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CONTENTS

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NOTICES

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THE METEOROLOGICAL MAGAZINE

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AIR MINISTRY : METEOROLOGICAL OFFICE

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OCEAN CURRENTS

By E. W. Barlow, B.Sc.

Ocean currents are usually considered as being mainly within the province of the oceanographer, but there is a very considerable degree of analogy between the movements of the surface and sub-surface currents of the oceans and those of the surface and upper wind-currents of the atmosphere. The analogy is, however, not a perfect one. There is no obstruction to wind by land masses on anything like the scale of that confining water movements, at the surface and at all depths, by, for example, the east coast of Africa. Neither has the atmosphere a definite limit such as is afforded by the depth of the oceans. There is a pronounced difference between the movements of the atmosphere and those of the hydrosphere. Ocean currents have no appreciable effect in the production of wind; on the other hand the surface currents of the oceans are mainly, though not entirely, produced by the direct or indirect effect of wind.

This external agency largely determines surface water movements and also plays a part in the production of sub-surface water movements near long stretches of coastline. As this agency is meteorological the relation between the two sciences is intimate. Furthermore the efficient study of the relationship demands a more complete and more accurate knowledge of the surface winds over the oceans, constituting the greater part of the earth's surface, than we have yet attained. Knowledge of surface ocean currents has been, until quite recent years, considerably less complete and less accurate than that of surface winds.

Oceanography and meteorology meet also in the common ground of sea temperature. Difference of sea temperature is one of the agencies controlling water movements, not only at the surface but at all depths, while this element is important to the meteorologist in several ways, such as in connection with climatology, with fog formation and with the study of general atmospheric circulation, since the movement of warm water masses constitutes one of the means whereby heat is transferred from lower to higher latitudes.

The source of the bulk of current observations is the voyage of an ordinary merchant ship. The method used to determine a current is as follows. The ship is at a known position, found by astronomical observation or land fixes. Proceeding on her voyage the position is again determined after an interval by similar means. The dead reckoning position is also worked out, this being the position in which the ship should be by reason of her course and speed during the interval, after certain allowances have been made. The vector difference of the dead reckoning and true positions gives the speed and direction of the current. The method is subject to error and is not capable of great precision, but it is the only practicable way of obtaining observations in quantity. As the errors are not likely to be systematic in the long run, the mean of a considerable number of observations in a limited region, spread over a number of years, should give a fair approximation to the true current. Mechanical devices for current measurement are only practicable in survey ships or those of oceanographical expeditions.

The possibility of measuring current may thus be said to date from 1765, when Harrison invented the chronometer, enabling longitude at sea to be accurately determined. Nevertheless, by cruder forms of observation or calculation, the existence, and probably some vague idea of the strength, of the more pronounced currents in regions commonly navigated was known long previously. The first chart of the Gulf Stream was published in 1770 by Dr. Benjamin Franklin. The nineteenth century saw the development of current charts of the oceans, but it was not until 1924 that the systematic statistical representation of the mean force and direction of current, and the percentage frequency of currents of different strengths and directions, was begun, in the Marine Division of the Meteorological Office.

Variations of atmospheric pressure have no measurable direct effect on the production of current. Apart from wind friction at the surface, there are two agencies which give rise to current, (*a*) slope of the sea surface, producing a horizontal pressure gradient, such as is established by the wind blowing obliquely over, or parallel to, a coastline, with consequent banking of water against the coast or withdrawal of water from the coast, (*b*) differences of density of the water. Density of sea water depends almost wholly on differences of temperature and salinity; the relative proportion of the various salts is remarkably constant. The range of density in any stratum, or between higher and lower strata, is small, but is sufficient, in the higher levels of the ocean, to produce very definite water movements. As in the case of air movement, all water movement, whatever its origin, is influenced by the deflective force due to the earth's rotation. The theoretical consideration of the formation of currents by wind action is very complex and the work that has been done by Ekman and others is based on certain simplifying assumptions.

The surface currents may be broadly divided into two classes, drift currents and gradient currents. Drift currents are produced by the frictional effect of wind blowing in the same general direction over a considerable extent of sea for a sufficiently long time. Such currents do not extend to any great depth, the actual depth depending on the mean wind force and on the latitude. It is about 140 feet for wind force 3 in lat. 50°, 540 feet for wind force 8 in lat. 50° and 835 feet for wind force 5 in lat. 5°. Owing to the deflective force of the earth's rotation, the direction of the surface flow of a drift current in deep water is about 45° to the right of the wind direction (northern hemisphere). Below the surface the speed of the current decreases, and the angle of deflection increases, until at the depth where the frictional influence of the wind ceases there is a very weak current flowing in a direction exactly opposite to that of the surface current. The integration of these movements in the stratum of water affected gives a resultant transport in a direction 90° to the right of the wind direction (northern hemisphere). Pure wind drift currents are only of importance in the general circulation when they are formed by the action of permanent or semi-permanent winds, the trades and monsoons, or by predominant wind.

The most important gradient currents are those formed at an extended coastline. Ekman has shown that the effect of steady or predominant wind blowing parallel to, or obliquely over, such a coast is to produce a deep-seated current, the midwater current, running parallel to the coastline. The direction of the current is determined in the same way as in Buys Ballot's law, substituting water slope for pressure gradient. This current is stronger than that produced by wind friction and may extend to much greater depths. The current at the surface is the resultant between the midwater current, which extends to the surface, and the direction which the surface current would take if the same wind were producing a wind drift alone. In some cases there are gradient currents along extended coastlines, due to the piling up of water from another current impinging on the coast. An example is the Agulhas Current, the more northern part of which is known as the Mozambique Current, due to the piling up of water on the east African coast by the Equatorial Current of the Indian Ocean. The Agulhas Current transports water from the Indian Ocean to the South Atlantic Ocean where it largely compensates the withdrawal of water from the south-west African coast by the Benguella Current.

These coastal currents are of major importance and include the strongest currents of the ocean. Besides the Agulhas Current, there are others whose names are well known, the Gulf Stream, the Kuro Siwo, the Peru or Humboldt Current and the East African Coast Current. Investigation is showing that in many, and probably all, cases the axis of maximum strength of these currents lies along the edge of the continental shelf (the 100-fathom line). In connection with these currents and the conformation of the side of the continental shelt, upwelling of cold water takes place from the ocean bottom to the region between the main current and the coast. Such upwelling is marked in the cases of the Gulf Stream, the Benguella Current and the Peru Current. This upwelling tends to produce a cold counter-current, usually of weak and intermittent character, running close inshore in the opposite direction to the main current.

It cannot be said that the formation of the coastal currents is at yet fully understood. The Gulf Stream has been explained on Ekman's theory as being caused by the prevailing south-westerly winds drawing water away from the eastern coast of the United States, yet these winds only prevail from May to August. On the other hand there is a definite accumulation of water from the South Equatorial Current of the Atlantic Ocean and the Mississippi river in the Gulf of Mexico. Off the mouth of this river the sea-level has been found to be 3–4 feet higher than that at Sandy Hook. The excess of water appears to emerge down the eastern side of the Gulf of Mexico and through Florida Strait, where the Gulf Stream is strongest.

Density differences in the open ocean, away from the great coastal currents, do not produce surface currents as strong as those caused by wind, but they are responsible for the whole of the sub-surface circulation in these regions beneath the shallow stratum influenced by wind. Such currents on the whole decrease with increasing depth in the ocean, since the greatest variations of temperature and salinity are found in the upper layers. The water movements at the ocean bed appear to be very slight. Density currents can be computed from an adequate number of temperature and salinity observations at various depths made at two stations. These observations form part of the routine of oceanographical expeditions and evidence is accumulating of pronounced stratification of the water between surface and bottom, with lines of convergence and divergence at the surface, vertical interchange taking place at the convergences.

An interesting surface current, not due to wind, and which flows in opposition to the prevailing wind, was found when the Indian Ocean currents were charted. In the Arabian Sea and Bay of Bengal the south-west monsoon and the coastal conformation produce a current flowing clockwise round the coast. The north-east monsoon similarly produces a counter-clockwise circulation, but only during its earlier and stronger period. After January, while the north-east monsoon still persists, the current gradually reverses to the clockwise direction. The explanation of this appears to be the gradual cooling by the monsoon of the water at the heads of these large bays. By January a temperature difference of about 5°F. is set up between the water at the heads and the mouths of the bays. This gives rise to a slope of the sea surface. The clockwise current so produced tends to die out as the temperature difference lessens in subsequent months but the south-west monsoon arrives in time to preserve the direction of the current and enhance its strength.

Some surface currents are due to the combined action of wind and density difference; in other cases these factors might act in opposition. The Gulf Stream is deflected to the right by shallowing water south-west of Newfoundland. It continues its course across the Atlantic Ocean as a weak current maintained by the prevailing south-westerly winds. It is enhanced, however, by the sea temperature being colder to the north of it than to the south. The deflection of a coastal current to the right by shallowing water (northern hemisphere) is deducible by theory. Conversely the deflection of such a current in a region the depths of which have not been properly sounded may suggest the existence of a submarine ridge or other form of shallowing depth. This occurred during the charting of Indian Ocean currents in connection with the deflection of the great East African Coast Current, during the south-west monsoon, eastwards from the coast south of Cape Guardafui. The existence of a great ridge running from the coast in a curve to as far as the Chagos Archipelago was soon afterwards discovered by the John Murray Expedition in 1933–1934, the least depth of the ridge below the surface being 1,000 fathoms. This has been named the Carlsberg Ridge.

The East African Coast Current between lats. 3°S. and 3°N., in May to July, is the strongest current so far investigated. It flows for a distance of 500 miles during this period, with a mean speed of 50–60 miles per day. Further north it is less strong. The Gulf Stream flows with a similar strength through Florida Strait between February and October, but the distance over which this strength is maintained is less. Over short distances the strongest current in the world appears to be that found south of Sokotra, where the East African Coast Current is deflected eastwards from the coast by the Carlsberg Ridge, during the period of the south-west monsoon. Between lats. 9° and 10°N., longs. 53° to 55°E., the mean current during July to September is from 70 to over 90 miles per day. Such a mean speed corresponds to exceedingly strong individual current observations at times, since the range of current strength is always considerable. The three strongest currents so far recorded in this region are one of 168 and two of 144 miles per day (7 and 6 knots). The strongest current observations in the coastal currents are as follows:—Agulhas Current, 121 miles per day, Gulf Stream 120 miles per day, 118 miles per day in the main body of the East African Coast Current, and 96 miles per day in the East Australian Coast Current. The currents of the North Pacific Ocean have not yet been treated statistically.

The strength of the currents which are essentially wind drifts is markedly less. The mean strength of the

South Equatorial Currents of the three oceans for each quarter of the year is given in the table below. It will be noted that there is considerable difference in the strength in different oceans, also in different longitudes of the same ocean.

Strength of South Equatorial Currents (miles per day)

Region.	Nov. to Jan.	Feb. to Apr.	May to July	Aug. to Oct.
Indian Ocean, 6° S. to 18° S., 90° E. to 100° E.	6	3	5	8
,, ,, 6° S. to 18° S., 70° to 80° E.	5	6	6	5
,, ,, north of Madagascar	11	8	24	21
Atlantic Ocean 3° N. to 6° S., 5° W. to 12° W.	8	7	12	8
South Pacific Ocean 2° S. to 6° S., 84° W. to 108° W.	13	10	13	15
,, ,, ,, 0° S. to 6° S., 108° W. to 124° W.	12	15	15	19
,, ,, ,, 0° S. to 6° S., 124° W. to 148° W.	13	18	12	14
,, ,, ,, 0° S. to 6° S. 148° W. to 172° W.	12	23	11	14

The table also gives an idea of the seasonal variation of currents, which is found to differ considerably in magnitude, being hardly noticeable in some cases and marked in others. Seasonal variation may be mainly in speed only, or in direction only, or both. In monsoon currents the greatest speeds can usually be related to wind strengths. The Equatorial Currents, when represented by monthly values, show two maxima during the year, which in the course of the same current may not occur at exactly the same time. Furthermore in the South Equatorial Current of the Pacific the principal maximum on the eastern side of the ocean becomes the secondary maximum on the western side.

The mean monsoon drifts in open sea are not very strong, that of the China Sea from November to January being 11–16 miles per day and in the Arabian Sea in August to October being 5–13 miles per day. The means of currents in the region of the permanent oceanic anticyclones are often much less than these values. It must however be remembered that all currents, even the strongest, are very variable, and the greater the variability the smaller the mean. Even in the regions of weakest mean current, actual currents of 12–24 miles per day are not infrequently met. The strong coastal currents show remarkable instances of current temporarily flowing in complete opposition to the usual current. Over considerable stretches of the great South Equatorial Current of the Pacific, extending over 7,000 miles between South America and New Guinea, the flow is steadier than any other current so far investigated.

In general the current circulation of an ocean is clockwise in the northern hemisphere and anti-clockwise in the southern hemisphere. Too much insistence must not however be placed on the idea of circulation of surface currents. It is becoming obvious that surface currents alone do not compensate for the movements of water masses observed. The surface circulation of mean current is not always perfectly continuous in direction, while there are obvious discontinuities in volume. For example, the great mass of water carried westwards by the wide equatorial currents is out of all proportion to the volume of the rest of the surface circulation. The great equatorial flows are partly compensated by the east-flowing counter-equatorial currents, which do not however always extend right across the ocean, and partly by upwelling from below the surface.

A considerable amount of work has already been done on the seasonal variation of current and a beginning is being made with some of the other problems that present themselves. Many more observations of surface current, covering longer periods, will be required for these investigations. Up to the present, except perhaps in a few restricted areas, the data are quite insufficient to provide an answer to the question whether currents vary in strength, width or position from year to year. The much greater knowledge of the water movements of the oceans, at all depths, which it is hoped will be attained in the future, will depend upon an adequate co-operation of meteorologist and oceanographer, and in each of these sciences much more data will be required before the structure of the oceans begins fully to reveal itself.

LETTERS TO THE EDITOR

Note on Mr. Poulter's photograph of cirrus zig-zags

The usual explanation of these cirrus zig-zags* is that they consist of streamers of ice crystals which fall into layers of air having different velocities. The sharpness of the zig-zags will depend upon the magnitude of the differences and the rate at which the crystals fall.

If a trail of them should fall from one layer of air into another moving more slowly by an amount equal to the rate at which the crystals are falling, then the trail will be bent at an angle of about 45 degrees to the vertical, thus:

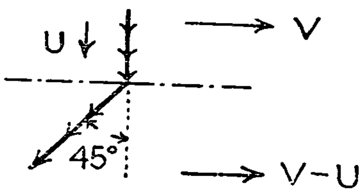

FIG. 1.

Now the rate of fall of cirrus particles certainly does not exceed 1 m.p.h. The cirrus trail in Mr. Poulter's diagram is bent *at about 45 degrees to the vertical.* Yet

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* See page 233 of the September–October, 1939, issue of this Magazine.

here the difference in velocity is stated to be about 6 m.p.h., a difference which should bend the trail almost horizontally. It may be that this was so, and that it is an effect of perspective that the trail appears to be bent much less sharply. If not, however, it is evident that the usual explanation of the bend is in this instance incorrect.

The obvious inference is that the cloud was not a falling trail at all, but that it was formed in a stream of air rising at about 6 m.p.h.

F. H. LUDLAM.

Meteorological Office, Mount Batten.
March, 1940.

Marked discontinuities of temperature at Oxford

The accompanying thermogram from this station is perhaps of enough interest to justify publication. It shows the very marked discontinuities of temperature

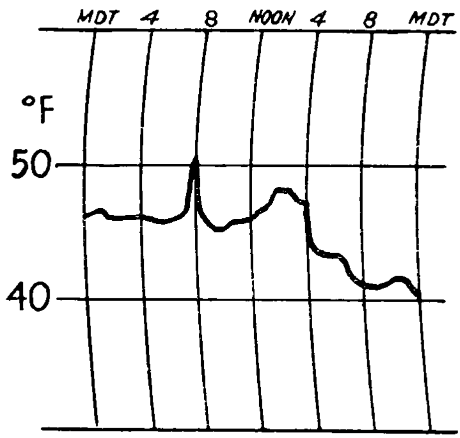

FIG. 1. OXFORD THERMOGRAM, NOVEMBER 27TH, 1939.

before and behind the warm sector of a shallow secondary depression which moved very rapidly across the south of England on November 27th, 1939. The steepness of the trace between 7h. G.M.T. and 9h. 30m. G.M.T. is the more remarkable in view of the obtuseness of the angle between the warm and cold fronts. Oxford seems to have been about the apex of the warm sector, for autographic records 15 miles north and beyond give no indication of a warm sector. At Oxford, and for at any rate some miles to the south, the wind was light and backed slowly to southward in front of the warm front, was south-westerly in the warm sector, and then veered rapidly to north with the sharp fall in temperature. The sky was overcast throughout, and the clouds became extremely dense and low with heavy rain in the warm sector.

W. G. KENDREW.

Radcliffe Meteorological Station, Oxford.
January 12th, 1940.

NOTES AND NEWS

Temperature under different conditions of exposure.

In December 1937 the meteorological station at Hinaidi, 7 miles SSE of Baghdad, was closed and an observation station opened at the Airport about one mile west of Baghdad.

The Hinaidi temperature record which extends over 15 years is probably the most homogeneous record available locally. The method of observation and site did not change during this period and it is usual to use the mean values for Hinaidi as a standard of comparison for temperatures taken near Baghdad. Mean daily values of maximum and minimum temperature for 1923–1936 at Hinaidi are extensively used for comparison purposes.

It was felt however that a direct comparison between the temperatures taken at the Airport and the mean values of temperatures at Hinaidi could not be made because of the difference in exposure. At the Airport the screen is sited on a lawn with a permanent grass cover whereas at Hinaidi the exposure was a typical desert one.

During August 1939 in addition to the observation made in the standard screen on the lawn at the Airport, observations were made of the maximum and minimum temperatures on a typical desert site about 100 yards further west. The results were as follows.

AUGUST 1939

	Lawn Exposure	Desert Exposure	Roof Exposure
Mean Max.°F.	106·3	108·6	108·3
Mean Min.°F.	75·2	74·2	76·4

The desert exposure gave the highest readings without exception and the difference was always between 2 and 3 degrees. It seems fairly obvious then that during the hot months the Airport maximum temperatures require an addition of approximately 2° F. before they can be compared with the mean values of Hinaidi. During the cold months, it is unlikely that any such " correction " would be necessary.

As regards minimum temperature the desert exposure gives practically always the lowest readings—the differences varying from 0° F. to 3° F., the mean being 1° F.

As it would often be a considerable advantage in Iraq to expose all instruments on the flat roofs of buildings, temperature observations were also made during August from a screen exposed on the Airport roof 35 feet above the ground. This roof has a layer of mutti 8 to 9 inches thick with a thin layer of bitumen about 2 inches below the surface. The roof is sufficiently large to allow the screen to be placed about 16 feet from any of the walls. The site was approximately midway between the screens referred to in the previous paragraph.

It was found that the maximum temperatures were in practically every case the same as those taken over the desert surface, but the minima were invariably higher—the average difference between the roof and the aerodrome being 2·2°F. The higher minimum was to be expected because of the outward nocturnal radiation from a fairly large building and of the greater height above the ground.

It is possible, however, that with a smaller building and a lower roof, that a roof exposure would give quite good results and steps will be taken to confirm this as soon as possible.

The screens used in the above experiment were identical in pattern, the thermometers of the sheathed type occupied the same relative position in each screen and the heights of the thermometer bulbs above the " ground " were the same in all cases to within one or two inches.

J. DURWARD.

Heavy snows on May 14th, 1294.

The remarkable snows which fell in London on May 14th, 1294, are described by an early and anonymous chronicler as " the grettest snowe that evere was seyn before thys tyme " and the writer gives an extremely doggerel Latin verse celebrating the event. Robert Fabyan, a much later chronicler, also refers to this event and quotes the Latin verse in much more satisfactory form. He adds: " The whiche verses may thus be englysshed as hereafter foloweth:

The morowe folowynge Tiburce and Valerian
The blessyd seyntes, of snowe fyll such plentie,
That at that daye was no lyvynge man,
That myght remembre of so great quantyte.
The northyn wynde blewe with suche fyerste,
That houses, tryes, with herbys, it overcast
And many other harmes by lande, and eke by see,
Of that wynde came, the whyle that it dyd laste."

C. E. BRITTON.

Belvoir Castle.

In connection with the recent death of the Duke of Rutland we should like to recall that a climatological station has been maintained at Belvoir Castle since 1855. Records have been published from 1855–1867 and from 1896 to date.

General Rainfall, April, 1940.

	Per cent.
England and Wales	110
Scotland	108
Ireland	137
British Isles	118

Sunshine, April, 1940.

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

	Total hrs.	Diff. from average hrs.		Total hrs.	Diff. from average hrs.
Stornoway	144	− 6	Chester	114	−25
Aberdeen	100	−44	Ross-on-Wye	127	−15
Dublin	118	−41	Falmouth	131	−56
Birr Castle	127	−25	Gorleston	132	−32
Valentia	127	−34	Kew	126	−20

Kew temp., mean, 49.2 diff. from average + 1.5° F.

REVIEW

The General Circulation of the Atmosphere over India and its Neighbourhood, by K. R. Ramanathan and K. P. Ramakrishnan. Memoirs of the India Met. Dept., Vol. XXVI, Part X, Delhi, 1939.

The authors of this publication are to be congratulated on the clear and concise way in which they have presented, both as regards winds and thermal conditions, a much more complete survey of the problem than has been attempted before of the circulation of the upper atmosphere over India.

In their acknowledgment at the end of the paper the authors state that the work is based on a large amount of observational material, collected over a period of 20 years. The area studied is roughly from Lat. 8°N. to 35°N. and Long. 50°E. to 100°E., extending from the Persian Gulf to lower Burma and from the North-west Frontier Province to Travancore. The principal characteristics of the upper wind and the temperature distribution in each month are described with their relation to the more important climatological features such as monsoons and storms. Tables of resultant and predominant winds and also frequencies of directions of cloud movement are given in appendices.

Charts showing the mean air movement in each month over the Indian region at different heights up to 8 km., from observations of pilot balloons, at the observatories of the India Meteorological Department are given at the end of the book. As the charts of the pilot balloon winds refer mainly to days of clear weather there are also small inset charts showing the movement of low, medium and high clouds for the five months January, April, July, October and November. Wind-roses for selected stations are inset at the bottom of the charts for the lower levels. Isotherms of upper air temperature deduced from the change of wind with height are also given on the charts.

The following are some of the points discussed and conclusions reached:—

(i) The boundaries between upper easterly and westerly winds in the different months. It was found that the most striking feature of the circulation is the regular seasonal northward and southward movement of this boundary. This is well illustrated in the diagrams, Figs. 3–8, which show the distribution in six months of the year of the westerly and easterly components of the wind at different levels and at latitudes varying from 10° to 30°N.

(ii) The influence of the Himalayas and adjacent mountain ranges on the circulation. It was found that in the north a great influence is exercised on the circulation throughout the year by the mountain systems up to a height of 6 km.

(iii) The increase of temperature in the upper levels over regions of heavy rainfall. It is concluded that regions of heavy rainfall become regions of high temperature and also of divergence of air at heights above 6 km.

(iv) The greater northward movement of air in cloudy weather than in clear weather. It was found that during the winter and hot seasons pilot balloon winds show that, on the average, the winds of the westerly circulation of the higher latitudes turn towards south and south-east and join the easterly circulation, but in cloudy weather in the same period the opposite is the case, air coming from the east turns towards the north and north-east.

There is a diagram, Fig. 2, showing the life-history of steadily rising air; it would possibly have been an advantage here if there had been a short explanation below the diagram to explain that the line drawn to represent the direction of the wind was supposed to be rising upwards from out of the page, as at the first glance this is not very obvious and the description on which the diagram is based is given in the text several pages back.

This publication should prove very useful to anyone who is writing on or studying the subject of the upper winds over India, and is a very valuable contribution towards the co-ordination of data for the study of the general circulation of the upper atmosphere.

E. W. WOODRUFF.

OBITUARY

ERNEST ARMITAGE.—We regret to record the death on April 6th, 1940, of Mr. Ernest Armitage, J.P., of Stroud. Mr. Armitage, who was well known in Gloucestershire and Herefordshire for his social and business activities, maintained a rainfall record at his residence, Berrimans, from 1909 until his death. It is hoped that this long and useful record will be continued.

ERRATA

Rainfall Table, January, 1940, page 19.
Seaforde. *For* 2·29/73 *read* 5·81/184.
Belfast, Queens Univ. *For* 6·28/220 *read* 5·28/185.
General Rainfall, January, 1940, page 14.
Ireland. *For* 102 *read* 104.
British Isles. *For* 90 *read* 89.
Rainfall Table, March, 1940, page 58.
Ross-on-Wye. *For* 1·60/179 *read* 1·60/79.

Rainfall: April, 1940: England and Wales

Co.	Station.	In.	Per cent of Av.	Co.	Station.	In.	Per cent of Av.
Lond'n	Camden Square	1·74	113	*Warw*	Alcester, Ragley Hall.	2·56	151
Surrey	Reigate, Wray Pk. Rd.	2·54	152	,,	Birminghm, Edgbaston	4·80	276
Kent	Tenterden, Ashenden.	1·58	98	*Leics*	Thornton Reservoir	2·40	141
,,	Folkestone, I. Hospital	1·47	..	,,	Belvoir Castle	1·33	87
,,	Margate, Cliftonville	·83	61	*Rutl'd*	Ridlington		
,,	Edenb'dg., Falconhurst	1·75	94	*Lincs*	Boston, Skirbeck	1·10	81
Sussex	Compton, Compton Ho	1·20	60	,,	Cranwell Aerodrome	1·12	85
,,	Patching Farm	1·14	65	,,	Skegness, Marine Gdns	1·13	84
,,	Eastbourne, Wil. Sq.	1·36	75	,,	Louth, Westgate	2·05	123
Hants	Ventnor, Roy. Nat. Hos.	·91	54	,,	Brigg, Wrawby St.	2·08	..
,,	Southampton, East Pk	1·22	66	*Notts*	Mansfield, Carr Bank	1·64	95
,,	Ovington Rectory	1·09	58	*Derby*	Derby, The Arboretum	1·75	102
,,	Sherborne St. John	1·14	64	,,	Buxton, Terrace Slopes	3·49	119
Herts	Royston, Therfield Rec	1·76	112	*Ches*	Bidston Obsy	1·73	106
Bucks	Slough, Upton	1·83	128	*Lancs*	Manchester, Whit. Pk.	1·94	101
Oxford	Oxford, Radcliffe	1·77	111	,,	Stonyhurst College	3·57	132
N'hant	Wellingboro, Swanspool	2·31	155	,,	Southport, Bedford Pk	1·97	106
,,	Oundle	1·60	..	,,	Ulverston, Poaka Beck	3·29	110
Beds	Woburn, Exptl. Farm.	2·46	164	,,	Morecambe	1·90	92
Cambs	Cambridge, Bot. Gdns.	1·24	91	,,	Blackpool	1·93	103
,,	March	1·18	89	*Yorks*	Wath-upon-Dearne	2·00	127
Essex	Shoeburyness	1·38	114	,,	Wakefield, Clarence Pk.	2·10	125
,,	Lexden Hill House	1·56	..	,,	Oughtershaw Hall	2·66	..
Suff	Haughley House	1·15	..	,,	Harrog'te, Harlow Moor	2·30	115
,,	Campsea Ashe, High Ho	1·34	95	,,	Hull, Pearson Park	1·53	98
,,	Lowestoft Sec. School.	1·33	90	,,	Holme-on-Spalding	1·50	90
,,	Bury St. Ed., Westley H	1·48	97	,,	Felixkirk, Mt. St. John	1·52	91
Norf.	Wells, Holkham Hall.	1·07	84	,,	York, Museum	1·77	111
,,	Thetford W. W.	1·38	..	,,	Scarborough	1·74	112
Wilts	Porton, W.D. Exp'l Stn	1·22	73	,,	Middlesbrough	2·00	146
,,	Bishops Cannings	2·70	134	,,	Baldersdale, Hury Res.	2·28	94
Dorset	Weymouth, Westham.	1·47	89	*Durhm*	Ushaw College	1·58	84
,,	Beaminster, East St	1·62	68	*Norl'd*	Newcastle, Leazes Pk.	·76	48
,,	Shaftesbury	1·91	..	,,	Bellingham, Highgreen	1·57	73
Devon	Plymouth, The Hoe	2·52	111	,,	Lilburn Tower Gdns.	1·51	76
,,	Holne, Church Pk. Cott	4·62	128	*Cumb*	Carlisle, Scaleby Hall.	1·43	73
,,	Teignmouth, Den Gdns	3·03	151	,,	Borrowdale, Seathwaite	4·75	69
,,	Cullompton	2·81	124	,,	Thirlmere, Dale Head H.	4·52	93
,,	Sidmouth, U.D.C.	3·22	..	,,	Keswick, High Hill	2·57	84
,,	Barnstaple, N. Dev. Ath	3·28	155	,,	Ravenglass, The Grove	1·52	61
,,	Dartm'r, Cranmere P'l	6·50	..	*West*	Appleby, Castle Bank.	1·37	70
,,	Okehampton, Uplands.	5·25	165	*Mon*	Abergavenny, Larchf'd	2·96	117
Cornw	Bude, School House	2·73	144	*Glam*	Ystalyfera, Wern Ho.	3·82	101
,,	Penzance, Morrab Gdns	4·45	183	,,	Treherbert, Tynywaun	5·19	..
,,	St. Austell, Trevarna	3·39	120	,,	Cardiff, Penylan	2·76	110
Soms	Chewton Mendip	2·81	95	*Pemb*	St. Ann's Head	1·94	95
,,	Long Ashton	2·20	101	*Card*	Aberystwyth	2·34	..
,,	Street, Millfield	2·63	134	*Radn'r*	Bir. W. W. Tyrmynydd	4·44	120
Glostr.	Blockley	2·19	..	*Mont*	Lake Vyrnwy	4·70	156
,,	Cirencester, Gwynfa	1·75	94	*Flint*	Sealand Aerodrome	2·15	148
Here	Ross-on-Wye	3·91	206	*Mer*	Blaenau Festiniog	5·97	107
,,	Kington, Lynhales	2·70	136	,,	Dolgelley, Bontddu	3·54	97
Salop	Church Stretton	3·52	..	*Carn*	Llandudno	2·04	121
,,	Shifnal, Hatton Grange	2·98	177	,,	Snowdon, L. Llydaw 9	8·70	..
,,	Cheswardine Hall	2·98	170	*Angl*	Holyhead, Salt Island.	2·56	123
Worc	Malvern, Free Library.	2·67	148	,,	Lligwy	2·34	..
,,	Ombersley, Holt Lock.	2·10	138	*I. Man*	Douglas, Boro' Cem.	4·64	190

Rainfall: April, 1940: Scotland and Ireland

Co.	Station.	In.	Per cent of Av.	Co.	Station.	In.	Per cent of Av.
Guern	St.PeterP't.GrangeRd.	1·41	70	*R&C*	Stornoway, C.G.Stn.	3·88	135
Wig	Pt. William, Monreith.	2·46	112	*Suth*	Lairg	3·58	155
,,	New Luce School	2·72	102	,,	Skerray Borgie	2·91	..
Kirk	Dalry, Glendarroch	2·53	83	,,	Melvich	2·14	92
Dumf	Eskdalemuir Obs.	3·85	113	,,	Loch More, Achfary	6·67	138
Roxb	Hawick, Wolfelee	1·50	66	*Caith*	Wick	2·92	147
,,	Kelso, Broomlands	1·45	92	*Orkney*	Kirkwall, Bignold Park	..	..
Peebs	Stobo Castle	2·50	120	*Shet*	Lerwick Observatory.	4·40	192
Berw	Marchmont House	1·85	92	*Cork*	Cork, University Coll.	3·51	134
E.Lot	North Berwick Res.	1·93	138	,,	Roches Point, C.G.Stn.	3·93	147
Midl	Edinburgh, Blackfd. H	2·17	148	,,	Mallow, Hazlewood	2·99	..
Lanark	Auchtyfardle	2·91	..	*Kerry*	Valentia Observatory.	..	..
Ayr	Kilmarnock, Kay Park	1·94	..	,,	Gearhameen	5·20	90
,,	Girvan, Pinmore	1·81	61	,,	Bally McElligott Rec.	3·42	..
,,	Glen Afton, Ayr San.	2·44	81	,,	Darrynane Abbey	3·65	106
Renf	Glasgow, Queen's Park	2·80	142	*Wat*	Waterford, Gortmore.	3·15	126
,,	Greenock, Prospect H.	3·26	95	*Tip*	Nenagh, Castle Lough.	3·17	126
Bute	Rothesay, Ardencraig.	2·55	86	,,	Cashel, Ballinamona	3·37	137
,,	Dougarie Lodge	2·30	81	*Lim*	Foynes, Coolnanes	3·70	152
Argyll	Loch Sunart, G'dale	4·04	97	,,	Limerick, Mulgrave St.	4·42	183
,,	Ardgour House	4·50	..	*Clare*	Inagh, Mount Callan	5·17	..
,,	Glen Etive	..	..	*Wexf*	Gorey, Courtown Ho.	3·48	159
,,	Oban	2·20	..	*Wick*	Rathnew, Clonmannon	3·47	..
,,	Poltalloch	2·51	83	,,	Newcastle	..	..
,,	Inveraray Castle	3·76	82	*Carlow*	Bagnalstown FenaghH	2·96	129
,,	Islay, Eallabus	3·73	130	,,	Hacketstown Rectory.	3·93	149
,,	Mull, Benmore	7·90	102	*Leix*	Blandsfort House	3·53	135
,,	Tiree	1·94	79	*Offaly*	Birr Castle	2·52	117
Kinr	Loch Leven Sluice	2·90	151	*Dublin*	Dublin, Phoenix Park.	3·28	181
Fife	Leuchars Aerodrome	1·06	67	*Meath*	Kells, Headfort	3·95	158
Perth	Loch Dhu	5·00	105	*W.M*	Moate, Coolatore	3·20	..
,,	Crieff, Strathearn Hyd.	2·68	122	,,	Mullingar, Belvedere	3·78	159
,,	Blair Castle Gardens	2·16	102	*Long*	Castle Forbes Gdns	3·14	131
Angus	Kettins School	1·37	75	*Galway*	Galway, Grammar Sch.	3·39	144
,,	Pearsie House	2·39	..	,,	Ballynahinch Castle	4·96	140
,,	Montrose, Sunnyside	1·21	66	,,	Ahascragh, Clonbrock.	4·02	158
Aberd	Balmoral Castle Gdns.	1·62	75	*Rosc*	Strokestown, C'node	3·33	151
,,	Logie Coldstone Sch	1·44	72	*Mayo*	Blacksod Point	2·86	99
,,	Aberdeen Observatory.	2·30	123	,,	Mallaranny	4·56	..
,,	New Deer SchoolHouse	2·91	146	,,	Westport House	4·03	149
Moray	Gordon Castle	1·80	103	,,	Delphi Lodge	3·93	121
,,	Grantown-on-Spey	..	..	*Sligo*	Markree Castle	3·82	144
Nairn	Nairn	1·47	98	*Cavan*	Crossdoney, Kevit Cas.	3·61	..
Inv's	Ben Alder Lodge	..	..	*Ferm*	Crom Castle	3·98	155
,,	Kingussie, The Birches	1·78	..	*Arm'h*	Armagh Obsy	2·92	139
,,	Loch Ness, Foyers	..	..	*Down*	Fofanny Reservoir	7·99	..
,,	Inverness, Culduthel R	1·74	105	,,	Seaforde	5·15	197
,,	Loch Quoich, Loan	..	..	,,	Donaghadee, C. G. Stn.	2·87	143
,,	Glenquoich	..	..	*Antrim*	Belfast, Queen's Univ	4·64	208
,,	Arisaig House	2·35	66	,,	Aldergrove Aerodrome	3·47	164
,,	Glenleven, Corrour	5·76	142	,,	Ballymena, Harryville.	4·10	155
,,	Ft. William, Glasdrum	3·61	..	*Lon*	Garvagh, Moneydig	4·56	..
,,	Skye, Dunvegan	2·64	..	,,	Londonderry, Creggan.	4·42	172
,,	Barra, Skallary	1·91	..	*Tyrone*	Omagh, Edenfel	3·86	147
R&C	Tain, Ardlarach	3·71	188	*Don*	Malin Head	4·12	170
,,	Ullapool	3·09	100	,,	Dunfanaghy	3·93	169
,,	Achnashellach	5·39	95	,,	Dunkineely	4·03	..

Climatological Table for the British Empire, October, 1939

STATIONS.	Pressure: Mean of Day M.S.L. (mb.)	Pressure: Diff. from Normal (mb.)	Temp. Absolute Max. (°F.)	Temp. Absolute Min. (°F.)	Temp. Mean Max. (°F.)	Temp. Mean Min. (°F.)	Temp. Mean ½ Max. and Min. (°F.)	Temp. Diff. from Normal (°F.)	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	1011·5	− 2·5	64	33	54·0	43·7	48·9	− 2·0	44·5	89	8·0	4·92	+ 2·22	16	2·9	27
Gibraltar	1015·2	− 2·0	77	51	69·0	59·6	64·3	− 2·1	58·6	82	6·3	6·36	—	16	6·3	56
Malta	1015·9	− 0·1	91	58	77·3	66·7	72·0	+ 1·1	65·5	76	5·8	6·05	+ 3·18	5	8·4	74
St. Helena	1017·7	− 1·3	65	54	62·6	55·4	59·0	− 1·5	56·2	91	9·9	1·30	− 0·01	17	—	—
Freetown, Sierra Leone	1011·6	+ 1·6	86	69	83·2	73·1	78·1	—	73·0	90	8·5	18·00	+ 5·38	27	—	—
Lagos, Nigeria	1011·7	+ 0·7	86	69	82·8	71·7	77·3	− 2·4	72·7	92	8·3	3·62	− 4·15	7	5·3	45
Kaduna, Nigeria	1010·0	—	91	62	87·0	65·6	76·3	− 1·4	69·1	90	6·6	7·44	+ 4·69	11	7·7	65
Zomba, Nyasaland	1011·4	+ 0·6	90	59	84·8	64·9	74·9	+ 0·8	67·4	65	3·4	2·54	+ 1·02	4	—	—
Salisbury, Rhodesia	1011·4	− 0·6	88	49	80·8	57·6	69·2	− 1·5	58·1	45	2·8	2·08	—	5	7·8	62
Cape Town	1016·6	− 0·8	85	48	73·6	53·9	63·7	+ 2·5	57·2	72	5·2	0·25	− 1·40	5	—	—
Johannesburg	1013·0	+ 0·2	82	47	73·3	53·0	63·1	+ 0·3	54·2	58	4·4	3·01	+ 0·45	13	8·8	69
Mauritius	1018·5	+ 0·3	82	59	79·2	64·8	72·0	− 0·7	67·1	65	5·2	1·09	− 0·58	14	7·8	63
Calcutta, Alipore Obsy.	1010·0	+ 0·6	93	70	88·8	76·1	82·5	+ 3·2	77·1	88	5·8	9·48	+ 4·58	14*	—	—
Bombay	1009·5	− 0·3	95	72	88·5	76·5	82·5	+ 0·1	75·9	80	4·1	0·17	− 1·50	1*	—	—
Madras	1008·2	− 0·7	95	73	89·1	76·1	82·6	+ 0·3	76·5	83	6·4	5·05	− 6·10	11*	—	—
Colombo, Ceylon	1010·3	− 0·3	87	71	81·7	75·1	78·4	− 2·1	77·5	81	7·8	12·83	− 0·53	23	5·7	47
Singapore	1010·1	+ 0·4	88	72	85·0	75·1	80·1	− 1·0	77·4	80	8·7	10·80	+ 2·73	23	4·5	37
Hongkong	1012·7	− 1·0	92	65	83·2	74·3	78·7	+ 1·8	71·3	67	5·3	1·41	− 3·53	5	6·6	57
Sandakan	1009·3	—	90	72	87·3	74·7	81·0	− 0·4	76·8	83	8·2	9·86	− 0·47	24	—	—
Sydney, N.S.W.	1019·1	+ 4·3	83	—	68·8	54·5	61·7	− 1·9	56·8	64	6·2	1·98	− 0·87	13	6·8	53
Melbourne	1017·5	+ 2·7	85	39	67·6	47·6	57·6	− 0·1	52·4	58	6·7	2·07	− 0·56	13	5·6	43
Adelaide	1018·3	+ 2·3	93	39	73·7	49·4	61·5	− 0·4	54·2	47	5·7	0·98	− 0·76	12	8·0	62
Perth, W. Australia	1016·7	− 0·1	92	43	71·1	54·1	62·6	+ 1·8	57·1	60	5·4	2·27	+ 0·05	9	8·5	66
Coolgardie																
Brisbane	1018·5	+ 2·3	82	52	75·0	57·8	66·4	− 3·4	60·8	63	5·0	2·31	− 0·22	9	8·4	66
Hobart, Tasmania	1013·6	+ 3·3	80	36	62·0	45·0	53·5	− 0·6	49·0	59	6·9	1·28	− 0·98	18	6·2	47
Wellington, N.Z.	1017·0	− 3·9	67	39	59·0	45·5	52·3	− 2·1	49·4	71	7·4	2·80	− 1·28	12	6·8	52
Suva, Fiji	1013·5	+ 0·3	88	68	81·8	71·3	76·5	+ 0·7	71·6	79	7·4	8·63	+ 0·34	21	4·2	34
Apia, Samoa	1010·5	− 1·0	89	70	85·4	74·3	79·9	+ 1·5	75·0	70	5·6	11·17	+ 4·79	8	8·1	65
Kingston, Jamaica	1010·8	− 0·7	94	71	89·0	73·9	81·5	+ 1·0	72·2	85	8·3	9·09	+ 1·63	14	7·0	59
Grenada, W.I.																
Toronto	1015·9	− 1·6	76	29	57·2	42·9	50·1	+ 1·5	43·6	86	6·2	1·89	− 0·68	10	4·8	43
Winnipeg	1014·2	− 0·7	63	15	44·5	29·1	36·8	− 3·9	30·9	82	8·1	0·32	− 1·05	6	2·5	23
St. John, N.B.	1014·6	− 1·2	68	25	54·5	40·7	47·6	+ 2·3	43·2	87	7·6	5·47	+ 0·93	17	4·1	37
Victoria, B.C.	1018·8	+ 1·7	67	35	56·8	46·0	51·4	+ 1·1	49·4	93	7·2	3·31	+ 0·74	14	4·2	39

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

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