SYMONS'S

MONTHLY

METEOROLOGICAL MAGAZINE.

CC.] SEPTEMBER, 1882. [PRICE FOURPENCE, or 5s. per ann. post free.

THE BRITISH ASSOCIATION AT SOUTHAMPTON.

ALTHOUGH no one can deny that the Southampton people did their best to make the meeting of the British Association a success, we are doubtful if it can be maintained that the results of recent meetings have been worth the time and trouble and money expended upon them, both by the local associates and by the members themselves.

Disguise it as we may, the fact remains that the state of science now differs so enormously from what it was half a century since, that it is *prima facie* improbable that an organization suitable to 1831 should be equally suitable to 1882.

And we doubt the expediency of the localities recently selected, or rather of their recent selection. It used to be a rule, or at any rate a frequent practice, to choose alternately large and small centres of population, so that if one meeting was small, it would be followed by one at say Liverpool, Manchester, or Edinburgh, which would restore both the prestige and the exchequer. But we have had Swansea, York, Southampton, and are promised Southport and Montreal. York, helped on by the éclat of a so-called jubilee (which it was not) had a good meeting, but both Swansea and Southampton were poor, especially the former, the attendance not half what it was at several towns under the genial guidance of Professor Phillips. Southport proposes to combine Liverpool and Manchester, but it can hardly flatter itself that it will have a meeting of 6,000 members and associates. As for Montreal, that is at present too uncertain for us to consider it.

We have incidentally referred to the geniality of Prof. Phillips, and revert to the topic, because we are sure that the Association is losing much by the diminution of that element. We will give two instances, neither very important, and neither matters in which the writer was the acting party.

A movement was set on foot, having for its twin objects (1) the establishment of closer relations between the British Association and the hundreds of Natural History Societies which have been established in various parts of the country, and (2) the representation of those societies on the General Committee, in accordance with one of the oldest rules of the British Association.

The Council of the British Association seem hitherto to have failed to perceive the very great local support which this movement would have ensured in nearly all parts of the country, and instead of assisting the movement have apparently regarded it solely as an attempt at unduly increasing the General Committee, and have resisted it accordingly.

The other still smaller matter (but a straw will show a current) is the Meteorological Breakfast, an arrangement intended to promote the personal acquaintance of those devoted to that branch of Science —and one which to our knowledge has drawn members to meetings which they would otherwise have neglected. This also has met with no favour at the hands of the authorities, and this year the new secretary, when applied to by one of the leaders of modern meteorology, refused to allow the posting of the usual notice of where the breakfast would be held. On arriving at Southampton, and learning what had occurred, remembering also that somewhat similar courtesy had been manifested before, a consultation of several meteorologists was held, and although they knew that if they chose to proceed, no action of the British Association could stop them, they decided that after this repetition of discouragement, they would drop that which had been originally designed chiefly as an incentive to attendance at the British Association meetings.

That there would have been a fair attendance at the breakfast may be inferred from the following list of meteorologists present at Southampton—no one being placed on the list unless either a Fellow of the Meteorological Society or an observer at the present time :—

Adams, Prof. J. C., F.R.S.	Cambridge.
Armstrong, Sir W. G., F.R.S.	Newcastle-on-Tyne.
Barrow, B.	Ryde.
Bateman, J. F., C.E., F.R.S.	London.
Baumhauer, Dr. G. H. Von	Haarlem.
Brett, A. T., M.D.	Watford.
Casella, L. P.	London.
Chapman, E.	Oxford.
Colman, J. J., M.P.	Norwich.
Crowley, F.	Alton.
Cushing, T.	Lambeth.
Davies, Rev. R. P.	Fairford.
Dines, G.	Hersham.
Edmonds, F. B.	London.
Evans, J., D.C.L., F.R.S.	Hemelhempstead.
Everett, Prof. J. D., F.R.S.	Belfast.
Fordham, H. G.	Royston.
Garrett, Rev. H.	Southampton.
Glaisher, J., F.R.S.	Blackheath.
Hankinson, R. C.	Southampton.
Harrison, J. P.	London.
Hawksley, T., C.E., F.R.S.	London.
Howlett, Rev. F.	Alton.
Lawton, W.	Hull.

Livesay, J. G.	Ventnor.
Mackeson, H. B.	Hythe.
Mann, R. J., M.D.	Wandsworth.
Mylne, R. W., C.E., F.R.S.	London.
Pengelly, W., F.R.S.	Torquay.
Pleydell, J. C. Mansell	Blandford.
Rawson, Sir Rawson W., C.B.	London.
Roberts, I.	Liverpool.
Shaw, Prof. H. S. Hele	Bristol.
Siemens, C. W., D.C.L., F.R.S.	London.
Smelt, Rev. M. A.	Cheltenham.
Smith, Basil Woodd	Hampstead.
Smith, Prof. H. J. S., F.R.S.	Oxford.
Stanley, W. F.	South Norwood.
Stewart, Prof. Balfour, F.R.S.	Manchester.
Symons, G. J., F.R.S.	London.
Vivian, E.	Torquay.
Walker, C. V., F.R.S.	Tunbridge Wells.
Westlake, T.	Fordingbridge.

The following is we believe, a complete list of all Meteorological papers :—

A. T. AITCHESON	*Report of Wind Pressure Committee.*
PROF. J. CRAFTS	*On the comparison of the Mercury and Air Thermometer.*
C. E. DE RANCE	*Report on the circulation of the Underground Waters in the Permeable Formations of England.*
PROF. EVERETT	(1) *Report of Committee on Underground Temperature;* (2) *Synopsis of all previous reports of this Committee.*
LITTON FORBES, M.D.	*The Geography and Meteorology of Western Kansas.*
A. MALLOCK	*On a mechanical Self-registering Anemometer.*
PROF. LORD RAYLEIGH	*On the effect of Wind on the draught of Chimneys.*
PROF. LORD RAYLEIGH	*On the tension of Mercury vapour at Common Temperatures.*
PROF. RÜCKER	*Report of the Committee on the methods employed in the calibration of Mercurial Thermometers.*
HON. F. A. R. RUSSELL	*On Cirrus and Cirro-cumulus.*
PROF. SCHUSTER	*Report of Committee on Meteoric Dust.*
PROF. SCHWEDOFF	*On the origin of Hail.*
PROF. BALFOUR STEWART	*On a comparison of Magnetical and Meteorological Weather.*
PROF. BALFOUR STEWART	*On a supposed connexion between the heights of Rivers and the number of Spots on the Sun.*
PROF. S. P. THOMPSON	*On Schwedoff's Theory of Hail.*

UNDERGROUND TEMPERATURE.

The Fifteenth Report of the Committee, consisting of Prof. EVERETT, Prof. SIR WM. THOMSON, Mr. G. J. SYMONS, Sir A. C. RAMSAY, Prof. GEIKIE, Mr. J. GLAISHER, Mr. PENGELLY, Prof. EDWARD HULL, Dr. C. E. LE NEVE FOSTER, Prof. A. S. HERSCHEL, Prof. G. A. LEBOUR, Mr. A. B. WYNNE, Mr. GALLOWAY, Mr. JOSEPH DICKINSON, Mr. G. F. DEACON, *and* Mr. A. STRAHAN, *appointed for the purpose of investigating the Rate of Increase of Underground Temperature downwards in various Localities of Dry Land and under Water, embodying a Summary of the previous fourteen reports. Drawn up by* Prof. EVERETT *(Secretary).*

The results were classified as follows :—

A. Instruments. B. Methods of observation. C. Questions affecting correctness of observations. D. Questions affecting deductions from observations. E. Comparison of results. F. Mean rate of increase of temperature with depth, and mean upward flow of heat.

A. INSTRUMENTS.—Under this head we have—

1. Instruments for observing temperature. 2. Subsidiary apparatus.

1. The thermometers which the Committee have employed have been of two kinds—slow-action thermometers and maximum thermometers. The present pattern of slow-action thermometer consists of a thermometer having its bulb surrounded by stearine or tallow, the whole instrument being hermetically sealed within a glass jacket, and had its origin in a conference between the Secretary and Dr. Stapff in the St. Gothard tunnel. Other slow-action methods described in the reports are—Ångstrom's thermometer in bottle of water, large spirit thermometer, and Symons' thermometer in a thick casing of felt.

Our present patterns of maximum thermometer are two—the Phillips, and the Inverted Negretti—both being hermetically sealed in strong glass jackets to prevent the bulbs from receiving pressure when lowered to a great depth in water.

Both instruments are used in a vertical position, and it is necessary that they register truly in spite of jolts in hauling up. The Phillips pattern was used first, and there were continual complaints of the detached column shaking down, till it was pointed out by Prof. Phillips himself, that the fault arose from the bore not being small enough. This defect was remedied, and the instrument has since worked perfectly, but it requires good light and sharp eyes to read it.

The Inverted Negretti was contrived by the Secretary with the view of overcoming the error from jolts, but the contrivance had been anticipated many years before by Messrs. Negretti and Zambra themselves. It is easily read and managed, but it has a theoretical defect in requiring a slight correction for the difference between the temperature at the time of taking the reading and the maximum temperature recorded.

References to some other kinds of maximum thermometers will be found in some of the reports—namely, to Walferdin's, Lubimoff's, and Magnus', all these being overflow thermometers.

References to Becquerel's thermo-electric method of observing underground temperature were made in three of the reports, and some laboratory experiments were subsequently carried out by the Secretary, which led to the conclusion that the method could not be relied on to yield sufficiently accurate results. It may be mentioned that Becquerel's observations are only carried to the depth of 100 feet, whereas we require observations at the depth of 1,000 or 2,000 feet.

As regards subsidiary (non-thermometric) apparatus, Mr. Symons' arrangement for lowering and raising thermometers to and from any required depth in a deep well (1,000 feet deep in this case), is described with an illustration in II.*

Plugs for preventing convection-currents in a bore or well, are suggested in the first report. Herr Dunker's two forms of plug successfully employed by him at Sperenberg are described in IX., and Professor Lebour's umbrella-like plug in IX., X., XII. In its final form it appears to be very convenient,

* This and all similar Roman numerals refer to the number of the report.

as it requires only one wire, XII. It remains collapsed as long as the wire is taut, but opens out and plugs the hole when it becomes slack.

B. METHODS OF OBSERVATION. These have chiefly been of two kinds.

1. Observations in holes bored to the depth of a few feet in newly opened rock, either in the workings of a mine or of a tunnel, or in a shaft during the sinking. The rock should not have been exposed for more than a week when the hole is bored, and a day may be allowed to elapse for the heat generated by boring to escape before the thermometer is inserted. Very complete plugging is necessary to exclude the influence of the external air. It is desirable to use about two feet of plugging, of which the outer part should be made air tight with plastic clay or greased rag. After the lapse of a few days, the thermometer is to be drawn out by means of a string attached to the handle of its copper case, and the reading taken. The slow-action thermometer above described is employed for this purpose, and there is time to read it with sufficient deliberation before any appreciable change occurs in its indication. It is recommended that the thermometer be then re-inserted and plugged as before, and a second reading taken after the lapse of a week. The majority of our successful observations have been made by this method.

2. Observations in deep bores of small diameter.

Report I. contained a successful application of this method to a bore about 350 feet deep, near Glasgow, which gave very regular results in a series of observations at every 60th foot of depth ; but in the majority of instances in which it has since been applied, there have been marked irregularities, due apparently to the influx of water from springs at particular points. One of the most valuable of our results was obtained by the application of the method to a bore 863 feet deep, executed at the bottom of a coal mine 1,066 feet deep, giving a total depth of 1,929 feet. The bore in this case was dry at the time of its execution, though full of water at the time of the observation. It was in South Hetton Colliery, Durham, and the observer was Mr. J. B. Atkinson. The instrument generally employed in the observations of this class was a maximum thermometer of either the Phillips or the Inverted Negretti construction, as described above.

The larger the diameter of the bore, the more uncertain does this mode of observation become. The South Hetton bore had a diameter of 2½ inches. The Kentish Town well, 1,000 feet deep, in which Mr. Symons' observations were made, had a diameter of 8 inches, and the well 2,165 feet deep at La Chapelle, in the north of Paris, had a diameter of 4½ feet. The temperatures in this last were proved to be largely affected by convection, the water at the top being too warm, and that at the bottom not warm enough. The observations of Herr Dunker, in the bore at Sperenberg, near Berlin, with a depth of 3,390 feet and a diameter of 12 inches, proved a similar disturbance, amounting at the top, and especially at the bottom, to several degrees. As regards the bottom, the proof consisted in showing that when a thermometer at the bottom was protected by a light plug from the influence of the water above, its indications were higher by 6¾° F. than when this precaution was not employed.

3. Where a shaft contains only a few feet of water at the bottom, a thermometer lowered to the bottom of this water may be assumed to give pretty nearly the normal temperature of the soil at this depth, and a few of our observations have been taken in this way. No observations of any value for

our purpose can be made in the portion of a shaft or well occupied by air, as the temperature of such air is largely influenced by that of the air at the surface. This is clearly proved by Mr. Symons' observation in 200 feet of air at Kentish Town.

C. QUESTIONS AFFECTING THE CORRECTNESS OF THE OBSERVATIONS.

This might theoretically include questions as to the correct working of the instruments employed, and as to the personal reliability of observers; but the latter topic has not come into discussion, and the former has not arisen since our present patterns of instrument came into use. The questions for discussion are thus confined to those which relate to possible differences between the temperature of the point at which the thermometer was placed, and the normal temperature at the same depth in its vicinity.

1. The heat generated by the action of the boring tool will vitiate the observation if sufficient time is not allowed for its escape.

A very full discussion on this subject in connection with the great artesian well at La Chapelle will be found in reports V., VI., and VII., clearly establishing the fact that the temperature at the bottom both on the third and the sixth day after the cessation of boring operations, was 7¼° F. higher than after the lapse of four months, though the water had been left to itself during this interval. Further evidence showing that the temperature in the lower part of a bore full of water may thus be raised several degrees, is furnished by the Sub-Wealden bore.

2. The generation of heat by local chemical action is well known to be a powerful disturbing cause when pyrites is present. In report X., the observers in the mines of Schemnitz say, "Pyrites and also decaying timber were avoided as being known to generate heat." In report IX., the observations in the coal mines of Anzin show a temperature of 70¾° F. in a very dry shaft at the depth of less than 70 ft. This must be about 15° F. above the normal temperature.

At Talargoch lead mine in Flintshire (XIII. XIV.), the discrepancies between the temperatures at the six observing stations are suggestive of local chemical action.

3. Convection of heat has proved a very troublesome disturbing cause.

As to convection of heat by air in a shaft or well not filled with water, evidence will be found in report II., both in the case of Mr. Hunter's observations in the shafts of two salt mines at Carrickfergus, having the depths of 570 and 770 feet respectively, and in the case of Mr. Symons' observations at Kentish Town, where the first 210 ft. of the well are occupied with air. At the depth of 150 ft. the temperature was 52°·1 in January, and 54·7 F. in July.

Convection of heat by water in old shafts which have been allowed to become flooded, is very manifest in some of the observations communicated by Mr. Burns in reports II. and IV. In Allendale shaft (Northumberland), 300 ft. deep, with about 150 ft. of water, the temperature was practically the same at all depths in the water, and this was also the case at Breckon Hill shaft, where the observations extended from the depth of 42 ft. to that of 350 ft. A similar state of things was found in a shaft at Ashburton (Devon), by Mr. Amery, who observed at every fiftieth foot of depth down to 350 ft.

Convection by water in the great well at La Chapelle, 2,165 ft. deep, and 4 ft. 5 in. in diameter at the bottom, appears probable from the following comparisons.

Very concordant observations (communicated by M. Walferdin to *Comptes Rendus* for 1838) at three different wells in the Paris basin, of the respective depths of 863 ft., 1,312 ft., and 1,968 ft., show by comparison with one another and with the constant temperature in the caves of the Paris Observatory, a rate of increase of 1° F. in 56 or 57 ft. These data would give at the depth of 328 ft. a temperature of 57°, and at the depth of 2,165 ft. a temperature of 90°; whereas the temperatures actually observed at those depths in the well at La Chapelle in October, 1873, when the water had been undisturbed for a year and four months, were 59°·5 and 76°. It thus appears probable that the upper part of the well is warmed, and the lower part cooled, by convection. Further light may be expected to be thrown on this point when the well reaches the springs, and the water spouts above the surface as it does at the *puits de Grenelle*. A letter received by the Secretary in July, 1882, states that engineering difficulties have prevented any deepening of the well since the above observations, but that arrangements for this purpose have now been made.

More certain and precise information as to the effect of convection in deep bores is furnished by the experiments of Herr Dunker at Sperenberg. The principal bore at Sperenberg has a depth of 4,172 English feet, and is, with the exception of the first 283 ft., entirely in rock salt. Observations were first taken at numerous depths, from 100 ft. to the bottom, and showed a fairly regular increase of temperature downwards. The temperature at 700 ft. was 68°·2 F., and at 3,390 ft. 108°·7 F. Plugs were then contrived which could be fixed tight in the bore at any depth with the thermometer between them, or could be fixed above the thermometer for observing at the bottom. Convection was thus prevented, and a difference of two to four degrees was found in the temperatures at most of the depths: at 700 feet the temperature was now 70°·4 F., and at 3,390 ft. 113°·3 F. We have thus direct evidence that convection had made the temperature at 3,390 ft. 4°·6 F. too low; and this, as Herr Dunker remarks, is an under estimate of the error, inasmuch as convection had been exerting its equalising action for a long time, and its effect could not be completely destroyed in the comparatively short time that the plugs were in position. Again as regards the effect of convection on the upper part of the bore, the temperature, 56°·7 F., was observed at the depth of 100 ft. in the principal bore when no plugs were employed, while a second bore only 100 ft. deep in its immediate vicinity showed a temperature, 52°·2 F., at the bottom. This is direct evidence that the water near the top of the great bore had been warmed 4½° F. by convection.

Suggestions for observations in filled up bores will be found in report XI., but they have not yet taken a practical shape.

D. Questions affecting Deductions from Observations.

1. In many instances the observations of temperature have been confined to considerable depths, and in order to deduce the mean rate of increase from the surface downwards, it has been necessary to *assume* the mean temperature of the surface. To do this correctly is all the more difficult, because there seems to be a sensible difference between the mean temperature of the surface and that of the air a few feet above it.

In Report III. some information on this point is given, based on observations of thermometers 22 in. deep at some of the stations of the Scottish Meteorological Society, and of thermometers 3 (French) feet deep at Greenwich and at Edinburgh. These observations point to an excess of surface temperature above air temperature, ranging from half a degree to nearly two degrees, and having an average value of about one degree.

Dr. Schwartz, Professor of Physics in the Imperial School of Mines at Schemnitz, in sending his observations made in the mines at that place, remarks on this point :—

"Observations in various localities show that in sandy soils the excess in question amounts, on the average, to about 1° F. In this locality the surface is a compact rock, which is highly heated by the sun in summer, and is protected from radiation by a covering of snow in winter ; and the conformation of the hills in the neighbourhood is such as to give protection against the prevailing winds. Hence the excess is probably greater here than in most places, and may fairly be assumed to be double the above average."

Some excellent observations of underground temperature at small depths were made at the Botanic Gardens, Regent's Park, London, for the six years 1871-76, along with observations of air temperature, and have been reduced by Mr. Symons. They are at depths of 3, 6, 12, 24, and 48 in. beneath a surface of grass, and their joint mean derived from readings at 9 a.m. and 9 p.m. for the six years is 49°·9 F., the mean for the 48-in. thermometer being 50°·05 F. The mean air temperature derived in the same way from the readings of the dry bulb thermometer is 49°·6 F. Hence it appears that the excess of soil above air is in this case about 0°·4 F.

Quetelet's observations for three years at Brussels (page 48 of his '*Mémoire*') make the earth, at depths of less than 1½ foot, colder than the air, and at greater depths warmer than the air.

Caldecott's observations for three years at Trevandrum, in India, make the ground at the depth of three feet warmer than the air by 5°·7 F.

Dr. Stapff, in his elaborate publications on the temperature of the St. Gothard tunnel, arrives at the conclusion that the mean temperature of the soil on the surface of the mountain above the tunnel is some degrees higher than that of the air, the excess increasing with the height of the surface and ranging from 4° F. near the ends of the tunnel to 9° or 11° F. in the neighbourhood of the central ridge.

Connected with this is the question—

2. Whether the mean annual temperature of the soil increases downwards from the surface itself, or whether, as is sometimes asserted, the increase only begins where annual range ceases to be sensible—say at a depth of 50 or 60 feet.

The general answer is obvious from the nature of conduction. Starting with the fact that the temperature increases downwards at depths where the annual range is insensible, it follows that heat is travelling upwards, because heat will always pass from a hotter to a colder stratum. This heat must make its way to the surface and escape there. But it could not make its way to the surface unless the mean temperature diminished in approaching the surface ; for if two superposed layers had the same mean temperature, just as much heat would pass from the upper to the lower as from the lower to the upper, and there would not be that excess of upward flow which is necessary to carry off the perennial supply from below.

This reasoning is rigorously true if the conductivity at a given depth be independent of the temperature, and be the same all the year round. By "conductivity" we are to understand the "flux of heat" divided by the "temperature-gradient;" where by the "flux of heat" is meant the quantity of heat which flows in one second across unit area at the depth considered, and by the "temperature-gradient" is meant the difference of temperature per foot of descent at the depth and time considered.

Convection of heat by the percolation of water is here to be regarded as included in conduction. If the conductivity as thus defined were the same all the year round, the increase of mean temperature per foot of depth would be independent of the annual range, and would be the same as if this range did not exist.

As a matter of fact, out of six stations at which first-class underground thermometers have been observed, five show an increase downwards and one a decrease. The following are the results obtained for the depths of 3, 12, and 24 French feet:—

	3 feet.	12 feet.	24 feet.
Brussels, three years	51·85	53·69	53·71
Edinburgh (Craigleith) five years	45·88	45·92	46·07
,, (Gardens), five years	46·13	46·76	47·09
,, (Observatory), seventeen years	46·27	46·92	47·18
Trevandrum, India, three years	85·71	86·12	—
Greenwich, fourteen years	50·92	50·61	50·28

In calculating the mean temperature at 12 feet for Trevandrum, we have assumed the temperature of May, which is wanting, to be the same as that of April.

Omitting Trevandrum, and taking the mean values at 3 and 24 French feet, we find an increase of 1° for about 34 English feet.

3. Another question which it has sometimes been necessary to discuss is the influence which the form of the surface exerts on the rate of increase of temperature with depth.

The practical inference is that the distance between the isotherms (in other words, the number of feet for 1° of increase), is greatest under mountain crests and ridges, and is least under bowl-shaped or trough-shaped hollows.

The observations in the Mont Cenis tunnel, and the much more complete observations made by Dr. Stapff in the St. Gothard tunnel, fully bear out these predictions from theory.

As regards the St. Gothard tunnel, Dr. Stapff reports:—"The mean rate of increase downwards in the whole length of the tunnel is, measured from the surface directly over, 1° F. for 88 feet. Where the surface is a steep ridge the increase is less rapid than this average; where the surface is a valley or plain the increase is more rapid."

4. The question whether the rate of increase downwards is upon the whole the same at all depths, was raised by Professor Mohr in his comments upon the Sperenberg observations, and is discussed, so far as these observations bear upon it, in reports IX. and XI. Observations in different localities give different results, but from a theoretical point of view, in places where there is no local generation of heat by chemical action, the case stands thus:—

The flow of heat upwards must be the same at all depths, and this flow is equal to the rate of increase downwards multiplied by the conductivity, using the word "conductivity" (as above explained) in such a sense as to include convection. The rate of increase downwards must, therefore, be the same at all depths at which this conductivity is the same.

This reasoning applies to superposed strata at the same place, and assumes them to be sufficiently regular in their arrangement to ensure that the flow of heat shall be in parallel lines, not in converging or diverging lines.

Clauses 5 and 6 deal with the conductivity through various geological formations, and at various angles, and seem to show that the effects of these two conditions are not very great.

Section E. deals with a comparison of the results, and occupies many pages, we must therefore refer our readers to the report for the details, and content ourselves with reprinting the synoptical table.

Collecting together the foregoing results, and arranging them mainly in the order of their rates of increase, but also with some reference to locality, we have the following list:—

	Depth feet	Feet for 1° F.
Bootle Waterworks (Liverpool)	1,392	130
Przibram Mines (Bohemia)	1,900	126
St. Gothard Tunnel	5,578	82
Mont Cenis Tunnel	5,280	79
Talargoch Lead Mine (Flint)	1,041	80
Nook Pit Colliery (East Manchester Coal Field)	1,050	79
Bredbury ,, (East Manchester Coal Field)	1,020	78½
Ashton Moss ,, (East Manchester Coal Field)	2,790	77
Denton ,, (East Manchester Coal Field)	1,317	77
Astley Pit, Dukinfield (East Manchester Coal Field)	2,700	72
Schemnitz Mines (Hungary)	1,368	74
Scarle Boring (Lincoln)	2,000	69
Manegaon Boring (India)	310	68
Pontypridd Colliery (S. Wales)	855	76
Kingswood Colliery (Bristol)	1,769	68
Radstock Colliery (Bath)	620	62
Paris Artesian Well, Grenelle	1,312	57
,, ,, St André	830	56
,, ,, Military School	568	56
London ,, Kentish Town	1,100	55
Rosebridge Colliery (Wigan)	2,445	54
Yakoutsk, frozen ground (Siberia)	540	52
Sperenberg, boring in salt (Berlin)	3,492	51½
Seraing Collieries (Belgium)	1,657	50
Monkwearmouth Collieries (Durham)	1,584	70
South Hetton ,, ,,	1,929	57½
Boldon ,, ,,	1,514	49
Whitehaven ,, (Cumberland)	1,250	45
Kirkland Neuk Bore (Glasgow)	354	53
Blythswood ,, ,,	347	50
South Balgray ,, ,,	525	41
Anzin Collieries (North of France)	658	47
St. Petersburg, well (Russia)	656	44
Carrickfergus, shaft of salt mine (Ireland)	770	43
,, ,, ,,	570	40
Slitt Mine, Weardale (Northumberland)	660	34

In deducing a mean from these very various results, it is better to operate not upon the number of feet per degree, but upon its reciprocal—the increase of temperature per foot. Assigning to the results in the foregoing list weights proportional to the depths, the mean increase of temperature per foot is found to be ·01563, or about $\frac{1}{64}$ of a degree per foot—that is, 1° F. in 64 feet.

[It may be well to point out that, accepting this value of 1° F. for 64 ft., we should have for the temperature under London :—

Depth. Feet.	Miles.		Temperature. Degrees F.
0	0	......	50·0
1000	0·2	......	65·6
5280	1·0	......	132·5
10368	1·9	......	212·0

So that the usual temperature of boiling water exists constantly at less than two miles below the surface ; while according to the observations made at Kentish Town the temperature of 212°, would be found at the depth of 8,910 feet, or about 1¾ miles.]

DIFFERENCE IN RAIN GAUGES.

To the Editor of the Meteorological Magazine.

SIR,—On measuring the rain gauges this morning, I found such a remarkable difference between that in the gauges near the ground and in the one at 11 ft., that I cannot refrain from publishing it, and shall be interested to know if any other observer remembers the like.

I may mention that the gauge 11 ft. above ground is 63 ft. from the one 2 ft., and still further from the other two ; the former is placed in an exposed position, and the piping is enclosed in a wooden case and out of the reach of anybody, and so constructed that the water (if any) running down the outside could not possibly enter the receiving bottle.

The bottle itself holds nearly an inch and half of rain, and as it happened I examined it last evening when it was raining fast. I took the bottle and measured the contents, fearing it might overflow, when I registered 1 in., and instead of putting it back again, kept it to be added to the fall during the night.

The rain that fell during the first part of the day was of a drizzling nature, but the principal part fell from about 6 p.m. and during the night.

All the gauges are 8 in. in diameter, consequently I need only one glass for measurement, and I flatter myself on being correct in noting the quantity before throwing the water away.

The gauges at the respective heights, viz. 6 in., 1 ft., and 11 ft., are registered every morning at 8.45, beginning at the one nearest the ground, but the one at 2 ft. I generally register once every week, though in this instance I measured it at the same time for comparison, and put the water back into the receiving bottle, so as not to interfere with the weekly measurement.

6 in.	1 ft.	2 ft.	11 ft.
0·72	0·74	0·71	1·45

Yours truly,

RICHARD GORTON.

Cirencester, Sept. 2nd, 1882.

CLIMATOLOGICAL TABLE FOR THE BRITISH EMPIRE, APRIL, 1882.

STATIONS. (*Those in italics are South of the Equator.*)	Absolute.				Average.				Absolute.		Total Rain.		Aver.
	Maximum.		Minimum.										
	Temp.	Date.	Temp.	Date.	Max.	Min.	Dew Point.	Humidity.	Max. in Sun.	Min. on Grass.	Depth.	Days.	Cloud.
	°		°		°	°	°	0–100	°	°	inches		0–10
England, London	65·5	21	32·6	16	58·2	40·8	41·1	78	116·6	27·4	2·83	14	6·4
Cape of Good Hope	82·8	4	47·2	22	72·4	56·3	56·4	82	...	...	1·99	9	5·5
Mauritius	82·3	18	70·3	26	81·0	73·0	68·0	75	...	...	1·46	13	4·3
Calcutta	101·5	26	67·4	18	95·5	73·9	70·6	67	161·7	60·5	·25	3	3·7
Bombay	91·4	17	74·9	23	88·5	76·7	73·2	72	151·1	63·6	·08	2	0·6
Ceylon	92·5	...	72·8	11	89·6	75·8	73·0	73	156·0	69·5	2·62	11	6·1
Melbourne	85·1	10	42·0	8	66·9	49·4	47·4	71	134·0	34·5	2·31	14	6·8
Adelaide	86·2	9	49·5	13	71·7	55·5	48·5	58	150·0	41·5	2·06	12	6·3
Wellington	67·0	16	45·0	23	63·3	53·4	...	...	123·0	40·0	6·58	15	...
Auckland	75·0	1, 3	48·6	24	69·6	56·5	55·9	78	131·5	46·0	4·84	14	5·6
Falkland Isles	55·2	23	27·2	8	45·2	35·2	37·2	87	105·3	21·2	3·03	23	7·1
Jamaica	89·6	18	66·8	24	84·7	70·1	69·4	76	...	60·2	·15	3	2·6
Barbados	83·0	26,27	69·0	5,6,7,8	80·7	72·0	69·7	75	150·0	...	1·80	9	6·0
Toronto	65·0	4	21·9	10	48·3	32·0	29·7	65	128·0	17·0	1·02	10	5·7
New Brunswick, S. John	49·0	17	6·0	1	38·7	26·8	28·6	82	...	...	4·16	14	6·6
Cape Breton, Sydney	50·0	30	4·6	6	37·2	21·9	25·3	80	...	...	2·86	11	6·1
Newfoundlnd, S. John's	...	...	...	...	...	...	...	...	...	...	...	...	...
Manitoba, Winnipeg	58·0	24	—9·3	4	46·1	22·0	28·1	74	...	...	·47	2	4·5

REMARKS, APRIL, 1882.

Mauritius.—Rainfall 4·49 in. below average; mean bar. 29·998 in.; mean hourly velocity of wind 10·5 miles, prevailing direction E. by S.—C. MELDRUM, F.R.S.

CEYLON.—TSS on 9 days, and L was seen on 8 other days. J. SYMONDS.

Melbourne.—Mean pressure, temp., humidity and rainfall all below the average, amount of cloud above it; prevailing winds N. and S.E., strong breezes occurring on 7 days; heavy dew on 8 days; L on 3rd, and T and L on 23rd. Aurora Australis on 17th and 20th. R. L. J. ELLERY, F.R.S.

Adelaide.—Though there were some showers at many of the coast stations during the first half of the month, the amount was hardly of consequence; but on the 21st a splendid fall commenced, which extended over all the settled districts of South Australia, south of lat. 30° and on the 23rd reached lat. 27° Rainy weather prevailed throughout the remainder of the month, the fall being exceptionally heavy in the N. of the colony on the 27th. Mean temp. 1° below the average; and rainfall ·48 in. above it. C. TODD.

Wellington.—On the whole showery unpleasant weather, though at times fine and bright; 2·21 in. of R fell on 28th; prevailing wind N.W., moderate except on 26th when it blew hard from that quarter; T and L on 29th and 30th, H on 29th; earthquakes on 6th and 16th. Brilliant auroræ on 16th, 17th and 20th. R. B. GORE.

Auckland.—Weather very broken and unsettled, with occasional very heavy falls of R, that of 28th accompanied by very low bar.; wind moderate, mostly W. and N.W.; magnificent aurora on 18th. E. B. DICKSON.

Falkland Isles.—Heavy gale on 6th, 7th and 8th, with snow squalls.—F. E. COBB.

BARBADOS.—Mean pressure below, and mean temp. (75°·6) a trifle higher than the average. Wind N.E., and averaged 13·8 miles per hour. Rainfall 37 per cent. and evaporation 10 per cent. below average. R. BOWIE WALCOTT.

SYDNEY.—On the 27th, horses still crossing the harbour on the ice.

SUPPLEMENTARY TABLE OF RAINFALL, AUGUST, 1882.

[For the Counties, Latitudes, and Longitudes of most of these Stations, see *Met. Mag.*, Vol. XIV., pp. 10 & 11.]

Div.	STATION.	Total Rain.	Div.	STATION.	Total Rain.
		in.			in.
II.	Dorking, Abinger	1·21	XI.	Solva	4·27
,,	Margate, Birchington	1·14	,,	Castle Malgwyn	...
,,	Littlehampton	1·61	,,	Rhayader, Nantgwillt	5·82
,,	St. Leonards	2·49	,,	Carno, Tybritle	5·17
,,	Hailsham	3·46	,,	Corwen, Rhug	3·20
,,	I. of W., St. Lawrence.	2·01	,,	Port Madoc	5·75
,,	Alton, Ashdell	1·85	,,	I. of Man, Douglas	...
III.	Great Missenden	1·50	XII.	Carsphairn	5·08
,,	Winslow, Addington	2·03	,,	Melrose, Abbey Gate	...
,,	Oxford, Magdalen Col.	1·36	XIII.	N. Esk Res. [Penicuick]	2·50
,,	Northampton	1·47	XIV.	Ayr, Cassillis House	4·44
,,	Cambridge, Beech Ho.	1·50	,,	Glasgow, Queen's Park.	1·82
IV.	Southend	1·02	XV.	Islay, Gruinart School	2·85
,,	Harlow, Sheering	1·37	XVI.	St. Andrews, Newton Bk.	2·40
,,	Diss	2·44	,,	Aberfeldy H.R.S.	...
,,	Swaffham	2·37	,,	Dalnaspidal	...
,,	Hindringham	2·15	XVII.	Tomintoul	...
V.	Salisbury, Alderbury	1·47	,,	Keith H.R.S.	3·00
,,	Calne, Compton Bassett	2·62	XVIII.	Forres H.R.S.	3·07
,,	Beaminster Vicarage	2·99	,,	Strome Ferry H.R.S.	3·81
,,	Ashburton, Holne Vic.	4·87	,,	Lochbroom	5·14
,,	Torrington, Langtree W.	5·74	,,	Tain, Springfield	1·54
,,	Lynmouth, Glenthorne.	5·51	,,	Loch Shiel, Glenaladale	6·24
,,	St. Austell, Cosgarne	...	XIX.	Lairg H.R.S.	...
,,	Taunton, Fullands	2·51	,,	Forsinard H.R.S.	3·00
VI.	Bristol, Clifton	5·18	,,	Watten H.R.S.	2·80
,,	Ross	2·37	XX.	Fermoy, Glenville	3·18
,,	Wem, Sansaw Hall	2·25	,,	Tralee, Castlemorris	2·90
,,	Cheadle, The Heath Ho.	2·68	,,	Cahir, Tubrid	3·42
,,	Worcester, Diglis Lock	2·04	,,	Newcastle West	4·21
,,	Coventry, Coundon	2·09	,,	Kilrush	...
VII.	Melton, Coston	2·72	,,	Corofin	3·59
,,	Ketton Hall [Stamford]	1·87	XXI.	Kilkenny, Butler House	...
,,	Horncastle, Bucknall	3·59	,,	Carlow, Browne's Hill	2·40
VIII.	Macclesfield, The Park.	4·68	,,	Navan, Balrath	2·91
,,	Walton-on-the-Hill	2·99	,,	Athlone, Twyford	5·58
,,	Broughton-in-Furness	6·70	XXII.	Mullingar, Belvedere	...
IX.	Wakefield, Stanley Vic.	1·42	,,	Clifden, Kylemore	6·41
,,	Ripon, Mickley	2·11	,,	Crossmolina, Enniscoe	6·40
,,	Scarborough	1·67	XXIII.	Carrick-on-Shannon	4·04
,,	East Layton [Darlington]	1·88	,,	Dowra	...
,,	Middleton, Mickleton	1·82	,,	Rockcorry	3·86
X.	Haltwhistle, Unthank	2·96	,,	Warrenpoint	3·70
,,	Carlisle, St. James Rd.	3·09	,,	Newtownards	2·89
,,	Shap, Copy Hill	3·42	,,	Belfast, New Barnsley	4·30
XI.	Llanfrechfa Grange	3·50	,,	Bushmills	2·90
,,	Llandovery	6·16	,,	Buncrana	3·21

AUGUST, 1882.

Div		STATIONS. [The Roman numerals denote the division of the Annual Tables to which each station belongs.]	RAINFALL. Total Fall.	RAINFALL. Difference from average 1870–9	Greatest Fall in 24 hours. Dpth	Greatest Fall in 24 hours. Date.	Days on which ·01 or more fell.	TEMPERATURE. Max. Deg.	Max. Date.	Min. Deg.	Min. Date.	No. of Nights below 32° In shade.	On grass.
			inches	inches.	in.								
I.	ENGLAND.	London (Camden Square)	1·48	— 1·26	·39	22	12	80·8	6	45·0	31	0	0
II.		Maidstone (Hunton Court)	1·25	— ·99	·24	15	14	...	...	...	...	...	...
,,		Strathfield Turgiss	1·61	— ·81	·43	31	13	83·7	6	44·0	31	0	0
III.		Hitchin	1·87	— ·41	·81	15	13	73·0	12	42·0	8	0	0
,,		Banbury	2·26	— ·44	·50	15	16	76·5	6	41·0	31	0	...
IV.		Bury St. Edmunds (Culford)	2·21	+ ·04	·57	22	15	77·0	6	40·0	30	0	...
,,		Norwich (Cossey)	1·73	— ·89	·38	25	16	80·8	12	43·0	11	0	...
V.		Bridport	3·13	...	1·13	31	17	..	..	...	...	...	...
,,		Barnstaple	5·86	+ 1·76	1·08	13	17	82·0	13	36·0	8	0	...
,,		Bodmin	4·14	— ·70	·76	24	19	73·0	9	50·0	26	0	0
VI.		Cirencester	3·24	— ·42	·80	15	15	...	...	...	...	...	...
,,		Church Stretton (Woolstaston)	2·64	— 1·44	·55	22	17	74·5	6	46·0	16*c*	0	0
,,		Tenbury (Orleton)	2·55	— 1·17	·43	22	17	80·2	6	41·0	11	0	0
VII.		Leicester	2·22	...	·44	25	15	79·0	12	42·0	11	0	0
,,		Boston	2·25	— ·36	·78	16	14	81·0	11	46·0	16	0	...
,,		Grimsby	3·97	+ 1·05	·75	25	19	76·0	11	40·5	31	0	...
,,		Hesley Hall [Tickhill]	1·93	...	·39	23	17	80·0	13	41·0	31	0	...
VIII.		Manchester (Ardwick)	2·94	— ·98	·44	29	16	77·0	13	47·0	24	0	...
IX.		Wetherby (Ribstone Hall)	...	...	...	...	...	...	...	...	...	...	...
,,		Skipton (Arncliffe)	4·27	— 1·53	·82	28	20	80·0	9, 10	40·0	30	0	...
X.		North Shields	4·42	+ 1·33	2·04	22	16	79·0	11	42·5	4	0	
,,		Borrowdale (Seathwaite)	9·05	— 1·99	1·46	20	21	...	...	...	...	..	...
XI.	WALES.	Cardiff (Ely)	7·26	+ 1·93	1·12	15*e*	12	...	...	...	...	...	...
,,		Haverfordwest	5·59	+ ·62	1·10	31	16	75·0	7, 11	40·0	28	0	...
,,		Plinlimmon (Cwmsymlog)	6·90	...	1·15	22	21	...	...	...	...	...	...
,,		Llandudno	3·15	— ·04	·53	28	15	70·6	10*a*	49·8	23	0	...
XII.	SCOTLAND.	Cargen [Dumfries]	2·54	— 1·73	1·19	22	11	...	...	...	...	...	...
,,		Hawick	1·96	— 1·94	·60	22	11	...	...	..	...	...	.
XIV.		Douglas Castle (Newmains)	3·70	— ·60	·59	15	17	...	...	...	...	...	...
XV.		Lochgilphead (Kilmory)	4·05	— 1·17	1·25	14	18	...	...	36·0	31	0	...
,,		Appin (Airds)	3·69	...	...	...	...	...	...	...	...	...	...
,,		Mull (Quinish)	3·10	...	·41	20	23	...	...	...	...	...	...
XVI.		Loch Leven Sluices	2·40	— 1·68	·40	15	9	...	...	...	...	...	...
,,		Arbroath	1·30	— 2·03	·39	31	11	73·0	7*b*	40·0	31	0	...
XVII.		Braemar	1·53	— 2·90	·46	28	15	77·8	10	37·0	24	0	3
,,		Aberdeen	1·68	...	·25	16*f*	19	81·0	11	44·0	8, 19	0	...
XVIII.		Skye (Sligachan)	...	...	...	...	...	...	...	...	...	...	...
,,		Culloden	1·51	— 1·49	·48	29	...	77·5	11	40·0	24	0	1
XIX.		Dunrobin	2·15	...	·54	28	12	78·8	11	43·0	4	0	...
,,		Orkney (Sandwick)	2·59	— ·31	·41	1	18	68·2	13	45·6	31	0	0
XX.	IRELAND.	Cork (Blackrock)	3 49	— ·34	·85	13	11	89·0	6	42·0	16	0	...
,,		Dromore Castle	4·23	...	1·12	22	14	80·0	8, 10	47·0	3*d*	0	...
,,		Waterford (Brook Lodge)	...	...	...	...	...	...	...	...	...	...	...
,,		Killaloe	3·80	...	·68	15	17	83·0	10	40·0	17	0	...
XXI.		Portarlington	2·29	— ·78	·58	31	23	77·0	8	44·5	16	0	...
,,		Dublin (Monkstown)	...	...	...	...	...	...	...	...	...	...	...
XXII.		Ballinasloe	...	...	...	...	...	...	...	...	...	...	...
XXIII.		Waringstown	3·20	— ·24	1·40	22	16	84·0	10	44·0	29	0	...
,,		Londonderry	...	...	...	...	...	...	...	...	...	...	...
,,		Omagh (Edenfel)	3·09	— ·56	·55	31	19	78·0	10	43·0	28	0	...

+ Shows that the fall was above the average ; — that it was below it.

a And 13. *b* And 10, 11. *c* And 23, 24. *d* And 17, 29. *e* And 24. *f* And 31.

METEOROLOGICAL NOTES ON AUGUST.

ABBREVIATIONS.—Bar. for Barometer; Ther. for Thermometer; Max. for Maximum; Min. for Minimum; T for Thunder; L for Lightning; T S for Thunderstorm; R for Rain; H for Hail; S for Snow.

ENGLAND.

STRATHFIELD TURGISS.—First fortnight very fine and dry, latter half of the month showery and unpropitious for harvest work; TS on 29th.

BANBURY.—First half of the month fine, latter part showery. Mean. temp. 58°·6; frequent T with a little L on evening of 25th, wind changing from S.W. by N. and E. to S.; high wind on 20th, 22nd and 23rd.

CULFORD.—The weather during the month was somewhat fickle and unsettled. T on 15th; high wind on 22nd and 23rd. Harvest progressing slowly.

COSSEY.—A fine harvest month until the 24th, after which date some rain fell every day, and delayed the carting; wheat secured in good order, but nearly half the barley was in the fields at the close of the month. Westerly gale on 23rd; the 12th was the only day during the summer on which the temp. reached 80°.

BODMIN.—Mean temp. 62°·0; the almost daily R after the 12th was most disastrous for the harvest.

CIRENCESTER.—Rainfall not so great as in June or July, but, although below the average, it was so distributed as to be unfavourable for getting in the corn crops.

WOOLSTASTON.—Early part of month fine and warm, but after the 13th it was cold with constant R; T and L on 12th. Harvest prospect very gloomy. Mean temp. 58°·4.

ORLETON.—The temp. was rather above the average, and the weather fine and dry till the night of the 12th when L and T occurred; the remainder of the month was very showery, with scarcely a dry day; very unfavourable for the wheat harvest; after the 18th the air was generally cold. Mean temp. 1°·5 below the average of 20 years; aurora on the night of the 30th.

BOSTON.—The cutting of the corn began generally in this neighbourhood on the 14th, but owing to the continuous showers and wet weather, very little was stacked before the end of the month.

NORTH SHIELDS.—There were two very remarkable falls of R during the month; on 26th ·66 in. fell in one hour from 11 a.m. to noon; no R fell at Newcastle, eight miles distant. From 2 a.m. to 11 a.m. on 23rd, nine hours, the fall was 2·24 in.; 2·04 in. was measured at 9 a.m. on the 23rd, and when the R ceased at 11 a.m., ·20 in. more had fallen; it began gently about 10 minutes to 2 in the morning, and fell without any high wind. T on 13th.

WALES.

HAVERFORDWEST.—The month opened fine with a rising temp.; after the 3rd it fell for a few days with a northerly wind; it was then fine but hazy, with great heat, until the evening of the 12th, when frequent flashes of L were seen, and at 2 a.m. (13th) a violent TS broke; from that hour till 4.15 a.m. the T and L were incessant, forked and sheet with torrents of R; this storm broke up the weather, and to the end of the month constant R prevailed, with some very tempestuous weather between the 21st and 29th, and again on 31st, when there was a heavy storm of R and wind from S.E., with an unusually high tide.

LLANDUDNO.—The first half of the month was, on the whole, fine and seasonable; a TS occurred on the morning of the 13th, after which the weather became unsettled, and the last ten days of the month were both wet and cold. Mean temp. 58°·6, 2°·5 below the average; sky cloudy, especially after the 18th, only 131·3 hours of bright sunshine. On only two days did the temp. exceed 70°, range for the month 20°·8, mean daily range 9°·2. The greater part of the grain was cut by the end of the month, though but little was carried owing to the wet state of the weather.

SCOTLAND.

CARGEN.—The fine weather which prevailed during the first half of the month ripened the crops rapidly, and harvest was general toward the end of the month; mean temp. 58°·5, 0°·4 below the average; T on 13th.

HAWICK.—The weather during the first half of the month was most beautiful.

BRAEMAR.—T and L on 13th.

ABERDEEN.—Rainfall only half the average; the early part of the month was characterised by dry warm weather and bright sunshine, but after a TS on the 13th, the weather became showery and unsettled; altogether the conditions were very favourable to the ripening of the crops.

CULLODEN.—Weather very dry up to the middle of the month. Harvest general after the 20th, crops a full average; hay crop safely got in; little appearance of potato blight; turnip crop greatly improved by the rainfall at the close of the month.

SANDWICK.—The temp. of August was pleasant, and the rainfall less than the mean of the previous 41 years. The amount of cloud was above the average, and the bar. was generally low. T and L on the night of 13th, T at noon on 14th and on 29th. Crops particularly good, and harvest just beginning at the close of the month.

IRELAND.

BLACKROCK.—T and L on 12th and 13th; gale on night of 22nd.

DROMORE.—First part of month very fine, constant sunshine, and temp. higher than July. Much cold R in the latter part. A heavy hay crop throughout the county, much of it got in without a drop of R. Green crops inferior from want of June heat; oat crop very fine, but rather laid by the rains of the last part of month; early potatoes injured by rains, potatoes on the whole an inferior crop.

KILLALOE.—Beautiful warm weather prevailed up to the 12th, effecting a marked improvement on hay making and harvest prospects generally; shooting stars very frequent during that period. Heavy R at the close of the month.

EDENFEL.—Weather for the first 12 days very fine, and some days very hot; remainder of month generally wet, cool and unsettled. Meadow hay a splendid and well-saved crop; oats abundant, but remaining crops below average.

THE RAIN BAND.

SPECTROSCOPIC PREVISION OF THE WEATHER.

To the Editor of the Scotsman.

SIR,—Last Friday morning, Sept. 1st, the spectroscopic "rain-band" was the blackest and most intense of the season; and your issue of Saturday morning announced destructive floods, from most heavy rainfalls in various parts of Scotland, to have occurred on that day, Friday.

But this morning—Monday, September 4—there is an absence of the "rain-band," and a clearing away of all the watery vapour lines in the spectrum of sky-light, to an extent not equalled during the last two or three months. In a powerful spectroscope, the two solar D lines now stand out clear and clean, in place of being almost lost, as all through last month, in a thicket of terrestrial water-vapour lines. So the farmers may be enabled to gather in their crops at last, dry and in good condition, though, probably, in rather cold and sharp weather.—I am, &c.

C. P. S.