

SYMONS'S MONTHLY METEOROLOGICAL MAGAZINE.

CCLX.]

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TO OUR READERS.

For the first time in our existence, that is to say for more than 20 years, we are puzzled by a plethora of matter beyond all precedent. We may as well enumerate some of the subjects calling for notice :—

The characteristics of one of the greatest droughts of the century.

The correspondence on definitions of droughts.

The thunderstorm of Aug. 17th, probably the most violent in London for thirty years.

An August frost.

Discussion in Parliament respecting the Meteorological Council.

Correspondence respecting the utility of Ben Nevis Observatory.

The British Association meeting.

Floods in Edinburgh.

Whirlwinds in Kent and Lancashire.

To treat all these fully would require 40 or 50 pages, we must therefore cut some of them short and postpone some for a month.

THE DROUGHT.

As regards the drought and the definitions thereof, we shall give a short article dealing with the total rainfall up to Sept. 1st, 1887, and, as regards the definition, Mr. Symons's paper read at Manchester, and reserve the many communications with which we have been favoured, for use in compiling a full account of the phenomena in *British Rainfall*, 1887, and we hope that this notice will not prevent any who think that they can help in the definition of What is a drought? doing so. We are by no means sure that our original proposals are of the right duration. Nobody has yet sufficiently investigated the matter, and very possibly the three kinds—Absolute, Partial, and Long—instead of starting with 14, 28, and 60 days respectively, should start with 20, 40, and 60. Absolute droughts of 14 days appear to be very common.

We have already devoted a considerable amount of space to The drought, and it cannot be thoroughly dealt with until the whole of

the returns are received at the end of the year. We purpose being very brief in our reference to it this month.

On page 85 (July number) 27 stations were selected from those usually published as being well distributed and having long records. In the present discussion we shall deal only with those stations.

Although July and August were decidedly dry, only three stations had *absolute* droughts, viz. Camden-square, 17 days; Bodmin, 18 days; and Orleton, 15 days; and none had a partial drought. As stated in Mr. Symons' letter to *The Times* (Aug 18th), there appears to be no definition of what may be called an engineering drought, *i.e.*, one seriously affecting waterworks—and the reading of the paper before section G of the British Association at Manchester (see p. 121) did not elicit any practical definition. We have therefore gone back to January—the first month of the dry series—and give in the following table the mean total rainfall from Jan. 1st to August 31st, 1870-79, the fall for the same period in 1887, the difference of 1887 from the average, expressed as a per centage, and the smallest previous fall in the period.

DRYNESS OF JANUARY—AUGUST, 1887.

Div.	STATION.	Mean 1870-79 Total fall Jan. to Aug.	1887.		Previous smallest fall. Jan. to Aug.			No. of cases of smaller falls.	Date of com- mence- ment of Obs.
			Total fall Jan. to Aug.	Per cent. of aver.	Year.	Amount	Per cent. of aver.		
		in.	in.			in.			
I.	London, Camden Square..	17.42	11.38	65	1874	9.07	52	3	1858
III.	Hitchen	16.35	10.35	63	1870	8.85	54	1	1850
IV.	Bury St. Edmunds, Culford	16.27	10.34	64	1874	7.82	48	3	1859
„	Norwich, Cossey.....	16.40	13.14	80	1864	9.00	55	8	1858
V.	Bodmin	32.20	13.71	43	1864	18.28	57	None	1850
VI.	Tenbury, Orleton	21.30	12.51	59	1864	12.18	57	1	1831
VII.	Boston	15.84	7.50	47	1870	9.07	57	None	1867
VIII.	Manchester, Ardwick ...	23.03	10.90	47	1868	13.31	58	None	1854
IX.	Skipton, Arncliffe	37.08	22.27	60	1858	18.80	51	4	1853
„	Hull, Beverley Road.....	16.46	9.34	57	1864	9.71	59	None	1858
X.	Borrowdale, Seathwaite..	79.63	57.90	73	1855	48.71	61	2	1845
XI.	Haverfordwest	31.35	18.03	58	1864	19.36	62	None	1849
„	Llandudno	18.53	11.58	62	1885	11.34	60	1	1859
XII.	Cargen [Dumfries]	28.09	16.32	58	1880	18.41	66	None	1860
„	Jedburgh, Sunnyside.....	17.60	10.80	61	1870	9.61	55	1	1864
XIV.	Old Cumnock	24.65	22.19	90	1880	19.02	77	5	1870
XV.	Lochgilhead, Kilmory ...	35.86	30.08	84	1869	27.40	76	2	1863
XVI.	Loch Leven Sluice.....	23.30	15.70	67	1870	11.00	47	1	1842
„	Arbroath	18.50	13.27	72	1870	10.87	59	2	1844
XVII.	Braemar	22.52	12.20	54	1864	14.16	63	None	1857
XVIII.	Culloden	15.73	9.69	62	1870	7.88	50	1	1841
XX.	Cork, Blackrock.....	28.85	13.83	48	1868	17.49	61	None	1865
XXI.	Carlow, Browne's Hill ...	22.29	13.17	59	1870	15.59	70	None	1866
„	Dublin, Fitzwilliam Sq...	17.78	9.45	53	1870	10.43	59	None	1865
XXII.	Ballinasloe	24.02	14.90	62	1870	17.87	74	None	1868
XXIII.	Waringstown	21.40	15.30	71	1870	14.81	69	3	1862
„	Omagh, Edenfel	22.44	15.54	69	1870	16.73	75	None	1865

		1887.	Previous smallest fall.
Mean per centage of average, England		59·8	55·4
„ „ „ Wales		60·0	61·0
„ „ „ Scotland		68·5	61·5
„ „ „ Ireland.....		60·3	68·0

In *British Rainfall*, 1881, p. 27. values are given for the *Extreme Limits of Fluctuation of Rainfall* in one year, three years, and seven years, and a rough calculation based on these gives as the approximate value for the driest eight months that may reasonably be expected 45 per cent. of the average fall. This value would seem to be rather too low, as it is reached only once in the table; Bodmin 43 per cent. in 1887, but there being five instances below 50 per cent. proves that it is not very far wrong as an extreme limit. And to look at the matter from another point we have—

	Mean period of observation.	Mean min. per centage of rainfall.
England	35·0 years	55·4
Wales	34·0 „	61·0
Scotland	32·9 „	61·5
Ireland	27·4 „	68·0

showing a marked decrease in the minimum rainfall, with an increase of period of observation, proving that the period under consideration is too short to give an absolute minimum.

These calculations may appear somewhat wide of the mark in considering the drought of 1887, but they give a valuable basis for calculation and, we believe, strongly support the hypothetical value of 45 per cent.

To return to 1887—the stations, of the 27 above tabulated, at which the drought was most severe, are—

Bodmin, Cornwall.....	43	per cent. of the average fall.
Boston, Lincoln	47	„ „ „
Manchester.....	47	„ „ „
Blackrock, Cork	48	„ „ „

In England out of 11 stations the drought is unprecedented at 6.

In Wales out of 2 stations the drought is unprecedented at 1.

In Scotland out of 8 stations the drought is unprecedented at 6.

And in Ireland out of 6 stations the drought is unprecedented at 5, but the duration of the observations is so much less that the comparison is unfair.

We may sum up by saying that the drought has been considerable over the whole of the British Isles, that Scotland has suffered least, and that in parts of England the deficiency of rain has been exceptional and has reached the extreme limit that may be expected.

METEOROLOGY IN PARLIAMENT.

A long and somewhat animated discussion occurred in Parliament on August 23rd, upon the vote of £23,900 for learned societies, &c. Many of the hon. members were puzzled as to the nature and titles of the various bodies referred to, and in the following report (based upon that in *The Times*) we have tried not only to be absolutely impartial, but to correct the many obvious errors, while reproducing as tersely as we can such arguments as were not based upon deficient information.

MR. BUCHANAN said that Scotchmen objected to the appropriation of the £4,000 placed at the disposal of the Royal Society for distribution for research, and thought that £3,000 might be left at their disposal and £1,000 sent to Edinburgh for disposal by the Royal Society of Edinburgh. He further said that out of the £15,300 voted to the Meteorological Council, Ben Nevis Observatory got nothing, except £100 a year in payment for observations. He proposed to reduce the vote by £1,000.

SIR E. BIRKBECK did not think that the Ben Nevis Observatory had satisfied the expectations raised with regard to it.

MR. McLAREN did not think that the Meteorological Council dealt fairly with the Scotch observatories, and there was no Scotch member on that Council.

DR. CLARK, MR. M'LAGAN, and COL. NOLAN all urged payments to Scotland, but their statements were either so incorrect, or else so inaccurately reported, that it would only be misleading to reproduce them—*e.g.*, Mr. M'Lagan is reported to have said that "out of £23,000 only £300 was voted for Scotland." We believe that out of their £15,300 the Meteorological Council pay for the support, or part support, of two first order observatories and of a number of telegraph stations; they pay (we presume) Mr. Buchan, the Secretary of the Scot. Met. Soc., as he holds the office of inspector of stations in that country; and doubtless the members of the Council could add other items. Col. Nolan also is reported to have said, "It was all absorbed by England." Why, the Irish observatory at Valentia and the reports and inspection of that station alone must use up nearly £1,000 a year, and the coast is dotted round with stations maintained out of the very vote under discussion.

SIR J. LUBBOCK said that Mr. Buchanan complained of a vote of £2,500 to the Marine Biological Station, but seemed to have forgotten that £12,000 had been voted for the Scotch Fishery Board while there was no similar vote for England. It had been complained that out of the £15,300 nothing went to the Scottish Meteorological Society, but neither did anything go to the Royal Meteorological Society. As regarded the £4,000 distributed through the Royal Society he saw no objection to the addition of Scotch members to that committee, but he thought that it would be a mistake to divide the amount; he had served on the Committee and had never

considered for a moment whether the applicant was English, Scotch, or Irish.

MR. HUNTER said that the importance of the Ben Nevis Observatory had been testified to by Sir W. Thomson, the Royal Society, and the British Association, and the Government should support it as a national institution.

MR. JACKSON referred to the inutility of certain telegrams from Ben Nevis, but as from a letter in *The Times* from Mr. Omond, the superintendent of the Ben Nevis Observatory, there seems to have been some misunderstanding between the Ben Nevis and the Victoria-street establishments, we pass that by. He said that as far as the Government was concerned there was no desire to limit the number of Scotchmen either on the Meteorological Council or on the Government Grant Committee of the Royal Society.

MR. BRYCE pleaded for additional representation of Scotland.

MR. H. FOWLER thought that doubts being prevalent as to the wisdom of the expenditure a small Select Committee should be appointed to enquire into the matter.

DR. CLARK complained that out of 60 members of the Government Grant Committee only two were Scotch.

THE CHANCELLOR OF THE EXCHEQUER advised Mr. Buchanan not to press his motion to a division, as the Government were prepared to consider the subject during the recess.

The Committee divided—

For the reduction	...	...	...	45
Against ...	...	...	...	99
				—
Majority against	...	...	...	54

COL. NOLAN thought that the harvest warning telegrams issued by the Meteorological Council should be exhibited at the telegraph office in each market town.

MR. HANBURY thought that this ought to be done; at present the predictions were inaccessible to farmers.

MR. M. STEWART said that in Scotland the farmers had the warnings sent to them every morning at their own expense, and he thought that the same might be done in England and Ireland.

MR. M. J. KENNY did not think that the Meteorological Council deserved the name of a scientific body, and did not know that their predictions were of much use.

COL. WARING referred to the observations in connection with rainfall conducted by Mr. Symons, and said that the time had come when the Government should consider his claims, with a view to giving him some assistance in carrying on his work.

MR. AIRD said that for the large works in which he was engaged he had paid for a daily telegram of probable weather, finding it very useful he thought that the dissemination of the forecasts should be encouraged.

SIR G. CAMPBELL was of opinion that everything possible should be done if the forecasts were trustworthy, but he did not think that science had yet reached that point. (Hear, hear.)

Mr. PROVAND pointed out that the Post Office was by statute prohibited from disseminating news.

DR. CLARK wished to know how much was paid to the members of the Meteorological Council.

Mr. JACKSON said that £500 was paid to the Chairman and £100 each to the other five members, the Secretary apparently got £800, and £1,000 was devoted to special researches and experiments.

DR. CLARK said that if this vote appeared on the Estimates next year, he would move its reduction by the sum of £1,800.

The vote was then agreed to.

It is not perhaps for us to offer detailed comment on this discussion, but we may be permitted to express our opinion that it may be regarded as equally satisfactory to the meteorologist and to the tax-payer ; for, apart from a little of the Home Rule line of argument, it seems to us to indicate a willingness to support hard and useful work, and on the other hand a determination to hunt out every doubtful payment. What more could we wish of our representatives ?

THE BRITISH ASSOCIATION AT MANCHESTER.

We well remember the rejoicing wherewith the announcement was made in 1861 that the Manchester meeting had been attended by 3,138 persons, the largest number ever assembled ; but this year Manchester has again eclipsed itself and all previous records, by the tremendous gathering of 3,823 members and associates. At so large a meeting the number of meteorologists was so great that we cannot spare space to give the list—among them we should find such leading men as Prof. Cleveland Abbé (of Washington, U.S.A), Messrs. Abercromby, Archibald, Buchan, Glaisher, and a host of others—in fact, more than one-fourth of the Council of the Roy. Meteor. Society was present. We are, however, by no means sure that such large meetings are either as pleasant or as profitable to science as smaller ones. In such crowds it is impossible to find one's friends, and a list of nearly four thousand names (not in strict alphabetical arrangement) is too formidable a book to wade through, in order to see who are at the meeting and where they are staying. Hence many apparent incivilities, and many cases where if A, B, and C had known that D, E, and F were at the meeting, pleasure would have been given and scientific work advanced.

Grants to the total amount of £1,975 were made, but only £160 was voted for meteorology, viz., £150 for Ben Nevis, and £10 for researches on Solar Radiation.

The following is a list of the meteorological papers :—

Report of the Committee on Ben Nevis Meteorological Observatory.

Report of the Committee on the Chepstow Meteorological Observatory.

Report of the Committee on Daily Synoptic Charts of the Indian Ocean.

Report of the Committee on Solar Radiation.

PROFESSOR CLEVELAND ABBÉ.—*The General Bibliography of Meteorology.*

HON. R. ABERCROMBY.—*The Different Varieties of Thunderstorms and a Scheme for their Systematic Observation in Great Britain.*

PROFESSOR E. DOUGLAS ARCHIBALD.—*The Direction of the Upper Currents over the Equator, in connection with the Krakatoa Smoke-stream.*

H. N. DICKSON.—*On the Hygrometry of Ben Nevis.*

PROFESSOR E. HULL, F.R.S.—*On the Effect of Continental Lands in altering the Level of adjoining Oceans.*

DR. H. R. MILL.—*Contributions to Marine Meteorology.*

R. T. OMOND.—*On a Peculiarity of the Cyclonic Winds of Ben Nevis.*

ANGUS RANKIN.—*On the Thermic Wind-Rose at the Ben Nevis Observatory.*

H. C. RUSSELL, F.R.S.—*On some Variations in the Level of the Water in Lake George, New South Wales.*

G. J. SYMONS, F.R.S.—*What is a Drought?*

PROFESSOR L. WEBER.—*Observations of Atmospheric Electricity.*

THE BEN NEVIS OBSERVATORY.

Mr. A. Buchan read the report of the Committee appointed for the purpose of co-operating with the Scottish Meteorological Society in making meteorological observations on Ben Nevis. The observing work had been carried on during the past year with the same intelligence, enthusiasm, and completeness as in previous years. There had been many failures in the prognostications and storm warnings, and the cause of these was being investigated. The committee grounded their claim on the countenance and assistance of the British Association on the scientific work of the observatory. One was surprised to meet occasionally in the daily press and scientific literature of the day statements to the effect that Ben Nevis was expected of itself, and without the help of synchronous low-level observations, to frame warnings of coming storms, and that if this was not done the establishment did not deserve public support. It was unnecessary to say that the British Association had never withheld moral and material support to investigations, unless and until it was shown that the results could be turned to practical purposes. The Committee believed that the high expectations formed as to the practical value of the high-level observations in forecasting weather and storms had been more than realised, all criticisms to the contrary notwithstanding. It was necessary that for forecasting purposes the observations taken at the top of Ben Nevis should be combined with those made at the same instant at Fort William. It had been stated in the House of Commons that the practical results to be obtained from the Ben Nevis Observatory did not warrant the grant asked for from the Treasury. The Meteorological Council had yet to take the first step towards commencing an investigation into the utility of the Ben Nevis Observatory for forecasting purposes, and in the meantime the Meteorological Council had not published any decision regarding this important public question. On the other hand, the Council of the Scottish Meteorological Society were of opinion that the Ben Nevis observa-

tions were of the highest utility in the development of meteorology, and in framing forecasts of storms and weather for the British Islands.

The Chairman expressed the hope that the observatory at Ben Nevis would continue the work in which it had been engaged for some years with so much advantage.

THE CHEPSTOW METEOROLOGICAL OBSERVATORY.

The Committee appointed for the purpose of co-operating with Mr. E. J. Lowe in his project of establishing on a permanent and scientific basis, a meteorological observatory near Chepstow reported that they met at 22, Albemarle-street, on March 26th, and passed the following resolution :—

“As your Committee have heard no further results from the action referred to by Mr. Lowe in his letter quoted in their last report, and there thus appears to be an absence of local support, they see no prospect of the scheme ever being carried out. The fundamental idea presiding over the establishment of the observatory was that it should be one of permanence, and hence it is obvious that adequate endowment is essential. To provide this, and properly equip the observatory, several thousand pounds are needed ; but the Committee have no assurance that anything at all approaching the necessary amount has yet been subscribed, or even promised. As they have now been in existence for between three and four years with this negative result, they are of opinion that the Committee should now be dissolved.”

In consequence of this resolution the committee have not drawn the £20 voted at Birmingham, and they do not now request their reappointment.

SOLAR RADIATION.

Prof. A. Schuster presented the fourth report of the committee appointed for the purpose of considering the best methods of recording the direct intensity of solar radiation. The committee reported that they had made the following additions to the instrument described in the last report :—(1) We have had it swung like the ordinary actinometers with a motion in altitude and azimuth, and with two moderately delicate adjusting screws, one for azimuth and another for altitude adjustments. (2) We have had a thermometer centrically placed in the interior. The graduation of the stem is very delicate, and extends from 20° to 120° Fahr., the reading being taken from one of the sides. The bulb is of green flint, and the stem of colourless, glass. (3) We have also had a small plate of quartz cut and polished and mounted so as to cover the hole, and to be easily removed and replaced. The object of the plate is to prevent irregularities arising from irregular issue of heated air through the hole, entrance of cooler air blown in by wind, &c., and the choice of material was influenced by the wish to permit of frequent cleaning without risk of alteration by scratching. We ought to mention that as it would be difficult to procure the loan of a good heliostat, and expensive to make one, we resolved that in the preliminary experiments the adjustments to keep the sun's image on the hole should be made by the observer. Hence the necessity for the adjusting-screws already described. The committee suggest that they should be re-appointed.

THE GENERAL BIBLIOGRAPHY OF METEOROLOGY.

Prof. Cleveland Abbé described the steps which had been taken in the United States Signal Office in completion of the Meteorological Bibliography begun by himself and Mr. Symons, and subsequently strengthened by the splendid work of Dr. Hellmann and others, whereby finally about 52,000 books and pamphlets had been catalogued. He stated that the work was now practically complete and ready for publication, and awaited only the necessary funds for its printing to be undertaken. Mr. Buchan, Mr. Symons and others congratulated Prof. Abbé on the completion of this great labour, and a resolution expressing the hope that it would be printed as soon as possible was passed by the Section.

Subsequently a resolution was carried unanimously by the General Committee of the whole Association to the following effect :—"That the Council be requested to take such steps as to them shall seem expedient in order to communicate to the Signal Office the high importance attached by British Meteorologists to the Bibliography compiled by the Signal Office, and their hope that it may speedily be rendered accessible to all nations by being printed and circulated."

WHAT IS A DROUGHT ?

By G. J. SYMONS, F.R.S.

Some years since, almost at the outset of my work in connection with rainfall, I was brought face to face with a hopeless confusion. People spoke of "Rainy days" and "Days with rain" and they compared the number of days at one place with that at another, and spoke of these relative values with great complacency. When, however, the subject was looked into, it became evident that the comparisons and conclusions were utterly useless, because what constituted a rainy day had never been defined ; and therefore comparable data did not exist. Eventually a clear definition* was adopted and the difficulty vanished. We are now in want of another definition, and the object of this short paper is to state what has been proposed and adopted *ad interim* and to invite suggestions.

In *British Rainfall*, 1864, I dealt with the drought chiefly in the form of total monthly fall, *i.e.*, the deficiency in certain calendar months, and though the dates of beginning and ending of the two droughts of that year are given, there is no rigorous analysis.

The first systematic effort at a strictly uniform discussion of a drought was in *British Rainfall*, 1868, and as the introductory note to that article clearly states what were then and what still are the difficulties to be surmounted, I venture to reproduce it.

"One great hindrance to the progress of the science of meteorology has been the absence of specific rules and definitions. We had difficulty enough in deciding what was to be considered a day of rain ; that has been surmounted, except that there are, of course, a few who will hold to their own opinions, however large may be the majority, and however strong the facts, against them. Having cleared up this and reduced sundry other vague matters to definite practice, the question arises, "What is a drought ?" Is it a series of days without *any* rain, if so, how could engineers speak of droughts of 140 or 150 days ? If the line is not to be drawn so tightly as to exclude even one shower, where

* Rainy day, or Day with rain, one upon which 0·01 inch of rain fell.

is it to be drawn—at falls of a tenth of an inch, or a quarter of an inch? All these rules are open to this difficulty—suppose a fall of 0·25 in. of rain in twenty-four hours is held to terminate a drought, are four separate daily falls of 0·20 in. to be included? If they are not, the limit must depend on a certain quantity in a certain longer period of time; yet the time must not be lengthened unduly, or we shall have such a case as 0·07 in. falling on, say six consecutive days; this would amount to 0·42 in., and on the last definition would terminate the drought; but we are sure that there are few reservoirs which would receive much benefit from, if they showed any trace of, these slight showers on the thirsty ground. It may occur to some that the flow of water into the reservoirs is the best guide to duration; but there are several objections thereto:—(1) Ordinary observers could not assist. (2) The duration assigned to the drought would depend considerably on the nature of the soil in the district, and the character of the rainfall. In drawing up the following tables, we have taken two or three consecutive days of rain, or one fall of half an inch, as terminating a period; and under the head of “exceptions” we have given all falls exceeding 0·10 in., and the aggregate of *all* amounts during the period.”

In *British Rainfall*, 1880, I adopted a classification which has been generally used up to the present time; it was as follows:—

Absolute droughts.—Periods of 14 or more consecutive days absolutely without rain.

Partial droughts.—Periods of 28 or more consecutive days in which the total rainfall did not exceed 0·25 inch.

It will be noticed that these definitions include the two elements of quantity of rain and of duration, and that neither opinion nor imagination can affect them. These points I regard as of the highest importance, for reasons too obvious to require enforcement.

These definitions have, however, no connection with or resemblance to that which engineers, who are familiar with water works construction, consider as a drought. And the object of this paper is to try and find a common ground whereby the records of the nearly three thousand observers of rainfall in the British Isles may be utilized in the form most useful to engineers.

During enquiries before Parliamentary committees as to the supply of water to towns I hear of droughts of 140, 160, 200, and even 240 days. It is quite certain that these are not “absolute” nor even “partial” droughts, according to the definition that we have laid down, because even in a dry place like London my own register for 30 years gives no “absolute” drought of more than 28 days, nor “partial” drought of more than 41 days. It is therefore evident that the drought of the engineer is something much less severe than even my “partial” drought.

I have already pointed out that as the change of rate of flow into reservoirs depends on the slope and character of the ground, it is not a satisfactory datum for comparison; and it is of course not available to the general public. Looking at the length of time ascribed to droughts by engineers, I am almost driven to conclude that with them “drought” is practically synonymous with “rainfall below the average,” but that no notice is taken of it unless its duration exceeds two months. But probably the real fact is that no definition has ever been given.

I should have thought that a fall of an inch of rain, or about fourteen million gallons per square mile, should be held to terminate a drought, but that does not seem the prevailing idea. Indeed, one of the most eminent water engineers

of the present, or of any, period has spoken repeatedly of droughts during which from 9 inches to 19 inches fell.

Suggestions on the subject having been invited by me in *The Times*, I have been favoured with several, but though very welcome as suggestions, I cannot see my way to recommending any of them, as they are mostly too vague or complicated; one would include the temperature, another the hygrometric state of the air; another (published in *The Times*) includes the relation of the actual to the average rainfall. There is something in that suggestion, but of course it should not be left in that crude form, but expressed as a per centage deficiency on the mean fall for the period.

I am anxious to obtain the advice of others, and think that the chief essentials are clearness and unmistakeableness.

Perhaps I ought not to refrain from offering a suggestion which might meet the requirements of engineers; at any rate, it will afford something to criticize.

Long droughts.—Periods of not less than 60 days with a total rainfall of less than 2.00 inches.

The droughts of the present year at Camden Square, London, according to the above definitions, have been—

Absolute Drought...	Feb. 3rd to 16th	14 days.
	April 6th to 20th	15 "
	June 9th to July 3rd	25 "
	July 29th to Aug. 15th	17 "
Partial Drought.....	June 4th to July 14th	41 "
Long Drought.....	Jan. 19th to March 30th.	71 "
	May 30th to Aug. 15th	78 "

ON THE HYGROMETRY OF BEN NEVIS.

By MR. H. N. DICKSON.

The author in this paper gave an account of observations which were undertaken for the purpose of testing the applicability at high-level stations, such as Ben Nevis Observatory, of existing tables and formulæ for calculating the dew-point and humidity from the readings of wet and dry bulb thermometers. The construction of the direct hygrometer used, that of Professor Chrystal, was described, and the action of the wet and dry bulbs under different meteorological conditions was examined in considerable detail; the results showing that for investigations of this kind a great range of humidity is necessary, the indications of the wet and dry bulbs being very uncertain when the difference between them is small. The reduction of the observations was performed in the first place by a graphic method, from which the following expression was deduced: $f' - f'' = (t - t') k$. f' being the vapour pressure at the temperature t' of the wet bulb, f'' that at the temperature of the dew-point, and t the air temperature. The truth of the above equation being assumed, the values of the quantity k were next found by direct calculation from the observations. The available observations—numbering in all about 300—made it possible to give fairly approximate values for each degree of temperature of the wet bulb from 13° to 45° F. A sudden large change took place at the freezing point, and a similar, though much smaller, discontinuity was shown to occur when the wet bulb stood between 39° and 40° F. Below 32° F. the quantity $1/k$ appeared steadily to increase from 26 to 61, while between 32° and 39° F. and from 40° F. upwards its values remained nearly constant at about 96 and 111 respectively.

CLIMATOLOGICAL TABLE FOR THE BRITISH EMPIRE, FEB., 1887.

STATIONS. (Those in italics are South of the Equator.)	Absolute.				Average.				Absolute.		Total Rain.		Aver.
	Maximum.		Minimum.		Max.	Min.	Dew Point.	Humidity.	Max. in Sun.	Min. on Grass.	Depth.	Days.	
	Temp.	Date.	Temp.	Date.									
°		°		°	°	°	0-100	°	°	inches		0-10	
England, London	54·1	5	22·6	17	45·2	33·1	34·9	86	97·8	16·6	·48	5	6·2
Malta.....	65·2	10	43·2	7, 23	60·1	48·5	47·1	84	123·8	36·0	1·30	11	3·9
<i>Cape of Good Hope</i> ...	98·4	3	51·5	12	83·2	58·9	...	68	...	...	·16	3	3·1
<i>Mauritius</i>	83·3	22	67·2	8	81·4	72·3	68·7	78	138·7	61·5	3·37	22	6·5
Calcutta.....	87·4	22a	47·6	12	80·9	57·1	54·4	63	146·4	35·4	·00	0	0·6
Bombay.....	91·3	18	55·9	9	82·5	66·7	62·3	66	144·9	41·9	·00	0	0·9
Ceylon, Colombo	94·2	19	66·8	1	88·5	71·3	66·3	66	145·8	56·0	2·20	7	3·2
<i>Melbourne</i>	99·6	9	46·7	20	78·4	58·9	55·1	66	147·9	38·0	2·67	8	6·0
<i>Adelaide</i>	101·7	9	53·3	5	85·4	63·1	51·0	44	158·1	44·7	·50	5	3·9
<i>Wellington</i>	78·5	17	46·5	22	71·1	56·8	55·8	76	145·0	41·0	1·43	9	3·5
<i>Auckland</i>	81·0	2, 3	59·0	9	77·3	62·4	65·3	85	147·0	46·0	3·07	7	6·2
<i>Falkland Isles</i>.....	...	...	37·3	24	...	43·2	46·2	81	126·8	30·2	2·24	16	5·8
Jamaica, Kingston.....	90·6	3	59·1	28	87·3	65·1	65·9	75	...	...	·11	...	...
Barbados	78·0	var.	66·0	13b	77·0	67·0	65·3	76	140·0	...	1·23	10	7·0
Toronto.....	45·1	8	— 8·4	13	29·6	13·2	19·6	83	...	—16·0	4·28	19	8·0
New Brunswick, Fredericton	42·9	27	—25·0	14	22·7	1·6	9·7	77	...	...	4·21	16	5·0
Manitoba, Winnipeg ...	24·3	17	—38·7	12	3·7	—20·3	—6·0	94	...	...	1·19	10	4·0
British Columbia, Victoria.....	48·0	27	6·0	2, 5	35·5	23·4	...	...	...	...	5·52	13	...

a And 25. b And 15, 21.

REMARKS, FEBRUARY, 1887.

MALTA.—Mean temp. 53°·4; mean hourly velocity of wind 8 miles. Sea temp. ranged between 58°·6 and 60°·2. TSS on 3 days; H on 2; squalls of R and H over the centre of the Island on 2nd. J. SCOLES.

Mauritius.—Rainfall 1·39 in., mean temp. of air 2°·0, and of dew point 1°·0 below the average; mean pressure ·031 in. above average; mean hourly velocity of wind (10·5 miles) 0·9 mile below average; extremes 26·1 miles on 4th and 1·6 miles on 18th; prevailing direction E. T on 3 days, L on 2. C. MELDRUM, F.R.S.

Melbourne.—Mean temp. of air 2°·2, of dew point 1°·9, rainfall ·69 in., and amount of cloud 0·7 above the average; mean pressure ·028 in. below the average; mean humidity average. Prevailing wind S., strong on 6 days. Hot, sultry, and very oppressive from 7th to 13th. L on evening of 24th, continuing on 25th, and culminating in a heavy TS on 26th with H and heavy R at 5 p.m.; T and L on 28th. R. L. J. ELLERY, F.R.S.

Adelaide.—Mean pressure ·031 in., and rainfall ·18 in. below average; mean temp. and mean amount of cloud slightly above average. C. TONN.

Wellington.—Early part of month showery, with strong N.W. wind; from 9th to the close generally fine, with variable wind. Prevailing wind N.W.; mean temp. 1°·4 above, and rainfall 2·11 in. below the average. R. B. GORE.

AUCKLAND.—Heavy TSS on 8th, 9th, and 18th, remainder of the month very dry and warm; mean temp. and pressure slightly above, and rainfall slightly below the average. T. F. CHEESEMAN.

BARBADOS.—Pressure steady; mean temp. (71°·6) 1°·8 below, and rainfall considerably below the average. Prevailing wind N.E.; mean hourly velocity 15·2 miles; extremes 18·6 miles and 11·0 miles; 8 days were overcast. R. BOWIE WALCOTT.

SUPPLEMENTARY TABLE OF RAINFALL, AUGUST, 1887.

[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	2·62	XI.	Castle Malgwyn	1·73
„	Margate, Birchington...	2·31	„	Rhayader, Nantgwillt..	4·25
„	Littlehampton	1·88	„	Carno, Tybrith ...	3·97
„	Hailsham	2·88	„	Corwen, Rhug	3·00
„	Ryde, Thornbrough	1·86	„	Port Madoc	2·38
„	Alton, Ashdell .....	...	„	I. of Man, Douglas	1·06
III.	Oxford, Magdalen Col...	2·19	XII.	Stoneykirk, Ardwell Ho.	·69
„	Banbury, Bloxham	·76	„	New Galloway, Glenlee	3·64
„	Northampton	1·29	„	Melrose, Abbey Gate...	2·32
„	Cambridge, Beech Ho...	1·23	XIII.	N. Esk Res. [Penicuik]	4·05
„	Wisbech, Bank House..	2·30	XIV.	Ballantrae, Glendrisaig	2·61
IV.	Southend	2·45	„	Glasgow, Queen's Park.	2·71
„	Harlow, Sheering	1·55	XV.	Islay, Gruinart School..	3·82
„	Rendlesham Hall	1·38	XVI.	St. Andrews, Pilmour Cot	2·09
„	Diss	1·46	„	Balquhiddy, Stronvar..	4·63
„	Swaffham	2·40	„	Dunkeld, Inver Braan..	3·22
V.	Salisbury, Alderbury ...	1·26	„	Dalnaspidal H.R.S. ...	3·44
„	Warminster	3·01	XVII.	Keith H.R.S.	2·77
„	Calne, Compton Bassett	..	„	Forres H.R.S.	1·47
„	Ashburton, Holne Vic..	2·70	XVIII.	Strome Ferry H.R.S....	4·20
„	Holsworthy, Clawton...	1·73	„	Tain, Springfield	1·66
„	Hatherleigh, Winsford.	1·45	„	Loch Shiel, Glenaladale	5·19
„	Lynmouth, Glenthorne.	1·86	„	S. Uist, Ardkenneth ...	2·13
„	Probus, Lamellyn	1·67	„	Invergarry	2·40
„	Wincanton, Stowell Rec.	2·05	XIX.	Laigh H.R.S. ....	...
„	Taunton, Lydeard Ho ...	1·31	„	Forsinard H.R.S.	2·65
„	Wells, Westbury	1·54	„	Watten H.R.S.	2·01
VI.	Bristol, Clifton	2·94	XX.	Dunmanway, Coolkelure	3·29
„	Ross	1·95	„	Fermy, Gas Works ...	2·26
„	Wem, Clive Vicarage ...	2·74	„	Tralee, Castlemorris ...	...
„	Cheadle, The Heath Ho.	2·48	„	Tipperary, Henry Street	2·09
„	Worcester, Diglis Lock	1·25	„	Newcastle West	2·95
„	Coventry, Coundon	1·79	„	Miltown Malbay .....	...
VII.	Melton, Coston	·61	XXI.	Gorey, Courtown House	2·36
„	Ketton Hall [Stamford	·69	„	Navan, Balrath	1·78
„	Horncastle, Bucknall ...	2·75	„	Mullingar, Belvedere ...	1·94
„	Mansfield, St. John's St.	2·03	„	Athlone, Twyford	2·88
VIII.	Macclesfield, The Park.	1·26	„	Longford, Currygrane...	2·48
„	Walton-on-the-Hill	2·00	XXII.	Galway, Queen's Coll...	4·85
„	Lancaster, South Road.	2·19	„	Clifden, Kylemore	7·60
„	Broughton-in-Furness ..	1·49	„	Crossmolina, Enniscoe..	4·74
IX.	Wakefield, Stanley Vic.	1·23	„	Collooney, Markree Obs.	3·54
„	Ripon, Mickley	1·59	XXIII.	Rockcorry	2·52
„	Scarborough, West Bank	1·25	„	Warrenpoint	2·08
„	East Layton [Darlington]	1·86	„	Newtownards .....	...
„	Middleton, Mickleton ...	2·21	„	Belfast, New Barnsley .	3·38
X.	Haltwhistle, Unthank..	2·56	„	Cushendun	2·70
„	Shap, Copy Hill	1·69	„	Bushmills	2·43
XI.	Llanfrehfa Grange	2·61	„	Stewartstown	2·43
„	Llandovery	2·61	„	Buncrana	4·14

AUGUST, 1887.

Div.	STATIONS. [The Roman numerals denote the division of the Annual Tables to which each station belongs.]	RAINFALL.						Days on which ·01 or more fall.	TEMPERATURE.				No. of Nights below 32°.	
		Total Fall.	Differ- ence from average 1870-9	Greatest Fall in 24 hours.		Deg	Date		Deg	Date				
				Inches	Inches.						Dpth	Date.		
I.	London (Camden Square) ...	3·15	+ ·41	1·44	17	8	88·5	6	42·5	15	0	0		
II.	Maidstone (Hunton Court)...	1·87	— ·37	·58	16	11	...	...	...	...	...	...
III.	Strathfield Turgiss	1·86	— ·56	·91	30	12	87·8	6	40·3	22	0	0		
III.	Hitchin	·99	— 1·29	·33	30	8	80·0	8	44·0	14	0	...		
IV.	Winslow (Addington)	1·01	— 1·94	·22	30	9	88·0	6	37·0	15	0	...		
IV.	Bury St. Edmunds (Culford)	1·81	— ·36	·58	30	11	82·0	8	34·0	22	0	...		
V.	Norwich (Cossey)	2·95	+ ·33	·51	19	12	...	...	...	...	...	...
V.	Weymouth (Langton Herring)	2·06	...	·88	30	10	77·0	7	48·0	15b	0	...		
"	Barnstaple	1·31	— 2·79	·36	30	9	86·0	7	47·5	3	0	...		
"	Bodmin	2·26	— 2·58	·64	28	11	76·0	6	46·0	15b	0	0		
VI.	Stroud (Upfield)	1·60	— 1·57	·44	28	12	80·0	9, 24	46·0	2, 20	0	...		
"	Church Stretton (Woolstaston)	2·34	— 1·74	·64	30	12	79·0	4, 6	41·5	14	0	0		
"	Tenbury (Orleton)	1·88	— 1·84	·45	16a	10	84·2	8	34·2	15	0	1		
VII.	Leicester	1·55	...	·32	18	10	86·3	6	39·8	15	0	1		
"	Boston	·96	— 1·65	·27	18	10	92·0	6	38·0	15	0	...		
"	Hesley Hall (Tickhill)	2·29	...	·73	30	10	84·0	6	37·0	14c	0	...		
VIII.	Manchester (Ardwick)	1·12	— 2·80	·33	31	9	77·0	25	44·0	17	0	0		
IX.	Wetherby (Ribston Hall) ..	2·07	— ·56	·61	21	9	...	...	...	...	...	...
"	Skipton (Arncliffe)	3·03	— 2·77	·67	30	12	82·0	6	36·0	14	0	...		
"	Hull (Beverley Road)	1·72	— 1·01	·38	18	10	80·0	6	40·0	22	0	0		
X.	North Shields	2·41	— ·68	·95	18	12	78·5	6	38·5	14	0	0		
"	Borrowdale (Seathwaite)	4·75	— 6·29	1·28	31	17	...	...	...	...	...	...
XI.	Cardiff (Ely)	2·91	— 2·42	·73	28	10	...	...	...	...	...	...
"	Haverfordwest	2·28	— 2·69	·93	30	12	77·8	8	39·0	14	0	...		
"	Plifflimmon (Cwmsymlog) ...	4·20	...	·77	30	12	...	...	...	...	...	...
"	Llandudno	1·78	— 1·41	·42	17	12	77·0	24	45·0	14d	0	0		
XII.	Cargen [Dumfries]	2·14	— 2·13	·78	28	10	73·8	5	35·0	14	0	...		
XII.	Jedburgh (Sunnyside)	1·70	— 1·67	·30	29	11	80·0	5	38·0	14	0	...		
XIV.	Old Cumnock	3·47	— ·67	·58	30	18	80·0	4	33·0	13	0	...		
XV.	Lochgilthead (Kilmory)	5·48	+ ·26	1·14	6	17	...	...	...	...	...	...
"	Oban (Craigvarren)	2·59	...	·75	6	19	71·0	4, 5	42·8	21	0	...		
"	Mull (Quinish)	2·92	...	·78	29	21	...	...	...	...	...	...
XVI.	Loch Leven Sluices	3·60	— ·48	1·00	7	11	...	...	...	...	...	...
"	Arbroath	2·56	— ·77	·81	6	10	74·0	8	43·0	14	0	0		
XVII.	Braemar	2·13	— 2·30	·65	16	21	73·8	4	36·0	3	0	4		
"	Aberdeen	1·88	...	·41	6	18	73·0	23	42·0	2	0	...		
XVIII.	Lochbroom	3·71	...	1·00	7	22	...	...	...	...	...	...
"	Culloden	1·28	— 1·72	...	...	...	76·0	26	41·0	22	0	0
XIX.	Dunrobin .....	...	...	...	...	...	...	...	...	...	...	...
"	Kirkwall (Swanbister) .....	...	...	...	...	...	...	...	...	...	...	...
XX.	Cork (Blackrock)	2·12	— 1·71	·44	16	14	85·0	8	41·0	13	0	0		
"	Dromore Castle	3·58	...	·93	25	16	75·0	2	41·0	13	0	...		
"	Waterford (Brook Lodge) ...	2·68	...	·50	26	12	83·0	8	38·0	16	0	...		
"	O'Briensbridge (Ross)	2·75	...	·62	26	15	78·0	6	44·0	18	0	0		
XXI.	Carlow (Browne's Hill)	3·21	— ·52	·96	16	13	...	...	...	...	...	...
"	Dublin (Fitz William Square)	1·52	— 1·66	·35	17	16	78·9	8	42·3	14	0	0		
XXI.	Ballinasloe	2·49	— 1·54	·40	28	17	73·0	5	38·0	14d	0	...		
XXIII.	Waringstown	2·41	— 1·03	·70	30	11	80·0	3, 25	35·0	13e	0	...		
"	Londonderry (Creggan Res.) ..	5·13	...	·90	16	21	...	...	...	...	...	...
"	Omagh (Edenfel)	4·45	+ ·80	1·35	6	16	73·0	5	39·0	20	0	...		

a And 30. b And 21. c And 22. d And 15. e And 20.

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

METEOROLOGICAL NOTES ON AUGUST, 1887.

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

ENGLAND.

STRATHFIELD TURGISS.—During the first half of the month the drought remained unbroken in this neighbourhood, and vegetation of all kinds suffered in consequence, the leaves on many of the trees drooping and withering. Moles died by hundreds, unable to penetrate the iron-bound earth. Towards the close a considerable fall in temperature occurred, with white frosts and local showers. TSS at 8.30 a.m. and at 2.30 p.m. on 17th, a man was killed at Riseley by L. Very heavy R (·91 in.) on 30th.

ADDINGTON.—Another month of very fine, warm, dry weather, the want of R showing itself very decidedly by the dried up pastures and the drooping appearance of many trees and shrubs. We had none of the heavy rains which some districts were favoured with, particularly on the 17th, when there was heavy R two miles E. of us, we had very little. At the close the drought seemed quite broken up. T on 17th; fog on 28th; high wind and distant T on 31st.

CULFORD.—The early part of the month was very hot and dry. R fell on 12th, and the closing days were wet and stormy. TSS on 18th and 29th.

LANGTON HERRING.—Most favourable weather for gathering in the harvest, though root crops suffered much from the drought. Mean temp. at 9 a.m. $0^{\circ} \cdot 3$ above the average. Distant T on 17th, 20th, and 31st, but no storm. The heavy rainfalls of 26th and 30th were preceded by thick fogs on 25th and 29th. The year of Jubilee will here be remembered as the year of the long drought. From February 4th to August 25th inclusive (203 days), only 6·18 in. of R fell; From February 4th to August 18th (196 days), only 5·90 in., or a little less than ·03 in. per diem for six months and a half.

BODMIN.—Mean temp. $61^{\circ} \cdot 6$. The drought affected our streams more than I ever witnessed before

STROUD.—A very fine dry month; vegetation much burnt up till the close. On the 17th a great quantity of R fell all round us at different intervals, just missing this village (Pakenhill) and Randwick to the N. of us. Very heavy R fell at Stroud, one mile from here, at noon, and a severe TS was seen from the hills in the Severn valley from 5 a.m. to 7 p.m. on 17th. T and L on 31st.

WOOLSTASTON.—The drought continued till the middle of the month. The harvest was unusually early, and secured in good condition, though deficient in quantity. Mean temp. $59^{\circ} \cdot 7$.

ORLETON.—Another warm and dry month, with a large amount of sunshine. No R fell during the first 11 days, and it was afterwards light and partial till the 26th. The pastures were all burning up at the middle of the month, but after R fell they rapidly recovered. The max. temp. was generally high and steady, but the min. was low, so that the mean temp. for the month was very little above the average of 26 years. Pressure was high and steady till the end of the month, when it became unsettled. L and T all night on 16th, with R at intervals; distant T on 17th and 28th. Frost on the morning of the 15th; fogs on 22nd and 23rd. The R for the eight months was about seven and a half inches below the average of 50 years, or only two-thirds of the average.

LEICESTER.—The first half of the month was hot and dry; in the second half came T and L, with some heavy and refreshing showers, which very much altered the appearance of the country.

WALES.

HAVERFORDWEST.—The fine, dry, warm weather lasted, with scarcely a break, up to the 24th, and no important change occurred until the 26th, when the weather became suddenly very stormy, with R; the next day was sultry, with R and L at night, and similar weather prevailed, with R and L at night, until the 30th, on which date, at 2 p.m., ·39 in. of R fell in 20 minutes, and at 3 a.m. of the 31st, ·54 in. fell in about 15 minutes. The month ended wet and

very stormy. Thundery weather prevailed from 7th to 12th, with close, sultry air; much cooler weather followed, until again on 15th and 16th temp. increased with much L at night; fine mackerel skies were observed on 18th and 19th. Grain crops were good; turnips small and much injured by the protracted drought. Temp. at or above 70° on ten days. The air was very dry throughout. The summer may now be said to be over. Taken as a whole, I do not remember one during the last 40 years in this locality to equal it for persistent high temperature, bright sunshine, and dryness.

SCOTLAND.

CARGEN.—Northerly winds prevailed from 1st to 20th and the night temperature of that period was unusually low. On the night of 13th min. in shade fell to 35° , and in only two Augusts during the last 28 years has it fallen so low. In many places in the higher parts of the country the potatoes were injured and the garden flowers destroyed. The temp. of the last ten days was above the average. The great bulk of the crops in the lower part of the country were got in before the close. Mean temp. $1^{\circ}8$ below the average; sunshine 33 hours above the average. T and L on 17th, 18th, and 27th; T on 6th.

JEDBURGH.—A remarkably fine August. The cereals rapidly ripened and, except in high lying districts, were mostly secured in fine order. Harvest was fully a month earlier than last year and crops are nearly an average. Potatoes were in splendid condition. With the dry, warm weather vegetation matured greatly, and the leaves on lime and beech trees began to change colour by the 14th. T and L on 17th and 27th.

CUMNOCK.—Potatoes, dahlias, &c., were injured by frost in several places on the morning of the 14th.

ABERDEEN.—Fine and dry; suitable for harvest operations. R about 1.30 in. below the average.

LOCHBROOM.—A beautiful month, with just the proper quantity of R and sunshine to fill and ripen the corn and make hill and dale most luxuriant. Potatoes and other crops are excellent. Very loud peals of T were heard on 29th.

CULLODEN.—A month of fine, sunny weather; frequent heavy R with T from 28th to 31st, though with very little L.

IRELAND.

BLACKROCK.—Generally very fine between slight showers. R 1.26 in. below the average of 22 years; mean temp. ($61^{\circ}3$) 2° below the average of 11 years. Falling fire-balls or shooting stars of considerable size and brilliancy were seen distinctly in N.W. on the night of 10th. Distant L on 26th; lunar rainbow on 30th, at 9 p.m. The R for the eight months was only slightly more than half the average of 22 years.

WATERFORD.—Mean temp. $59^{\circ}5$; total R since January 1st 14.50 in., considerably less than for the same period in any year since 1860. T and L on 17th and 27th.

O'BRIENSBRIDGE.—The long drought ended on 23rd; two inches of R in the last week greatly improved grass and green crops. T and L on 15th and 16th.

DUBLIN.—The change towards less settled weather, noticed in July, continued through August, which proved to be rather cool, very breezy and showery. At first, indeed, conditions were settled and the weather was dry and warm, but after the 11th R fell in larger or smaller quantities on 14 days, and high winds from opposite quarters—chiefly N. or S.—prevailed. The last few days were unsettled, showers and local TSS being reported from all districts. The close of the month witnessed the termination of the protracted drought, for which the spring and summer of 1887 will long be memorable.

EDENFEL.—Notwithstanding the heavy R of 1.35 in. on 6th, the weather till the 24th was generally fine and summerlike. The last week, however, was squally and unsettled, with heavy drenching showers, in one of which, on 30th, .15 in. of R fell in eight minutes, and an unusually early harvest was much imperilled by persistent wet. At 9 p.m. on 31st, the most distinct lunar rainbow I have ever seen spanned the northern heavens.