

FIG. 1.—CALSHOT ANEMOGRAM, JUNE 1ST-2ND, 1915.

<h1 style="margin: 0;">The Meteorological Magazine</h1>				
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ATMOSPHERIC SODIUM

By Professor S. CHAPMAN, F.R.S.

To anyone who has seen sodium hissing and spitting on the surface of water, with a hydrogen flame playing around it (the hydrogen being evolved in the combination of the sodium with the water), it must come with rather a shock to learn that there is free sodium in the atmosphere. It exists there, however, only in the form of an extremely rare vapour, and doubtless it survives long only at levels where water also is rare, causing combination of the sodium atoms with water molecules to be a very infrequent event.

The discovery and proof of the presence of sodium in the atmosphere are due to the skilled efforts of several distinguished pupils of Professor Fabry—MM. Cabannes, Dufay and Déjardin, and their own pupils MM. Gauzit and Bernard. Spectroscopic methods were employed, the well-known D lines of sodium (at wave-length 5893A) having been detected in the spectrum of the light from the sky, at twilight and also, with much longer photographic exposures, during the night. During the few minutes after sunset, when the sky is rapidly darkening, the continuous spectrum of the sunlight scattered by the air fades much faster than does the light emitted by the sodium atoms in the air, so that the spectrum reveals this light by bright lines superposed on a faint background. The sky spectrum also shows the famous green auroral line now known to be due to atomic oxygen, but whereas this line is visible, without great change of intensity, from twilight onwards throughout the night, the sodium yellow lines, which are at least as strong as the oxygen line just about sunset, fade almost completely away during an interval of a few minutes. Delicate measurements of their wave-length, by interferometer methods, confirm the identity of these lines with the

double D line of sodium, both at twilight and also during the night.

The rapid fading of the sodium light at sunset is interpreted as indicating that the sodium is stimulated to luminescence by sunlight : at the time when the sodium light has sunk to insignificance compared with the oxygen green light, the lower limit of the sunshine still traversing the highest layers of the atmosphere is about 60 kilometers or 40 miles, and this is taken as indicating that the sodium lies mainly below this level. During the night the emission of sodium light is at an altogether lower intensity, corresponding to a much weaker stimulus ; it seems not unlikely that the energy necessary to excite the sodium atoms to emit light is then imparted to them by collisions with other atoms or molecules around them, which already possess excess energy ; the emission of the green oxygen light throughout the night implies the presence of metastable oxygen atoms, continually produced during the recombination of atomic oxygen to form oxygen molecules ; the sodium light doubtless derives its energy from the same source, that is, the energy of dissociation of oxygen by ultraviolet sunlight during the day.

Sodium is a light element—its atomic weight is 23, as compared with the molecular weights 28 and 32 for nitrogen and oxygen (though atomic oxygen, at 16, is lighter) : hence sodium atoms can easily remain at high levels. They will probably tend to combine with molecular oxygen (and with atomic oxygen in triple collisions involving also a third atom or molecule), as well as with water molecules. Such combinations will load the sodium atom with a companion, forming a heavier molecule, which will tend to sink to lower levels ; but this process is slow and the sodium compound may also be sundered again into its constituent atoms by sunlight. Hence the life of the sodium at great heights, where these processes go on slowly, is likely to be long.

Speculation is already active concerning the source of the sodium of the high atmosphere. Professor Fabry, in a recent lecture before the Royal Astronomical Society, broached the suggestion that the sodium might come from interstellar space, which is not absolutely empty but contains gas of a very low density, notably of calcium vapour and also a small amount of sodium vapour. The sun with all its family of planets is travelling through space with a speed of about twenty kilometres per second, and the earth must sweep up the sodium and other atoms lying along its track. In the course of the few thousand million years of the earth's existence an appreciable amount of sodium must thus have entered the earth's atmosphere from outside. Even if this amount is as large as that which to-day exists in the atmosphere, we cannot be sure that this atmospheric sodium is of interstellar origin without knowing the rate at which free sodium is removed from the atmosphere by combination and settling down to the ground, or in other ways.

Professor Fabry has also discussed the possibility that the atmospheric sodium is of terrestrial origin ; when spray from the oceans

evaporates in the air sodium chloride is left behind, and some of this may be in molecular form instead of in larger aggregations. The sodium chloride molecules will be carried up to heights of many kilometres, and possibly up to 60 km. height, by atmospheric turbulence. Above the ozone layer, at least, such molecules would doubtless be dissociated into sodium and chloride ions, which in the presence of the many ions and electrons known to exist at high levels would soon become neutralized by gaining or losing an electron. As yet we are far from having sufficient knowledge to calculate the rate at which this process could supply free sodium atoms to the upper atmosphere. It would also supply free chlorine to the upper air, and though this has not been detected there it would be premature to deny the possibility of its presence.

The sun is yet another possible source of the atmospheric sodium. The Fraunhofer spectrum of sunlight shows by its absorption lines that the outer layers of the sun's atmosphere, which absorb some of the light which passes through them, contain sodium vapour among many other constituents. The occurrence of magnetic storms and auroræ is generally attributed to the emission of streams of gas from the sun, which affect the earth when they impinge upon it. The precise cause and method of emission of such streams are unknown, though Professor E. A. Milne has outlined one process which must result in the emission of sodium and calcium atoms, amongst others, from the sun. It seems quite possible that the sodium in our atmosphere has been supplied and is from time to time replenished by this means. But here again we have too few facts on which to base a satisfactory quantitative estimate of this means of supply. For the present, therefore, the origin of the sodium in our atmosphere must remain in doubt.

The Gales of June, 1938

Over a considerable part of southern England the gale on the night of June 1st-2nd attained a violence unprecedented for the time of year since systematic wind measurements began and possibly for a much longer period. Its full ferocity was felt on the south coast, where considerable damage was done, notably at Bournemouth. The anemogram at Calshot (fig. 1, frontispiece) shows that shortly before 23h. the mean velocity reached 55 m.p.h. The highest gust of 88 m.p.h. occurred about 2h. 40m., when the mean velocity was less. Other notable gusts were 80 m.p.h. at the Lizard, 76 m.p.h. at Pembroke, 68 m.p.h. at Lympne and Scilly, 67 m.p.h. at Croydon.

The gale was the climax of three very disturbed days, at a season when the average gale frequency is at about its minimum. On the night of May 29th-30th gale force was reached at Yarmouth and Spurn Head, and gusts touched 55 m.p.h. at Croydon and 54 m.p.h. at Cranwell. These were outstanding for the season, though eclipsed 48 hours later. Another active depression on the 31st caused a gale at Pembroke and Hartland Point.

The three successive gales accompanied separate depressions moving northeastward on the same frontal system, deepening as they approached our southwest coasts. They were associated with a large difference of temperature between tropical air and polar air from the Greenland-Spitzbergen area. The temperature difference between Mildenhall and Aldergrove on the morning of 1st was at its maximum at 600 mb. pressure (about 13,500 feet), where it amounted to 17°F. The depression of June 1st was first noticeable as a small secondary just north of the Azores at 7h. on May 31st and at 13h. it was more definite, with an observed pressure of 1012 mb. near the centre. There was a wavy front and a chain of depressions extending to Florida, but it is almost certain that the all-important disturbance was a new one. By 7h. on June 1st the depression was centred about 250 miles southwest of Scilly, with a pressure below 998 mb. at the centre. The situation at 18h. is shown by the chart on fig. 2. Pressure was below 988 mb. at the centre, and a gale had developed behind the cold front. A remarkable feature of the chart is the secondary warm sector within the main warm sector. This was largely the result of solar heating over France. The warm front was diffuse and did not extend far eastward, but the cold front was definite. If one only had this chart one would consider the first cold front as the main cold front of the depression but a comparison with previous charts shows that this was not so. The first front formed off the French coast and the second front was the real polar front. Frontogenesis on the continental coasts is common in summer but a warm sector within a warm sector is rare. Both cold fronts can be identified on autographic records in southeast England.

The secondary disturbance which moved up from France gave thunderstorms and heavy rainfall in Kent and Sussex, mostly ahead of the warm front. The main depression also gave heavy rain near the centre (1.93 in. at Scilly) but in between the two belts of heavy rain there was not much rain. The main cold front gave practically no rain in the southeast, indeed after the thunderstorm rains there was no appreciable rain in southeast England till June 10th, when showers caused a temporary break in the dry spell.

The distortion of the isobars caused by the French disturbance greatly increased the suddenness of onset of the gale. This is well shown on the anemogram at Calshot (fig. 1) where the main cold front passed at about 18h. 30m. The instability of polar air often gives an increase of wind behind the cold front, but in this case there was also a great increase of pressure gradient. As with nearly all very severe gales, the peak velocity occurred at a non-frontal trough in the polar air after the depression had assumed something of the structure of a travelling vortex. The wind direction record at Calshot (fig. 1) shows a steady slow veer. The barogram in London also showed the typical smooth rounded structure of the trough. The comparative absence of rain in front of these troughs is due to

the fact that there is no convergence when the motion is of the type specified, once the deepening of the depression has ceased, apart

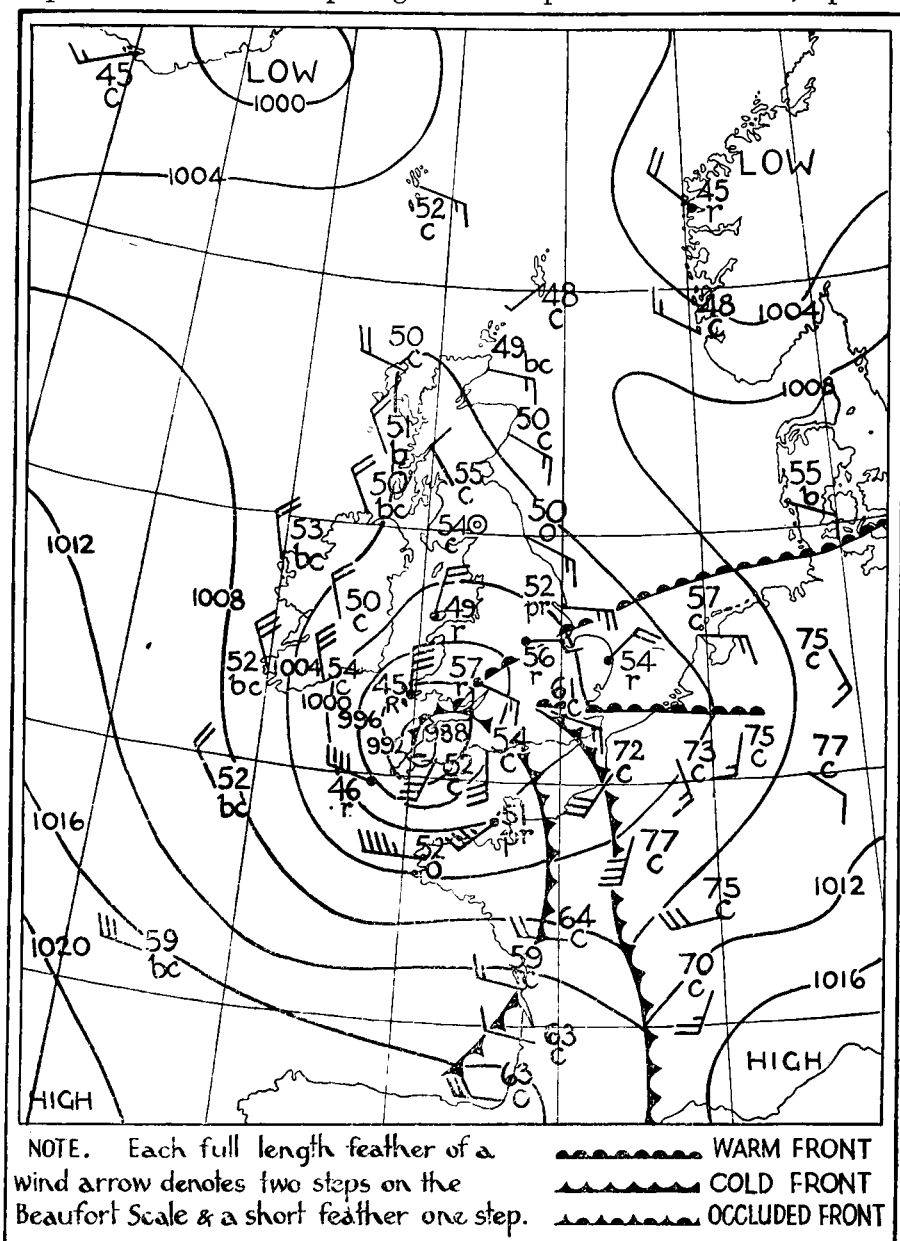


FIG. 2.—SYNOPTIC CHART, 18H., JUNE 1ST, 1938

from the relatively small frictional influence; there may even be slight divergence ahead of the trough, owing to the curvature effect.

By 1h. on the 2nd the depression was centred just west of Spurn Head and had become slightly less deep. An occlusion extended

north from the centre, curving eastward and dividing into warm and cold fronts over the North Sea. At the occlusion there was a departure from the pure vortex structure.

The last three days of June provided two depressions with gales almost as severe as those described above.

On Sunday, June 26th, a complex system travelled over the Atlantic without much development. During Monday, whilst the system crossed Scotland, the pressure at the centre fell from 996 mb. to 968 mb. Widespread gales occurred and gusts of 77 m.p.h. were reported from Aldergrove and 66 m.p.h. from Eskdalemuir.

The next day, Tuesday, June 28th, another complex disturbance, which had formed further west on the same frontal system, crossed the British Isles. The deepening of this disturbance took place throughout its rapid journey across the Atlantic. At 13h. G.M.T. on Monday, about 900 miles west of Valentia the lowest pressure was 1006 mb. At 18h. on Tuesday the lowest pressure over Northern Ireland was about 978 mb. The strongest winds occurred in the south. Gusts of 78 m.p.h. were reported from Manston, 68 m.p.h. from Croydon, and 63 m.p.h. from Pembroke and Lympne. A feature common to all these depressions was the complexity of the frontal structure in the early stages. (The structure of a vigorous disturbance must of necessity be complex later in its life history.) These exceptional disturbances afforded little relief from the dry conditions prevailing in southeast England.

Note on the Effect of Wind on the Temperature of a Thermometer

By E. GOLD, F.R.S.

The experimental measurement of wind and of wind pressure has shown that the pressure of the wind on a small circular obstacle is $\frac{1}{2}\rho V^2$ per unit area, where V is speed and ρ is density. This is precisely the pressure to be expected if the obstacle brings to rest the moving air in whose path it lies. But if the obstacle effected this change it would simultaneously turn the kinetic energy of the moving air into heat-energy of the air at rest. In the neighbourhood of the obstacle itself we may suppose that the change will be effectively adiabatic and the temperature of the air brought to rest will be increased by the same amount as the temperature of air in which the pressure is increased adiabatically by an amount $\frac{1}{2}\rho V^2$.

If we write $\Delta p = \frac{1}{2}\rho V^2$ (1)
then if p is the pressure of the air we have

$$p = k\rho T \quad \dots \quad \dots \quad \dots \quad \dots \quad (2)$$

and for an adiabatic change we also have

$$\frac{\Delta T}{T} = 0.284 \frac{\Delta p}{p} \dots \quad \dots \quad \dots \quad \dots \quad (3)$$

where k is a constant $= 2.87 \times 10^6$ in c.g.s. units and T is the temperature on the absolute scale.

We derive from equations (1)–(3)

$$\begin{aligned}\Delta T &= 0.142 V^2/k \quad \dots \quad \dots \quad \dots \quad \dots \quad (4) \\ &= 4.95 \times 10^{-8} V^2 \quad (V \text{ in cm./sec.})\end{aligned}$$

If we transform this to fit the units degrees F and miles per hour we get

$$\Delta T = 1.78 \times 10^{-4} V^2 \quad \dots \quad \dots \quad \dots \quad (5)$$

The following small table shows the value of ΔT in degrees F. for different values of V in m.p.h.

$V =$	40	60	80	100	120	140	160	180	200	250	300	350
$\Delta T =$	0.3	0.6	1.1	1.8	2.6	3.5	4.6	5.8	7.1	11.1	16.0	21.8

These values have been derived on the hypothesis that the compression is strictly adiabatic: actually there is certain to be some departure from the adiabatic law, depending among other things on the shape of the thermometer.

Naturally thermometer bulbs are not in ordinary circumstances exposed to winds of the higher speeds of the table: but the thermometers exposed freely on aeroplanes may pass through the air at these 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 interesting thing which emerges from equations (4) and (5) is that the increase of temperature depends only on the speed and not on the density of the air. Thus the increase will be the same at a height of 10,000 or 20,000 feet as it is at the surface for the same speed. This result surprised me when I saw it and I have therefore thought it might interest other meteorologists also.

Note.—Mr. H. W. Absalom has drawn my attention to a reference to a paper by Polkhausen in Kleinschmidt's "Handbuch de Meteorologischen Instrumente," p. 549, on ΔT 's independence of density.

[*Note.*—The reading of a thermometer carried on an aeroplane is modified also by the pressure of the air—not the dynamic pressure of the moving air stopped by the bulb but the static or barometric pressure which decreases with altitude. This pressure effect, though appreciable, is much smaller than the effect of fast moving air. The latter may increase the temperature by several degrees F. The fall of pressure even at heights of 15,000 to 20,000 feet affects the reading of the thermometer by an amount depending on the shape and strength of the bulb but generally less than 0.5°F. The effect is to decrease the reading—the bulb expands slightly as the external pressure on it is reduced and mercury or spirit is taken from the column to fill up the expanded bulb. Thus the effect is on the *reading* of the thermometer—the bulb is not cooled. Even if the aeroplane went to 100,000 feet this pressure effect on the reading would still be small, i.e. between 0.4° and 0.8°F. See *Q.J.R. Met. S.*, 1927, pp. 211 and 438.—Ed. *M.M.*]

OFFICIAL NOTICE

Secretariat of the International Meteorological Organisation

It is announced that Dr. H. G. Cannegieter has resigned his post as Chief of the Secretariat on his appointment as Director of the Meteorological Service of the Netherlands. Dr. Gustav Swoboda has been appointed to succeed Dr. Cannegieter as Chief of the Secretariat.

Royal Meteorological Society

A meeting of the Society was held on Wednesday, the 15th instant, in the Society's rooms, at 49, Cromwell Road, South Kensington. Dr. B. A. Keen, F.R.S., President, was in the Chair.

The following papers were read and discussed.

W. P. Kennedy.—*The intensity of ultra-violet radiation from the sky in Iraq.*

Hæmatological investigations in Baghdad suggested that the climate altered the blood of normal persons as compared with Britain and, as part of the analysis of the climatic factors, day-to-day measurements were made of the ultra-violet component of northern sky-shine, using Owens's instrument. The daily measurements from August, 1936, to August, 1937, are given in graphic form, and also as monthly means. With the latter, various other meteorological data are tabulated to show the trend and range of climatic variation, and to indicate some of the major causes of fluctuation in the ultra-violet values.

R. C. Sutcliffe, B.Sc., Ph.D.—*On development in the field of barometric pressure.*

The rate of change of surface pressure is defined by the horizontal divergence of momentum integrated vertically through the entire atmosphere. The approach to the theory of the movement and development of depressions and anticyclones is through a study of the departure of the velocity from the geostrophic value, or, what is the same thing, a study of the field of acceleration. By expanding the acceleration into partial derivatives to time and space, four terms, one of which is the well-known isallobaric term, are obtained. Some justification for considering the terms as physically distinct is given. It is shown that isallobaric effects alone cannot account for the integrated divergence associated with pressure developments and it is suggested that all four terms may be significant. The effect of the vertical space derivative, proportionate to the vertical velocity and to the horizontal gradient of temperature, previously enunciated as a formal proposition (Durst and Sutcliffe, 1938) is stressed as a novel contribution which may be of fundamental importance.

D. Brunt, M.A., B.Sc., and A. K. Kapur, M.Sc.—The amount of water vapour in the stratosphere and upper troposphere.

It is shown that within the stratosphere the humidity mixing ratio should remain constant with height and a simple formula is derived by means of which the total water vapour content of the stratosphere can be derived. This formula indicates that the total is 0.62 times the amount which would be derived on the basis of Dalton's law. The actual amount in the stratosphere above the tropics is found to be very small, equivalent to about 0.01 mm. of precipitable water. The results of computations of the level above which there will be 0.3 mm. of precipitable water (*a*) assuming saturation everywhere in the upper troposphere and (*b*) assuming relative humidity 50 per cent., indicate that in the first case the level of the base of the layer coincides with the isothermal surface of 235° A., and in the second case with the isothermal surface of 245° A. Similar computations are made for 1.2 mm. of precipitable water, assuming 50 per cent. relative humidity in the upper troposphere, and again yield the result that the base of the layer so computed coincides with an isothermal surface.

C. S. Durst, B.A.—The wind structure beneath warm fronts.

Fourteen cases of warm fronts passing over the British Isles were selected and the winds observed by means of pilot balloons were compared with the geostrophic winds, at various heights up to 10,000 feet and at distances varying up to 500 miles. The results were combined in order to get an average value of the departure from the geostrophic wind at certain points. An evaluation is made of the second order terms in the equations at these points and it is concluded that in this region of a depression the departures from the geostrophic wind are primarily dependent on (*a*) the isallobaric term and (*b*) a term involving the velocity of the cold air away from the oncoming warm air and the variation of that velocity in the same direction.

S. Chapman.—The lunar atmospheric tide at Accra, Gold Coast, Africa.

The lunar atmospheric tide has hitherto been determined at two stations on the African continent, Helwan and Kimberley. A new determination has now been made from about three years' bi-hourly data for the tropical African station, Accra (5° 33' N. ; 0° 12' W.). The annual mean amplitude of the lunar tidal variation of pressure is found to have the rather small value 45 microbars; the phase angle, 72°, implies that the high (lunar) tide in the atmosphere over Accra occurs about half an hour after the moon's transit; this phase lag is quite normal.

The Council of the Royal Meteorological Society has awarded the Howard Prize (an aneroid barometer, given annually for the best essay on a selected meteorological subject) to Cadet Colin Derek Thorpe, of H.M.S. *Conway* School Ship. Consolation prizes have been awarded to Cadet Arthur Vernon Baker (H.M.S. *Conway*), Cadet Godfrey Harry Hayes (H.M.S. *Conway*) and Cadet Richard Christopher Stancliffe Hurst (H.M.S. *Worcester*) who were bracketed second. The subject of the essays was "Clouds."

Correspondence

To the Editor, *Meteorological Magazine*

Sunset Phenomenon at Khartoum

An interesting optical phenomenon was observed in Khartoum on the evening of Sunday, March 13th. The sky was clear except for a few patches of altocumulus cloud at a high elevation and several bands of cirrus extending at an angle of 45° from the horizon near the setting sun to an elevation of about 30° at 1801 Z.T. and patches of colour were noticed on the cirrus cloud with red and green predominating. These patches spread until almost the whole of the cloud above an elevation of 10° displayed colours. In general any patch displayed red above green, but there was no regular rainbow-like configuration. As the sun began to set the colours gradually faded and the cloud went into shadow for a few minutes before developing the usual pink sunset glow. During these last stages it was seen that the cloud was very tenuous and it became almost invisible as the sunset faded. The colours lasted from 1801 to 1808 Z.T. and the sunset pink appeared at 1814 Z.T. According to the "Nautical Almanac" the sun set at 1800 Z.T. at Khartoum on the evening in question.

The phenomenon was of quite a different character from that to which the name iridescence has been given, since the colours were apparent over extended areas of cloud and not merely at the edges (*c.f.* "Observer's Handbook"). Refraction through ice crystals may have been responsible and partial separation of the colours was brought about by certain more favourable planes of orientation although these planes were not sufficiently well defined to give a complete halo-like spectrum.

A. W. IRELAND.

Khartoum, March 17th, 1938.

Sand Devils in the Central Sudan

During the spring of this year some excellent examples of sand devils were observed near Khartoum and near Wad Medani.

One day in March a particularly fine example was observed to form above an area of sand between the White and Blue Nile just across the river from Khartoum. A whirling mass of sand some 50 ft. in diameter appeared first and rapidly developed vertically. The rotation as far as could be ascertained at a distance of approximately 500 yards was anticlockwise. The sand was carried up to a height of about 300 ft. in less than 30 seconds and then growth paused temporarily before a second period of rapid growth

during which the upper portion increased in diameter. Within five minutes a sand devil 1,000 ft. in height had developed and there were two apparent breaks in its length in which there did not appear to be any sand. In the lowest 300 ft. sand was very thick and the limits of the whirl well marked, but above 500 ft. the column appeared to be mixing with the surrounding air so that it increased in size laterally and gradually disappeared. Although the active life of this devil, that is its period of development, was only five minutes it persisted in the air stream for at least a further 20 minutes. About the time of development a slow moving cold front was passing Khartoum.



SAND DEVIL SEEN TO EAST
OF KHARTOUM, APRIL 1937.

An example of different type was observed at Wad Medani above cotton soil—very fine silt—on May 3rd, 1937. In this case a sand devil developed from a whirl about 6 ft. in diameter. It grew to 10 ft. in diameter at a height of 3 ft. and thereafter exhibited no change in lateral extent up to its upper limit at 150 ft. above the ground. After the initial rapid growth to 150 ft. there did not appear to be any further vertical growth although particles of soil appeared to be carried upwards for at least ten minutes. The density of suspended matter was very great in the lowest 10 ft. where visibility was nil, but above this height the amount of silt in suspension was much less as it was just possible to observe objects on the other side of the whirl. The life of this devil was 15 minutes after which it appeared to “collapse” while the active life was less than one minute. The rotation was anticlockwise.

On another occasion, in April, 1937, a most imposing sand devil developed to the east of Khartoum, and when first observed appeared like a waterspout, see diagram. The sky was cloudless, and the time noon; it was estimated that the devil was 3,000 ft. high and 50 ft. in diameter. Owing to the distance of the devil from the observer it was not possible to observe any rotation.

During May 4th and 5th, 1937, 28 sand devils were observed in the Wad Medani district. In 21 cases the rotation was anticlockwise while in the others the devils were too distant for this feature to be decided; further, all but three were over 200 ft. tall.

WILLIAM D. FLOWER.

Meteorological Service, Khartoum, December 19th, 1937.

Lunar Rainbow

Observations of lunar rainbows are rare. During the last ten years I have only been able to find references to five observations in the British Isles, so I am sending an account of the phenomenon I witnessed myself on Whit Monday, June 6th.

Late at night I was cycling from Brynhydyarian to Trefnant and at 2236h. G.M.T. I was at a point a few miles W. of Denbigh when a short sharp shower occurred. This soon passed, and just as the rain was ceasing a perfect lunar rainbow became visible, both the primary and secondary bows being complete against a background of mountains and heavy black clouds. It lasted for a minute. The colour was a silvery white, and I was able to discern plainly that the sky below the primary bow and above the secondary was lighter than that between the two bows. All this is the more noteworthy since the moon was only $7\frac{1}{3}$ days old at the time and also since a good deal of twilight persisted. The wind was S., force 6-7 on the mountains and less in the valleys, and frequent rainstorms came up and passed quickly. I had previously observed a rainbow in sunlight at 1724h. G.M.T. at Rhydgaed, three miles to the S.

I believe I am correct in stating that Aristotle was the first to report having seen a rainbow in moonlight and also to have stated that they only occur at full moon. About ten years ago I read in a meteorological work that that statement had never been definitely disproved. However, on this occasion, with the transparency of the air and the favourable conditions for rainbow formation which occur in the Welsh mountains during stormy spells, it is quite definite that the moon at first quarter can give enough light to produce a rainbow.

S. E. ASHMORE.

Llannerch Gardens, St. Asaph, Flintshire, N. Wales, June 10th, 1938.

Two Sand Devils

On April 7th, 1938, at 1314h. Sudan Time, while the train in which I was travelling was stationary outside Musmir station, roughly midway between Atbara and Port Sudan in the Sudan, the unusual spectacle of one sand devil moving into the ambit of another was observed. The ground in the region of Musmir is desert, fairly coarse in texture and rather dark in colour, with occasional rocky outcrops and a few scattered bushes. In April the bushes appeared to be dead but no doubt would burst into leaf after the first rainstorm of the "wet" season. For about 500 yards to the south of the railway the ground is unbroken desert while rocky outcrops and bushes

occur beyond and the two sand devils to which reference is made developed along the boundary between the two areas. In the initial stages of development it appeared as though two fires of brushwood had been lighted about 300 yards apart. Sand was carried upwards and gave the impression of smoke and this was followed by much denser streaks of sand-laden air which sprang up from the base and played amongst the less dense region much as tongues of flame "lick" upwards from a fire of brushwood. The diameter of the base initially was about 20 feet in each case. The "devils" developed rapidly: the right hand, or westerly, one was the more active and remained almost stationary—its position was fixed relative to a bush—while the other moved slowly towards the west.

At the end of 6 minutes both "devils" were roughly 300 feet tall: the left hand one was 50 feet in diameter at the base and 100

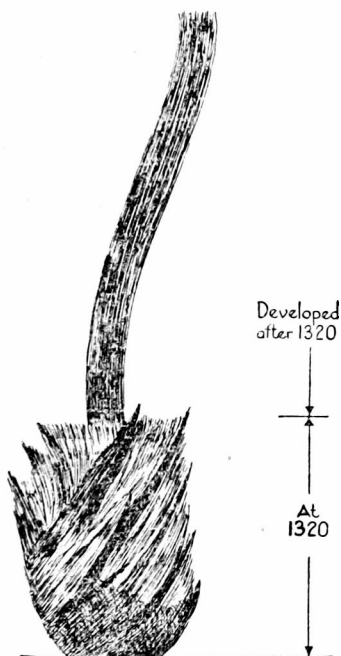


FIG. 1.—SAND DEVIL ON APRIL 7TH, 1938.

feet in diameter above a height of 50 feet while the one to the right was 100 feet in diameter at the base and 200 feet in diameter above a height of 50 feet. The latter "devil," which was almost black in appearance, was still in process of development as its edges were still "smoking" and "tongues" of heavily sand-laden air continued to shoot out from its upper half. The behaviour of these "tongues" gave the impression that the disturbance was rotating in an anticlockwise sense when viewed from above. The left hand "devil" was less dense and the boundaries fairly sharp: tongues of sand-laden air were no longer in evidence and it was not possible to decide whether there was any rotation.

At this time the disturbances were 200 feet apart and a dark wave, about 50 feet high and obviously consisting of heavily sand-laden air, was observed to travel rapidly from the smaller to the larger "devil" as though the latter was sucking the substance from

the less energetic system. The "devils" appeared joined at their bases for about two minutes after which the left hand one no longer extended right down to the ground but was floating at about a height of 50 feet and it subsequently moved slowly south-eastwards and dispersed. The larger sand devil continued to develop and a sharply defined column, not more than 50 feet in diameter, grew

out from the centre of the top. This extended up to at least 1,000 feet and the disturbance was still "active" when the train moved on and hid it from further observation at 1330h.

WILLIAM D. FLOWER.

Meteorological Service, Khartoum, May 2nd, 1938.

NOTES AND QUERIES

Heavy Rainfall at Malta, February 19th—20th, 1938

During February 19th–20th, 1938, Malta experienced a severe storm accompanied by a rainfall which is the heaviest on record for the month of February and the heaviest ever recorded during any month since the Meteorological Office was opened here in 1922.

The synoptic situation was, in many respects, similar to that which gave rise to the gales on November 24th, 1936 (*Meteorological Magazine*, March, 1937) but, as on that occasion, analysis is hampered by the paucity of observations to the south and south-west of Malta

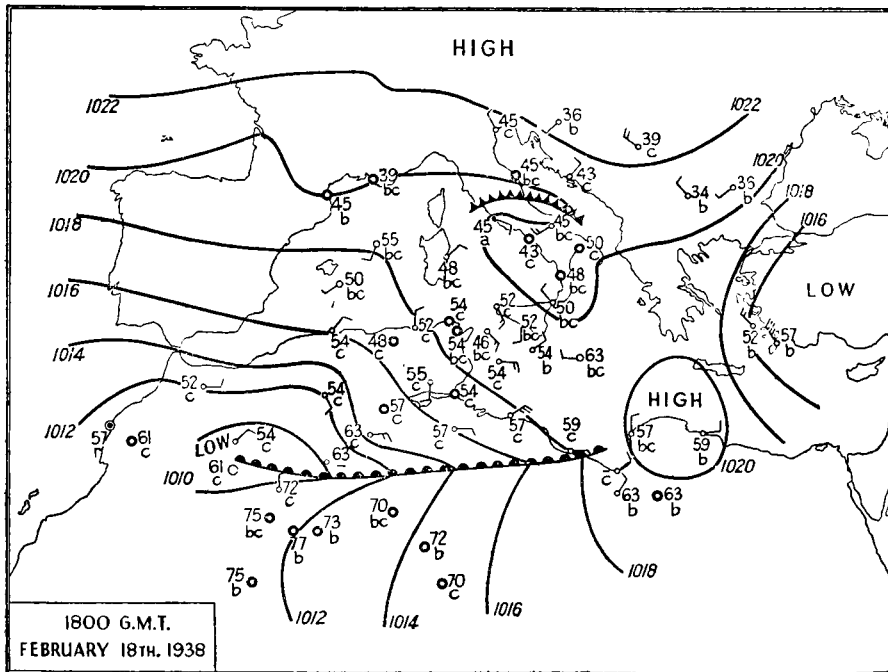


FIG. 1.

and the complete absence of information regarding upper air temperatures in those regions. It is hoped, however, that the following notes may be of interest. It should be noted that north-east gales are of particular interest at Malta owing to the harbours being exposed to wind and swell from this direction.

For several days prior to February 19th there had existed a stationary front running east to west across southern Tunisia and Algeria between cool air to the north and warm air, which was relatively moist for that region, to the south. These conditions are shown on the chart for 1800h. G.M.T. February 18th (fig. 1). A nephoscope observation at 1300h. on the 18th gave a velocity of 75 m.p.h. from 280 degrees at the cirrus level. During the night of the 18th-19th a depression developed on this front over the Gulf of Gabes. At 0400h. G.M.T. on the 19th pressure at the centre was 1012 mbs. and light rain had already commenced to fall over a wide area of Algeria and Tunisia. By 0700h. G.M.T. (fig. 2) a

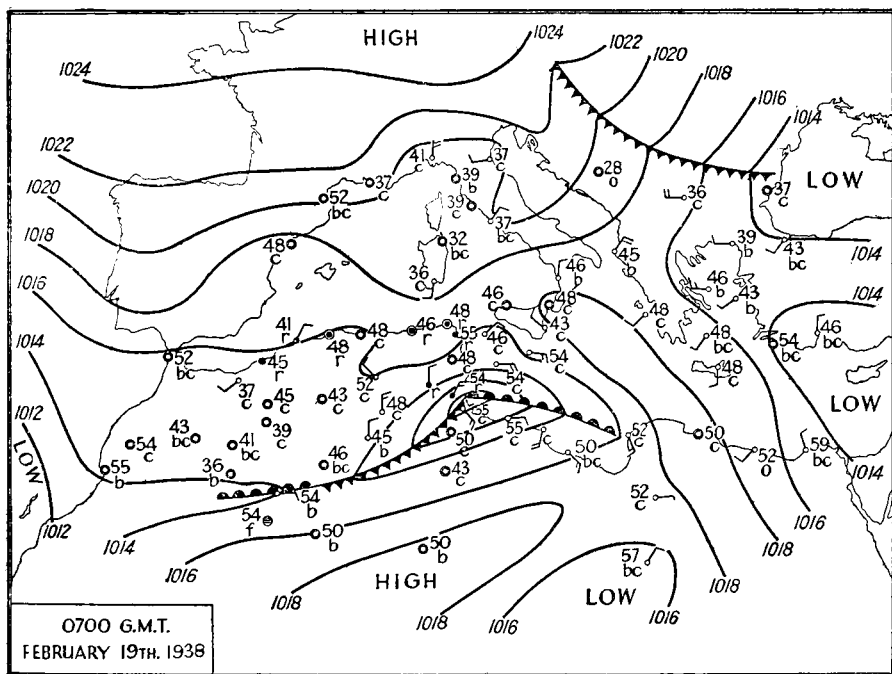


FIG. 2.

further deepening of the centre to 1010 mbs. had occurred and the sky at Malta had clouded over with a sheet of altostratus. From 0700h. G.M.T. to 1300h. G.M.T. the depression moved rather slowly ENE. while pressure at the centre fell to 1006 mbs. and the wind at Malta backed to ENE. and freshened (*see* fig. 5). (N.B.—The times shown on figs. 5 and 6 are one hour ahead of G.M.T.) By

1300h. G.M.T. the depression had begun to occlude and the cold front was moving eastwards over Libya. Temperatures in the warm sector over Libya exceeded 75°F. at some places during the afternoon.

From 1300h. G.M.T. to 1800h. G.M.T. pressure fell steadily at Malta at a rate of about 1 mb. per hour. Rain began at 1340h. G.M.T. and the wind had steadily increased to force 7 from ENE., by 1800h. G.M.T., with gusts to nearly 60 m.p.h. At 1800h. G.M.T. (fig. 3) the centre was apparently just SSW. of Malta, the lowest pressure reported being 1007 mbs., though it was evident from the strength of the winds that the pressure at the centre must have been considerably lower.

The full violence of the storm occurred at Malta during the night. The 0700h. G.M.T. chart for February 20th (fig. 4) showed that the centre continued to move ENE., passing just south of Malta. The barogram at Malta showed a minimum pressure of about 996 mbs.

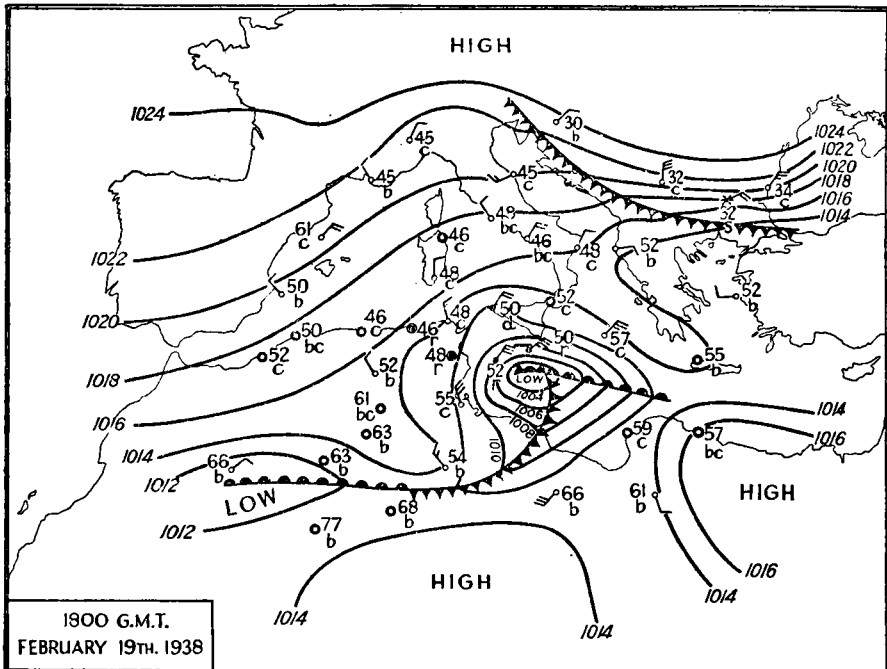


FIG. 3.

between 0030h. and 0300h. G.M.T. on February 20th, more precise measurements being unobtainable owing to the fluctuations of the pen caused by the wind. The anemogram (fig. 5) shows a more or less steady wind velocity of 33 m.p.h. from about 1800h. to 2100h. G.M.T. after which it increased to about 42 m.p.h. with two gusts

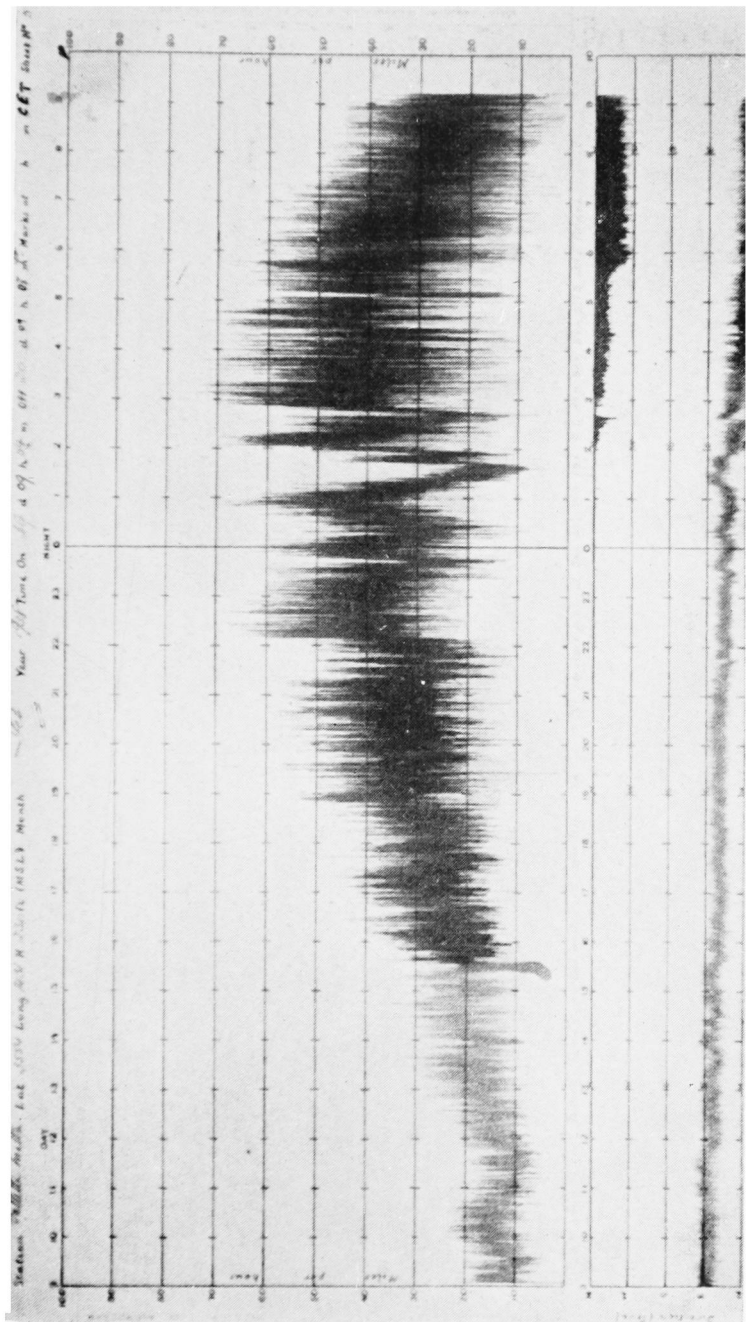


FIG. 5.—MALTA ANEMOGRAM, FEB. 19TH-20TH, 1938.

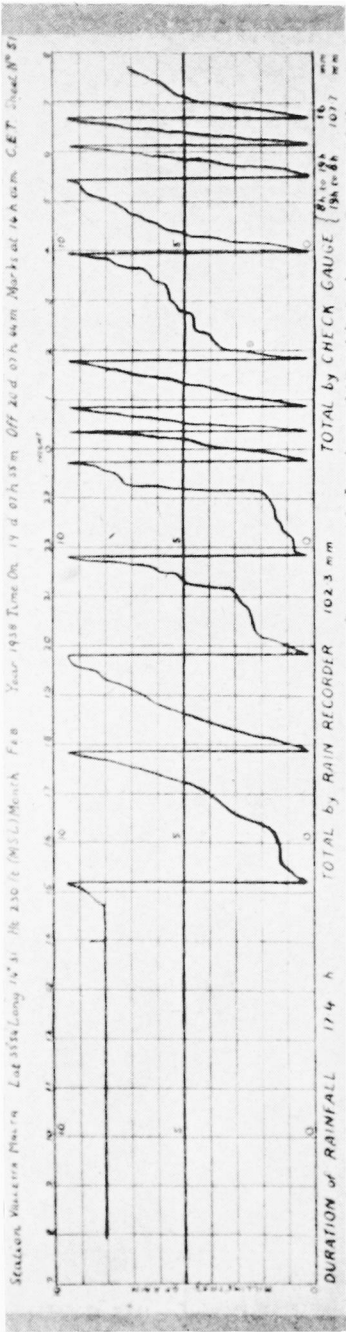
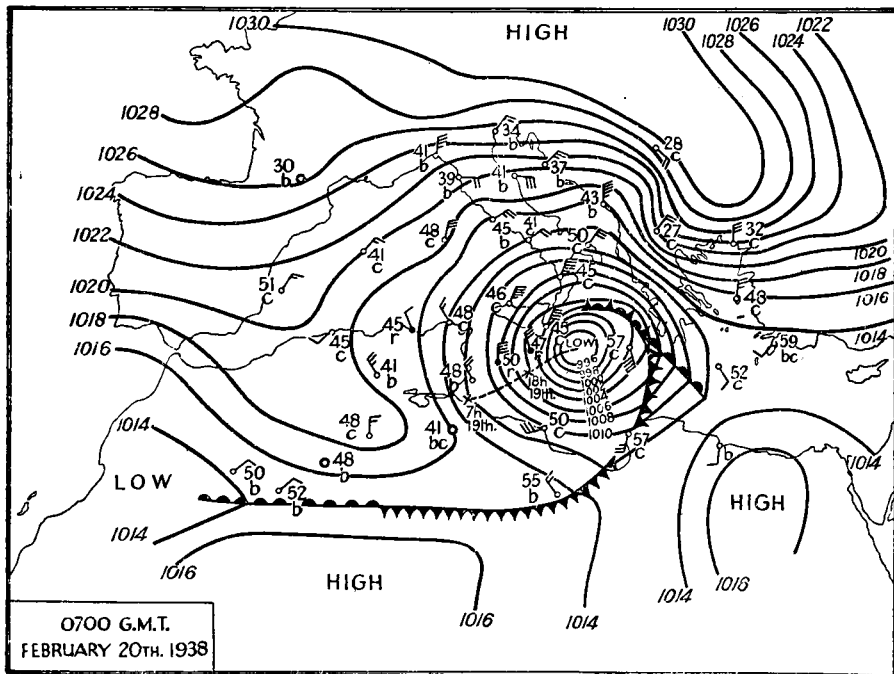


FIG. 6.—MALTA HYETOGRAPH, FEB. 19TH-20TH, 1938.

over 70 m.p.h. Minor fluctuations followed until about 0010h. G.M.T. when the velocity commenced to fall rapidly, reaching a minimum value of about 15 m.p.h. at about 0035h. G.M.T. Subsequently the wind increased rapidly again, attaining a mean speed of 50 m.p.h. for a short period about 0110h. G.M.T. and an hour later there was one gust of about 80 m.p.h. During this period the wind direction had been more or less steady from north-east. After 0200h. G.M.T., as the centre moved further away, the velocity fell slowly and the direction backed slowly to north-west.

Apart from the wind the outstanding feature of the storm was the exceptionally heavy rainfall. As may be seen from fig. 6 rain commenced to fall about 1340h. G.M.T. on the 19th and was almost continuous until 0640h. G.M.T. on the 20th. The succeeding rain record shows that the rain continued to fall until 0940h. on the 20th. During the period 0700h. on the 19th to 0700h. on the 20th 123.7 mm. (4.87 in.) of rain were recorded at the Meteorological Office. As may be seen this total actually fell in the period 1340h. on the 19th to 0700h. on the 20th. The normal monthly total of rainfall in February in Malta is 56 mm. (2.21 in.) and the maximum fall for any one day in February hitherto recorded is 79 mm. (3.11 in.) although of course there have been heavier falls in other months. There were two periods when the rainfall was heaviest, viz., 2310h. to 2400h. on the 19th and 0430h. to 0600h. on the 20th. During



the first of these periods 17·2 mm. (·68 in.) fell in 50 minutes and the wind increased steadily from 31 m.p.h. to 50 m.p.h. with a gust to 69 m.p.h. During the second period 24 mm. (·94 in.) were recorded in $1\frac{1}{2}$ hours and the mean wind velocity fell steadily from 45 m.p.h., with gusts to 68 m.p.h., to 35 m.p.h. Thunder was reported only once during the night at Malta.

As might be anticipated considerable damage was done locally. A number of walls were blown down and considerable flooding occurred. Quantities of soft soil were washed away into the sea—a point of some importance in Malta where the ground is very rocky and soil scarce. A defence boom across the mouth of Grand Harbour broke adrift and the hospital ship *Maine*, at anchor in one of the creeks, dragged her moorings and swung on to the mud. Finally the P. & O. liner *Ranpura*, after lying off the entrance to Grand Harbour for some time, continued her voyage eastwards without landing the passengers booked for Malta since the heavy sea and swell rendered the passage through the entrance to the harbour too dangerous.

A. C. BEST.

L. DODS.

REVIEWS

The sources of energy of storms. By C. W. B. Normand, C.I.E., M.A., D.Sc. Presidential Address to the Section of Mathematics and Physics, 25th Indian Science Congress, Calcutta, 1938. Calcutta, 1938. Pp. 19.

The object of the paper is to estimate the relative importance of the processes which Margules examined a third of a century ago as possible sources of the energy of storms. The potential energy of the pressure system being found quite inadequate, there are left three sources, (a) from vertical decrease of entropy apart from effects due to saturation, (b) from horizontal differences of temperature, (c) from effects of water vapour: and Normand makes it clear that the last of these plays a very big part in storm formation. He gives a number of easy yet effective methods of determining the energy provided when simplifying assumptions are made; and though these assumptions inevitably lessen materially the value of the numerical results derived, Normand's analysis must add greatly to the amount of insight into the physical processes. There follow applications of these principles to thunderstorms, duststorms and tropical cyclones.

Normand's methods have been found of real practical use in forecasting in India and they must have frequent applications in more temperate climates. This address contains no mathematics beyond easy geometry and is very strongly to be recommended to all who wish for clearer ideas over the fundamental processes of weather. Some of the results of pp. 10–13 are subsequent to Normand's paper recently communicated to the Royal Meteorological Society.

G. T. WALKER.

Latent Instability in the Atmosphere revealed by Some Indian Tephigrams. By V. V. Sohoni and M. M. Paranjpe. Poona. Mem. Ind. Met. Dept., 26, Pt. 7, 1937.

It is the practice in the London Meteorological Office to estimate qualitatively, with the aid of the T- σ diagram, the latent instability of the air by means of readings of dry and wet bulb temperatures obtained twice daily from aeroplane ascents at Mildenhall and Aldergrove. The criterion of latent instability is that, if a sample of air be raised adiabatically, more energy will be released during the higher portion of its ascent than would have to be supplied in the lower portion. As a frontologist, the meteorologist uses the aeroplane data as an aid to the identification of air masses. As a forecaster, he also uses the data to estimate the possibility of showers or thunderstorms, although he must, of course, allow for a possible change of air-mass. In both cases, the probable effects of radiation, subsidence, turbulence, etc., have to be taken into account.

In the publication under review, the authors summarise their examination of the records of approximately 250 ballon-sonde ascents made at Agra, Poona and Hyderabad. Like the frontologist and the forecaster mentioned above, the authors arrive at certain conclusions regarding latent instability in relation to an air-mass and vice-versa. They find that latent instability is associated with cumuliform cloud, rain and thundery conditions—and generally with incursions of oceanic air of tropical or equatorial origin; similarly, absence of latent instability is associated with dry, fine weather—and mainly with continental air. These findings simply confirm two conclusions already formed by the writer as the result of experience. Firstly, continental air (which tends to predominate in N.W. India during the winter), is more often than not, subsiding air—hence its dryness and relative stability. Secondly, the oceanic air originating from low latitudes (which predominates over most of India during the summer months) is, generally, nearly saturated and potentially unstable; local heating, convergence, or merely the effect of hills or coast lines will produce as a rule sufficient ascent to cause precipitation.

The apparent discrepancies found by the authors may be due, in part, to the fact that trajectories of air based on pilot-balloon ascents separated by an interval of 24 hours cannot be very reliable, especially when it is assumed that no vertical motion has taken place. Moreover, there is little doubt that replacement of continental air by oceanic air is a feature of the western disturbances and possibly of the monsoon depressions also.

R. G. VERYARD.

BOOKS RECEIVED

Borough of Darwen : Annual Report of the Medical Officer of Health for the year ending December 31st, 1937. (Section VIII—Meteorology.) Darwen, 1938.

Borough of Worthing : Annual Report on the Health of Worthing, 1937. (Part III—Meteorology.) Worthing, 1938.

OBITUARY

Hugo Hergesell.—Through the death of Geheimrat Hugo Hergesell, which was recorded in our last issue, there has passed away an outstanding figure in the investigation of the upper atmosphere during the past half century. Hergesell was born at Bromberg in 1859 and graduated at the University of Strassburg. In 1891 we find him, still a young man in the early thirties, as the director of the Meteorological Service of Alsace-Lorraine.

Judged by present-day standards it was no doubt a small service, the official functions of which were mainly concerned with the organisation of observations at stations of the second order and the preparation of the usual statistical summaries. But in the Germany of those days the meteorological services of the several states were in close contact with the Universities and as a rule the director also held appointment as professor or lecturer. This double employment had fortunate repercussions. Meteorological work was carried on in academic surroundings and it followed almost as a matter of course that facilities for experimental and other research should be available.

The young Hergesell threw himself with characteristic zeal into the then new field of research of using kites and balloons for extending meteorological observation in the third dimension. He did this to such good purpose that when a proposal to form an international commission to co-ordinate the new work being done in different countries was adopted by the Conference of Directors in Paris in 1896, Hergesell was invited to become its president. He continued to guide the work of the Upper Air Commission up to the outbreak of the War and on the motion of the French members he was asked to resume office at the Leipzig meeting in 1927. He remained President until three years ago when advancing years compelled his resignation. The Commission took advantage of the opportunity for recording its appreciation of the services he had rendered to aerology by nominating him Honorary President.

In 1914 Hergesell left Strassburg to accept the directorship of the Upper Air Observatory at Lindenberg, rendered vacant by the death of Assmann. From the point of view of opportunities for scientific work this was perhaps the most important post that the world had to offer to any meteorologist but pure science was soon to be forced into the background. As Director of Lindenberg it fell to Hergesell's lot to organise the German meteorological service during the War and later on to adapt official meteorology to meet the new needs of aviation. Nevertheless the scientific output from Lindenberg has been fully maintained during the 19 years of Hergesell's directorship.

As president of the Aerology Commission Hergesell was untiring in his efforts to stimulate observation in the free atmosphere in all parts of the world. At a time when facilities for observing were much more limited than they are now he arranged for the concen-

tration of effort on selected "international" days and for the publication of the data for those days in collective form. The financial arrangements for carrying out the latter enterprise by a system of international subscription were made at a meeting of the Commission in St. Petersburg in 1906 and still survive after 30 years which include the Great War.

Of Hergesell's personal work, the researches which he carried out in association with the late Prince of Monaco from the latter's yacht *Princesse Alice* are perhaps the most outstanding. He induced the Prince to extend his interests from oceanography to meteorology and a number of cruises to the trade wind regions and also to the Arctic were arranged. In the course of these Hergesell perfected a method for making ascents with registering balloons at sea. In keen rivalry with Teisserenc de Bort valuable data were collected during the years 1904-6 on which our knowledge of upper air conditions in the trade winds is largely based, while in the Arctic the low altitude of the stratosphere was recorded by observation.

To those of the present generation of meteorologists who had the good fortune to meet him the memory of Hergesell as a genial figure at international meetings will always remain. When in the Chair he was never ruffled even if the discussion became acrimonious. He had the happy knack of putting every one at his ease and converting formal gatherings into pleasant reunions of friends when the day's work was done.

It goes without saying that Hergesell should have been the recipient of many honours and decorations both at home and abroad. He was elected an Honorary Member of the Royal Meteorological Society in 1913 and was awarded the Symons Gold Medal in 1928.

R. G. K. L.

NEWS IN BRIEF

We learn that J. Wadsworth has resigned the directorship of Apia Observatory, Samoa, and expects to leave Samoa shortly.

We learn from *Petermanns Geographische Mitteilungen*, May, 1938, that the *Oesterreichische Gesellschaft für Meteorologie* is in future to be incorporated in the *Deutsche Meteorologische Gesellschaft*.

We learn that Commandant Fortunato Pires da Rocha has become Director of the *Serviço Meteorológico*, *Ministerio da Marinha*, Lisbon, Portugal.

The Weather of June, 1938

Pressure was high (1024 mb.) over the Azores and low over Finland (1004 mb.) and Alaska (1008 mb.). Over most of Europe pressure was almost uniform, about 1018 mb. or 2 mb. above normal but in the British Isles it decreased from 1018 mb. in the south, the normal figure for June, to 1007 mb., 6 mb. below normal, at Lerwick. Thus the gradient for westerly winds was stronger than usual. Areas more than 5 mb. below normal included Iceland, northern Scandinavia and Finland, Arctic Canada and Alaska, but most of North America was slightly above normal. No data were received from the U.S.S.R. Temperature ranged from about 37° F. in the Arctic to above 80° F. in the south-eastern U.S.A. and 90° F. in Egypt. In the British Isles the range was from 50° F. at Lerwick to 61° F. at Kew. Most of Europe was slight above normal but western Ireland, southern Norway, south-west Norrland and north-west Svealand were 1–2° F. below normal. In North America the deviations were mostly small and irregular but the Atlantic coast was warm. Rainfall was above normal in the British Isles (except southern England), Sweden (where the excess was 100–200 per cent. in the western parts of northern Norrland and averaged 60 per cent. over the whole country), Portugal and the Azores, but elsewhere in western Europe it was generally slight. The total of nearly 10 inches (300 per cent. of normal) at Eskdalemuir is notable. Over most of the U.S.A. rainfall was below normal.

In the south-east pressure was above 1020 mb. over south-western Australia, decreasing north-eastwards to 1005 mb. in French Indo-China. The extreme south-west of Australia was 5 mb. above normal, but northern Australia, New Zealand and the East Indies were slightly below normal. Temperature ranged from 45° F. in the south of New Zealand and 47° F. in Tasmania to above 80° F. on the north coast of Australia, Malaya and Indo-China. Northern and central Australia were some degrees above normal, elsewhere the deviations were small. Rainfall was very heavy in Indo-China where totals of 6 to 16 inches were from 2 to 6 inches above normal. Rains were heavy (about 6 inches, or twice the normal) in southern South Australia and on the east coast of South Island, New Zealand, but elsewhere in Australasia they were slight and deficient.

The weather of June over the British Isles was remarkable for the severe gales of the 1st–2nd and 27th–29th*. It was wet in Ireland Scotland, Wales and northern England, but dry in most places elsewhere in England, particularly in the south-east. The excessive rainfall in Scotland was notable; at Eskdalemuir the total was nearly three times the average and at Kirkwall, Orkney, it was the wettest June since records were first taken in 1841. Sunshine was

* See p. 139.

deficient on the whole ; there was, however, an appreciable excess locally in south-east England and the Channel Islands.

During the opening days of the month a depression off the mouth of the English Channel moved north-east across England to the North Sea causing severe gales in England on the 1st and 2nd. Thunderstorms were widespread in England on the 1st and occurred locally in northern England on the 2nd, and rainfall was heavy in some parts of Great Britain on the 1st, 3·20 in. at Trecastle, Brecon, and 3·06 in. at Bethesda, Carnarvon, being among the heaviest falls reported. It was very cool on the 2nd, the maximum temperature being only 45° F. at Dalwhinnie and 47° F. at Buxton and Newton Rigg. A secondary depression over west Ireland moved north-east on the 4th and a depression off the west of Ireland moved north-east along the north-west seaboard on the 5th and 6th ; rain fell at times in the west and north but little occurred in the south-east. Between the 7th and 9th a depression off the Hebrides moved slowly north and weather was rather unsettled but records of bright sunshine were good on the whole ; local thunderstorms were reported in the northern half of the country on the 8th and 9th. Gales occurred locally in the west and north from the 6th-7th. On the 10th a trough of low pressure crossed Great Britain ; the day was sunny for the most part but widespread thunderstorms occurred in England. Thereafter the Azores anticyclone moved north-east and a period of mainly anticyclonic weather prevailed from the 13th-17th. High maximum temperatures were registered locally in Scotland on the 13th, in south and east England on the 14th and more generally from the 16th to 18th ; 78° F. was registered at Dundee on the 13th, and 79° F. at Bournemouth, Southsea and Southend on the 14th, at Cheltenham on the 17th and at Cleethorpes on the 18th. A trough of low pressure west of Ireland moving over the country caused a renewal of unsettled conditions with local thunderstorms on the 18th, though little or no rain occurred in the south-east. Subsequently pressure was high to the south and south-west of the British Isles, while depressions moved east across the north of Scotland ; rain fell at times in the north and west but little was recorded in southern England except on the 22nd. Coastal fog occurred rather frequently on the south-west coasts from the 22nd-27th. Temperature rose to 80° F. at Southend and Camden Square, London, on the 21st and at Walton-on-Naze on the 24th.

A period of very unsettled weather ensued with widespread and severe gales. On the 26th an Atlantic depression approached the west of Ireland and on the 27th it became very intense as it passed north-east across Scotland. On the 28th a new depression moved rapidly north-east across the British Isles. Widespread gales occurred from the 27th-29th and rain fell generally, though the falls were relatively slight in the south-east. Among notable falls in 24 hours were 3·14 in. at Blaenau Festiniog, Merioneth, 2·34 in.

at Rothesay and 2·28 in. at Hawkshead, Lancs, on the 26th and, 3·10 in. at Borrowdale on the 28th.

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

		Diff. from			Diff. from
	Total	normal		Total	normal
	(hrs.)	(hrs.)		(hrs.)	(hrs.)
Stornoway ..	101	— 66	Chester ..	176	— 19
Aberdeen ..	162	— 19	Ross-on-Wye	197	— 10
Dublin ..	129	— 53	Falmouth ..	229	+ 2
Birr Castle ..	130	— 30	Gorleston ..	208	— 1
Valentia ..	184	+ 11	Kew.. ..	207	+ 4

Kew, Temperature, Mean, 61·3°F, Diff. from average +1·4°F.

Miscellaneous notes on weather abroad from various sources.

A gale off the coast of Brittany on the 1st caused loss of shipping and of several lives. In the middle of the month strong winds and high seas off the Dutch coast delayed dredging operations on the *Lutine*. The river Ume in the north of Sweden was in flood in the early part of the month; it was reported that 100 families were homeless; huge masses of logs were swept downstream by the current, and threatened damage to the port of Umea. In the middle of the month about 48 hours of rain in Switzerland caused several rivers to overflow; The Rhine rose more than 3 feet and navigation was interrupted. Towards the end of the month very hot weather was experienced in much of southern and central Europe; several cases of sunstroke occurred in northern Italy, and six deaths were reported from Budapest where the temperature rose above 98° F. on the 30th. (*The Times*, June 6th–July 1st.)

The S.W. monsoon rains began at Bombay, India about a fortnight earlier than usual, and the rainfall at the city for the first half of June was said to be a record for the last half century; the monsoon was active in most regions. In a duststorm in the western part of Tokachi Province, Hokkaido, Japan, several buildings were destroyed; a layer of dust more than half an inch thick lay on the houses. A very large area in northern Honan, China was flooded by the Yellow river due to the breaching of the dykes and to the high level of the river, which had not however reached its summer peak. In the middle of the month much rain fell in the Yangtze valley region; in Shanghai where the amount for the month exceeded 18 in. streets were flooded for several days. After six days of rain the Yangtze river was much above its normal level; it overflowed south-west of Auking inundating the district near Taihu. At the end of the month there were very heavy rains in the Kwanto district of Japan, during the 24 hours ended at 6 a.m. on the 30th about 11 in. fell at both Tokyo and Yokohama; much damage was done by floods and landslips entailing considerable loss of life. (*The Times*, June 6th–July 1st.)

Heavy rains across the prairie region of Canada on the 8th and 9th gave more than an inch to many districts. On the night of the 10th a tornado struck Clyde, a village in Texas, 13 people were killed, there was considerable damage to property and a goods train was blown off the rails. A hurricane damaged the docks and buildings at the port of Acapulco on the Pacific coast of Mexico on the 27th. (*The Times*, June 11th-29th.)

Daily Readings at Kew Observatory, June, 1938

Date	Pressure, M.S.L. 13h.	Wind, Dir., Force 13h.	Temp.		Rel. Hum. 13h.	Rain.	Sun.	REMARKS
			Min.	Max.				
	mb.		F.	°F.	—	in.	hrs.	
1	1005.1	S.3	51	65	71	0.10	1.1	r 15h-16h., r ₀ 19h.
2	11.1	WSW.5	47	57	56	—	2.6	
3	18.0	WSW.4	45	63	39	—	8.9	
4	13.5	SSW.4	51	70	42	trace	11.8	pr ₀ 21h.
5	12.3	WSW.3	54	67	39	trace	10.2	pr ₀ 1h. and 3h.
6	16.4	SSW.4	48	67	57	trace	3.5	d ₀ 8h.
7	17.1	SSW.4	56	73	65	—	3.4	
8	20.0	SW.3	60	71	75	trace	2.7	pr ₀ 13h.
9	21.6	W.2	52	67	44	0.01	7.1	ir ₀ -r 20h.-22h.
10	21.0	W.3	47	64	41	0.02	11.0	pr 9h., 13h. and 14h.
11	23.0	WNW.2	45	64	43	—	9.5	
12	22.1	NW.2	50	64	54	—	2.2	
13	27.1	NNE.4	49	67	46	—	12.6	
14	25.0	WNW.2	55	77	47	—	10.8	
15	25.0	NW.3	52	67	58	—	8.0	
16	27.6	NW.3	51	74	42	—	13.2	
17	23.9	ESE.3	55	76	52	—	6.0	
18	16.1	S.3	52	75	51	trace	4.1	w early, pr ₀ 17h.
19	17.6	WSW.3	54	73	44	—	8.4	
20	26.1	WSW.2	49	71	40	—	13.0	w early
21	22.0	S.3	50	77	39	—	14.8	
22	20.5	SSW.4	56	75	54	0.01	2.5	ir ₀ 16h.-18h.
23	20.7	WSW.2	60	75	53	trace	2.0	d ₀ 7h.
24	17.2	WSW.3	62	75	56	—	7.0	
25	09.7	WSW.4	60	75	53	—	7.9	
26	15.8	SW.4	56	73	50	—	3.6	
27	05.5	SSW.5	62	67	92	0.16	1.1	r ₀ -r 11h.-14h.
28	06.6	SSW.5	53	68	58	0.02	3.3	ir ₀ -r 20h.-23h.
29	07.9	W.5	57	66	38	—	7.4	
30	1009.5	SW.4	51	63	55	0.03	7.7	pr ₀ -pr 17h.-20h.
*	1017.5	—	53	70	52	0.35	6.91	* Means or Totals.

General Rainfall for June, 1938

England and Wales	96	} per cent of the average 1881-1915.
Scotland ...	201	
Ireland ...	155	
British Isles ...	133	

Rainfall : June, 1938 : England and Wales

Co.	STATION.	In.	Per cent of Av.	Co.	STATION.	In.	Per cent of Av.
<i>Lond</i>	Camden Square.....	.34	17	<i>Leics</i>	Thornton Reservoir ...	1.64	76
<i>Sur</i>	Reigate, Wray Pk. Rd..	.65	31	"	Belvoir Castle.....	1.50	79
<i>Kent</i>	Tenterden, Ashenden...	.72	38	<i>Rut</i>	Ridlington	1.30	68
"	Folkestone, Boro. San.	1.15	...	<i>Lincs</i>	Boston, Skirbeck.....	1.00	55
"	Margate, Cliftonville....	1.26	72	"	Cranwell Aerodrome...	1.00	60
"	Eden'bdg., Falconhurst	.64	29	"	Skegness, Marine Gdns.	.76	42
<i>Sus</i>	Compton, Compton Ho.	.77	31	"	Louth, Westgate.....	1.14	53
"	Patching Farm.....	.69	34	"	Brigg, Wrawby St.....	1.57	...
"	Eastbourne, Wil. Sq....	1.15	63	<i>Notts</i>	Mansfield, Carr Bank...	1.67	74
<i>Hants</i>	Ventnor, Roy.Nat.Hos.	.39	21	<i>Derby</i>	Derby, The Arboretum	1.42	60
"	Southampton, East Park	.77	38	"	Buxton, Terrace Slopes	4.27	133
"	Ovington Rectory.....	.90	39	<i>Ches</i>	Bidston Obsy.....	2.65	120
"	Sherborne St. John.....	.66	31	<i>Lancs</i>	Manchester, Whit. Pk.	3.60	136
<i>Herts</i>	Royston, Therfield Rec.	.61	27	"	Stonyhurst College.....	4.30	140
<i>Bucks</i>	Slough, Upton.....	.55	27	"	Southport, Bedford Pk.	4.07	188
<i>Oxf</i>	Oxford, Radcliffe.....	.95	42	"	Ulverston, Poaka Beck	5.45	169
<i>N'hant</i>	Wellingboro, Swanspool	1.60	76	"	Lancaster, Greg Obsy.	4.57	179
"	Oundle	1.62	...	"	Blackpool	4.06	186
<i>Beds</i>	Woburn, Exptl. Farm...	1.19	61	<i>Yorks</i>	Wath-upon-Deane.....	1.82	82
<i>Cam</i>	Cambridge, Bot. Gdns.	.65	31	"	Wakefield, Clarence Pk.	1.59	74
"	March.....	.83	42	"	Oughtershaw Hall.....	6.84	...
<i>Essex</i>	Chelmsford, County Gdns	.29	15	"	Wetherby, Ribston H.	2.25	107
"	Lexden Hill House.....	.54	...	"	Hull, Pearson Park.....	1.94	94
<i>Suff</i>	Haughley House.....	.89	...	"	Holme-on-Spalding.....	2.50	114
"	Rendlesham Hall.....	.51	27	"	Felixkirk, Mt. St. John.	2.49	114
"	Lowestoft Sec. School...	.50	50	"	York, Museum Gdns...	2.47	119
"	Bury St. Ed., Westley H.	1.03	49	"	Pickering, Houndgate...	2.04	96
<i>Norf.</i>	Wells, Holkham Hall...	2.08	106	"	Scarborough.....	2.43	132
<i>Wilts</i>	Porton, W.D. Exp'l. Stn	.77	40	"	Middlesbrough.....	1.87	99
"	Bishops Cannings.....	1.85	76	"	Baldersdale, Hury Res.	3.40	144
<i>Dor</i>	Weymouth, Westham.	.41	23	<i>Durk</i>	Ushaw College.....	3.13	145
"	Beaminster, East St...	1.50	66	<i>Nor</i>	Newcastle, Leazes Pk...	2.83	134
"	Shaftesbury, Abbey Ho.	1.13	49	"	Bellingham, Highgreen	3.10	135
<i>Devon.</i>	Plymouth, The Hoe.....	1.12	52	"	Lilburn Tower Gdns....	3.47	168
"	Holne, Church Pk. Cott.	2.80	98	<i>Cumb</i>	Carlisle, Scaleby Hall...	4.30	171
"	Teignmouth, Den Gdns.	1.04	54	"	Borrowdale, Seathwaite	13.75	225
"	Cullompton	1.33	63	"	Thirlmere, Dale Head H.	12.64	305
"	Sidmouth, U.D.C.....	1.50	...	"	Keswick, High Hill.....	8.52	293
"	Barnstaple, N. Dev. Ath	1.66	74	"	Ravenglass, The Grove	4.91	188
"	Dartm'r, Cranmere Pool	3.80	...	<i>West</i>	Appleby, Castle Bank...	2.84	124
"	Okehampton, Uplands.	2.67	96	<i>Mon</i>	Abergavenny, Larchf'd	1.99	82
<i>Corn</i>	Redruth, Trewirgie.....	1.97	79	<i>Glam</i>	Ystalyfera, Wern Ho....	5.95	158
"	Penzance, Morrab Gdns.	2.11	95	"	Treherbert, Tynywaun.	6.84	...
"	St. Austell, Trevarna...	2.00	77	"	Cardiff, Penylan.....	2.07	82
<i>Soms</i>	Chewton Mendip.....	1.91	65	<i>Carm</i>	Carmarthen, M. & P. Sch.	5.21	177
"	Long Ashton.....	1.29	51	<i>Pemb</i>	Pembroke, Stackpole Ct.	...	...
"	Street, Millfield.....	1.57	76	<i>Card</i>	Aberystwyth	3.10	...
<i>Glos</i>	Blockley	1.20	...	<i>Rad</i>	BirmW.W.Tyrmynydd	5.64	172
"	Cirencester, Gwynfa....	1.68	70	<i>Mont</i>	Newtown, Penarth Weir	...	...
<i>Here</i>	Ross-on-Wye.....	1.05	48	"	Lake Vyrnwy	6.68	211
<i>Salop.</i>	Church Stretton.....	2.56	106	<i>Flint</i>	Sealand Aerodrome.....	2.52	124
"	Shifnal, Hatton Grange	1.45	65	<i>Mer</i>	Blaenau Festiniog	12.09	203
"	Cheswardine Hall.....	1.97	81	"	Dolgelley, Bontddu.....	7.33	211
<i>Worc</i>	Malvern, Free Library...	1.24	53	<i>Carn</i>	Llandudno	3.03	150
"	Ombersley, Holt Lock.	1.10	49	"	Snowdon, L. Llydaw 9..	21.55	...
<i>War</i>	Alcester, Raglev Hall...	1.04	46	<i>Ang</i>	Holyhead, Salt Island...	4.07	189
"	Birmingham, Edgbaston	2.02	87	"	Lligwy	5.05	...

Rainfall : June, 1938 : Scotland and Ireland

Co.	STATION.	In.	Per cent of Av.	Co.	STATION.	In.	Per cent of Av.
<i>I. Man</i>	Douglas, Boro' Cem....	5.97	247	<i>R&C</i>	Achnashellach	8.44	213
<i>Guern.</i>	St. Peter P't. Grange Rd.	.29	16	"	Stornoway, C. Guard Stn.	4.62	210
<i>Wig</i>	Pt. William, Monreith.	4.14	176	<i>Suth</i>	Lairg	3.43	164
"	New Luce School	4.87	169	"	Skerry Borgie	4.17	...
<i>Kirk</i>	Dalry, Glendarroch	6.38	229	"	Melvich	3.61	186
<i>Dumf.</i>	Dumfries, Crichton R.I.	...	...	"	Loch More, Achfary....	7.65	207
"	Eskdalemuir Obs.	9.31	296	<i>Caith</i>	Wick	3.51	195
<i>Roxb</i>	Hawick, Wolfelee	3.93	168	<i>Ork</i>	Deerness	4.30	234
<i>Peeb</i>	Stobo Castle	4.67	200	<i>Shet</i>	Lerwick Observatory...	4.13	231
<i>Berw</i>	Marchmont House	4.03	174	<i>Cork</i>	Cork, University Coll...	2.78	110
<i>E. Lot</i>	North Berwick Res.	3.05	184	"	Roches Point, C.G. Stn.	2.93	110
<i>Midl</i>	Edinburgh, Blackfd. H.	2.87	143	"	Mallow, Longueville....	2.53	115
<i>Lan</i>	Auchtyfardle	4.26	...	<i>Kerry</i>	Valentia Observatory...	4.20	131
<i>Ayr</i>	Kilmarnock, Kay Park	4.50	...	"	Gearhameen	8.20	164
"	Girvan, Pinmore	6.19	214	"	Bally McElligott Rec...	4.56	...
"	Glen Afton, Ayr San. ...	6.49	216	"	Darrynane Abbey	3.62	115
<i>Renf</i>	Glasgow, Queen's Park	5.81	252	<i>Wat</i>	Waterford, Gortmore...	3.67	140
"	Greenock, Prospect H.	7.39	237	<i>Tip</i>	Nenagh, Castle Lough.	3.16	129
<i>Bute</i>	Rothessay, Ardenraig...	7.65	249	"	Cashel, Ballinamona....	3.45	152
"	Dougarie Lodge	5.17	190	<i>Lim</i>	Foynes, Coolnanes	3.65	141
<i>Arg</i>	Loch Sunart, G'dale....	9.49	295	<i>Clare</i>	Inagh, Mount Callan....	8.31	...
"	Ardgour House	11.52	...	<i>Wexf</i>	Gorey, Courtown Ho...	3.54	146
"	Glen Etive .....	...	...	<i>Wick</i>	Rathnew, Clonmannon.	2.54	...
"	Oban	6.76	...	<i>Carl</i>	Bagnalstown, Fenagh H.	3.02	122
"	Pottalloch	6.78	222	"	Hacketstown Rectory...	...	...
"	Inveraray Castle	11.62	293	<i>Leix</i>	Blandsfort House	3.54	137
"	Islay, Eallabus	4.50	172	<i>Offaly</i>	Birr Castle	3.44	149
"	Mull, Benmore .....	...	...	<i>Kild</i>	Straffan House	3.59	158
"	Tiree	3.52	138	<i>Dublin</i>	Dublin, Phoenix Park..	2.58	130
<i>Kinr</i>	Loch Leven Sluice	4.08	186	<i>Meath</i>	Kells, Headfort	4.05	153
<i>Fife</i>	Leuchars Aerodrome...	2.50	150	<i>W.M.</i>	Moate, Coolatore	3.46	...
<i>Perth</i>	Loch Dhu .....	...	...	"	Mullingar, Belvedere...	4.26	164
"	Crieff, Strathearn Hyd.	4.53	172	<i>Long</i>	Castle Forbes Gdns	4.87	189
"	Blair Castle Gardens ...	4.04	204	<i>Gal</i>	Galway, Grammar Sch.	4.39	171
<i>Angus</i>	Kettins School	2.48	119	"	Ballynahinch Castle....	6.77	191
"	Pearsie House	3.91	...	"	Ahascragh, Clonbrock.	3.99	143
"	Montrose, Sunnyside...	3.15	190	<i>Rosc</i>	Strokestown, C'node....	4.20	179
<i>Aber</i>	Balmoral Castle Gdns...	3.29	194	<i>Mayo</i>	Blacksod Point	5.24	188
"	Logie Coldstone Sch...	3.98	204	"	Mallaranny	7.21	...
"	Aberdeen Observatory.	3.33	195	"	Westport House	3.72	138
"	New Deer School House	2.59	130	"	Delphi Lodge	9.89	172
<i>Moray</i>	Gordon Castle	3.11	152	<i>Sligo</i>	Markree Castle	5.58	185
"	Grantown-on-Spey	4.71	209	<i>Cavan</i>	Crossdoney, Kevit Cas..	4.45	...
<i>Nairn</i>	Nairn	3.03	172	<i>Ferm</i>	Crom Castle	4.27	158
<i>Inw's</i>	Ben Alder Lodge	6.33	...	<i>Arm</i>	Armagh Obsy	3.55	141
"	Kingussie, The Birches.	3.86	...	<i>Down</i>	Fofanny Reservoir	7.32	...
"	Loch Ness, Foyers	4.21	190	"	Seaforde	3.80	138
"	Inverness, Culduthel R.	3.44	181	"	Donaghadee, C. G. Stn.	4.41	189
"	Loch Quoich, Loan	15.47	...	<i>Antr</i>	Belfast, Queen's Univ....	...	...
"	Glenquoich	13.88	283	"	Aldergrove Aerodrome.	4.55	189
"	Arisaig House	8.02	246	"	Ballymena, Harryville.	5.11	176
"	Glenleven, Corrour .....	...	...	<i>Lon</i>	Garvagh, Moneydig....	3.89	...
"	Fort William, Glasdrum	8.74	...	"	Londonderry, Creggan.	5.56	197
"	Skye, Dunvegan	7.04	...	<i>Tyr</i>	Omagh, Edenfel	4.75	168
"	Barra, Skallary	4.08	...	<i>Don</i>	Malin Head	4.95	187
<i>R&C</i>	Tain, Ardlarach	2.98	146	"	Dunfanaghy, St. Pat's..	...	...
"	Ullapool	4.46	189	"	Dunkineely	5.23	...

Erratum : Malin Head, May, for 2.38/97 read 2.58/105.

Climatological Table for the British Empire, January, 1938

STATIONS	PRESSURE		TEMPERATURE							Mean Cloud Am't	PRECIPITATION		BRIGHT SUNSHINE		
	Mean of Day M.S.L.	Diff. from Normal	Absolute		Mean Values			Mean Wet Bulb	Diff. from Normal		Days	Hours per day	Per-cent age of possible		
			Max.	Min.	Max.	1/2 Min.	Diff. from Normal								
														°F.	°F.
London, Kew Obsy...	1012.3	- 5.3	55	33	48.4	38.8	43.6	3.1	40.7	87	2.23	0.47	21	1.4	17
Gibraltar	1023.6	+ 2.1	62	35	57.7	48.1	52.9	- 2.0	48.3	80	2.17	...	5	...	...
Malta	1015.9	- 1.1	62	42	57.2	49.4	53.3	- 2.0	48.8	78	5.36	2.15	14	5.2	52
St. Helena	1014.9	- 1.1	70	57	65.8	59.1	62.5	- 0.9	60.2	95	4.17	2.13	22	...	...
Freetown, Sierra Leone	1009.5	+ 0.4	90	71	86.9	73.6	80.3	...	74.6	81	0.00	0.41	0	...	...
Lagos, Nigeria	1009.5	- 0.1	90	69	87.8	74.3	81.1	+ 0.2	74.9	90	0.86	0.18	4	5.9	50
Kaduna, Nigeria	1012.2	...	98	55	89.8	59.2	74.5	+ 1.1	53.3	41	3.2	0.00	0	8.6	75
Zomba, Nyasaland	1008.4	+ 0.8	87	61	79.1	66.3	72.7	- 0.1	71.2	87	8.1	...	4	...	...
Salisbury, Rhodesia...	1019.2	- 0.6	84	55	77.8	61.0	69.4	- 0.3	63.2	79	8.5	...	26	5.6	43
Cape Town	1013.1	- 0.3	96	48	79.1	60.9	70.0	+ 0.1	62.0	69	3.8	0.96	6	...	...
Johannesburg	1009.4	- 0.1	86	52	77.3	57.2	67.3	+ 0.6	59.2	72	5.5	1.02	14	7.2	53
Mauritius	1012.0	+ 0.3	90	68	85.5	73.0	79.3	+ 0.0	74.5	74	5.7	2.91	19	9.2	70
Calcutta, Alipore Obsy.	1015.3	+ 0.1	86	52	81.0	58.8	69.9	+ 3.3	59.9	88	2.3	0.41	2*	...	...
Bombay	1012.9	- 0.7	87	63	82.1	66.6	74.3	- 1.2	64.7	70	0.8	0.00	0	...	...
Madras	1013.9	- 0.2	86	66	84.2	68.5	76.3	+ 0.1	70.9	88	5.8	1.14	12	...	...
Colombo, Ceylon	1011.0	+ 0.2	92	69	87.7	72.6	80.1	+ 0.6	74.2	74	4.2	1.74	10	7.7	65
Singapore	1010.7	+ 0.3	89	70	85.2	73.9	79.5	- 0.2	75.7	77	7.9	2.25	18	4.7	39
Hongkong	1020.7	+ 1.0	77	48	65.7	56.7	61.2	+ 1.0	55.9	74	7.4	0.35	4	4.3	39
Sandakan	1009.9	...	87	72	84.2	75.1	79.7	- 0.1	76.3	87	8.3	22.07	20	...	...
Sydney, N.S.W.	1012.8	+ 0.4	88	57	78.6	65.9	72.3	+ 0.7	66.3	65	5.9	9.36	12	8.1	57
Melbourne	1012.9	+ 0.0	103	46	79.1	57.2	68.1	+ 0.7	59.9	55	5.9	1.45	10	7.1	49
Adelaide	1014.2	+ 1.2	104	51	84.4	61.3	72.9	- 0.8	60.6	41	5.2	0.61	7	8.9	63
Perth, W. Australia ..	1013.7	+ 1.2	103	52	84.1	61.9	73.0	- 0.8	60.3	45	2.8	0.21	2	...	...
Coolgardie	1012.7	+ 1.3	103	49	87.4	61.1	74.3	- 3.1	61.3	55	2.1	0.70	2	11.8	97
Brisbane	1011.6	+ 0.3	95	66	83.9	70.0	76.9	- 0.3	70.7	70	6.6	7.70	16	6.7	49
Hobart, Tasmania	1011.2	+ 0.9	89	44	69.6	52.8	61.2	- 0.8	54.2	59	6.5	3.65	15	7.0	47
Wellington, N.Z.	1016.8	+ 3.5	78	48	70.0	55.8	62.9	+ 0.4	59.4	75	6.9	5.16	9	8.0	54
Suva, Fiji	1008.1	+ 0.6	89	71	86.8	75.7	81.3	+ 1.4	76.4	83	6.8	12.53	25	6.2	47
Apia, Samoa	1007.0	- 0.9	90	73	85.9	75.5	80.7	+ 1.7	76.7	79	6.7	20.64	22	6.8	53
Kingston, Jamaica	1015.2	- 0.1	88	64	85.5	68.4	76.9	+ 0.1	66.3	82	4.4	0.05	3	5.6	50
Grenada, W.I.	1010.9	- 1.9	88	71	86	73	79.5	+ 2.4	74	78	5	5.84	17	...	...
Toronto	1016.2	- 1.7	47	- 4	28.7	15.9	22.3	+ 0.1	...	...	8.2	1.63	15	2.1	23
Winnipeg	1020.0	- 0.9	30	- 41	8.9	- 10.0	- 0.5	+ 3.4	...	...	4.4	1.36	9	3.1	36
St. John, N.B.	1017.4	+ 1.9	48	- 12	29.3	13.5	21.4	+ 2.2	16.1	76	5.9	3.95	9	4.4	48
Victoria, B.C.	1019.0	+ 3.0	51	28	44.1	37.5	40.8	+ 1.8	39.6	91	8.3	2.51	19	1.7	19

* For Indian stations a rain day is a day on which 0.1 in. or more rain has fallen.