Frontispiece

Sir George C. Simpson, F.R.S.

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PRESENTATION TO SIR GEORGE SIMPSON AND LADY SIMPSON

The retirement of Sir George Simpson, K.C.B., C.B.E., D.Sc., F.R.S., on September 2nd after 18 years service as Director closed another chapter in the history of the Meteorological Office. The occasion was marked by a memorable ceremony in the library of the Office at South Kensington at which a presentation was made to Sir George and Lady Simpson from the staff of the Office.

Mr. R. G. K. Lempfert, Assistant Director, presided, and opened the proceedings by offering congratulations to Sir George on his 60th birthday. He proceeded, in a very interesting speech, to trace the early history of the Meteorological Office and included some recollections of Mr. G. C. Simpson, as he was then, when in 1905 he worked in the Office for a time as a voluntary assistant. He gave also an outline of Sir George Simpson's career and experience in various parts of the world and referred in particular to his important researches in geophysics. In speaking of the period subsequent to the appointment of Sir George as Director of the Office in 1920, Mr. Lempfert recalled the difficulties which had to be surmounted at that time when the Office was still in process of transfer to the Air Ministry and the many important developments which had since taken place, especially during the last few strenuous years. He asked Sir George to accept a silver tray, suitably inscribed, and an album containing the signatures of members of the staff at home and abroad, as a concrete expression of their regard and as a reminder of happy days spent in the Meteorological Office.

Lady Simpson was the recipient of a travelling watch in a leather case, which was presented on behalf of the staff by Miss D. G. Chambers, who referred to the many ways in which Lady Simpson had, during the whole of her husband's term of office, shown her interest in the Office and the staff. In a charming and witty speech Lady Simpson expressed her gratitude for the gift and particularly for the thoughts which had prompted it.

A further tribute to Sir George Simpson took the form of a handsome silver cup which the staff of the Meteorological Office presented to the Air Ministry Athletic Association, to be known as the Simpson Cup and awarded annually for the best individual performance in departmental sport and athletics. Mr. H. L. B. Tarrant acted as spokesman for the staff and asked Mr. Richards, Chairman of the Athletic Association, to accept the cup in commemoration of the deep interest which Sir George had always displayed in every kind of sport in the Office and the Air Ministry. In accepting the cup, Mr. Richards spoke in terms of warm appreciation of the valuable assistance which Sir George had rendered to the Athletic Association, particularly since 1925 as Vice-Chairman of the Executive Committee and later as Vice-President of the Association and as Treasurer of the Sports Committee. Mr. Richards regarded it as very appropriate that the name of Sir George should be perpetuated in that way and expressed the thanks of the Association to the staff of the Meteorological Office for presenting the cup.

Sir George Simpson said that it was difficult to express one's feelings on such an occasion. Of the gifts which had been made he appreciated most of all the album of signatures because it was a personal token and he had always laid great stress upon the personal relationship between the different grades in the Office. Next in order of his appreciation was the silver cup which had been presented to the Athletic Association. He had, indeed, always taken a keen interest in departmental sport and he hoped that one of the names to be inscribed upon the cup would be that of a member of the staff of the Office. Sir George recalled the many changes that had taken place since he became Director and, as a matter of personal pleasure, to the improvement which had been effected in the grading of the staff. He expressed warm thanks to all members of the staff for their help and support and mentioned specially the friendship and co-operation which had been given to him throughout by the Assistant Directors.

The Thunderstorms of August, 1938

The first twelve days of August provided a remarkable series of thunderstorms over practically the whole of the British Isles. Among the stations from which observations are published in the *Daily Weather Report,* only Blacksod Point and Lerwick escaped thunder in the period. Blacksod had heavy rains of thunderstorm origin, but Lerwick had no rain and 125 hours of sunshine in the twelve days. There was a period of 13 consecutive days of more or less widespread thunderstorms as recently as June 14th–26th, 1933,[1] but the recent storms were of a severer type, occurring in warmer and damper weather.

The 46 stations for which day and night observations are published on page 1 of the *Daily Weather Report* give a fairly good indication of the frequency of the storms. The following table gives the number of reports of thunder in the period, after entering up certain observations missing in the original issue, owing to telegraphic breakdowns caused by the storms.

August, 1938.	1h.–7h.	7h.–13h.	13h.–18h.	18h.–1h.	Total.
1	0	3	6	2	11
2	0	4	2	2	8
3	1	0	2	4	7
4	9	7	9	15	40
5	7	8	4	6	25
6	4	1	2	3	10
7	2	3	3	4	12
8	6	2	7	1	16
9	0	3	8	3	14
10	0	2	2	1	5
11	0	0	9	7	16
12	2	7	20	7	36
Total ...	31	40	74	55	200

It will be noted that there was a considerable number of night storms, and it was only on the 1st and after the 8th that the characteristic diurnal variation asserted itself. Up till the 8th the storms were mainly of frontal type. Fig. 1 shows the chart for 13h. on August 1st, the first day of thunder. The pressure distribution had changed greatly since July 30th, when there was a pronounced southwest current, with flooding in the Lake district. In the 48 hours ending at 7 h. on 1st pressure had risen by 26 mb. at Wick, and 35 mb. at a point about 400 miles west of Blacksod Point. This development originated in an ordinary wedge of high pressure. The storms on

[1] W. A. L. Marshall, "The Thunderstorms of June, 1933", *London Quart. J.R. Met. Soc.*, 59, 1933, p. 416.

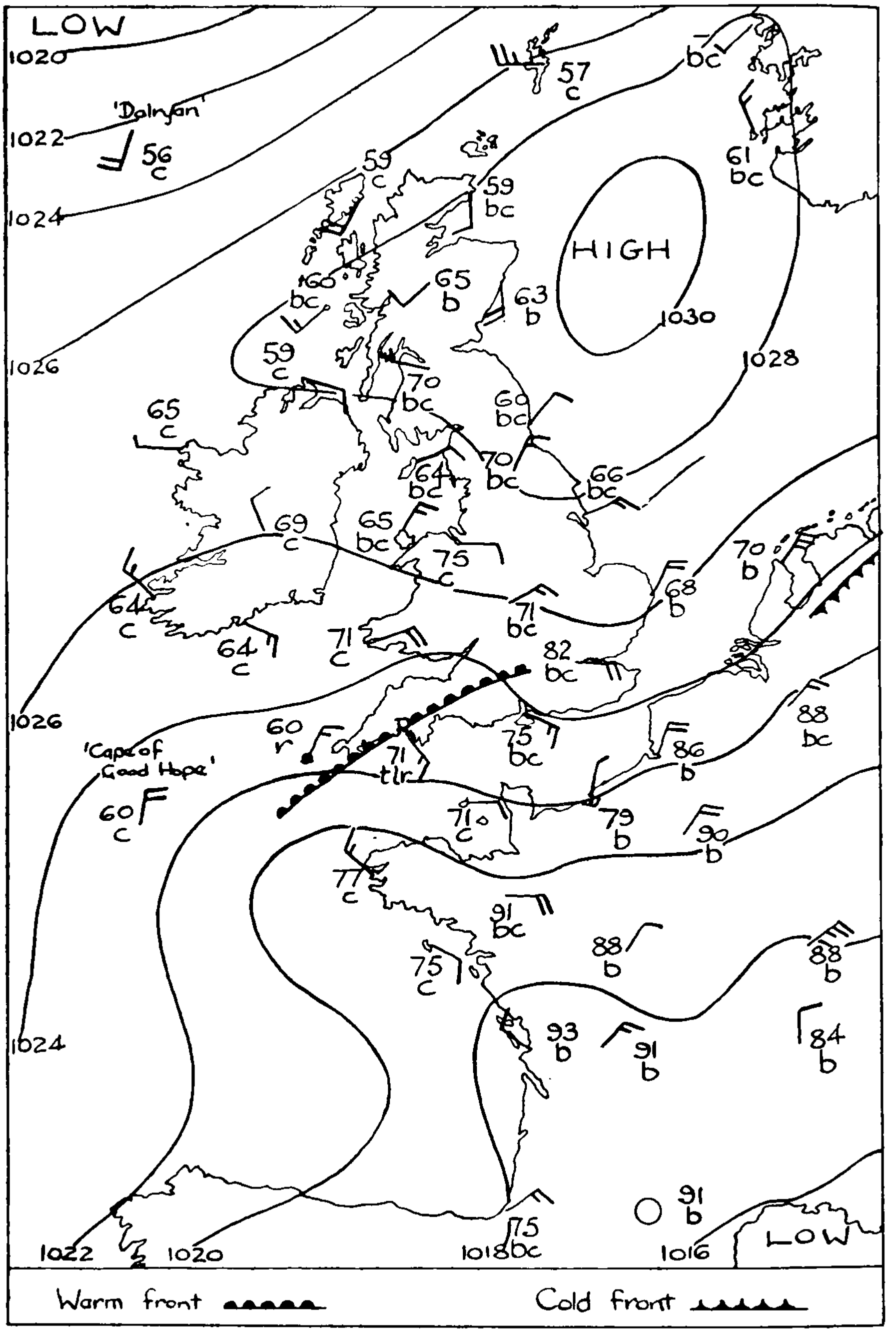

FIG. 1. 13H. 1ST AUGUST, 1938, MONDAY

the 1st were general and severe in southwest England, and moved northwest over Wales and Ireland during the next 24 hours. The warm front marked on the chart, which gave rise to the storms, was originally a long cold front of Atlantic origin, and was associated with the rains of the 29th and 30th ; but only a part of the original front was still active in our area on the 1st, when it moved back under the influence of the reversed pressure distribution. It gave no rain over most of southern England till the surface air had been warmed and thunderstorms broke out. The cold front shown on fig. 1 over north-west Germany was originally joined to it. The bulge in the isobars off Brittany was separate from the front, and was due to the spreading of low pressure from the western Mediterranean. This development continued and was accompanied by a series of thunderstorms which moved northwest from France across southwest England to Wales and Ireland. Their source was the very warm continental air, which had spread westward from southern Russia during the last week of July. Much of the moisture must have been evaporated from the land surface. Since the surface layers contain most heat, moisture evaporated into them is specially effective for thunderstorm formation. (The humidity question is discussed more fully below, in relation to the aerological data.) At Rennes, Brittany, the temperature at 13h. on the 3rd was 91° F., and the (coded) relative humidity between 40 per cent. and 49 per cent., giving a wet bulb reading between 74° F. and 77° F. There were severe storms on the 2nd (2·18 in. of rain at Tenby) and the 3rd (*e.g.*, Roches Point), but these were completely eclipsed by the tremendous outbreak of the 4th, which made a land-mark in the meteorological history of southwest England. This was a most exceptional storm, outstanding for severity, duration, and the area covered, which included the whole of southwest England and the Scilly Isles. Full details are not yet available, and in any case will be confined to the land area, but there seems no doubt that the area where a heavy thunderstorm was simultaneously in progress must have been remarkably large. The storm arrived about midnight on the 3rd–4th, and over a considerable area in Devon and east Cornwall it lasted for eleven hours with little intermission. The largest rainfall so far reported was 6·39 in. at Torquay, and the area with over 2 inches extended to the north coast of the peninsula at Tintagel, Ilfracombe and Bude. Much damage was done, and traffic on the main Great Western Railway line had to be suspended for some hours owing to the threat of the flooded Teign to the bridge at Newton Abbot. Numerous roads were flooded.

The chart for 13h. on the 4th (chosen to show up the temperature distribution) is reproduced in Fig. 2. When the gradient for easterly winds died away over France the cooler air over the Bay of Biscay had a chance to cut into the very warm air and form a cold front. On the evening of the 3rd there was an outbreak of thunderstorms all along the west coast of France. By next day the very warm air over Brittany had risen between the cooler easterly and southwesterly currents. This scissors action undoubtedly contributed greatly to the severity and size of the storm. The hilly nature of southwest

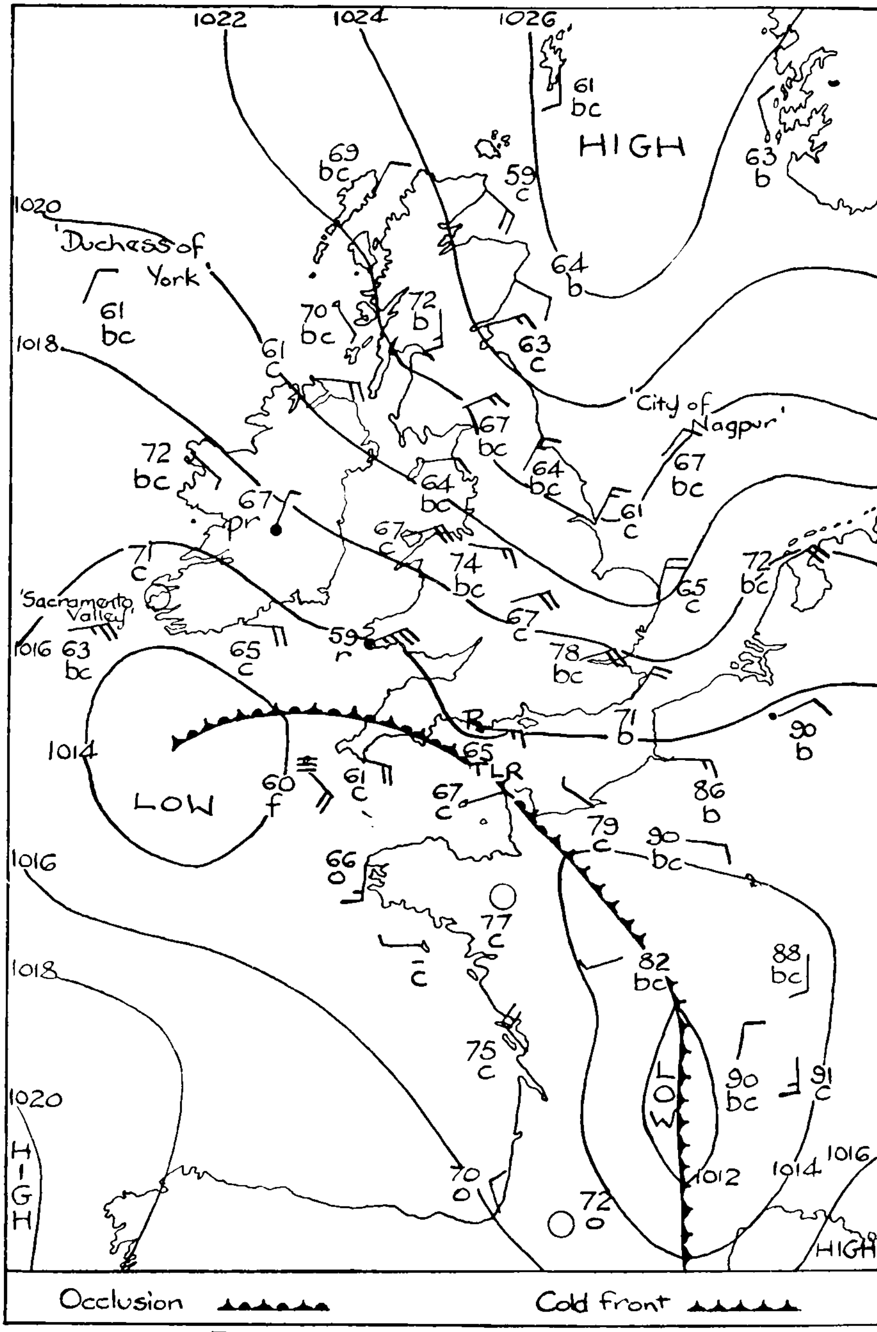

FIG. 2. 13H. 4TH AUGUST, 1938, THURSDAY

England probably also contributed. In the Channel area the front had the nature of an occlusion[1], but its exact position is doubtful,

[1] No warm front is included as there was a gradual transition between the very warm air and the less warm air.

owing to the complexity which is characteristic of thundery fronts. The precipitation and barometric tendency indicated a position northeast of Guernsey, but the final veer of surface wind followed later. The storms were on the northeast side of the front. There was a general movement of the storm belt towards northeast, but the individual storms moved to a point between northwest and north. Before midnight the storms had spread to most of the midlands and one passed only a little to westward of London, evidently high up. Another series of violent storms broke out just ahead of the front over Paris and northeast France generally and moved northwards over Kent, giving a spectacular display of lightning during the night. Subsequently they moved north-northwest over northeast England to Scotland, drifting in the upper current right over the stable layers below.

From the 6th onwards the thundery period entered a new phase. The complex shallow depression which had worked up slowly from off southern France was over the British Isles, with high pressure to northeast and southwest. The occlusion shown in Fig. 2. could be traced as a complex fluctuating line of wind discontinuity up to the 9th, and a high proportion of the thunderstorms formed along it. The continental current still prevailed in the north (with much fog on the northeast coast) but elsewhere there was little air movement near the ground, though up above there was still a southeast current, in which

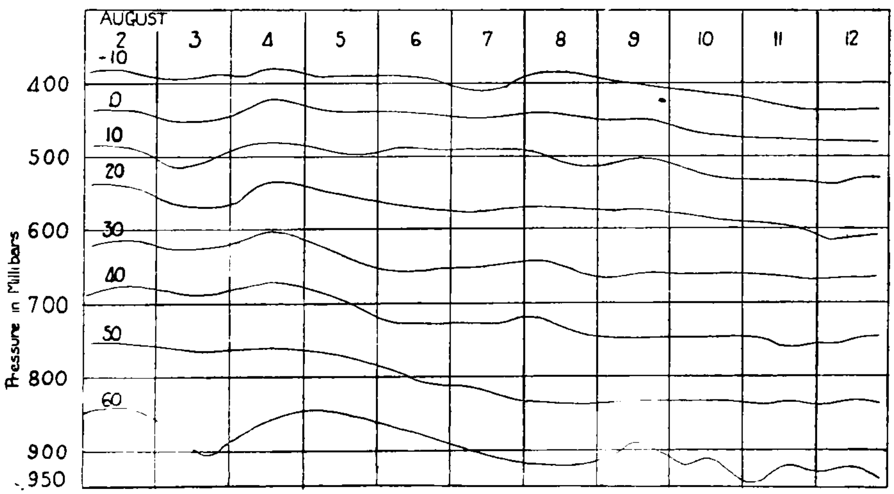

FIG. 3.—ISOPLETHS OF UPPER AIR TEMPERATURE AT MILDENHALL FOR EACH 10°F AUGUST 2ND TO 12TH, 1938.

the storms drifted, up to and including those of August 11th. This implied colder air to the southwest, and this worked in slowly, though high up its movement was masked by the larger wind component parallel to the isotherms. Fig. 3 shows isopleths of upper air temperatures at Mildenhall, based on observations at about 6h. every day and also about noon except on the 6th and 7th. The pressure of 400 mb. corresponds to a height of about 25,000 feet, and 950 to about 2,000 feet. In the upper levels temperature was 5° to 10° F. above the August normal for most of the thundery period, but towards the end it dropped to normal, and diurnal convectional thunderstorms became more widespread and severe. On the 7th and 8th storms were mainly in Wales, northwest England and the midlands, but during the night of the 7th to 8th there was a thunderstorm with heavy rain in Kent, Ramsgate having 2·00 in. On the evening of the 11th there was a severe storm in south and west London, which caused flooding on the Kingston by-pass road. Previously London had curiously escaped the storms, though there had been welcome rains of thundery origin.

On the 12th there was much the worst outbreak since the 4th, affecting all Great Britain except the southwest. Cooler air was then spreading from west, but the storms in the south were mostly ahead of the cold front. Heavy hail fell locally, and at Wold Newton, near Bridlington, lay deep on the ground and lasted till next day. Violent thunder and lightning occurred locally over a wide area, but the regions of extreme severity were much smaller than on the 4th. Among the populous regions severely affected were Manchester, Sheffield and north London. The storm in the north London area developed very quickly, and the worst thunder and lightning was in the early stage, about 12h. G.M.T. Later in the afternoon the storm became general over London and extended far to the north-west, north and northeast, but though it was vigorous locally it was not of extreme violence.

The later storms were relatively straightforward, but the earlier ones are worth some further discussion, as they illustrate a type which is of extreme violence when once formed, but is difficult to predict. The associated front is not always clearly defined, and there is often fine weather near the storms, with dry air aloft. For example, at Duxford about noon on June 19th, 1936, relative humidity was below 40 per cent. from 2,000 to 5,000 feet and about 60 per cent. from 6,000 to 10,000 ft., while there was a severe storm over south and west London about 50 miles away. The Mildenhall observations on August 4th showed dry air aloft and nothing approaching "latent instability"[1], but the lapse-rate from 850 to 500 mb. (about 5,000 to 19,000 feet) was in excess of the saturated adiabatic, and only moisture was needed to cause instability. The dryness aloft continued on the 5th, when the thunderstorms were to northwards. The continental observations also showed no latent instability in the upper air, though evening thunderstorms formed in some cases quite near, but it was easy to deduce that the surface

[1] C. W. B. Normand, "On Instability from Water Vapour." *London Quart. J.R. met., Soc.* 64, 1938, p. 47.

air in the afternoon must have had marked latent instability and often actual instability. The conceptions of " wet bulb potential temperature "[1] and of " latent instability " are of undoubted value in forecasting thunderstorms, but some additional terms would facilitate descriptions of possible thunderstorm conditions. One is a term indicating the existence of a lapse rate exceeding the saturated adiabatic. The other is a ready method of labelling the dry bulb temperature in terms of saturated adiabatic lines, which are numbered on the standard tephigram in terms of " wet bulb potential temperature ". At high levels it is the dry bulb and not the wet bulb readings which are important, since these layers constitute the environment of rising air. Over an area including Aldergrove, Mildenhall, Germany, Holland and north France the dry bulb temperatures at about 600 to 500 mbs. (14,500 to 19,000 feet) on August 4th and 5th were on the 64° F. to 68° F. saturated adiabatic lines on the tephigram. The temperature was fairly uniform at those levels in the area, and only air with a wet bulb potential temperature exceeding 68° F. would have possessed buoyancy all over the area after ascent to the heights mentioned. The available observations showed that only the air on or very near the surface on the Continent had a wet bulb potential temperature even as high as 64° F., but that at 13h. various places at ground level had wet bulb readings of about 75° F.

There were some severe thunderstorms on the Continent, almost all associated with fronts. The central European storms on the evenings and nights of the 2nd and 3rd were associated with colder air spreading slowly from north. (According to Press reports, 26 people were killed by lightning in Poland.) The storms in northeast France later on the 4th broke out ahead of the front, but there was doubtless convergence. It is easy to see that convergence piles up the surface air and so supplies the moisture, but it is not clear why thunderstorms should travel far from the source of warm damp surface air, often well ahead of the front (*e.g.*, the storms over northern England on the 5th), unless there is a really damp layer aloft from which continuous supplies of moisture are available. Further observations are needed on this point, especially evening observations. The humidity mixing ratio[2] practically always decreases upwards, but vigorous mixing, associated with dry air convection in the lowest few thousand feet, must reduce the rate of decrease with height.

The local variations of humidity are the chief difficulty in forecasting thunder. Local variations of upper air temperature are limited by statical and dynamical considerations, but there is no such restriction on humidity variations. It is also obvious that large scale convection causes more horizontal variation of humidity than of temperature.

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[1] See e.g. D. Brunt, " Dynamical and Physical Meteorology " (Cambridge Univ. Press, 1934), p. 82.

[2] Weight of water vapour per unit mass of dry air.

As already mentioned, the upper current carrying the thunderstorms was southeasterly, occasionally veering temporarily to south, till the 11th. Up to the 5th the cirrus motion was southwest, but the veer was evidently right above the important layers. In a quasi-geostrophic wind system a wind veering with increased height involves advection of warmer air, but this only helps thunderstorm development when the layer of maximum temperature increase is low enough. If this layer is high up the effect, if any, is negative. In spite of the wind veer high up, the big storms of the 4th obviously penetrated to great heights, and great quantities of cirrostratus and altostratus streamed away at high levels. After August 6th, the southeast upper current extended to cirrus levels.

Really spectacular night storms are always preceded by great heat at no great distance. As a rule the air is maritime tropical in origin and is heated for a few days over land. In some cases prolonged continued heating over the land seems to be the cause of the great heat. In the case under discussion it is impossible from the information at present available to trace the air back previous to the appearance of very high temperatures over south Russia on July 23rd, with an east wind. Since thunderstorm frequency is high in eastern Europe, it is evident that the moisture is often there, and its occasional westward transport presents no difficulty.

C. K. M. D.

The Thunderstorm Rains of August 1st–12th, 1938

During the first twelve days of August a remarkable series of widespread thunderstorms, giving intense rains locally, was experienced. Of these the most outstanding was that recorded at Torquay during the morning of the 4th, when as much as 5·72 in. fell in five hours and ten minutes, between 6h. 50m. and 12h., of which 4·25 in. occurred in 108 minutes from 7h. 12m. to 9 h. At Paignton the intense rain was of shorter duration, 2·71 in. occurring in 45 minutes from 5h. 56m. to 6h. 41m.

At Tenby, in Pembrokeshire, 2·15 in. was recorded on the 2nd, the bulk of which fell during a thunderstorm between 14h. and 17h. 35m.

The heavy rain of the morning of the 4th gave totals exceeding one inch for the rainfall days, 3rd and 4th, over most of Cornwall, Devon and west Somersetshire. There was more than two inches over an area stretching from Bodmin to Seaton and including Dartmoor. More than four inches occurred from Torquay and Paignton to Moretonhampstead and Two Bridges. The entries for Torquay (Abbey Gardens) were 5·61 in. and ·78 in., a total of 6·39 in. To the west the totals were smaller, 3·97 in. being recorded at Ipplepen Vicarage. Further north-west in the neighbourhood of Hedgebarton, Ilsington and Ashburton the totals increased, the daily entries being at Hedgebarton 5·86 in. and ·59 in., Ilsington 5·35 in. and ·65 in.

and Ashburton 3·79 in. and 1·28 in. respectively. The distribution of the heavy rain has some resemblance to that which prevailed on July 17th, 1926 and on August 15th, 1905, although in these cases the areas of heavy rain were further east and the totals not nearly so large as those for August 3rd to 4th, 1908.

At Torquay, Mr. Bellinger reports that there was distant thunder at midnight ; louder thunder at 4h. ; heavy rain and hail 5h. 5m. to 5h. 15m. ; at 6h. 17m. rain recommenced ; from 6h. 50m. to 12h. the thunderstorm grew in intensity ; two types of clouds were observed, one coming from the south-east and the other, a lower type of nimbostratus, from the north-east ; heavy rain (·44 in.) fell during the period 12h. 30m. to 14h. The observer at St. Marychurch reports that the hailstones were the size of large lumps of sugar and formed about four inches of what looked like snow on the ground. At Hedgebarton, 15 miles to the north-west of Torquay, Mr. W. K. Kitson noted that the rain did not begin until about 4h. 15m. and by 8h. as much as 5·86 in. was recorded. Rain ceased at about 10h. 30m. but the maximum intensity was from 4h. 30m. to 8h. Very large hailstones occurred, but the hail was of short duration. For four hours the lightning appeared to be continuous. At Ilsington, Mr. J. F. Caley measured 5·35 in. of rain and hail from 4h. 30m. to 9h. 45m. Mr. Caldwell Harpur writing from Newlyn, to the south of Penzance, comments on the numerous lightning flashes " about 6,000 flashes of sheet lightning and six flashes like red bars from cloud to sea without any apparent thunder ". At Dunster, in north-west Somersetshire, the total rain amounted to 1·54 in. of which ·75 in. fell in 20 minutes.

Thunderstorms occurred in many parts of England and Wales on the 5th and intense falls were reported from parts of Lincolnshire and Yorkshire, E.R. At Horncastle ·96 in. fell in 50 minutes between 8h. 10m. and 9h. and at East Kirkby Manor, 7 miles to the south-east of Horncastle, 2·22 in. in 75 minutes between 8h. and 9h. 15m. At Bridlington, thunderstorms occurred at intervals during the day and in one storm three-quarters of an inch fell in an hour. It was on this day that some four hours from high water the sea receded suddenly for about 15 ft., leaving vessels high and dry, only to return with renewed force and refloat other craft further up the harbour.

The most intense rains for the 6th occurred at stations in Essex. Mr. E. F. Duggan at Holmwood House School, Lexden, reports that 2·25 in. occurred between 16h. 30m. and 17h. 30m., when the screen temperature fell from 83° F. to 65° F. At Corringham, 10 miles west of Southend, Mr. H. Mousley reports that 1·57 in. occurred in 57 minutes from 18h. 3m. to 19h. There was also heavy rain and considerable flooding in the neighbourhood of Liverpool in the early morning of the 6th.

At Fairford (Draycott), in Gloucestershire, 1·78 in. was recorded between 13h. and 16h. on the 7th during heavy rain accompanied by little thunder and lightning. The total for the day was 2·28 in. Falls of 1·68 in. and 1·64 in. were recorded for the 7th at Sudbury, Middlesex and Pyrton Manor near Watlington in Oxfordshire respectively. The 8th gave heavy thunderstorm rains accompanied by local flooding in Lancashire. The daily amount at Cathedine Rectory in Breconshire was 3·65 in.

As much as 2·40 in. was reported at Wath-upon-Dearne, near Rotherham, for the 9th, while intense falls were recorded at widely distributed stations, e.g., 1·44 in. in 45 minutes at Bishops Cannings; ·84 in. in 45 minutes at Ketton Cottage, Rutlandshire; ·53 in. in 12 minutes at Wellingborough and ·50 in. in 15 minutes at Birmingham. At Wallasey the total for the day was 2·75 in., of which 1·80 in. fell in 105 minutes from 14h. 25m. to 16h. 10m. and ·75 in. from 18h. 10m. to 18h. 50m.

On the 10th 1·13 in. fell in 48 minutes at Blandford (Bryanston Gardens) Dorsetshire. Intense thunderstorm rains occurred on the 11th at Edenbridge, in Kent, 1·21 in. occurring from 16h. to 16h. 45m. At Wembley, Mr. J. Monger measured 2·25 in. for the period 17h. to 18h. 30m. Some of the roads became rivers so that the carburettors of cars were flooded and trolley-buses stranded. Thunderstorms of unusual intensity, with precipitation running up to over five inches, occurred also in south-west Scotland. Flooding resulted quickly in wash-outs at two points on the railway near Strathaven, Lanarkshire, and caused the derailment of a passenger train. On the 12th, Edenbridge also recorded a fall of 2·26 in. from 16h. 15m. to 18h. 30m. At Blisworth, Northamptonshire, Mr. A. Westley recorded ·81 in. from 14h. 55m. to 15h. 15m., ·47 in. from 17h. 20m. to 17h. 50m. and ·58 in. from 18h. 30m. to 18h. 50m., a total of 2·30 in. in 5 hours. At Peterborough, 1·18 in. was recorded in 20 minutes when hail also occurred. Intense rains also occurred in Lancashire; at Chatburn School, to the north-west of Pendle Hill, 1·15 in. fell in 45 minutes. At Wold Newton, near Bridlington, there was 2 ft. of hail, so that roads were blocked and cars had to be dug out.

J. G.

Note on Experiments with No-Lift Balloons at Leuchars, Fife

S. T. A. Mirrlees, M.A.

Various expedients have been tried to get a sort of "Lagrangian" investigation of wind flow, varying from the simple one, applicable near the ground, of watching the movements of the winged seeds of the dandelion or thistle, to the much more complicated one, applicable to higher levels, of following the movements of a series of smoke puffs by cine-cameras. The "no-lift" balloon offers a compromise in that it can be used at moderate heights and does not involve very elaborate apparatus or several observers; it is, as the name indicates, a pilot balloon inflated with hydrogen so that it floats when carrying the usual tail system without rising or falling, so long as the air has no vertical component of motion. The balancing process has usually to be finished inside a building, conditions out-doors seldom being calm enough. When the balloon has been satisfactorily balanced (the final stages of the process being done by adding ballast of small wire paper-clips or taking off a small piece of the paper tail) some arrangement has to be made for lifting the balloon system to the required height and releasing it by some form of time-fuse. The latter must be simple and within the resources of the ordinary meteorological station using pilot balloons.

It may be mentioned that the direct process of carrying the balloon to the desired height by an aeroplane and then releasing it has been found impracticable, and a " carrier balloon " is used. The real problem is the time fuse, and the experiments were made in the first instance to test various methods of release which had been proposed. The first method suggested by Mr. C. Wilde when at the Meteorological Office, Worthy Down, in 1932, was rather complicated —the tail system of the no-lift balloon included a kind of " harness " made of a ring of aluminium wire and some threads and the complete system included three balloons, first the carrier inflated with hydrogen to give the lifting power, then a balloon which may be called the trigger, attached to the carrier, and then the no-lift balloon attached to the trigger by the harness. The trigger balloon was inflated with air so as to distend the harness ; it was fitted with a plug of hard wood, an aperture in which allowed the air content to leak away, so that after a time, determined mainly by the size of the leak, the trigger balloon deflated enough to slip clear of the harness and the no-lift balloon was left floating free. Much time was taken up by the preparation for an ascent by this method and a simpler method, proposed by Mr. B. A. Copping, of Upper Heyford, in 1934, was tried using an ordinary pilot balloon lantern attached to the carrier balloon. A thread was taken from the no-lift system through a hole in the cardboard base of the lantern and looped round the candle at a suitable distance from the top. The time taken by the candle, lighted just before release, to burn down to the thread loop determined the time at which the separation from the carrier balloon took place. The third method, also due to Mr. Copping, which proved to be the most satisfactory and was used in 70 per cent. of the experiments, involved the use of a small piece of wick such as is used in cigarette lighters. The wick was put in a loop of the thread which joined the carrier to the no-lift system, a suitable length being measured and lighted just before the start of the ascent. After the desired interval, the wick having burnt down to the thread, the thread was burnt through and the carrier separated from the no-lift system. Impregnation of the wick with potassium chlorate was proved to be an unnecessary refinement.

Once the no-lift system has been released at the desired level, readings of the pilot balloon theodolite are made at 1-minute intervals and the working-up resembles an ordinary pilot balloon ascent by tail method. In launching the no-lift balloon attached to the carrier it was found best to lay the tail on the ground in a down-wind direction. For convenience in balancing, the paper tail was rolled into a cylinder round which the thread was wound ; after balancing, a wooden spindle thrust through the cylinder allowed it to revolve freely when the thread of the tail was being unwound before launching.

The number of experiments made at various times between April 23rd, 1934, and January 31st, 1936, was 31. The no-lift balloons were released at heights between 1,000 and 2,000 feet above ground and the position of the balloon at each minute determined by the usual method for pilot balloons ; the rates of ascent during the one-minute periods were evaluated, these being the magnitudes of up- and down-currents in the one-minute periods, assuming the no-lift condition to have been achieved.

The ascents were classified in the following way, the progression of the classes being in order of increasing topographical irregularity of the tracks of the balloons :—

Class a. Trajectory of balloon towards NE., above flat ground.

Class b. Trajectory of balloon towards E., above flat ground to sea-shore.

Class c. Trajectory of balloon towards SE., above river and gently-rising ground.

Class d. Trajectory of balloon towards S., above narrow part of river and rising ground.

Class e. Trajectory of balloon towards W., above rising ground.

The results of examining the ascents in these classes are shown in Table I.

TABLE I

Class	A	B
a	− 29	+ 90 to − 190
b	− 4	+ 180 to − 270
c	+ 21	+ 200 to − 110
d	+ 58	+ 475 to − 180
e	+ 49	+ 400 to − 200

A. Mean velocity of vertical currents measured.

B. Range of velocity of vertical currents measured. The units are feet/minute.

Although the number of observations is not large enough to be fully representative, the regular progression shown in the table suggests that the classification is suitable, the vertical currents being mainly " dynamical turbulence." Observations of upper-air temperature being not available, the ascents were examined with regard to association with stratiform and cumuliform cloud, but the results were inconclusive.

There were five ascents which did not fit in with the above classification ; three of them, when the balloon was travelling above flat ground or water surfaces, showed up-currents more appropriate to sloping ground, as shown in Table 1. The results were attributed to thermal turbulence of a degree not present in the other ascents. One showed an average descending current of −65 feet/minute above flat moorland on a summer day. The remaining ascent was made in the region ahead of an occluded front, and the no-lift balloon showed a continuous ascent averaging 260 feet/minute and ranging from 420 to 100 feet/minute (upward velocity). The isallobaric wind component at the time of observation was about 10 mi./hr. and rainfall at the rate of about 2 mm./hour started at the time of the ascent. No other case of this kind occurred during the experiments and it would be desirable to have other ascents made under similar weather conditions, as a slight error in the balancing of the no-lift balloon would give a fictitious value for up-currents caused by convergence.

Summarising the experiments it may be said that the up-currents measured are on the whole small and of the order found in previous work (using other methods) by various investigators, when account is taken of the slopes of ground and wind velocities involved.

Correspondence

To the Editor, *Meteorological Magazine*

Divergent Isobars and Winds

Owing to some aberration, I wrote "convergence" instead of "divergence" in the third sentence of my note on this subject! Actually the effect of the curvature of the path of the air is entirely negligible in the case of the published mean isobaric charts for the droughts of 1921 and 1933, but might be appreciable on the 1887 chart. Since numerical methods cannot be applied to the accelerations on average charts, it would be best to investigate ordinary daily charts in the first place. In the case of a typical travelling wedge of high pressure, the relative motion of the air mass is from front to rear, so that the divergence is in front of it, the convergence behind it. The situation is reversed if the air movement is through the wedge from rear to front. This is rare at low levels, and, when it occurs, the movement across the wedge is normally exceedingly small and the corresponding accelerations are also small.

C. K. M. DOUGLAS

Meteorological Office, London, August 26th, 1938.

Snow in June, 1938

At 10h. G.M.T. on Saturday, June 9th, during a heavy north-westerly squall there was a shower of snow here lasting nearly five minutes. The flakes were big white flakes such as one associates with a winter's storm. The flakes eventually became mixed with rain, terminating in a squall of rain. The same shower also passed over Liverpool a few minutes later and was freely reported in the Press.

ERIC F. ROBSON

St. Andrew's Vicarage, West Kirby, Cheshire, August 3rd, 1938.

Radiation Frosts in August

That inland stations in south-eastern England at times experience decidedly " Continental " climatic conditions is well known, and the exceptionally low night minima at valley stations such as those recorded from time to time in this magazine by Mr. E. L. Hawke at Rickmansworth, Herts, are of considerable interest.

The meteorological station at Goff's Oak, although in the same county, is not a valley station, being in fact on the summit of a fairly steep ridge of hills. This being so, radiation frosts are not usually experienced in summer months.

On the night of August 20–21st, 1938, however, the grass minimum fell to 29·3° F.—the first radiation frost recorded here in August since the station was opened in the year 1934. The night was very clear, visibility excellent and the mean wind speed at 23 ft. above the soil was only 2·7 m.p.h. The screen minimum was 41° F. so that radiation appears to have been very active. This frost seems to have been the first recorded in this district in August for at least 13 years, since grass minima are available back to the year 1925 from Waltham Cross, a valley station 3½ miles to the south-east, where the lowest grass minimum previously recorded in this particular month was 32° F. on the night of August 25–26th, 1931.

DONALD L. CHAMPION

Meteorological Station, 7, Robinson Avenue, Goff's Oak, Herts, 21st August, 1938.

Tornado-like Cloud at Shoeburyness, July 5th, 1938

At 11h. G.M.T. on July 5th, 1938, at Shoeburyness, Essex, the sky was covered with 8/10ths cumulonimbus and fractonimbus cloud (height of bases estimated at 1,800 ft.) and 1/10th " anvil " cirrus. Several inverted conical shaped clouds, one of exceptional clarity were seen to be drawn out of the fractonimbus at the base of a very large cumulonimbus over the sea about three miles east of the station. Heavy rain was seen to be falling from this cloud at the time of observation and a thunderstorm followed at 11h. 30m. G.M.T. The phenomenon was, in appearance, similar to the cloud formation of a waterspout and disintegrated with great rapidity after lasting

2 or 3 minutes, the " funnel " breaking up into very small individual cloudlets which were drawn up into the main clouds. The " funnel " did not quite reach the ground. Meteorological conditions at the time of observation were :—

Surface wind, NW. 2 mi./hr. Visibility, 6–11 miles. Dry bulb, 53·9° F. Humidity, 92 per cent. Barometer, 1001·7 mb. (m.s.l.) tendency unsteady, rising slightly.

A. SCRAGG

Meteorological Office, New Ranges, Shoeburyness, July 5th, 1938.

A Miniature Tornado at Cranwell, May 17th, 1938

The first appreciable rainfall at Cranwell since April 29th was heralded by a cloud pendant which was observed at 17h. 15m. G.M.T. on May 17th, 1938, to be moving in an east-north-easterly direction from a point near the village of Caythorpe towards the aerodrome. The anemometer trace showed that the wind veered sharply from south to north as the storm passed overhead, with gusts from 2 mi./hr. to 20 mi./hr., later backing to north-west. Heavy rain fell with the passage of the storm, some 30 millimetres of rain being measured by the recording raingauge from 17h. 15m. to 18h. 20m. G.M.T., and moderate rainfall continued for the next 23 hours. Thunder was heard locally.

In a field about half a mile from the anemometer the path of a tornado-like disturbance was found later traced by tree cuttings which were distributed across the field by the wind for a distance of 300 yards from the point where they had been stacked. The debris was confined to a track 20 yards wide, and must have been lifted over a wall 3 feet high.

R. E. BOOTH

Meteorological Office, Cranwell, Lincs, May 25th, 1938.

Wind Erosion in Scotland

The weather of April 2nd, 1938, at Montrose should not pass without remark, for a full gale wrought unusual devastation on the ploughed and sown land. March, 1938, at Montrose was very dry and warm; 60° F. was exceeded for the first time this season on March 11th (c.f. May 23rd in 1937 !) and 65° was reached before the end of the month. Rainfall totalled 0·28 in., most of which fell in slight showers of brief duration and dried quickly from the land. Humidities under 60 per cent. were measured on ten days of the month, with an extreme reading of 34 per cent. on the 25th. In some respects the season is two months ahead of last year, and it has been proclaimed the best season for sowing for at least 50 years in this part of the country.

Thus the light soil, lately sown or turned by the plough, was in a very vulnerable state when on April 2nd at 9h. G.M.T. a west-south-westerly gale increased to force 9. The violence of the gale was not experienced at Leuchars or Aberdeen, and may have been due here to converging air-streams near the southern face of the Grampian Mountains. The wind blew at Montrose with force 9 to 10 from 8h. 40m. until 11h. Winds of force 6 to 7 in the foregoing week had shown signs of lifting the topsoil from the many fields whose soil had been turned ; and now a great cloud of soil was raised to the treetops, reducing visibility as far as the coast. On one main road visibility was 15 to 20 yards from 9h. till nearly 11h. ; and afterwards the soil lay to an even depth of 4 inches across the road, with some drifts 1 foot deep. Traffic was in difficulties and few cyclists or footwalkers made their way through owing to the sting of the flying earth along 200 yards of roadway. In spite of this accumulation near hedges and on roadways a large proportion, possibly half, of the lifted soil was blown out to sea and lost forever.

It would seem therefore that big, flat, open fields with only low hedges, or none at all, are occasionally liable to serious erosion even in Britain. One big field in this case lost all its topsoil, leaving only a stony bed at which point the soil ceased to blow, an hour before the wind dropped. In the U.S.A. such erosion has been common in recent years. The writer has seen one similar storm of blowing earth, although less extensive, in the wide open fields of the Fenland, but Scotland is more liable to violent winds than eastern England.

H. H. LAMB

Meteorological Office, Montrose, Angus, April 6th, 1938.

Rainfall on July 29th–30th, 1938

A remarkable rainstorm occurred along a belt including parts of Ireland, northwest England and southwest Scotland on July 29th and 30th, with the heaviest falls in the Lake District. During the 24 hours ending 17h. G.M.T. on the 30th, Ambleside reported a rainfall of 4·40 in., following a fall totalling 1·48 in. in the preceding 48 hours. The totals for the rainfall days of the 29th and 30th amounted to 8·06 in. at Borrowdale and 7·45 in. at Watendlath Farm in an adjoining valley. The rainfall occurred in a pronounced southwesterly current, mostly in the warm sector close to a slow-moving cold front, which was so poorly defined that its precise correct position is doubtful. This meteorological situation is favourable for heavy rainfalls, especially in hilly districts. A good example, on Nov. 2nd to 3rd, 1931, is described in detail in *British Rainfall*, 1931, pp. 67–73.

C. K. M. DOUGLAS

Meteorological Office, London, September 2nd, 1938.

NOTES AND QUERIES

The Effect of Wind on the Temperature of a Thermometer

In the *Meteorological Magazine*, July, 1938, p. 142, Col. Gold discusses the effect of a high velocity air stream on the temperature of a thermometer, on the assumption that the kinetic energy of the moving air is transformed into heat energy by the action of an obstacle—in this case, the thermometer bulb. Col. Gold says " Thermometers exposed freely on aeroplanes may pass through the air at . . . higher speeds, and have their temperatures affected by several degrees F.—nearly 30° F. for a really fast plane of 400 m.p.h." The reading of a freely exposed thermometer moving at such a speed would not necessarily, however, be 30° F. above the temperature of the surrounding air; this result could only be affirmed for an insulated thermometer placed at the stagnation point of a bluff body moving at 400 m.p.h. A freely exposed thermometer bulb (supposed cylindrical shape) would be in contact with the still air at 30° F. above the true air temperature over a small area only; elsewhere, the air would be moving around the bulb at a pressure lower than the stagnation pressure, and its kinetic energy would not be wholly transformed into heat energy. At the rear of the body, the pressure reaches a minimum with the formation of a turbulent wake. The true temperature of the thermometer is a result of (1) conduction of heat from the still air at the stagnation point, (2) conduction of heat from the moving air at varying pressure and temperature up to the point of separation, (3) convection of heat by the eddies in the wake and (4) any frictional heat developed. The problem of the determination of the mean temperature of the bulb is thus difficult, being analogous to that of finding the drag and so depending, among other things, on the shape of the bulb. In view of the fact that convection is usually much more important than conduction in problems of heat transfer, one might anticipate that the reading of a thermometer of conventional shape would not differ vastly from the true temperature of the air, even at the speed of a modern aeroplane, but how far this is realised in practice I do not know.

When really high speeds are considered the problem is different. It is a fact of experiment that a thermocouple placed in a high velocity jet of air in a divergent orifice connected to a high pressure reservoir records, not the expected low temperature due to the adiabatic expansion, but the temperature of the unexpanded air in the reservoir. Pohlhausen* has thrown light on this by examining the case of an ideal thermometer in the form of a thin lamina placed along the direction of flow, making use of Blasius' boundary layer

* *Zeit. f. angew. Math. u. Mech., 1.* (1921.)

solution. Stodola, in his treatise on turbines†, commenting on this result, says "No method is known that will determine the true temperature in flowing fluids. The friction of the fluid against the thermometer or thermocouple generates heat affecting the readings to an extent yet unknown."

In view of the high speeds which may be attained in stratosphere flights in the future, it is of interest to consider what is known of the behaviour of compressible fluids as regards heat transfer. In a recent paper‡, Kàrmàn and Tsien have considered, among other things, the flow of heat from a body whose temperature differs from that of the surrounding high speed stream. They give a general relation between drag and heat transfer as a function of Mach's number (ratio of the fluid velocity to that of sound at the same temperature), and find that cooling ceases at certain values of Mach's number, depending on the ratio of temperatures of the body and the fluid. A similar result has been found experimentally by Santon§ for hot wire anemometers in high speed streams. For low velocities the wire is cooled by the air stream but for velocities above 0·8 of that of sound the temperature of the wire rises as the speed increases.

The relationship that exists between heat transfer and drag suggests that some consideration should be given to the shape of the bulb in the design of thermometers for use with high speed aircraft. Of equal interest to meteorologists is the behaviour of a wet bulb in a high velocity current but, as far as I am aware, this problem has never been considered on the lines indicated above.

O. G. Sutton

I thought I had provided a protective shelter for the vital part of my Note by the statement: "Actually there is certain to be some departure from the adiabatic law, depending among other things on the shape of the thermometer." But Mr. Sutton has struck a little lower down, metaphorically, like Joab, under the fifth rib.

The thermometers used for meteorological observations in aeroplanes in this country usually have their bulbs in a metal honeycomb, through which the air streams past the bulbs. The honeycomb is like a metal box of dimensions 4 in. by 3½ in. by 1¼ in. open at both ends. The air stream is parallel to the 4 in. side. The honeycomb openings are about ¼ in. square and they extend for about ½ in. from each end, the intervening 3 in. being an open space except for the bulbs of the thermometers. The dry bulb thermometer is about ½ in. behind the front honeycomb and the bulb of the wet bulb thermometer about ½ in. from the rear honeycomb. The bulbs are about ½ in. in thickness and there

† "Steam and Gas Turbines," *trans.* Lowenstein (1927).

‡ Kàrmàn and Tsien, "Boundary Layer in Compressible Fluids," *Jour. Aero. Sciences*, 1938. *5* (6), pp. 227–32.

§ L. Santon, *Pub. Scient. et Tech. du Ministère de l'Air*, No. 68 (1935).

is one inch clearance between them. Thus the air strikes on the dry bulb first before it reaches the wet bulb. Such observations as I have seen indicate that the effect of the motion of the aeroplane on the temperature of the thermometer is nearly equal to the adiabatic effect. This does not apply to the wet bulb for which the increase of temperature is much smaller, but the difference between the effect on the wet bulb and on the dry bulb is not due to the shielding of the dry bulb, because if the wet bulb is run (in the same position) as a dry bulb instrument, i.e. with the muslin dry, the temperature effect on both thermometers is about the same.

Mr. Sutton suggests that if the thermometer were exposed without the protective honeycomb the temperature recorded by it would not be far different from that of the air through which it passed ; but I do not think he gives any good grounds for his opinion and the fact which he mentions in the next paragraph that " a thermocouple placed in a high velocity jet of air in a divergent orifice connected to a high pressure reservoir records, not the expected low temperature due to the adiabatic expansion, but the temperature of the unexpanded air in the reservoir," suggests that the thermocouple is heated substantially by the air moving with high velocity which it brings to rest temporarily.

Fortunately the problem is one amenable to experimental treatment in the atmosphere, as the true temperature of the air through which an aeroplane moves rapidly at a given level can be determined from an aeroplane moving slowly at that level, and the variations of temperature in the distances traversed by the aeroplane are usually small compared with the variations due to speed.

E. GOLD

Excessive Rainfall in Southern California, February 27th—March 3rd, 1938

Although the recent floods in southern California caused far greater damage and loss of life than have ever been known before in that part of the world, neither in total amount nor in intensity of rainfall was a new record created. The nearest approach to the millions of dollars of damage and serious loss of life so recently experienced, was that resulting from the Long Beach earthquake of March, 1933. Apart from this, the only other serious catastrophe which has occurred in the region came about through a combination of causes rather than through one single element. In this case an enormous forest fire denuded miles of mountain side in the early autumn of 1933, after which a complete drought prevailed until the record storm on New Year's Eve. It was on this occasion that the all-time record for intensity of rainfall in southern California was broken. Seven and a half inches were measured in 24 hours at the U.S. Weather Bureau station in Los Angeles and amounts up to 13 inches for the same period in the smaller towns which lie along the base of a range of mountains a short distance to the north. Torrential rainfall washed down the bare, burnt-over mountain slopes and a village which happened to be in the path of the flood waters was completely wiped out.

In comparison the total rainfall in Los Angeles for the storm of last winter was eleven inches; it fell fairly continuously over a five day period. It is interesting to discover that on both the occasions mentioned the weather charts showed a similar type of synoptic situation and the same explanation can be given to both phenomena. As a matter of fact, the meteorological situation was not exceptional and is by no means of infrequent occurrence.

Southern California lies just north of the 35th parallel of north latitude and is placed in the belt of sub-tropical or Mediterranean type climate. Geographically the region is bounded to the north and east by mountain ranges averaging 6,000 feet in height but which contain occasional peaks and passes where the general level may rise to 10,000 feet or fall to 3,500 feet. The coastline runs in a northwest–southeast direction and apart from a few ranges of low hills the coastal plain extends inland to the foothill towns at the base of the northern mountain range. Taking a due north-south line passing through Los Angeles, from the ocean to the mountains, (see fig. 1) the coastal plain would extend 30 miles inland and this distance would decrease to the west and increase to the east of this line; Los Angeles itself would be found two thirds of the way inland along this line. The northern mountain range runs almost due east and west while that to the east is much more irregular in its direction almost approaching the coast in its southern portion but extending a hundred miles inland further north. On the outer sides of both ranges, however, are arid deserts upon which less than three or four inches of precipitation falls annually.

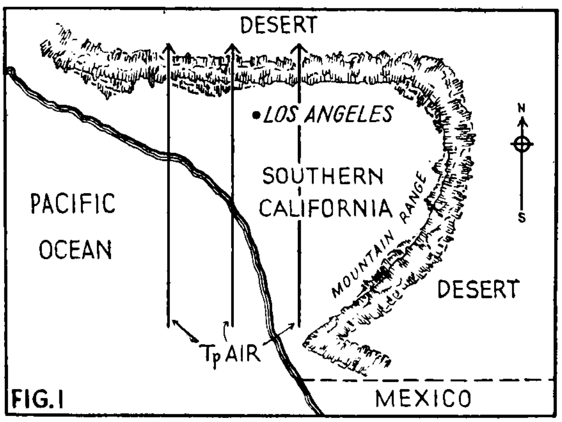

Fig. 1.

The main source of the rainfall of southern California is the winter overrunning of Polar Pacific (Pp) by conditionally unstable Tropical Pacific (Tp) air. Rain falls on comparatively very few days of the year but while it lasts it is usually fairly heavy and after two or three days of rain the sky frequently remains cloudless for several weeks. The total amount of rainfall slowly increases as the coastal plain slopes northward. Annual averages of ten inches are reported from coastal towns, of 25 inches at Pasadena in the foothills and of over 40 inches in places on the higher windward slopes of the mountains. The average monthly rainfall for Los Angeles is shown in the following table :—

Monthly Table of Average Rainfall in Los Angeles (1877-1937).

Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
3·15	3·10	3·00	1·00	0·50	0·10	0·00	0·00	0·20	0·75	1·20	2·75	15·75

The number of rainy days is about the same for all stations so it can be seen that the orographic effect is a most important factor in the intensity of precipitation.

Towards the end of February, 1938, the semi-permanent Hawaiian anticyclone which is responsible for the normal dry weather periods receded southwards and the main polar front approached the sub-tropical latitudes. Pp air occupied the region to the north, Tp air that to the south. Several waves formed on this front and developed into depressions which occluded and moved eastwards over the continent. The Tp air, however, was not true equatorial air, but greatly modified old Polar Siberian air. This originally continental mass remained cold in its upper levels and during its slow passage over the long semi-circular trajectory between Japan, the Hawaiian Islands and the coastline of southern California it gained a vast amount of available energy in the form of warmth and moisture from the ocean. By the time this mass had reached the American coastline it was extremely unstable—but only conditionally unstable ; an initial lifting force was necessary to release the instability.

In southern California the lifting force is provided either by warm front overrunning or by the orographic effect. The Aleutian " low " affects the weather of the western coasts of America rather as the Icelandic " low " affects the weather of the British Isles. When a depression is moving eastwards over the north Pacific Ocean the upper winds in the warm air ahead of the warm front will be frequently due south. Warm air will then flow normal to the east-west lying mountain range and there will be the additional lifting force present. Once the air has been started on its vertical course the total amount of its instability becomes released.

Meteorological data for the five-day period February 27th–March 3rd, 1938, clearly demonstrate this process taking place. A southerly gradient wind averaging 50 m.p.h. between 4,000 and 7,000 feet forced the warm air rapidly upwards. Aerological soundings showing high negative values of $\frac{d\theta_E}{dh}$ (change of equivalent potential temperature with height) gave proof of the conditional instability of the air. When the charts showed a brief veer of the upper wind as a front passed by the rain temporarily slackened or ceased but it restarted with great intensity when the wind again backed to its former southerly direction.

An unusual but interesting phenomenon with regard to the length of the period of continuous rainfall and its intensity in these examples of excessive rainfall is the entrapping of the cold air below the mountain range (*see* fig. 2).

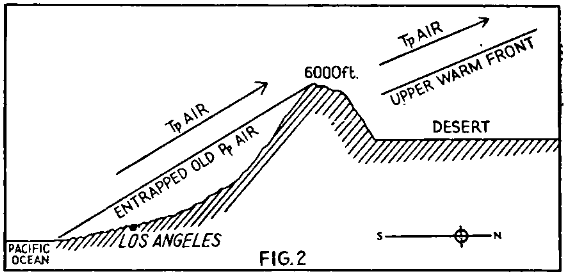

Fig. 2.

As the warm front advances inland it lines up with the mountain ranges—the upper part of the front breaks off and continues on its course as an upper front. The lower part remains stationary some distance away from the mountains and as long as the warm air continues to flow normal to the range and overrun the colder air this situation will remain unchanged. This explains the large extent of rainfall in places a considerable distance away from the mountains

I should like to express my gratitude to Dr. Irving P. Krick of the Meteorology Department of the California Institute of Technology for the help he has given me in providing me with copies of his charts.

A. H. GORDON

Sand Devils at Heliopolis

A considerable amount of information is now available regarding sand devils at Heliopolis and a discussion of the observations for the period 1927–1936 may be of interest. In Professional Note No. 71 of the Meteorological Office, Mr. W. D. Flower discusses the results of observations in Egypt, the Sudan, and Iraq during the period 1927 to 1932. His discussion has been borne in mind in what follows.

The total number of sand devils observed at Heliopolis in the period 1927–1936, was 138. This does not mean that only that number of sand devils developed. In summer, sand devils are regarded as a normal feature of the weather and, unless they develop near the observer or are of exceptional size or violence, they often pass unrecorded. The frequency of sand-devils varies with the time of day, and with the idea of finding what relationship, if any, existed between it and the diurnal variation in lapse rate near the ground, a series of simultaneous readings of the temperature of the ground surface and of the air in the thermometer screen was made. The results of these observations are given below :—

TABLE I.—LAPSE OF TEMPERATURE BETWEEN GROUND SURFACE AND THERMOMETER SCREEN

(Temperature of the ground obtained from thermometer lying on ground, its bulb covered with thin layer of sand and only its index showing.)

Local Time	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800
	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F
May 1, '35.	—	—	—	—	22·8	23·1	25·0	28·2	25·6	21·0	11·6	1·5	−3·9
May 2, '35	−5·3	0·9	3·8	12·2	19·5	—	27·6	—	26·2	21·5	16·8	4·5	−3·1
May 3, '35	3·0	9·8	15·1	19·8	—	24·3	29·0	32·2	24·9	20·9	17·4	—	3·3

The greatest lapse rate apparently occurs at 1300h. L.T. (1100 G.M.T.) the hour around which the greatest number of sand devils develop. From 1100h. to 1500h. L.T. inclusive, the frequency of sand devils was 92 per cent. of the total number observed at all hours. Their size and violence does not appear to bear any relation to the time at which they occur but the larger dust devils seem to develop over certain small areas, one of which is the centre of the aerodrome, clear of obstructions. The annual variation in the frequency of sand devils is similar to that found by Flower. None were observed in December, January and February, the percentage frequencies in the other months being: March, 4%, April, 9%, May, 14%, June, 9%, July, 28%, August, 13%, September, 17%, October, 4% and November, 1%. The dip in the curve of annual frequency for the month of June is a characteristic also found by Flower.

Although sand devils occur during the hottest months, they need not necessarily occur on the hottest days. This may be because high surface temperatures need not necessarily be accompanied by the lapse rates appropriate to their formation whatever these may be. The association of high lapse rate with the occurrence of sand devils as brought out by Table I above may be used in estimating upper air temperatures when no other information is available. The unusual bumpiness whilst flying in the vicinity of sand devils has frequently been commented on by pilots and the evidence of the anemometer is that they are invariably accompanied by gusty conditions, wind directions oscillating through 90 degrees or more and occasionally boxing the compass. The results of 17 pilot balloon observations carried out in 1936, in the early afternoon when dust devils were forming are given in Table II. The method of observation was the " tail " method, so that vertical currents could be observed.

TABLE II.—VERTICAL CURRENTS ON SAND DEVIL DAYS IN 1936. (ASCENTS ABOUT 1500 L.T.)

Date.	Sand Devils Observed.				Vertical current in feet per minute.				
	Local Time.	*Rotation.	Height in feet.	Base in feet.	1st Minute.	2nd Minute.	3rd Minute.	4th Minute.	5th Minute.
March 19th	1330	A	5	3	140	100	−190	−110	—
March 31st	1300	A	50	10	150	60	−140	130	−60
April 3rd	1305	A	50	40	580	420	250	110	−120
May 29th	1357	C	500	40	210	230	440	450	370
June 16th	1305	C	200	3	270	270	270	270	†270
June 23rd	1300	C	400	10	150	−40	110	130	40
July 12th	1330	C	300	5	−15	−5	−50	0	180
July 18th	1310	A	200	30	−50	−50	−60	−300	−240
August 16th	1420	C	200	3	170	280	30	20	−150
August 22nd	1445	A	200	50	−145	−155	−260	−230	−180
August 31st	1255	C	1,000	10	20	0	30	−360	100
September 3rd ...	1510	A	50	50	−20	−130	−190	−180	−410
September 6th ...	1510	C	200	4	170	90	40	20	10
September 12th ...	1257	C	200	3	210	410	140	190	90
September 15th ...	1506	C	100	2	50	150	80	−20	−60
September 30th ...	1256	A	30	8	−70	−70	10	80	150
October 7th	1145	C	2,000	10	188	90	20	20	−80

* A=Anti-clockwise, C=Clockwise. † Average.

On five occasions these reveal downward currents in the layer affected by the sand devil and there are other indications that such currents occur, sometimes associated with a fall in temperature. Incidentally, in regard to the change of temperature, it may be remarked that the arrival of relatively cool, moist Mediterranean air during the early afternoon is often accompanied by a line of sand devils. It seems, however, that once this air is established conditions are no longer favourable for the development of sand devils. Table III gives the percentage frequencies of specified estimated heights and diameters of the sand devils discussed in this note.

An extraordinary feature is the apparent change in the sense of direction of six of the sand devils observed. However difficult it may be to interpret this observation its accuracy is vouched for by the observer. In Table III the sand devils are classified according to their sense of rotation.

TABLE III.—DIMENSIONS AND SENSE OF ROTATION.
PERCENTAGE FREQUENCIES.

Sense of Rotation.	Estimated Heights in Feet.						Estimated Diameters of Base in Feet.				
	Under 50	50–100	100–200	200–500	500–1000	Above 1000	Under 5	5–10	10–20	20–40	Over 40
	%	%	%	%	%	%	%	%	%	%	%
Clockwise	12	23	13	9	7	1	27	18	7	7	0
Anti-clockwise ...	4	4	3	4	1	0	1	4	3	1	1
Anti-clockwise, becoming clockwise.	1	2	0	0	0	0	2	1	0	0	0
Clockwise, becoming anti-clockwise, then clockwise.	1	0	0	1	0	0	0	0	0	1	0
Doubtful... ...	14						27				

WM. JAMES

Oldham Road, Manchester

After more than 57 years of regular service the climatological station maintained by the Manchester Corporation at 299, Oldham Road, has been closed. The station was established in 1881 by the Public Health Department within the grounds of one of the Cleansing Committee's yards and the statistics which it furnished have been included regularly in the annual report on the health of the City of Manchester. Since 1892 the station has also been in co-operation with the Meteorological Office, and the readings have been included in various periodical publications devoted to climatological data. Early in 1938 it became known that the ground was wanted for a workshop and the readings ceased at the end of June.

Situated as it was in the very heart of industrial Manchester, and surrounded on all sides by buildings, the exposure of the station was unorthodox, but it served a very useful purpose as representing the characteristics of a thoroughly urban site. It is perhaps not fully realised that most of our data for large towns are derived from park sites, the micro-climates of which may differ quite noticeably from those of the congested areas in which a large proportion of the inhabitants live, or of the factory areas where the industries are carried on. Oldham Road was one of the very few stations which provided information relating to the latter class of terrain. A careful comparison between the Oldham Road records and those of the station at Whitworth Park maintained by the University of Manchester would undoubtedly bring to light many interesting points.

Oldham Road was perhaps best known on account of its very low sunshine records, the average daily duration being only 2·65 hours. It should be noted, however, that the exposure of the recorder was badly obstructed by buildings and it is estimated that these reduced the daily record on the average by about six per cent. Making this allowance the Oldham Road value comes into close agreement with the daily average at Whitworth Park, 2·82 hours, and that figure is probably about correct for central Manchester as a whole.

REVIEW

Climate, A treatise on the principles of weather and climate. By W. G. Kendrew, M.A. 2nd Ed. Size 9 in. × 5½ in., pp. ix+327, *Illus.* Oxford, at the Clarendon Press, 1938. Price 15*s*. net.

The first edition of this work was reviewed in this Magazine for May, 1931 ; in the new edition there has been a considerable amount of revision, the most extensive alterations being, according to the author's preface, in the chapters dealing with insolation and wind systems. The general plan of the book remains as before, a short introductory chapter, which gives the scope of climatology, being followed by parts II to X, on insolation and temperature ; pressure and winds ; humidity, rainfall, evaporation, clouds, thunderstorms ; sunshine and cloud (cloudiness) ; fog ; mountain and plateau climate ; the weather of temperate regions ; local winds ; and, finally, some climatic types—the Sudan, the Mediterranean type, the Westerlies.

In such a tremendous array of facts, it is not surprising if even in a second edition some points remain for comment, and attention may be drawn to the following :—page 31, probably lower temperatures are found at Oimekon in Siberia than at Verkhoiansk ; page 69, some more explanation should be given of the statement that mean pressure is constant for any given place and season ; page 72, the explanation of the relation of barometric gradient to wind force might be extended, with some more data than those quoted from Whipple and Baker ; page 118, the term " rainy day " suggests a larger fall than 0·01 in., the official quantity for a " rain-day " in this country ; page 122 mentions quantity of water vapour measured in grains per cubic foot and page 187 gm. per cubic metre but the tables of equivalents at the end of the book do not mention these units ; page 125, the conditions in which ions act as nuclei for condensation might be mentioned ; page 197, the whole story of the Sahara is not given by data for Helwan ; page 210, fog is usually defined by visibility below 1,100 yards. The section on the weather of temperate regions (p. 239 ff.) includes an interesting account of weather systems which affect our weather.

There may not be complete agreement, however, about what goes on inside a depression. On several of the weather maps are now marked "fronts" in the conventional symbols. The fronts are stated to be based on Norwegian daily charts. Misprints are few—the figures for heights of mother-of-pearl clouds and luminous night clouds on page 172 have been interchanged; the only other misprint noted is in the quotation from Tacitus (on page 200) which is an early example of the comments made by visitors on the weather of this country.

Apart from these points there are a few which might to some extent be regarded as amongst the "matters of theory on which unanimity is hardly to be expected" mentioned in the preface, but in regard to which the student should be given something of the more modern views. On page 78 appears a diagram stated to be a diagrammatic sketch of the arrangement that might (1st edition—"probably would") be found on the globe if the surface were homogeneous. The term planetary circulation is not used, but the diagram seems to be the usual one. Let the student who has mastered Chapter XV sketch in the isobars over this ideal circulation and he will find that the idea of a cellular circulation in the sub-tropical highs is more satisfactory. On page 17 more of the whole story of the "greenhouse effect" should be given—the main action of the glass is in stopping convection. The Brückner cycle, as everyone knows, is of 35 years, but a 35-year cycle is not so easy to find in the data as cycles of 33, 34 or 38 years. Whether any of these would be better for reaching the true mean value depends on what a true mean value is, an argument which could be expanded into a separate treatise. More can be said about the formation of stratocumulus cloud than the description as a combination of stratus and cumulus (page 174). There are limitations to the goodness of the approximation given by mean of maximum and minimum temperatures to the true mean for the day (page 19). A hurricane area has been found in the *eastern* equatorial sector of the Pacific. The 12 plates, most of which are reproduced from very fine photographs of meteorological phenomena such as the banner cloud and the tornado, and 117 diagrams illustrate the text very well, and on the whole the work may be recommended as a useful and interesting account of the principles of weather and climate, as well as a very good example of printing.

S. T. A. Mirrlees

BOOKS RECEIVED

County of Surrey : Rainfall statistics for the county for the year 1937. County Engineer, Guildford, 1938.

Meteorological report from readings taken at the Greg Observatory, Lancaster, 1937. Neville Holden, Lancaster, 1937.

Jahrbücher der Zentralanstalt für Meteorologie und Geodynamik Jahrgang, 1935. Pub. No. 149. Wein, 1938.

Annales-del Observatorio Nacional de San Bartolome en los Andes Colombianos. Obs. Met. de 1934. Bogota, 1937.

ERRATA

March, 1938, p. 52.

The rainfall at Adelaide in February (2·45 inches) has been exceeded on 7 occasions.

June, 1938, p. 130. line 9. *For* Adelaide *read* Brisbane.

The Weather of August, 1938

High pressure was centred north of the Azores and a low was situated off western Greenland. Pressure was mainly uniform over Europe being slightly below normal over southern Europe and the Mediterranean Basin and above normal over the North Atlantic Ocean and northern Europe. At 50° N. 30° W. there was a mean pressure of 1018 mb., 5 mb. above normal whilst at Sortavala, Finland 1016 mb., 6 mb. above normal was recorded. Over North America pressure was fairly uniform, the north-east and centre being below normal and the south, coming under the influence of the Azores anticyclone, was above normal, whilst off the western Canadian coast pressure was relatively high, Prince Rupert and Juneau, Alaska each recording 1019 mb., 2 mb. above normal. No data were received from the U.S.S.R. Temperature ranged from 40° F. over Spitzbergen, south-eastern Greenland and the mouth of the Hudson Bay (Isfjord Radio 40·6° F. Myggvukta 39·9° F. and Resolution Island 36·4° F.) to 80° F. over northern Africa and the southern United States (New Orleans 84·6° F.) and 90° F. over south-west Asia (Mosul 89·4° F.). Over the Great Lakes and centre of North America and the Baltic Sea temperature was above normal, these being included in the 5° F. isanomaly, elsewhere over North America and Europe small deviations from normal were experienced ; southern Europe and the western Mediterranean were below normal while the eastern Mediterranean was above normal. Rainfall was heavy over central Europe, light over the eastern Mediterranean and mainly below normal in Sweden ; stations in Egypt, Palestine and Iraq have recorded no rain, which is normal for the season. The wettest parts of North America were the area between the Great Lakes and the Hudson Bay, and off the Gulf of St. Lawrence, Sable Island having the largest rainfall of 5·5 in.

Pressure was high over south-eastern Australia and low over southern China ; the highest recorded pressure was at Bourke with 1022 mb. Over the East Indies, the Malay States and northern Australia pressure was below normal (Boulia — 7 mb.) while over the south of Australia and New Zealand it was above normal. Temperature was mainly normal over southern China, Siam, the Malay States, the East Indies, south-eastern Australia and New Zealand, western Australia being below normal where Onslow with a temperature of 60·3° F. was 6·3° F. below normal, and north-eastern Australia was above normal (Boulia 69·8° F., + 6·3° F.) Heavy rain fell in Indo China, at Vientiane over 20 in. fell (nearly 9 in. above normal); more than 7 in. was recorded in western Australia and in the south part of North Island New Zealand. There was a marked deficiency of rain over the Philippine Islands, Manilla rainfall was more than 6 in. below normal. Rainfall in east and north Australia was below normal while the rest of Australia and the greater part of New Zealand was above.

The weather of August over the British Isles was remarkable for frequent thunderstorms, particularly during the first twelve days.* As far as can be estimated at present the total rainfall for the month was below average over practically the whole of Scotland and in most parts of Ireland ; in England and Wales it varied considerably owing to intense local falls of rain during some of the frequent thunderstorms. The month was dull on the whole in England and southern Ireland but sunshine exceeded the average for the most part in Scotland and in the north of Ireland. In the extreme north of Scotland the excessive sunshine was notable ; at Lerwick, in the Shetland Islands, the total was 229 hours, representing an excess of 112 hours above the average. The first twelve days were warm but subsequently the weather became considerably cooler and the last few days were decidedly cool. Much fog was reported from the 1st–12th ; it was persistent and thick at times on the north-east coast of England from the 5th–12th.

During the opening days of the month an anticyclone moved north-east from northern England to the west of Norway. Meanwhile pressure was relatively low over the Bay of Biscay ; thunderstorms were reported in Ireland and the south-western districts of England and Wales but little rain occurred elsewhere. On the 4th a shallow depression was centred south of Ireland and further shallow depressions moved north from France ; thunderstorms were widespread in England and Ireland. The thunderstorms on the 4th were accompanied by unusually heavy rains at numerous places in south-west England ; at Torquay 5·72 in. fell between 6h. 50m. and 12h, of which 4·25 in. fell in 108 minutes from 7h. 12m. to 9h. From the 5th to the 10th a complex area of shallow low pressure covered most of the British Isles, while an extension of the anticyclone over Scandinavia stretched westward to the north of Scotland ; thunderstorms were reported daily from the 5th to the 12th. Temperature was high during the first 12 days ; 80° F. was reached or exceeded at some place or other on each day and among the highest maxima recorded were 87° F. at Camden Square (London) on the 1st and at Poole on the 2nd and 3rd, and 86° F. at Regent's Park (London), Brighton and Tottenham on the 1st and at Bournemouth and Southsea on the 3rd.

Subsequently the Azores anticyclone spread north-east over the British Isles and mainly fair weather prevailed for the most part on

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* See p. 195 *et. seq.*

the 13th and 14th, though it was considerably cooler. At Lerwick and Kirkwall rain on the 15th ended an absolute drought of 15 days.

A deep depression south of Greenland and an associated trough extending to south-west Ireland moved east and caused further rain, chiefly in the west and north, between the 15th and 17th. Strong, squally winds prevailed at exposed places in Great Britain on the 17th, with a gale at Wick. A further spell of cool, unsettled weather was associated with the eastward passage of depressions to the north of Scotland; rain fell at times, and gales were recorded locally in the west on the 18th and 19th, while local thunderstorms occurred on each day from the 19th to the 22nd. On the 23rd a wedge of high pressure crossed Great Britain giving a fair day in the eastern half of England but much fog on the south-west coasts. Meanwhile a depression on the Atlantic moving north-east and an associated trough approaching Ireland caused heavy rain in west Ireland and west Scotland on the 23rd and later in north England. Thereafter a belt of high pressure stretching from the Azores across the British Isles to northern Scandinavia occasioned fair weather in many parts on the 25th and 26th, but a trough of low pressure passing east over the country brought renewed unsettled weather on the 27th and 28th.

Subsequently pressure was low over central Europe and relatively high to the south-west and north-west of the British Isles. Cool weather prevailed during the last few days, with scattered rain or showers and good records of bright sunshine locally. Low screen minima were registered at some stations on the morning of the 31st, for example 32° F. at Barton, Manchester.

The distribution of bright sunshine for the month was as follows:—

	Total hrs.	Diff. from average hrs.		Total hrs.	Diff. from average hrs.
Stornoway ..	187	+59	Chester ..	149	−10
Aberdeen ..	199	+59	Ross-on-Wye	129	−43
Dublin	127	−27	Falmouth ..	163	−33
Birr Castle ..	105	−32	Gorleston ..	187	−10
Valentia ..	108	−40	Kew.. ..	158	−25

Kew temperature, mean, 61·3°F: diff. from average, −1·4°F.

Miscellaneous notes on weather abroad from various sources

The first half of August was characterised by a series of violent thunderstorms in Europe. On the 4th, Paris was visited and Le Havre was flooded while in eastern Poland lightning killed 26 persons and started 85 fires. On the 6th storms raged over the northern half of France causing three deaths and much damage, and Le Havre was again flooded, some hailstones being reported to weigh over three ounces. The storms continued for several days; lightning damaged an insulator on the Radio Paris broadcasting station, interrupting the broadcasts during the 9th. Storms occurred in

Brussels and other parts of Belgium on the 8th, the Riviera on the 11th and Paris on the 12th. In North America the month opened with heat and drought, temperature reaching 93° F. in New York on the 3rd and 15th. Crops in Canada were damaged by hail. In India the monsoon rainfall was heavy and floods covered a very large area in the United Provinces. The Nile Food also rose to an unusually high level, submerging wide areas in Egypt and destroying large quantities of cotton. A typhoon passed close to Shanghai on August 10th (*The Times*—various dates).

Daily Readings at Kew Observatory, August, 1938

Date	Pressure, M.S.L. 13h.	Wind, Dir., Force 13h.	Temp. Min.	Temp. Max.	Rel. Hum. 13h.	Rain	Sun	REMARKS
	mb.		°F.	°F.	%	in.	hrs.	
1	1024·3	NE 3	63	84	48	—	10·8	w early.
2	23·9	NE 3	60	82	59	—	6·6	
3	21·2	E 4	59	80	50	—	10·8	
4	16·8	E 4	57	81	46	—	9·4	tl 19h.–20h.
5	15·4	NNW 2	58	79	59	trace	3·6	pr_0 21h.
6	14·8	W 3	62	83	45	—	8·0	
7	14·6	NNE 2	63	67	91	0·55	0·0	ir_0–r 9h.–22h.
8	12·6	Calm	63	77	70	0·22	4·8	r_0 3h.–5h., r 5 h.–7h.
9	13·5	S 2	60	79	63	trace	7·1	pr_0 8h.
10	14·9	NW 2	61	67	74	0·43	0·0	r–r_0 3h.–10h. and 13h. 18h.
11	14·1	WSW 1	58	79	61	0·72	9·3	tlr 17h.–20h., R 18h.
12	12·5	WNW 2	56	79	74	0·14	5·5	tlR 17h., tlr 20h.
13	12·7	W 3	57	69	55	—	6·5	
14	14·2	Calm	56	67	73	0·01	0·0	r_0 6h.–7h.
15	15·5	E 1	52	73	54	—	7·7	mw early.
16	06·8	SW 5	60	71	73	trace	3·6	d_0 10h.
17	12·1	W 3	57	68	41	trace	5·2	pr_0 3h.
18	12·8	SW 4	54	70	54	—	6·8	
19	00·0	SSW 5	58	68	89	0·02	1·3	r_0–r 11h–12h., pr_0 15h.
20	07·1	SW 4	54	66	56	trace	6·1	pr_0 15h.
21	15·2	WSW 2	45	67	47	0·01	9·1	pr_0 15 h. & 6h.
22	18·9	WSW 2	49	63	64	0·04	0·7	pr_0, 10h., ir_0 15h.–18h.
23	21·6	E 3	51	71	51	—	11·1	mw early.
24	19·8	SE 2	53	74	48	—	5·8	w early.
25	19·8	S 2	51	74	48	trace	2·6	pr_0 17h. & 19h.
26	21·3	NNE 2	56	65	65	0·21	2·1	r_0–r 0h.–4h.
27	19·3	SW 1	54	71	60	—	3·9	fe till 8h.
28	12·7	SW 2	53	67	62	0·24	0·1	r_0–r 7h.–8h. & 19h.–24h.
29	12·1	NNW 4	53	58	83	0·11	0·0	r_0–r 0h.–9h.
30	15·1	W 3	45	63	57	—	3·7	w early.
31	1016·6	SW 2	46	64	47	—	5·8	w early.
*	1015·2	—	56	72	60	2·70	5·10	* Means or Totals.

General Rainfall for August, 1938

England and Wales	100	per cent of the average 1881–1915.
Scotland	68	
Ireland	83	
British Isles ...	89	

Rainfall : August, 1938 : England and Wales

Co.	Station.	In.	Per cent of Av.	Co.	Station.	In.	Per cent of Av.
Lond .	Camden Square	1·80	81	*Leics* .	Thornton Reservoir	2·86	102
Sur .	Reigate, Wray Pk. Rd.	2·42	99	,, .	Belvoir Castle	4·10	156
Kent .	Tenterden, Ashenden	1·89	83	*Rut* .	Ridlington	2·36	94
,, .	Folkestone, Boro. San.	1·83	...	*Lincs* .	Boston, Skirbeck	1·95	82
,, .	Margate, Cliftonville	2·28	118	,, .	Cranwell Aerodrome	2·20	81
,, .	Eden'bdg., Falconhurst	4·79	183	,, .	Skegness, Marine Gdns.	1·84	75
Sus .	Compton, Compton Ho.	2·16	70	,, .	Louth, Westgate	2·97	106
,, .	Patching Farm	1·54	61	,, .	Brigg, Wrawby St.	2·71	...
,, .	Eastbourne, Wil. Sq.	1·45	58	*Notts* .	Mansfield, Carr Bank	1·67	60
Hants.	Ventnor, Roy.Nat.Hos.	1·39	70	*Derby*.	Derby, The Arboretum	1·59	95
,, .	Southampton,East Park	2·48	95	,, .	Buxton, Terrace Slopes	2·32	53
,, .	Ovington Rectory	1·60	59	*Ches* .	Bidston Obsy	4·33	141
,, .	Sherborne St. John	1·42	59	*Lancs*.	Manchester, Whit. Pk.	2·54	74
Herts .	Royston, Therfield Rec.	1·56	61	,, .	Stonyhurst College	3·97	78
Bucks.	Slough, Upton	2·22	102	,, .	Southport, Bedford Pk.	3·90	112
Oxf .	Oxford, Radcliffe	3·61	158	,, .	Ulverston, Poaka Beck	3·05	57
N'hant	Wellingboro, Swanspool	4·16	175	,, .	Lancaster, Greg Obsy.	3·90	86
,, .	Oundle	2·22	...	,, .	Blackpool	3·90	109
Beds .	Woburn, Exptl. Farm	2·83	123	*Yorks*.	Wath-upon-Dearne	4·91	205
Cam .	Cambridge, Bot. Gdns.	...	...	,, .	Wakefield,Clarence Pk.	4·33	167
,, .	March	1·20	50	,, .	Oughtershaw Hall	5·83	...
Essex.	Chelmsford,County Gdns	1·15	53	,, .	Wetherby, Ribston H.	3·60	132
,, .	Lexden Hill House	1·66	...	,, .	Hull, Pearson Park	2·84	98
Suff .	Haughley House	2·53	...	,, .	Holme-on-Spalding	2·73	102
,, .	Rendlesham Hall	1·46	73	,, .	Felixkirk, Mt. St. John.	2·74	96
,, .	Lowestoft Sec. School	·53	24	,, .	York, Museum Gdns	2·15	85
,, .	Bury St. Ed., WestleyH.	2·00	77	,, .	Pickering, Houndgate	3·14	122
Norf. .	Wells, Holkham Hall	1·07	45	,, .	Scarborough	2·95	106
Wilts .	Porton, W.D. Exp'l. Stn	1·77	79	,, .	Middlesbrough	3·64	133
,, .	Bishops Cannings	4·17	135	,, .	Baldersdale, Hury Res.	3·37	97
Dor .	Weymouth, Westham.	...	...	*Durh* .	Ushaw College	1·69	58
,, .	Beaminster, East St.	2·43	78	*Nor* .	Newcastle, Leazes Pk.	2·08	74
,, .	Shaftesbury,Abbey Ho.	2·52	87	,, .	Bellingham, Highgreen	2·01	57
Devon.	Plymouth, The Hoe	4·57	148	,, .	Lilburn Tower Gdns	2·72	96
,, .	Holne, Church Pk. Cott.	8·46	189	*Cumb*.	Carlisle, Scaleby Hall	2·78	68
,, .	Teignmouth, Den Gdns.	3·77	167	,, .	Borrowdale, Seathwaite	8·75	80
,, .	Cullompton	4·09	134	,, .	Thirlmere, Dale Head H.	5·39	70
,, .	Sidmouth, U.D.C.	3·74	...	,, .	Keswick, High Hill	2·96	57
,, .	Barnstaple, N. Dev.Ath	7·38	224	,, .	Ravenglass, The Grove	3·51	77
,, .	Dartm'r,Cranmere Pool	7·90	...	*West* .	Appleby, Castle Bank	2·15	65
,, .	Okehampton, Uplands.	7·01	165	*Mon* .	Abergavenny, Larchf'd	3·56	119
Corn .	Redruth, Trewirgie	3·58	105	*Glam* .	Ystalyfera, Wern Ho.	6·56	106
,, .	Penzance, Morrab Gdns.	4·79	151	,, .	Treherbert, Tynywaun.	6·34	...
,, .	St. Austell, Trevarna	5·36	148	,, .	Cardiff, Penylan	3·14	74
Soms .	Chewton Mendip	3·65	81	*Carm* .	Carmarthen,M. & P. Sch.	3·64	76
,, .	Long Ashton	3·36	96	*Pemb* .	Pembroke,Stackpole Ct.	...	...
,, .	Street, Millfield	2·28	85	*Card* .	Aberystwyth	3·35	...
Glos .	Blockley	2·91	...	*Rad* .	BirmW.W.Tyrmynydd	3·68	68
,, .	Cirencester, Gwynfa	4·48	149	*Mont* .	Newtown, Penarth Weir	...	...
Here .	Ross-on-Wye	2·81	110	,,	Lake Vyrnwy	4·71	91
Salop.	Church Stretton	3·43	106	*Flint* .	Sealand Aerodrome	4·07	148
,, .	Shifnal, Hatton Grange	3·70	132	*Mer* .	Blaenau Festiniog	6·55	64
,, .	Cheswardine Hall	3·34	101	,, .	Dolgelley, Bontddu	5·88	104
Worc .	Malvern, Free Library	3·87	134	*Carn* .	Llandudno	2·60	92
,, .	Ombersley, Holt Lock.	2·19	81	,, .	Snowdon, L. Llydaw 9.	7·75	...
War .	Alcester, Ragley Hall	3·42	123	*Ang* .	Holyhead, Salt Island	2·05	65
,, .	Birminghm, Edgbaston	3·29	121	,, .	Lligwy	1·15	...

Rainfall: August, 1938: Scotland and Ireland

Co.	Station.	In.	Per cent of Av.	Co.	Station.	In.	Per cent of Av.
I. Man	Douglas, Boro' Cem....	2·17	57	*R&C* .	Achnashellach............	...	...
Guern.	St.Peter P't.Grange Rd.	2.28	97	,, .	Stornoway,C.GuardStn.	4·52	120
Wig .	Pt. William, Monreith.	3·01	78	*Suth* .	Lairg........................	2·51	79
,, .	New Luce School.........	2·72	61	,, .	Skerray Borgie...........	...	...
Kirk .	Dalry, Glendarroch......	2·16	45	,, .	Melvich.....................	2·81	94
Dumf.	Eskdalemuir Obs........	3·02	59	,, .	Loch More, Achfary....	5·75	98
Roxb .	Hawick, Wolfelee........	1.04	31	*Caith* .	Wick.........................	2·37	86
,, .	Kelso, Broomlands......	1.40	47	*Ork* .	Deerness	2·48	86
Peeb .	Stobo Castle	1·78	50	*Shet* .	Lerwick Observatory...	1·61	53
Berw .	Marchmont House......	3·06	92	*Cork* .	Cork, University Coll...	1·85	55
E.Lot .	North Berwick Res.....	3·92	124	,, .	Roches Point, C.G. Stn.	3·19	84
Midl .	Edinburgh, Blackfd. H.	1·15	36	,, .	Mallow, Longueville....	2·57	83
Lan .	Auchtyfardle	3·37	...	*Kerry*.	Valentia Observatory...	5·62	117
Ayr .	Kilmarnock, Kay Park	2·73	...	,, .	Gearhameen...............	6·50	86
,, .	Girvan, Pinmore.........	2·67	60	,, .	Bally McElligott Rec...	5·19	...
,, .	Glen Afton, Ayr San....	4·09	76	,, .	Darrynane Abbey.......	5·84	134
Renf .	Glasgow, Queen's Park	4·17	118	*Wat* .	Waterford, Gortmore...	3·53	93
,, .	Greenock, Prospect H..	2·48	48	*Tip* .	Nenagh, Castle Lough.	5·29	134
Bute .	Rothesay, Ardencraig...	3·14	64	,, .	Cashel, Ballinamona....	2·90	83
,, .	Dougarie Lodge..........	2·96	70	*Lim* .	Foynes, Coolnanes......	5·76	149
Arg .	Loch Sunart, G'dale....	4·92	86	*Clare* .	Inagh, Mount Callan....	8·30	...
,, .	Ardgour House..........	6·52	...	*Wexf* .	Gorey, Courtown Ho...	2·27	68
,, .	Glen Etive.................	6·12	81	*Wick* .	Rathnew, Clonmannon.	2·06	...
,, .	Oban........................	4·70	...	*Carl* .	Bagnalstown,Fenagh H.	3·41	97
,, .	Poltalloch.................	...	...	,, .	Hacketstown Rectory...	3·26	80
,, .	Inveraray Castle.........	5·64	86	*Leix* .	Blandsfort House.......	4·06	103
,, .	Islay, Eallabus...........	3·70	85	*Offaly*.	Birr Castle................	4·09	107
,, .	Mull, Benmore...........	9·50	81	*Kild* .	Straffan House...........	2·60	69
,, .	Tiree........................	...	...	*Dublin*	Dublin, Phoenix Park..	2·12	67
Kinr .	Loch Leven Sluice......	1·56	41	*Meath*.	Kells, Headfort..........	2·72	66
Fife .	Leuchars Aerodrome...	2·12	69	*W.M* .	Moate, Coolatore.........	...	...
Perth .	Loch Dhu..................	4·10	61	,, .	Mullingar, Belvedere...	2·39	57
,, .	Crieff, Strathearn Hyd.	2·81	67	*Long* .	Castle Forbes Gdns......	3·70	90
,, .	Blair Castle Gardens....	2·39	71	*Gal* .	Galway, Grammar Sch.	4·52	110
Angus.	Kettins School............	1·74	48	,, .	Ballynahinch Castle....	6·35	116
,, .	Pearsie House............	1·33	...	,, .	Ahascragh, Clonbrock.	4·55	109
,, .	Montrose, Sunnyside...	·65	23	*Rosc* .	Strokestown, C'node.....	3·31	87
Aber .	Balmoral Castle Gdns..	1·36	45	*Mayo*.	Blacksod Point..........	4·22	92
,, .	Logie Coldstone Sch....	1·91	60	,, .	Mallaranny	6·92	...
,, .	Aberdeen Observatory..	1·13	41	,, .	Westport House.........	4·32	107
,, .	New Deer School House	1·37	46	,, .	Delphi Lodge............	6·24	72
Moray	Gordon Castle............	2·47	78	*Sligo* .	Markree Castle..........	3·56	82
,, .	Grantown-on-Spey	1·61	50	*Cavan*.	Crossdoney, Kevit Cas..	2·65	...
Nairn.	Nairn	1·33	55	*Ferm* .	Crom Castle..............	2·22	54
Inv's .	Ben Alder Lodge.........	2·32	...	*Arm* .	Armagh Obsy............	2·57	71
,, .	Kingussie, The Birches.	1·67	...	*Down*.	Fofanny Reservoir......	3·06	...
,, .	Loch Ness, Foyers	1·97	64	,, .	Seaforde	2·26	60
,, .	Inverness, Culduthel R.	1·76	69	,, .	Donaghadee, C. G. Stn.	1·87	56
,, .	Loch Quoich, Loan......	6·67	...	*Antr* .	Belfast,Queen's Univ....	2·77	75
,, .	Glenquoich................	6·91	84	,, .	Aldergrove Aerodrome.	2·26	63
,, .	Arisaig House............	4·29	74	,, .	Ballymena, Harryville.	3·18	74
,, .	Glenleven, Corrour......	4·44	81	*Lon* .	Garvagh, Moneydig....	2·33	...
,, .	Fort William, Glasdrum	...	...	,, .	Londonderry, Creggan.	3·01	65
,, .	Skye, Dunvegan.........	4·77	..	*Tyr* .	Omagh, Edenfel.........	2·52	59
,, .	Barra, Skallary........	3·72	...	*Don* .	Malin Head...............	2·65	63
R&C.	Tain, Ardlarach..........	1·24	43	,, .	Dunfanaghy...............	2·27	61
,, .	Ullapool	3·67	103	,, .	Dunkineely................	4·18	...

Erratum: Galway Grammar School, July, *for* 4·68/146 *read* 4·78/149.

Climatological Table for the British Empire, March, 1938

STATIONS.	PRESSURE. Mean of Day M.S.L. mb.	PRESSURE. Diff. from Normal. mb.	TEMPERATURE. Absolute. Max. °F.	TEMPERATURE. Absolute. Min. °F.	TEMPERATURE. Mean Values. Max. °F.	TEMPERATURE. Mean Values. Min. °F.	TEMPERATURE. Mean Values. ½ Max. and ½ Min. °F.	TEMPERATURE. Mean Values. Diff. from Normal. °F.	TEMPERATURE. Mean Wet Bulb. °F.	Relative Humidity %	Mean Cloud Am'nt 0–10	PRECIPITATION. Am'nt. in.	PRECIPITATION. Diff. from Normal. in.	PRECIPITATION. Days	BRIGHT SUNSHINE. Hours per day.	BRIGHT SUNSHINE. Percentage of possible.
London, Kew Obsy.	1025·1	+11·7	65	31	58·3	40·3	49·3	+ 6·2	45·1	88	6·2	0·26	− 1·43	3	5·6	47
Gibraltar	1023·0	+ 5·9	65	49	58·9	53·0	55·9	− 1·7	51·2	78	6·0	2·71	...	3	...	...
Malta	1022·9	+ 8·7	66	44	58·6	49·2	53·9	− 3·2	49·3	77	4·2	1·99	+ 0·51	8	8·5	71
St. Helena	1014·7	− 1·4	72	58	69·3	62·1	65·7	+ 0·6	63·1	91	9·5	3·24	− 0·78	17	...	...
Freetown, Sierra Leone	1009·9	+ 0·9	92	72	88·4	74·7	81·5	...	75·2	73	4·0	0·09	− 1·07	2	...	...
Lagos, Nigeria	1008·5	− 0·4	92	72	89·3	76·8	83·1	− 0·3	77·1	85	4·8	1·66	− 2·09	7	6·0	50
Kaduna, Nigeria	1009·6	...	102	59	94·5	67·3	80·9	− 0·2	63·2	47	4·1	0·06	− 0·48	1	8·7	73
Zomba, Nyasaland	1009·5	− 0·1	87	50	78·1	63·2	70·7	− 0·6	68·6	86	7·4	12·68	+ 3·60	20	...	...
Salisbury, Rhodesia	1011·3	− 0·8	82	50	77·6	56·2	66·9	− 1·3	60·8	73	4·5	3·37	...	11	8·5	70
Cape Town	1014·2	− 0·3	91	52	78·5	59·3	68·9	+ 0·8	61·5	81	4·0	0·65	− 0·23	8	...	...
Johannesburg	1011·7	− 0·1	83	49	77 5	55·3	66·4	+ 3·0	56·6	66	2·0	1·75	− 2·69	9	8·6	70
Mauritius	1009·5	− 2·4	88	68	84·6	73·6	79·1	+ 1·1	75·2	77	5·9	6·37	− 2·22	20	8·5	70
Calcutta, Alipore Obsy.	1006·7	− 3·2	101	62	96·4	73·4	84·9	+ 4·7	74·4	86	2·4	0·52	− 0·86	2*	...	...
Bombay	1008·6	− 2·3	91	70	86·9	73·5	80·2	+ 0·7	72·3	76	1·4	0·00	− 0·02	0*	...	...
Madras	1008·5	− 2·4	95	67	89·9	74·3	82·1	+ 1·0	76·1	81	3·9	1·45	+ 1·11	1*	...	...
Colombo, Ceylon	1008·8	− 1·3	89	70	86·6	74·8	80·7	− 1·1	77·0	77	6·8	8·14	+ 3·86	16	6·9	57
Singapore	1008·6	− 1·1	91	73	85·6	75·1	80·3	− 0·9	77·0	80	7·8	7·60	+ 0·20	16	4·2	35
Hongkong	1014·8	− 1·2	83	47	68·0	59·5	63·7	+ 0·4	59·7	79	8·5	5·75	+ 2·81	14	2·7	22
Sandakan	1009·0	...	89	73	86·1	75·4	80·7	− 0·3	76·9	86	7·4	9·24	+ 0·77	16	...	...
Sydney, N.S.W.	1014·6	− 1·7	94	55	77·9	64·6	71·3	+ 2·0	65·9	68	5·0	1·32	− 3·66	7	6·6	54
Melbourne	1016·0	− 0·9	97	48	75·3	56·2	65·7	+ 1·2	53·8	40	6·9	1·16	− 1·02	8	5·7	46
Adelaide	1017·6	+ 0·5	103	49	82·4	59·9	71·1	+ 1·2	60·5	49	5·1	0·13	− 0·89	5	8·0	66
Perth, W. Australia	1015·9	+ 0·6	98	51	79·6	61·1	70·3	− 0·9	61·0	56	6·2	1·75	+ 0·94	8	8·2	67
Coolgardie	1015·1	+ 0·2	98	52	86·4	61·1	73·7	+ 1·8	62·3	62	4·5	0·60	− 0·34	2	...	...
Brisbane	1014·0	− 0·4	91	60	83·3	67·1	75·2	+ 0·9	69·1	72	5·9	4·24	− 1·53	15	7·2	58
Hobart, Tasmania	1015·1	+ 0·9	81	44	67·2	51·6	59·4	+ 0·1	53·7	67	6·8	4·66	+ 2·96	12	5·9	48
Wellington, N.Z.	1020·1	+ 2·9	78	47	69·9	57·8	63·9	+ 3·3	60·5	78	7·3	0·95	− 2·38	10	6·4	52
Suva, Fiji	1010·0	+ 1·6	92	71	85·9	74·5	80·2	+ 0·1	74·8	80	5·4	8·54	− 5·95	25	5·8	48
Apia, Samoa	1009·7	+ 0·5	87	71	85·6	74·2	79·9	+ 0·6	75·9	76	6·1	10·80	− 3·18	14	6·0	49
Kingston, Jamaica	1015·2	+ 0·3	89	65	85·3	67·8	76·5	− 0·6	65·6	79	1·4	0·75	− 0·27	5	6·4	53
Grenada, W.I.	1011·1	− 1·9	89	70	86	73	79·5	+ 1·7	75	79	6	4·18	+ 1·52	17	...	...
Toronto	1014·1	− 3·2	73	− 5	44·1	27·4	35·7	+ 6·1	...	...	6·5	1·64	− 0·77	17	4·2	35
Winnipeg	1010·9	− 8·3	66	−12	38·2	18·2	28·2	+13·2	...	...	4·3	0·50	− 0·66	4	5·5	46
St. John, N.B.	1014·9	+ 0·8	49	− 7	34·8	19·3	27·1	− 1·3	21·8	75	6·3	4·49	− 0·05	16	5·5	46
Victoria, B.C.	1011·4	− 4·5	57	32	50·3	38·9	44·6	+ 1·1	41·9	81	7·4	2·62	+ 0·19	20	4·9	41

* For Indian stations a rain day is a day on which 0·1 in. or more rain has fallen.

(43645) Wt. 21/31 1,125 9/38 Hw. G.377/6