could prove a worthwhile exercise in view of the current activity in the field of cloud seeding, especially in the United States[4].

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2. HUSCHKE, R. E.: Ice fog. *Glossary of Meteorology*, Boston, Mass., p.296 (1970).
3. MASON, B. J.: Ice forming nuclei. *The Physics of Clouds*. Oxford, p.126 *et seq.* (1957).
4. Various. *Journal of Applied Meteorology*, A.M.S., Boston, Mass., **14**, no 5 (August 1975).

27, Cantley Crescent, Wokingham B. J. BURTON

On the matter of *the seeding of supercooled fog* in Bradford-on-Avon, it may be relevant that the Avon Rubber Company Ltd. has factories in the centre of the town. Apart from the usual combustion products associated with the burning of heavy fuel oil, the most likely airborne effluents would seem to be those associated with the use of rubber solvents (naphtha and toluene) and with chlorination processes (ammonia).

Mr. G. N. Bodman, who operates a weather station at an adjacent site, reports that the temperature in the dense fog of Saturday, 17 February 1973 fell to —7°C. In his diary he noted a 'half inch fall of snow'. My own notes, made the same morning, show that I had found out that the precipitation commenced 'before 08 G.M.T.' and terminated 'between 0930 and 1000'.

Sample Collection for Analysis. It would be helpful if, on future occasions, observers would collect samples of crystal fall-out from supercooled fog for forwarding to me for chemical analysis.

G.T.M.

RAINFALL IN THE EDINBURGH AREA—1972 to 1975

Even those who are only marginally interested in the weather must have been aware of considerable variations in the incidence and amounts of precipitation during the past few years. During the prolonged dry spell in the summer and autumn of 1972 some experts predicted a succession of dry years. Certainly, that year produced a rainfall some 200 mm below the average in this area. The following year was even drier, yielding no more that 581.9 mm, nearly 300 mm below the average. In 1974 the total rose to within 20 mm of the average, but in 1975 it was again over 250 mm short. These figures are based on a recording station at an altitude of 227 m on the slopes of the Pentland Hills, just beyond the village of Balerno to the west of Edinburgh. Not only have the totals declined, but the distribution of the rainfall shows interesting anomalies. The table below gives the two wettest and the two driest months in each of the years 1972 to 1975 inclusive.

	WETTEST	DRIEST
1972	May 89.7, April 87.1	September 11.1, August 14.1
1973	July 97.3, December 93.7	June 20.0, March 24.1
1974	December 137.8, November 118.7	April 24.3, May 44.6
1975	January 140.6, September 124.8	December 20.5, May 27.6

Three months, May, September and December, feature in both categories as wettest and driest months. The only absent months are February and October. February was never very wet—the least was 37.3 mm and the most 75.9 mm. October tended to be drier, ranging from 19.5 to 49.9 mm.

In the long term, the wettest season in the Edinburgh area has been the summer, and the driest has been the spring, with August and March at the extremes. However, during the past four years August features only among the dry months. Even considering the three wettest months in each year, August does not appear. In fact, the only summer month to appear on a two-month basis is July 1973. Similarly, from 1972 to 1975 on the basis of the three driest months, March appears once only (namely, in 1973 when it was the second driest month), and no other spring month features at all.

This then is the local evidence for changes in the pattern of precipitation during the past four years.

Department of Geography, The University of Edinburgh. M. G. PEARSON, O.B.E.

HEAVY RAIN OF 10 JULY 1968

I was interested to see in the February issue (page 152) that the rainfall at Rugby on 10 July 1968 was the highest-ever for a 24-hour period in the long record of the station, because I happened to be there staying with a friend over the nights 9/10 and 10/11.

I recorded in my diary that in the morning an unexpected thundery low had developed to the south bringing outbreaks of rain. (The further outlook the previous morning had been 'Sunny spells, a few showers, chiefly in the north' while the forecast in *The Times* of 10 July was 'Most areas will have variable cloud and sunny spells after clearance of local mist and fog patches': in the *Daily Telegraph* 'Mainly dry, sunny spells, early mist'). My diary noted that it was still raining after lunch and that it hardly stopped all day. At 9 p.m. it was still pouring, and at 11 a violent thunderstorm began, with thunder and lightning which kept me awake until 1 a.m. During the following two days I witnessed a good deal of flooding in the country to the south, which I photographed.

Whitewater House, Budleigh Salterton, Devon R. B. M. LEVICK

[A short article by M. K. Vickers on the heavy storms of this day will be published in due course. In North Somerset over 150 mm rain fell in six hours, and 8 people were drowned or killed in the ensuing floods.]

SOME RECENT RESEARCH ON HALOES: A CORRIGENDUM

The suggestion, contained in the antepenultimate paragraph of this recent paper *J. Met.* **1**, 158—9) that the undersun may lie within the 'loop' of the lower tangential arc, is incorrect. In fact, it always lies at the crossing of the arms of the arc, i.e. at the lower point of the loop.

However, the result stands that the intensity there is much greater than at neighbouring points of the arc, and this may contribute to the brightness in Slazvik's picture. No illumination, by the class of crystal producing the tangent arcs, is possible in regions of the sky contiguous to and outside the loop, except for an inverted v-shaped region below, enclosed by the two arms of the arc. The latter is not observed in Slazvik's picture. It might theoretically be somewhat fainter than the loop, but its total absence in this case suggests the absence of ice crystals along this line of sight.

Department of Mathematics and Statistics,
City of London Polytechnic. R. WHITE

WORLD WEATHER REVIEW: DECEMBER 1975

United States. *Temperature*: Warm, most areas (+2 deg some W. States, Iowa and round Chicago); cold, W. California, W. Colorado, Gulf coast, Minnesota and extreme N.E. *Rainfall*: above 150% of normal in N.W. Washington, N. Idaho, Wyoming, the W. half of the Dakotas, coast of Texas, and large areas of E. and N.E. Below 50%, most of Louisiana, parts of Florida.

Canada and Alaska. *Temperature*: S.W. areas and part of Baffin Island rather warm; elsewhere, cold or very cold, —3 to —4 deg in Quebec and Labrador; —4 to —6 deg in Alaska. *Rainfall*: wet, coastal Alaska (especially Panhandle), Alberta, Saskatchewan, most of Baffin Island; very wet in S.E. of country. Dry extreme N. and W. Alaska and around James Bay.

South America. Northern coast mainly cold and wet; Amazon Basin warm and dry; other areas not yet available.

Europe. *Temperature*: Warm most of Scandinavia, N. and E. Germany, European Russia (+2 deg S.E. Norway, W. Sweden, Russia). Cold, S. of 50°N (—3 deg round Bay of Biscay) and extreme N. Scandinavia. *Rainfall*: wet, much of Scandinavia, European Russia, S. and E. Spain; elsewhere dry or very dry, under 25% S. Germany, S.W. France, Paris Basin, S. Brittany, large area round Danube Basin; 6th driest December at Paris since 1872. ***Notable rainfalls***: 2nd: 90 mm in 12 hrs. Santa Maria di Leuca, Italy; 5th: 78 mm, Valencia, Spain; 6th: 70 mm, Castellón de la Plana, Spain; 7th: 129 mm, Antalya, Turkey; 8th: 88 mm, Faro, Portugal; 15th: 78 mm, Ceuta, Spain; 16th: 80 mm, Mont Aigoual, France; 17th: 91 mm, Hercegovni-Igalo, Jugoslavia; 18th: 89 mm, Tripolis, Greece; 22nd: 73 mm, Lajes, Azores.

Africa. *Temperature*: Warm, most of Sahara (+2 deg Mauritania, W. Libya); elsewhere mostly cold, —2 deg in Sudan and Central African Republic. *Rainfall*: wet, coast of Tunisia and W. Libya, S.W. Algeria, coast from Accra to Lagos, most of area 0° to 10°S. Dry, Ivory Coast, W. Ghana, Central African Republic to Kenya. *Notable rainfalls*: 14th: 220 mm, Funchal, Madeira; 16th: 64 mm, Tangier; 17th: 60 mm, Casablanca; 150 mm, Rabat; 57 mm, Meknes; 57 mm in 12 hrs, Marrakesh (all Morocco); 160 mm in 12 hrs, Songea, Tanzania; 22nd: 40 mm, Djerba, Tunisia; 23rd 53 mm, Djerba,.

U.S.S.R. and Arctic. *Temperature*: Almost whole of U.S.S.R. warm, +5 deg N. of Caspian and Aral Seas; Siberia extremely warm, +11 deg at 68°N 110°E; also warm from there across North Pole to N.W. Greenland. Cold, most of Greenland (—4 deg) to Spitzbergen; N.E. Siberia very cold (—9 deg). *Rainfall*: wet, most of U.S.S.R., especially from Leningrad to S. Urals; Taimyr Peninsula; around 140°–150°E (all over 200%). Dry. N.E. Siberia, W. of Lake Baikal, S.E. of country; Spitzbergen very dry. *Notable rainfalls*: 12th: 119 mm, Narssarssuaq; 77 mm, Fredericksbab (both Greenland).

Far East. *Temperature*: Warm in Manchuria (+4 deg), Pakistan, extreme N. India; cold, Persian Gulf, most of India, Bangladesh, S.E. Asia, most of China. *Rainfall*: wet, Iraq, S. Philippines, S. Japan; dry N. India, N. Philippines, N. Japan. *Notable rainfalls*: 4th: 77 mm, Kagoshima, Japan; 9th: 65 mm, Hachichojima, Japan; 80 mm, Chumphon, Thailand; 10th: 70 mm in 12 hrs, Suphan Buri, Thailand; 16th: 80 mm in 12 hrs, Colombo.

M. W. ROWE

FEBRUARY WEATHER SUMMARY: 1976

February was an anticyclonic, generally dry month in northwest Europe. Rainfall was less than one third of normal in parts of eastern England, Denmark and Holland, and just above normal in parts of northwest Britain, Wales, the west Midlands and the Channel Islands. Cold or mild spells developed, according to the position of the main anticyclone, and resulted in a month which was a little milder than average. The anomaly was greatest in northern areas; in the south, where temperatures were nearer to the normal, it was a notably dull month.

February began with high pressure over Scandinavia, and an E. to S.E. airstream which brought wintry conditions to all areas. A succession of slow-moving, occluded fronts produced intermittent light snow, sleet or freezing drizzle, and glazed frost developed widely from the 1st–5th. It was most general and severe on the 2nd when it led to hundreds of road accidents. Some localities had a cover of snow in this period. Temperatures remained below zero night and day in places. Among the lowest maxima were —0.6°C at Stithians (Cornwall) and —1.7°C at Epping (Essex) on the 1st, and —2.4°C at Butser Hill, near Petersfield (Hants) on the 3rd. Minima were not exceptional in England, apart from —3.3°C at Stithians on the 1st which was noteworthy for Cornwall. In Scotland, —14.0° at Inverdruie, Aviemore on the 2nd was the lowest in Britain reported so far this winter.

From the 7th, as the anticyclone moved further eastwards, the winds veered towards the west, and a milder, less settled spell commenced; this lasted until the 12th. There were short periods of rain in all areas and some snow in the north. During the 10th and 11th, a non-frontal trough in a windy, showery airstream gave rise to a burst of showers with local hail and thunder as it moved eastwards across the British Isles. Then on the 12th a deepening depression crossed Scotland, bringing a day of rain to many parts of Britain while moving southeast towards the Low Countries. Between 0900 and 2100 h 25.0 mm rain fell at Gurney Slade (Somerset), and 20 mm at Rhoose (S. Wales) and Guernsey. The same depression was responsible for a 12-hour fall of 37.5 mm rain at Grenoble on the 13th, and there were abundant snowfalls in the Alps.

As pressure rose again, the cold easterlies returned, and night frosts were frequent from the 14th–20th. There were several avalanches in France on the 15th which killed 12 and injured another 12 people. Then as the high became centred over eastern Europe, a mild regime with southerly winds affected the west. Apart from some weak fronts on 21st–23rd caused by a mid-Atlantic depression and its subsequent waves, quiet mild weather predominated until the last day of the month. 15°C was reached in the London area and at Torquay (S. Devon) on the 24th, and 15°C was fairly widespread the next day. Finningley, to the east of the Pennines, recorded 16.5°C and Dyce, in east Scotland, recorded 16.6°C (a station record). Even Aviemore had 12.7°C and Donski (Norway) 12.6°C on the 25th. 15°C was also reached in England on the 26th and 29th. Leuven (Belgium) had 15.4°C on the 28th, and Grenoble 19–20°C on 27th–29th. The mild air brought fog to parts of the Continent and to English Channel coasts. Finally, on the 29th a cold front swept briskly southeastwards bringing squalls and thunder to Humberside and later to northern Holland (see articles).

Over Central England the mean February temperature was 4.5°C, which was above the average for the sixth consecutive year.

Professor Lamb's classification of daily circulation types for *February* is as follows: 1 AE; 2–3 E; 4 AE; 5 E; 6 SE; 7 S; 8–10 W; 11 NW; 12 C; 13 —; 14–16 A; 17 SE; 18–22 S; 23 SW; 24–25 W; 26 AW; 27 A; 28-29 SW.

For *January* it was: 1–2 C; 3 NW; 4 AW; 5 W; 6 AW; 7–9 W; 10–11 NW; 12–13 AW; 14 ANW; 15 A; 16 AW; 17 A; 18 AW; 19–20 W; 21 NW; 22 CNW; 23 NW; 24–25 N; 26 NW; 27 —; 28 CS; 29 S; 30–31 E. (More details are given in the Climatic Research Unit Monthly Bulletin, cf *J. Met.*, no 4, p. 139).

SUPPLEMENTARY WEATHER NOTES: FEBRUARY 1976

LEUVEN UNIVERSITY, Belgium (H. Poppe): 74.3 h sun; snow 3rd, 11th and 13th.
FREDERIKSSUND, Denmark (E. Skjodt): 49.9 h sun; fog on 13 days.
GRENOBLE, Poisat, France (H. L. Cheyroux): 19-20°C le 27, 28 et 29.
AMERSFOORT (K. W. Bijker): Snow lay from 27 January to 8 February.
MARKEN (J. Visser): M.S.L. pressure 1019.4 mb; 8 days with fog.
TEN POST (H. A. Veldman): Sixth successive winter with mean temperature above average (this year by 1.3°C, compared with 3.5°C last winter).
DONSKI, Norway (Bernt Lie): Snowiest February since 1966, but mean temperature 1.7°C above normal; the 25th was warmest in February since 1943.
STRAIDE, Co. Mayo (M. Sweeney): tl on 10th at 1945 and 2215: rainfall 53% of average; mean temperature 1.2°C above average.
ARMAGH OBSERVATORY: 63 h sun, 70% of average; rainfall 71%.
BESSBROOK, Newry: 57.0 mm on 16 days; 12 mm on 20th; snow lay on 11th.
WHALSAY (S. G. Irvine): 36.1 h sun; snow lay on 12th.
BRAEMAR (J. C. Donaldson): 30.8 mm rain; snow lay on 1st-12th, 17th-18th.
INVERDRUIE, Aviemore: Ground frost every day from 14 January to 25 February, and ground frozen for 21 days up to the 21st.
EDINBURGH: Winter rainfall 71.5 mm (54%); winter temperature, 1.6 deg above average.
CRIBYN (G. N. Sumner): 74.4 mm rain on 15 days; 33.0 on 12th; snow lay 4th/5th.
SWANSEA City (B. C. Mayor): tlrh at 2230-35 on 10th. 10 km to the W.
SWANSEA, Sketty (I. Jones): 52.6 h sun; 30 cm earth temperature, 4.5°C.
STITHIANS: 47.0 h sun; winter rainfall only half the normal.
ILMINSTER: 20 cm earth temperature rose from 1.0°C on 1st to 7° on 29th.
GURNEY SLADE (W. J. Newman): Snow lay 2nd-5th; t on 10th late p.m..
DUNDRY HILL, 230 m: Extremes of 11°C (29th) and —2°C (1st, 2nd).
TROWBRIDGE: Glazed frost on 2nd and 3rd; hail at 01 on 11th.
CORSHAM: Glazed frost 1st-3rd; winter rainfall 40% of the average.
CODFORD: Rainfall 66% of average; severe icing on morning of 2nd caused road chaos in the locality.
BOSCOMBE DOWN, Wilts (P. Brown): Freezing drizzle from 2200 on 1st gave glaze 1-2 mm thick by dawn which mostly melted in the afternoon; glaze formation renewed in the evening of 2nd, and persisted until 4th.
SANDHURST: Rainfall 54%; 203 h AF; snow lay on 1st.
ROMSEY, Hants (C. Watts): 36.7 h sun; 38.3 mm rain at Lyndhurst.
NEWPORT, Shide (D. J. Simmons): The driest winter at nearby Ryde since at least 1918 (40% average), and the second dullest with 33.8 h sun.
BRIGHTON: Very dull, dry month; snow lay on 4th; thick fog on 28th.
HASTINGS: Local h, 10 km north at Battle on 11th; 5 days of fog.
EAST MALLING Research Station: 40.6 h sun; fog on 6 days.
GILLINGHAM (B. M. Smith): Snow lay 2nd-4th; 68h of air frost.
GUILDFORD, Stoughton: Overall winter rainfall of 72.2 mm.
WORPLESDON, Merrist Wood: 39.7 h sun; 27.2 mm rain (15.3 mm on 12th).
EPSOM DOWNS: Mean maxima and minima of 6.9 and 2.1°C; 14°C on 25th and 29th; 30.4 mm rain; 16.6 on 12th; snow 5 days; snow lay from 2nd to 4th.
HAMPSTEAD OBSERVATORY (R. Tyssen-Gee): 38.4 h sun; 26.0 mm rain in 20.3 h on 10 days; 14.4 mm on 12th; slight snow on 1st, 2nd and 3rd.
EPPING (R. J. Prichard): Freezing drizzle on 1st and 3rd; hail on 11th.
GREAT EASTON: Glazed ice on the 3rd thickened to 2-4 mm by evening; 18.3 mm rain on 10 days, 8.9 mm on 12th; snow lay 1st-2nd.
BUXTON, Norfolk: Mean 30 cm earth temperature. 4.2°C (1.9°C on 3rd, 7.0°C on 27th); snow lay 1st-5th; rainfall $\frac{1}{3}$ of the average.
STROUD: Rainfall 62% of average; snow lay on 4th.
OXFORD UNIVERSITY, Radcliffe: 42.6 h sun (26.6 h below average); rainfall 45%; the winter rainfall was the third lowest in 160 years; mean air temp. +0.4 deg; mean 30 cm earth temp. 4.2°C (+0.4 deg); snow lay on 2nd-5th.
BUCKINGHAM: Periods of snow and freezing drizzle in first 5 days; snow lay 1st-5th; heavy hail in the early hours of 11th; rainfall 48% of average.

KETTERING, Northants, 50 m A.S.L. (T. J. Keech): 20.6 mm rain on 17 days (49% of average), 5.8 mm on 10th; snow lay 1st-3rd.

NORTHAMPTON, 100 m A.S.L.: 14.4 mm rain (25% average); winter rainfall of 74.0 mm; hail on 11th; snow lay 2nd-4th.

BIRMINGHAM UNIVERSITY, Edgbaston: Three days in last week warmer than in any February since 1961; 26th, highest since 28 Feb. 1960; mean temperature 0.3° above average; 58.9 h sun (1.0 above average); 7 fogs at 0900.

LONG LAWFORD (S. D. Burt): Rainfall 55%, sunshine (56.7 h) 97% of average; mean temperature, 0.8°C above average; 30 cm ground mean, 4.1°C; glaze 2-5 mm thick 2nd-3rd; temperature fell from 9.5 to 5.5°C in 2-3 min. on 29th at 19h.

LEICESTER, Braunstone: Mean temp., 1.2° above average; winter rain, 61%.

NEWARK (I. T. Lyall): 26th, warmest February day since 1960; t on 29th (1815).

WINGERWORTH (D. Fellowes): 51.6 h sun; severe glaze on 2nd, continuous on hilltops from 1st-5th, ice thickness up to 3.5 cm; mean 30 cm earth temp 3.6°C.

BORROWASH, Derby (N. Hudson): 20.6 mm rain on 16 days; 5.1 mm on 12th.

KEELE UNIVERSITY, Staffs. (M. Edge): 51.2 h sun; mean temperature, 0.9 deg. and rainfall 8% above average; MSL pressure 1017.6 mb; maximum 1034.8 mb (26th).

LIVERPOOL, Knotty Ash: Third successive very mild winter (mean of 6.2°C); geraniums planted in 1972 surviving well; mean maximum 12.9°C in final week.

LEIGH, R. C. School: 43.4 mm rain, 14 days; temperature extremes 13.5°C (25th), —2.3°C (14th).

ST. HELENS (Pilkington, Central Laboratory): 53.3 mm rain, 16.9 mm on 12th.

BILLINGTON (T. K. Suttie): Sixth consecutive mild February; 1971-76, the warmest run of winters in the Ribble Valley since records began at Stoneyhurst College, 1848.

SHEFFIELD (J. A. Groocock): Widespread glazed frost 2nd-5th, many accidents on 2nd; 25th, warmest in February since 1961; snow lay 3rd, 4th, 11th.

HIGH BRADFIELD (Dr. Smithson, Sheffield University): 44.4 mm, 7.2 on 12th.

HULL (J. Edson): t on 29th; 21.4 mm rain on 16 days.

COTTINGHAM: 22.1 mm rain on 16 days; 4.1 mm 12th; line squall and tl 29th.

CUMBRIA (P. R. Cutforth): Mean temperature, Carlisle 5.2°C (+1.7), Penrith 4.1°C, Ambleside 3.9°C (+0.8); rainfall, Grasmere 138 mm, Ambleside 125, Kendal 95, Carlisle 49, and Penrith 43 mm.

DEVONPORT, Auckland, N.Z. (M. R. Blake): 65% average rain; mean maximum 3.1°C below normal; tl on 10th.

SAN FRANCISCO (N.O.A.A.): rainfall 70% of average; tlh 4th, tl 5th, 10 fogs.

HALIFAX, Nova Scotia: 107.1 h sun; MSL pressure 1006.6 mb.

TEMPERATURE TABLES: FEBRUARY 1976

STATION	MEAN Max	MEAN Min	HIGHEST Max	HIGHEST Min	LOWEST Max	LOWEST Min	GRASS Min	AF	GF
BELGIUM: Leuven	7.0	1.0	15.4(28)	8.1(25)	—2.4(2)	—7.1(22	—9.4(2)	10	15
DENMARK: Fred'k'd	2.0	—3.2	7.7(26)	3.2(15)	—2.7(15)	—10.4(1)	—12.4(1)	24	26
NETH'L'S: Amersfoot	6.2	0.7	13.7(28)	6.4(24)	—5.1(1)	—8.6(1)	—9.2(1)	9	13
,, Gorredijk	4.7	—0.8	12.5(22)	5.2(24)	—6.0(1)	—9.8(1)	—10.3(1)	16	17
,, Marken	4.5	—0.8	11.0(29)	4.1(26)	—4.5(1)	—8.9(1)	—9.0(1)	17	19
,, Ten Post	4.0	—0.8	12.0(28)	4.5(a)	—5.1(1)	—9.5(1)	—11.0(1)	17	21
NORWAY: Donski	—0.1	—6.6	12.6(26)	1.5(26)	—6.9(3)	—17.8(3)	—22.4(3)	28	29
SWEDEN: Valla	0.6	—5.2	9.3(26)	5.2(26)	2.1(2)	—4.0(16)	—	25	28
EIRE: Straide	8.9	2.7	12.8(9)	9.1(26)	2.1(2)	—4.0(16)	—	3	0
N. I'LAND: Armagh	7.6	2.1	12.0(9)	8.3(26)	1.5(2)	—1.9(7)	—4.9(b)	8	19
,, Bessbrook	7.8	2.6	13.2(26)	8.3(26)	1.7(2)	—1.7(18)	—	4	—
Moneydig	8.1	1.5	13.5(25)	8.2(26)	2.8(2)	—2.7(16)	—7.6(16)	9	15
MAN: Port St Mary	6.5	3.5	10.8(26)	7.5(27)	2.7(2)	0.0(3)	—	0	1
SHETLAND: Whalsay	6.1	2.9	9.8(25)	6.9(28)	2.6(1)	—0.5(5)	—3.7(12)	3	10
SCOTLAND: Keiss	7.3	2.6	12.2(25)	6.8(28)	4.3(11)	—2.5(11)	—4.8(20)	4	11
,, Braemar	5.2	—0.8	10.7(25)	5.6(c)	0.9(3)	—8.9(3)	—10.6(2)	16	21
,, Inverdruie	7.0	—1.2	12.7(25)	8.9(25)	2.0(2)	—14.0(2)	—18.7(2)	14	23
,, Ed'burgh	6.9	2.9	12.7(25)	9.1(25)	2.6(18)	—2.8(14)	—6.8(14)	5	11
WALES: Lampeter	7.0	1.6	12.7(25)	6.9(d)	0.4(1)	—4.0(14)	—7.5(9)	11	19
,, Cribyn	6.8	1.3	12.7(29)	6.1(e)	0.1(1)	—4.5(14)	—	11	—
,, Swansea	6.5	2.2	10.8(24)	6.5(27)	0.5(1)	—3.0(1)	—5.8(1)	7	10
ENGLAND									
Penryn, *Cornwall*	8.8	4.3	13.0(24)	10.9(22)	0.7(1)	—1.3(13)	—3.5(14)	4	7
Stithians, *Cornwall*	7.6	3.3	11.7(22)	8.9(23)	—0.6(1)	—3.3(1)	—	5	—
Ilminster, *Som*	7.3	2.4	14.3(24)	9.5(24)	—0.5(1)	—4.0(15)	—9.0(15)	11	16
Gurney Slade, *Som*	5.9	0.8	11.8(26)	7.8(23)	—1.1(1)	—5.3(15)	—6.9(15)	11	15
Bath, Odd Dn, *Avon*	6.3	1.4	12.5(29)	8.4(24)	—0.6(1)	—3.4(1)	—5.3(15)	12	15
Trowbridge, *Wilts*	7.1	2.3	13.0(29)	9.3(24)	0.2(3)	—3.5(15)	—7.5(15)	9	14
Corsham, *Wilts*	6.8	2.2	12.5(29)	8.8(24)	—0.3(1)	—2.6(15)	—5.8(15)	10	14
Codford, *Wilts*	7.2	1.3	12.1(24)	7.1(24)	0.0(1)	—4.7(15)	—5.3(15)	11	12
Reading Univ, *Berks*	7.3	2.2	14.5(29)	8.5(24)	0.5(1)	—2.5(4)	—7.5(9)	8	20
Sandhurst, *Berks*	7.8	2.1	15.0(29)	9.4(24)	0.5(f)	—4.4(9)	—8.9(9)	8	24
Butser Hill, *Hants*	4.6	1.4	9.5(24)	6.0(24)	—2.4(3)	—3.9(4)	—5.0(4)	11	—
Newport, *Wight*	7.0	3.2	12.8(24)	8.7(24)	0.2(3)	—1.4(1)	—5.8(9)	5	13
Brighton, *Sussex*	6.7	2.2	10.6(24)	7.2(27)	0.6(f)	—2.2(g)	—3.9(15)	7	14
East Malling, *Kent*	7.3	1.8	14.0(29)	7.4(24)	0.4(1)	—1.5(h)	—7.1(9)	8	18
Gillingham, *Kent*	6.6	2.2	13.4(21)	8.3(24)	—1.1(3)	—1.7(2)	—	7	—
Sidcup, *Kent*	7.7	1.9	15.4(25)	7.2(24)	0.0(1)	—3.8(15)	—7.0(15)	8	18
Guildford, *Surrey*	7.7	2.8	14.7(29)	9.5(24)	0.0(3)	—1.7(4)	—3.8(16)	7	17
Worplesdon, *Surrey*	7.2	1.9	13.8(29)	7.8(24)	—0.1(1)	—2.0(1)	—6.6(9)	9	19
London, S.W.18	8.0	2.4	15.3(29)	9.4(22)	0.0(i)	—3.3(15)	—7.5(15)	5	15
,, Hampstead	6.9	1.9	14.2(29)	8.0(24)	—0.5(1)	—2.6(1)	—6.5(15)	7	19
Rickmansworth, *Herts*	7.3	2.0	15.0(29)	9.6(24)	—0.1(1)	—3.9(9)	—7.5(9)	7	14
Epping, *Essex*	6.1	0.8	14.6(29)	8.0(24)	—1.7(1)	—4.2(15)	—9.3(15)	12	20
Great Easton, *Essex*	6.7	1.4	14.4(s)	9.1(24)	—0.6(1)	—3.3(15)	—7.7(15)	10	21
Leigh-on-Sea, *Essex*	7.1	2.2	14.4(29)	8.4(24)	0.0(3)	—2.5(7)	—4.7(7)	7	15
Buxton, *Norfolk*	7.0	2.0	15.0(25)	7.5(24)	0.7(2)	—1.2(9)	—4.8(15)	7	19
Ely, *Cambs*	7.1	1.1	14.6(25)	6.6(23)	0.5(3)	—2.0(14)	—7.4(14)	10	17
Stroud, *Glos*	8.1	2.9	14.4(29)	7.8(23)	1.1(3)	—2.2(1)	—4.1(15)	7	13
Witney, *Oxon*	7.1	1.8	14.3(24)	9.4(24)	0.0(3)	—3.3(3)	—5.4(9)	11	12
Oxford (Radcliffe)	7.4	2.2	14.4(29)	9.2(24)	0.1(3)	—2.5(1)	—5.6(j)	8	14
Buckingham, *Bucks*	6.9	1.5	14.3(29)	8.8(24)	—0.2(3)	—2.8(16)	—16.7(16)	11	14
Kettering, *North'ts*	7.0	1.5	14.5(25)	7.2(24)	0.2(k)	—3.9(16)	—6.6(16)	12	18
Edgbaston, Birm'ham			13.4(26)	7.2(26)	—0.4(2)	—2.3(3)	—8.3(15)	11	14
Long Lawford, *Wks*	7.0	1.1	14.6(26)	7.2(23)	—0.3(k)	—3.3(14)	—6.6(14)	13	20
Hinckley, *Leics*	6.9	1.4	13.9(l)	6.8(23)	—0.2(2)	—3.1(16)	—5.2(15)	11	16
Braunstone, *Leics*	6.7	1.8	13.7(25)	7.0(23)	0.2(3)	—2.3(16)	—6.0(m)	11	16
Newark, *Notts*	7.3	1.9	15.2(26)	7.1(23)	0.5(3)	—4.0(16)	—7.0(16)	8	15
Nottingham, *Notts*	7.7	1.9	15.0(26)	8.3(25)	0.9(2)	—3.0(15)	—	7	—
Wingerworth, *Derby*	6.4	1.1	14..3(25)	7.2(23)	—0.1(2)	—5.3(16)	—9.1(16)	11	21
Borrowash, *Derby*	7.6	2.2	14.9(26)	7.8(23)	0.9(3)	—2.6(9)	—6.1(15)	9	18
Keele Univ, *Staffs*	6.0	1.1	13.1(26)	6.8(23)	—0.5(2)	—2.6(16)	—5.1(n)	12	17
Liverpool (Kn Ash)	7.8	3.1	13.9(23)	8.5(26)	2.3(2)	—2.4(14)	—7.8(14)	5	13
St. Helens, *M'side*	7.2	1.8	13.6(25)	6.2(26)	2.5(o)	—2.7(1)	—	7	—
Billington, *Lancs*	7.1	2.5	13.1(25)	8.2(23)	1.4(2)	—4.0(14)	—8.3(14)	6	11
Sheffield, *S. Yorks*	6.3	1.7	14.4(25)	7.2(23)	0.0(2)	—2.8(16)	—6.7(16)	8	18
High Bradfield, *Yorks*	2.4	—1.0	9.0(25)	3.3(27)	—2.8(16)	—5.2(16)	—	18	—
Hull. *Humberside*	7.2	2.5	14.4(25)	7.2(p)	2.8(i)	—3.3(16)	—7.2(16)	4	10
Cottingham, *H'side*	7.3	2.2	15.1(25)	7.3(25)	2.7(q)	—4.7(16)	—5.8(16)	4	12
Pickering, *N. Yorks*	6.4	1.2	13.2(25)	7.1(26)	2.0(15)	—3.5(16)	—6.3(16)	8	13
Low Etherley, *Dur*	5.4	0.7	11.8(23)	6.5(26)	1.0(16)	—2.9(14)	—5.2(14)	14	24
CANADA, Halifax	2.4	—7.8	10.6(2)	1.3(27)	—10.2(6)	—16.8(7)	—	27	29
U.S., San Francisco	14.6	5.9	21.1(1)	10.5(28)	5.0(5)	1.1(5)	—	0	—
N.Z., Devenport	22.6	16.9	25.0(13)	21.0(6)	21.1(r)	13.3(26)	—	0	0

(a) 26, 28; (b) 16, 20; (c) 27, 28; (d) 26, 27; (e) 23, 27; (f) 1, 2, 3; (g) 1, 3, 15; (h) 4, 19; (i) 1, 3; (j) 9, 16; (k) 2, 3; (l) 25, 26; (m) 14, 16; (n) 9, 14; (o) 1, 2, 3, 18; (p) 23, 25; (q) 1, 2; (r) 1, 24, 26; (s) 25, 29:

RAINFALL TABLES: FEBRUARY 1976

STATION	RAINFALL 9—21	RAINFALL 21—9	RAINFALL 9—9	WETTEST PERIOD 9—21	WETTEST PERIOD 21—9	WETTEST PERIOD 9—9	RAINY PERIODS 9—21	RAINY PERIODS 21—9	RAINY PERIODS 9—9	snow	hail	snow lay
Leuven*	13.5	13.6	27.1	4.3(11)	12.6(12)	15.5(12)	5	3	9	3	1	—
Frederikssund*			12.3			3.8(25			8	3	0	10
Grenoble*	45.0	31.3	76.3	37.5(13)	15.8(8)	42.5(13)	3	5	6	1	—	1
Amersfoort*	12.1	16.2	28.3	4.5(11)	6.2(29)	7.2(12)	5	5	7	4	1	8
Gorredijk*			26.8			10.1(13)				6	—	11
Marken*			18.7			5.9(12			7	4	1	8
Ten Post*	11.4	15.4	26.8	8.0(13)	4.7(11)	10.6(13)	4	5	6	5	1	16
Donski*	29.6	33.0	62.6	9.4(21)	11.2(23)	12.0(23)	10	8	15	16	1	29
Valla*			8.8			2.8(10)				14	0	18
Straide			46.0			9.3(11)			15	2	2	0
Armagh			40.3			8.6(11)			15	2	2	1
Moneydig			50.7			12.2(11)			12	4	2	1
Port St. Mary†			53.7			11.5(23)			19	1	1	0
Whalsay			98.7			17.5(22)			21	6	8	1
Inverdruie			30.7			6.1(15)			15	10	0	11
Braemar			30.8			7.0(22)			18			14
Edinburgh	7.1	16.0	23.1	1.6(6)	5.7(14)	5.7(14)	7	9	11	3	0	1
Lampeter			68.8			32.0(12)			16	6	0	1
Swansea†			90.1			24.3(18)			18	5	0	0
Penryn†			67.9			20.6(12)			18	0	0	0
Stithians			86.2			23.4(12)			23	2	1	0
Gurney Slade	53.6	20.3	73.9	25.0(12)	7.4(10)	27.5(12)	14	13	17	5	2	4
Dundry Hill	30.6	22.7	53.3	10.3(12)	5.5(5)	12.0(5)	10	11	18	5	0	3
Bath, Odd Dn†			40.0			8.6(5)			13	6	0	2
Bradford/Avon	24.9	15.8	40.7	8.6(12)	6.4(10)	8.7(a)	11	8	14	5	1	0
Trowbridge	24.8	13.1	37.9	8.1(12)	4.3(10)	8.4(5)	10	8	14	5	1	0
Corsham*	17.9	22.3	40.2	6.8(6)	7.5(10)	10.8(6)	11	8	13	7	0	0
Reading Univ			28.4			15.2(12)			14	3	0	1
Sandhurst	20.9	5.5	26.4	15.5(12)	2.5(10)	17.0(12)	5	6	8	2	0	1
Romsey	23.8	8.3	32.1	13.6(12)	1.8(5)	13.6(12)	10	8	14	4	0	0
East Malling	18.7	6.7	25.4	17.0(12)	1.9(10)	18.4(12)	4	8	9	5	0	1
Gillingham	18.3	6.0	24.3	12.0(12)	3.3(12)	15.3(12)	11	4	13	5	0	3
Sidcup	18.7	6.9	25.6	13.0(12)	2.5(10)	14.5(12)	8	5	11	5	0	2
Guildford	21.7	7.4	29.1	15.2(12)	2.2(21)	16.9(12)	6	8	12	4	0	2
London, SW.18	14.0	7.3	21.3	11.6(12)	2.5(10)	13.6(12)	6	6	10	5	0	1
Rickmansworth†	8.4	15.0	23.4	10.4(12)	3.3(22)	10.4(12)	10	5	14	4	0	0
Epping	15.3	7.6	22.9	10.6(12)	1.6(12)	12.2(12)	9	8	13	3	1	0
Leigh-on-Sea	7.2	6.7	13.9	2.5(12)	1.3(21)	3.5(12)	6	9	12	3	0	0
Buxton	5.5	8.3	13.8	3.3(12)	2.8(9)	4.0(12)	5	6	10	1	1	5
Ely†	9.5	10.1	19.6	5.7(12)	6.4(10)	6.6(12)	6	5	10	2	0	0
Stroud	20.5	17.5	38.0	7.5(12)	5.5(5)	9.0(6)	7	9	12	4	0	1
Witney	16.5	4.9	21.4	9.6(12)	1.6(12)	11.2(12)	11	5	16	6	0	2
Oxford			18.8			11.0(12)			13	5	0	3
Buckingham			22.6			10.1(12)			15	5	1	5
Edgbaston	20.8	16.8	37.6	10.5(12)	3.5(6)	10.9(12)	12	13	17	10	0	6
Long Lawford	11.4	10.7	22.1	5.8(12)	4.3(10)	6.3(12)	9	10	13	5	0	3
Braunstone	10.8	7.9	18.7	4.3(12)	1.8(10)	5.1(12)	13	10	17	4	1	1
Hinckley	13.0	11.5	24.5	5.9(12)	2.6(6)	6.4(12)	10	10	16	7	0	3
Nottingham	7.2	9.2	16.4	2.8(12)	1.8(10)	3.1(12)	9	11	16	4	2	1
Newark†			12.9			2.9(12)			15	3	1	0
Wingerworth	18.2	13.0	31.2	3.5(3)	2.9(23)	4.1(3)	16	15	21	7	4	1
Keele Univ			51.3			15.0(12)			17	5	3	—
Billington†			42.9			8.5(12)			16	4	1	1
Sheffield			35.5			5.1(12)			19	6	1	3
Pickering	6.6	11.1	17.7	1.7(29)	3.0(11)	3.0(11)	17	9	17	2	1	4
Low Etherley			37.0			6.2(6)			20	6	0	11
Halifax			128.4			41.4(22)			19	25	—	15
San Francisco			54.1			34.0(29)			11	2	1	0
Devonport	14.6	14.6	29.2	6.8(16)	14.6(6)	21.4(6)	4	1	4	0	0	0

* Observation hours 06, 18 GMT; † other hours; (a) 5, 12.

WANTED

A second-hand Stevenson screen. Details with price to Mr G. C. Jackson, 10 Handel Close, Edgware, Middlesex, HA8 7QZ.

Out-of-print meteorological books, pamphlets, and the following journals: Met. Mag. 1932–1969; Q. J. R.M.S. pre-1958, British Rainfall 1878, 1881/2, 1888, 1903, 1910–12, 1914–16, 1923–24, 1927–39. Details to the editor, J. Met.

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FRONT COVER: Distribution of heavy rainfall over the county of Cumbria on 24 September 1975 (see the article by P. R. Cutforth).