*Report on Hygrometric Researches mainly at the Ben Nevis Observatories.**

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Introductory.

Since the beginning of meteorological work on the summit of Ben Nevis, occasional spells of wonderfully fine weather have been experienced, in which the exceeding dryness of the air has been very remarkable. It was observed by Mr WRAGGE in 1882, and has been recorded nearly every year since then. The most notable of these dry periods occurred in March 1886,† and at that time the relative humidity, as calculated by APJOHN's formula, was as low as 6. These low humidities are associated with a high pressure area, and a marked departure from the mean temperature difference of the top and bottom stations; indeed, the normal condition of temperature descending with increasing height may be reversed, and the air on the summit of Ben Nevis be warmer than that of Fort-William. An example of this reversal of temperature conditions occurred in December 1892, when the observers on Ben Nevis spent Christmas Day in a warm, sunny, and very dry atmosphere; while those in Fort-William were shivering in raw, dull, cold air, at times over 8°F. lower than that on the summit.

These remarkable drynesses are not found at any low-level station in our islands, and, naturally, GLAISHER's hygrometric tables, used in this country, do not provide for them, although the Greenwich observations on which the tables are based were supplemented by results obtained in India and in Canada. The students of Ben Nevis observations, who wished to deduce from the readings of the dry and wet bulb thermometers what was the temperature of the dew-point, the pressure of the water vapour in the air, and the relative humidity during these dry spells, were in a difficulty. If they employed GLAISHER's factors for calculating the dew-point to extend his tables, they were using data which had never been tested for such extreme conditions; and if they took advantage of the formulæ published by APJOHN, or AUGUST, or REGNAULT, they were making the reductions of these remarkable readings in quite a different way from that employed for ordinary observations.

To solve some of these difficulties, Dr H. N. DICKSON spent part of the autumn of 1885 on the summit of Ben Nevis. He made an extended series of direct determinations of the dew-point, using Professor CHRYSTAL's modified form of Mr DINE's hygrometer, and read the temperatures of the dry and wet bulb thermometers at the same

* Summary of communications to the Scottish Meteorological Society on 13th March 1893 and 20th July 1894, and to the Royal Society of Edinburgh, 6th February 1893 and 20th May 1895, with some supplementary notes.

† 'Meteorology of Ben Nevis,' Dr A. Buchan, *Trans. R.S.E.*, vol xxxiv. pp. xxiii., xxiv.

time. The results showed that GLAISHER's tables extended by using his factors were unsatisfactory, for, to quote Dr BUCHAN, 'As regards the remarkably dry states of the air, which form so prominent a feature in the climatology of Ben Nevis, GLAISHER's factors were found to be altogether inapplicable, and for such hygrometric observations a specially constructed set of tables is therefore required.'* Comparing his dew-point results with the values given in GLAISHER's tables, Dr DICKSON found† that the tabulated dew-points 'are at first lower than those found by the hygrometer, the difference first increasing to a maximum, and then diminishing to zero. After the point of coincidence, the calculated dew-points are *above* those got directly, and the differences go on increasing rapidly.' Leaving out of account the extreme cases, 'it is to be remarked that the results deduced from GLAISHER's tables . . . do not, on the whole, agree so well with direct observations at high levels as with those low down.' One result of these investigations of Dr DICKSON's is to show that if the ordinary employment of these tables does not involve any considerable error, this is not true for extensions of them based on the same factors.

The data for calculating the special hygrometrical tables to be used for Ben Nevis observations during very dry weather have not yet been obtained, and the reductions of dew-points, vapour pressures, and relative humidities are at present made by means of an extension of GLAISHER's tables. This is eminently unsatisfactory, but it must be observed that if one system of making reductions is used for very dry states of the air, the same system ought to be employed in ordinary conditions.

The Directors of Ben Nevis Observatory, and the members of the Ben Nevis Committee of the British Association, have stated in their reports the need for arriving 'at some accurate knowledge of the absolute amounts of aqueous vapour at different heights under different weather conditions,' and suggested 'the desirableness of instituting a system of special observations on the hygrometry of the atmosphere at the two observatories, with a third station half-way up the hill.'‡

The nomination of the writer in 1892 by the University of Edinburgh to a research scholarship, granted by the Commissioners for the Exhibition of 1851, gave him the opportunity for continuing hygrometrical research, and to co-operate with the Directors of the Ben Nevis Observatory.

September 1892 to January 1893 was spent at Ben Nevis mainly at the High Level Observatory. Owing to the limited accommodation the work of an ordinary observer had also to be undertaken, but every fine moment was used for hygrometric work. In the spring of 1893 some time was spent in Professor FRIEDEL's Laboratory in Paris testing the methods used during the previous winter, which were found to be satisfactory. Unfortunately a medical prohibition prevented further high level work, and in August and September 1893 the writer carried out the experiments at Fort-William, while at Ben Nevis Messrs A. RANKIN, F. J. HAMBLBY, and T. R. MARR were good enough to

* *Op. cit.*, p. xlviii.

† *Proceedings R.S.E.*, vol. xiii. p. 958.

‡ Report of Council to Meeting of S.M.S., 7th March 1892.

execute the simultaneous ones at Ben Nevis. Being ordered to pass the winter in the south, a series of determinations were made at the Montpellier meteorological station through the kindness of Messrs CROVA, FOËX, HONDAILLE, and LEGATUR, who placed all the resources of the meteorological, physical, and chemical departments at the writer's disposal. Work at Fort-William was continued in the summer of 1894. Mr MARR again went to Ben Nevis for hygrometrical work at Christmas 1893, and in the summer and early autumn of 1894. Special simultaneous observations of dry and wet bulb thermometers in the ordinary Stevenson screen and in Assmann's aspiration-psychrometer were made by Mr DRYSDALE at Fort-William in August 1896, and at the mid-station half-way up Ben Nevis in July and August 1897.

Numerous notes have been received from Mr OMOND and Mr RANKIN at different times. To all those, to the Ben Nevis Directors, and to Messrs JAMES WOOD and G. GUYOU, who have at various times helped with calculations, the writer would return his grateful acknowledgments. The kindness of the late Professor TAIT, of Dr BUCHAN, and of Mr OMOND, requires special mention and thanks.

Dry and Wet Bulb Thermometers and Vapour Pressures.

The common method of ascertaining the humidity of the air is to observe the dry and wet bulb thermometers placed in some screen, and from the readings obtained, to calculate the pressure of water vapour present in the air, and the relative humidity, which is the relationship between the actual vapour pressure and the maximum possible at the temperature of the observation. The tables usually employed in this country are those compiled by GLAISHER from a series of comparisons between readings of dry and wet bulb thermometers and simultaneous observations of DANIELL's condensation-hygrometer. The classic researches of REGNAULT, on the pressure of saturated water vapour at various temperatures, are utilised, the temperature at which dew appears on the cooled, polished surface of the condensation-hygrometer being assumed to be that at which the air would become saturated, were the mass of vapour to remain unchanged but the temperature of the air to fall to that temperature. Hence a relationship is found between readings of the dry and wet bulb thermometers and vapour pressure, and the relative humidity can be calculated.

GLAISHER tabulates his 'factors,' which must be employed to multiply the difference between dry and wet bulb readings so that the product may give the departure of the dew-point from the actual shade temperature, and then uses REGNAULT's results. REGNAULT, however, following AUGUST and others, expresses the dry and wet bulb readings directly in terms of vapour pressure. The equation he employs is:—

$$f = f' - \frac{0.480 (t - t')}{610 - t'} p \text{ when } t' \text{ is over } 0^{\circ} \text{ C. and } f = f' - \frac{0.480 (t - t')}{689 - t'} p \text{ when } t' \text{ is under } 0^{\circ} \text{ C.}$$

where f is actual vapour pressure, f' is the pressure of saturated vapour at the

temperature of the wet bulb t' , the air temperature is t , and p is the barometric pressure.*

The following table shows that vapour pressures calculated from REGNAULT's formula do not closely agree with those founded on GLAISHER's factors in low temperatures and low humidities.

TABLE.—Comparing Vapour Pressures, in inches of Mercury, and Relative Humidities calculated by Glaisher's and by Guyot's Tables.

The Temperatures are in F°.

WET BULB.	15°	20°		30°				40°				
DRY - WET.	1°	1°	2°	1°	3°	5°	7°	1°	3°	5°	7°	10°
<i>Vapour Pressure—</i>												
Glaisher, . . .	·060	·078	·059	·148	·129	·118	·107	·235	·215	·197	·181	·162
Guyot, . . .	·074	·096	·085	·155	·132	·109	·086	·235	·208	·182	·156	·117
Glaisher-Guyot, .	—·014	—·018	—·016	—·007	—·003	+·009	+·021	...	+·007	+·015	+·025	+·045
<i>Relative Humidities—</i>												
Glaisher, . . .	67	70	50	85	69	58	49	92	78	66	56	45
Guyot, . . .	83	85½	72	89	70	54	39	91	75	61	48	32
Glaisher-Guyot, .	—16	—15½	—22	—4	—1	+4	+10	+1	+3	+5	+8	+13

Above 40° F. (say 4°·5 C.) these differences are not so marked, especially when the air is not very dry.

A graphic representation shows this difference at low temperatures even more vividly. In fig. 1 the mass of water vapour per cubic foot is used instead of vapour pressure, and the dot and dash line for 0·87 grain per cubic foot has been plotted from data found in GUYOT's tables (Tables VII. and X.). No correction has been made for pressure.

The results of the preliminary Observations at Ben Nevis have already been discussed.† From them a diagram was drawn in which the abscissæ represent temperatures of the dry-bulb thermometer, the ordinates the difference between the temperatures of dry and wet bulb thermometers, and the mass of water is noted for each experiment. It was found that they could be used for the construction of three straight lines drawn through points representing 0·5, 1·0, and 2·0 milligrammes of water vapour per litre of air. (See fig. 1.)

* Except in the comparison of GLAISHER and GUYOT's tables, the barometric and vapour pressures are expressed in millimetres of Mercury, and the temperatures are given in C°.

† See *Proc. R.S.E.*, xx. pp. 176–184; *Journ. Scot. Met. Soc.*, x. pp. 41–49.

FIG. 1.

Assuming these lines to be parallel and equidistant, which they approximately are, their equation is (when t is the temperature of the dry-bulb thermometer in centigrade degrees, $t-t'$ the difference between it and that of the wet-bulb one, and w is the weight of water vapour per litre of air expressed in milligrammes)

$$t - t' = \frac{1}{3} (t + 20) - 1.8w.$$

Comparing GLAISHER's and GUYOT's lines for 1.31 grain per cubic foot together, it is seen that from 20°·3 F. to over 31° F. GLAISHER gives a smaller difference between dry and wet readings for the same quantity of water vapour, and that at a temperature below 36° F., and for all above it, the conditions are reversed, and GUYOT needs a smaller difference; and lastly, that at about 42° F. GLAISHER's curve for 1.31 cuts GUYOT's for 0.87. Otherwise expressed, this may be summarised by saying that at temperatures below the freezing-point GLAISHER gives much lower dew-points (*i.e.* his factors are too high), and above 35° F. (1°·7 C.) his dew-points are higher (*i.e.* his factors are too low), compared with those derived from REGNAULT's formulæ, as well as with those obtained by Dr H. N. DICKSON;* and further, that the present experiments show analogous results. The differences at the higher temperatures are by no means so marked, and at the ordinary temperatures and humidities of low-level stations in our islands the two tables give more concordant results.

Such divergencies might be explained were some influence neglected by one or both of these distinguished men, which modified the results. REGNAULT suspected that the speed of the wind would affect the temperature to which the wet bulb is lowered by evaporation, and made observations to test this, but did not consider it necessary to make any correction in ordinary circumstances. SWORYKIN† gives the influence of wind on the factor necessary to convert wet bulb departures into dew-point departures as follows:—

Speed of wind in metres per second, .	0	0.85	1	2	4	6	10	∞
Percentage variation of factor, .	71.5	24.9	22.4	13.3	7.3	5.0	3.1	0.0

So that in calm, or almost calm weather, the condition of the air round the wet bulb is markedly different from that of the surrounding air, which forms the atmosphere around the bulb when there is current enough to constantly remove the water evaporated from the muslin-covered surface of the bulb.‡

The divergencies in the tables arise from the observations on which they were based not being comparable, those made in a calm being treated exactly as those made in windy weather. This, too, explains why, at low temperatures and humidities,

* *Proceedings R.S.E.*, vol. xiii, p. 958.

† Treated in Professor ASSMANN's paper, *Abhandlung Königl. Preuss. Meteorolog. Inst.*, i. 234, 1892.

‡ Reference may be made to the work of Professor HAZEN and others in America, and to that of Professor ASSMANN and others in Germany.

GLAISHER's tables should be so markedly different from those based on REGNAULT's formulæ, for the factors rapidly increase in value below the freezing-point, and the effect of wind under such conditions becomes much more noticeable.

The wet bulb thermometer in an ordinary screen is an unsatisfactory instrument in calm or almost calm weather, and to obtain reliable results, some means of causing air currents to pass it must be devised.

There are two ways of doing this, (a) by moving the thermometer through the air, as DE SAUSSURE and ESPY did, or (b) by moving the air past the thermometer, following the example set by BELLI in 1830.

American meteorologists have discarded the stationary for the sling-psychrometer, and the tables published in the new edition of the *Smithsonian Tables* are intended for the reduction of observations made by swung instruments.*

The psychrometric tables in the Smithsonian collection are calculated from a formula of the late Professor FERREL:—†

$$f = f' - 0.000660 (t - t') p \{1 + 0.00115 (t - t')\},$$

the symbols having the same meaning as in REGNAULT's formulæ on page 531.

The sling-psychrometer should be continuously whirled 'for one minute at the rate of 8 metres per second, or for two minutes at the rate of 3 metres per second, in order to attain the true temperature of evaporation.'‡ Under such circumstances, differences due to the shape and size of the thermometer bulb also vanish.§ But in these investigations the temperature observations are usually made every minute, and sometimes oftener, and only rarely every two minutes. And this could not be done were a sling-psychrometer used, except by employing another observer. Therefore the aspiration-psychrometer was chosen, as the clockwork was sufficiently powerful to keep the ventilating fan in action for nine minutes, and a few turns of a key wound it up again when nearly run down.

A description of the *aspiration-psychrometer* of Professor ASSMANN of Berlin used in the following experiments may be given.

Each thermometer near the bulb is surrounded by double tubes nickelled inside and outside, the outer tubes being bent round to join each other, and then form a single tube which passes parallel to and between the two thermometer stems to a chamber with a ventilating fan which is worked by superposed clockwork. The fan draws the air past the bulbs at a rate of $2\frac{1}{3}$ metres per second, and the clockwork requires to be wound every nine or ten minutes to keep the air-current constant. The nickelled tubes

* Swinging need not be in a vertical plane, but may be in a horizontal one. A simple arrangement may be used whereby the thermometers may be mechanically turned in a horizontal plane round a vertical axis.

† W. FERREL. *Annual Report of Chief Signal Officer for 1886*, Appendix 24.

‡ CLEVELAND ABBÉ—*Meteorological Apparatus and Methods*, p. 375. *Annual Report of the Chief Signal Officer for 1887*, Appendix 46. Washington, 1888.

§ ASSMANN. Paper cited above, i. 114–270.

prevent any radiation affecting the bulbs, and the apparatus may be held by the hand just over the bulbs without affecting the temperature reading, but care must be taken that the current of air drawn past the bulbs is not heated in any abnormal way.

Professor SPRUNG of Berlin, by means of direct dew-point and gravimetric determinations, has arrived at the following formula for reducing observations made by the Assmann aspiration-psychrometer :—

$$f = f' - 0.5 (t - t') \frac{p}{755} :$$

which is practically identical with that given by Professor FERREL.

The tables calculated from these formulæ may be used for expressing dry and wet bulb readings as vapour pressures, provided the air was moving at least at $2\frac{1}{3}$ metres per second. In the reduction of observations made with stationary instruments hung in a Stevenson's screen, the same tables could be used for readings made in windy weather; but, in more or less calm conditions, a considerable correction would need to be applied to the departure of the wet bulb before any approximately accurate determination of vapour pressure could be calculated. The rapid variation of this correction in almost calm air makes it doubtful if the ordinary estimates of wind speed are sufficiently minute to give complete confidence in the results of its application under such conditions.

Comparison of Dry and Wet Bulb Records in Stevenson Screen and Aspiration-Psychrometer under Different Weather Conditions.

The observations made at Ben Nevis and Fort-William during the course of the winter investigations have been tabulated under different wind forces, the differences in C° between the readings of the dry and wet bulb thermometers exposed in the ordinary Stevenson screen and those of the aspiration-psychrometer, at different forces of the wind, are summarised in the following table :—

Force of the Wind (1-12.)	0	0-1	1	1-2	2 & over.
<i>Ben Nevis Observatory—</i>	C°	C°	C°	C°	C°
Dry (Stevenson—Aspiration) Readings .	+ 0.31	+ 0.27	— 0.04	— 0.09	— 0.21
Wet do. do. .	+ 0.62	+ 0.39	+ 0.14	+ 0.17	— 0.16
Departure of Wet from Dry do. .	— 0.31	— 0.12	— 0.18	— 0.26	— 0.05
<i>Fort-William Observatory—</i>					
Dry (Stevenson—Aspiration) Readings .	+ 0.51	+ 0.49	+ 0.34	+ 0.32	+ 0.17
Wet do. do. .	+ 0.61	+ 0.61	+ 0.44	+ 0.44	+ 0.28
Dry-Wet do. do. .	— 0.10	— 0.12	— 0.10	— 0.12	— 0.11

This table shows that both dry and wet bulb thermometers give lower readings in the aspiration-psychrometer when the air is still or comparatively so, and that this affects the wet bulb more than the dry bulb. On Ben Nevis, however, both the Stevenson screen instruments gave lower readings than those of the aspiration-psychrometer with winds over force 2, and the dry bulb with winds of force 1 and over. This suggests that thermometers should, when tested, be compared with standard instruments in air currents of different speeds as well as in a calm room.

Wind, however, is not the only modifying factor to be considered. In foggy weather at the summit of Ben Nevis the two thermometers give similar records even in calm weather, but when the air is dry and the Sunshine considerable, differences of temperatures are registered.

The following table has been prepared from the more continuous hourly observations at both summit and base stations. The differences between the readings of the dry bulb thermometers in the Stevenson screen and of the aspiration-psychrometer are shown at different hours, and the fog, force of wind (scale 0—12), and Sunshine (scale 0—4), are noted.

The influence of wind in promoting uniformity of records is clearly shown in this table. Compare the Ben Nevis records on the 12th, 17th, and 18th, after 10 hours on the 10th September 1894. On these days the Sun was unclouded. On the 12th, when the air was still, the Stevenson screen thermometer indicated a temperature averaging $0^{\circ}34$ C. above that of the aspiration-thermometer. On the other days, when the wind varied from force 1—2 to force 4, the temperature indicated by the Stevenson screen instrument averaged $0^{\circ}10$ C. below that of the aspiration-psychrometer.

The same results are obtained at Fort-William. Compare, for instance, the calm sunny 11th September 1893 with the equally sunny 18th May 1894, when the wind force varied from 2—3 to 3—4. The average difference of temperature readings in Stevenson screen and aspiration-psychrometer was $+ 0^{\circ}70$ C. on the calm day, but only $+ 0^{\circ}20$ C. on the windy one.

The influence of the Sun on the differences of the readings is equally notable unless the wind is strong. When observations made in fog or in winds over force 2 are eliminated, an almost smooth curve of differences is obtained with a maximum excess in the Stevenson screen readings at 13 hours. At both stations higher temperatures are most marked in the Stevenson screen between 11 and 17 hours, and can be explained by the heating of this screen. In the early morning and towards and after sunset the differences between the two differently situated thermometers are not so great at Fort-William, but that in the Stevenson still is the higher, whereas at Ben Nevis the Stevenson screen thermometer reads lower than that in the aspiration-psychrometer. This may be a function of radiation.

During foggy or misty weather the two thermometers give very similar readings at all hours, even when the air is calm.

Eliminating the effects due to the heating or cooling of the Stevenson screen, the

COMPARISON OF DIFFERENCES OF DRY BULB OBSERVATIONS.

STEVENSON'S *minus* ASPIRATION.

(Figures in italics obtained when Fog or Mist was on Summit. For additional Weather Notes see Tables at end of Paper.)

Sun Full = 4. Temperatures C°.

BEN NEVIS.

Hours.	8	9	10	11	12	13	14	15	16	17	18	19	20	Notes.
1893. August	...	-0.44	-0.47	-0.27	+0.89 ^d	...	+1.14 ^a	...	-0.09 ^e	...	-0.31 ^c	...	...	Wind, 2, 1-2, 2, 0, 0, 1, 1. Sun, 4, 4, 4, 4, 3, 0, 1.
September	...	...	...	...	...	+0.33 ^a	+0.33	+0.40	+0.38	+0.42	+0.14 ^b	-1.83 ^g	-1.16	Wind, 0-1, 0-1, 0, 0, 0, 1, 0, 0. Sun, 0, 1, 3, 2, 0, 0, 0, 0, 0.
3	+0.08 ^f	+0.02 ^a	+0.66 ^c	+0.90	+0.08	+0.55 ^{b,d}	+0.17	+0.44 ^k	+0.65 ^d	-0.40	-0.37	-0.42	...	Wind, 1, 1-2, 0-1, 0-1, 1-2, 1. Sun, 1, 0, 0, 1, 0.
4	-0.18	-0.43	-0.26	+0.07	+0.27	+0.65	+0.24	+0.28	+0.13	-0.75 ^k	+0.05	-0.15	...	Wind, 1, 0-1, 1, 1, 0-1, 0+, 0+, 1, 0-1, 1, 1-2, 1-2. Sun, 1, 2, 2, 3, 4, 4, 4, 4, 2, 4, 4, 4-0.
11	-0.32	-0.43	-0.26	+0.38 ⁷	+0.83 ^b	+0.40	+0.47 ^b	-0.25	+0.05 ^b	+0.24 ^b	-0.36	-0.23	...	Wind, 1-2, 1, 1, 0+, 0+, 0-1, 1, 1, 1-2, 0-1, 1, 1. Sun, 4, 4, 4, 4, 3, 1-, 1+, 0, 0+, 0, 0, 3, 0.
1894. September	0.00	-0.02	-0.08	-0.08	-0.40	-0.28	...	...	-0.16	-0.10	...	...	...	Wind, 2-3, 2-3, 1-2, 1-2, 3, 3, 3, 4. Sun, 0, 2, 4, 4, 4, 4, 4, 4, 4.
12	...	...	+0.36	...	+0.39	+0.14	...	...	...	...	+0.46	...	...	Wind, 0, 0, 0, 0. Sun, 4, 4, 4, 4, 4.
13	...	...	...	+0.19	+0.28	+0.08	...	+0.45	...	+0.36	...	...	...	Wind, 0-1, 0-1, 0-1, 0, 0-1. Sun, 0, 0, 0, 0, 0.
17	...	...	...	...	...	-0.23	...	+0.01	-0.04	+0.20	...	...	...	Wind, 2-3, 2-3, 2-3, no record. Sun, 4, 4, 4, no record.
18	-0.05	-0.08	...	+0.02	-0.16	...	...	...	-0.11	...	...	...	...	Wind, 1-2, 1-2, 1-2, 1-2, 1-3. Sun, 4, 4, 4, 4, 4.
20	...	...	...	...	+0.09	+0.02	+0.23	...	+0.16	...	...	...	...	Wind, 0, 0, 0, 0. Sun, 0, 0, 0, 0, 0.
Mean Difference.	-0.10	-0.23	+0.01	+0.18	+0.25	+0.18	+0.43	+0.22	+0.12	-0.02	-0.06	-0.66	-1.16	
Wind.	1.5	1.7	0.9	1.0	0.8	0.9	0.4	1.1	1.2	1.2	1.1	0.7	0	
Sun.	2	3	3½	3	2½	2	1½	2	2½	2½	2	0	0	
omitting fog.	-0.15	-0.34	-0.16	+0.19	+0.20	+0.32	+0.29	+0.22	+0.13	+0.3	-0.05	-0.66	-1.16	
Sept. 10-17,														
1894 and k.														
Wind.	1.3	1.2	0.9	1.0	0.6	0.3	0.3	0.6	0.8	0.3	0.9	0.7	0	
Sun.	3	3½	3½	3	3	2½	2½	1½	3½	1½	3	0	0	

a, f[∞]. *b*, f[∞]. *c*, fog passing at times. *d*, fog part of observation. *e*, mist. *f*, mist passing. *g*, clear, sun down behind Observatory. *h*, f[∞] or f[∞] passing for a short period. *i*, Temperature rapidly rising as shown by Aspiration-Psychrometer, but only slowly in Stevenson Screen. *j*, warm puffs from S., with f[∞].

differences between the readings of the two dry bulb thermometers cannot be explained by different wind speeds, although such a factor must be taken into account in the case of moistened bulbs. These differences really indicate different sensitivenesses of two instruments exposed to similar variations in the atmosphere under slightly different conditions. In persistent fog and steady strong winds the ærial conditions remain uniform and the temperature differences of the two instruments are small. This is shown in the minute to minute records of table.

On the other hand, in clear calm weather the physical conditions of the atmosphere vary greatly and rapidly, especially at such a station as Ben Nevis, where air may come from below as well as from all sides and from above.* No doubt under such circumstances the two thermometers are not in identical atmospheres, but the minute to minute observations indicate that on the whole their progressive readings have a similar trend, but that the aspiration-psychrometer is more sensitive to change than that shut in the Stevenson screen.

This extra sensitiveness of the aspiration-thermometer is shown in the hourly observations tabulated above, and some of its successive records may be examined before proceeding to discuss minute to minute variations.

A very remarkable instance of the value of the aspiration-psychrometer is seen at 19 hours on 2nd September 1893 at the summit station. A slight fog enveloped or lay just above the summit at 16, 17, and 18 hours, but cleared before the 19 hours' observation. The aspiration-psychrometer dry bulb rose from $6^{\circ}\cdot18$ C. to $8^{\circ}\cdot52$ C., and the wet bulb fell from $6^{\circ}\cdot08$ C. to $3^{\circ}\cdot56$ C. The instruments in the Stevenson screen, however, were not affected to this extent. The Stevenson wet bulb reacted to the drier air, falling from $6^{\circ}\cdot28$ C. to $3^{\circ}\cdot89$ C., but the dry bulb scarcely moved, rising from $6^{\circ}\cdot28$ C. only to $6^{\circ}\cdot67$ C.

At 20 hours the readings were :—

Aspiration-psychrometer, dry, $7^{\circ}\cdot28$ C.; wet, $5^{\circ}\cdot41$ C.; Stevenson screen, dry, $6^{\circ}\cdot11$ C.; wet, $5^{\circ}\cdot11$ C.

This lowness of the Stevenson screen dry bulb is probably to be explained by the dampness of the Stevenson screen.

On 3rd September 1893, after a series of variations which can be correlated with changes in the fog, the difference between the Stevenson and aspiration-thermometers suddenly altered from $+0\cdot65$ at 16 hours to $-0\cdot49$ at 17 hours, owing to the fog sinking after the 16 hours' observation. The warmer air caused the Stevenson screen temperature to rise from $9^{\circ}\cdot00$ C. to $12^{\circ}\cdot44$ C., *i.e.* $3^{\circ}\cdot44$ C., but it increased that of the aspiration-psychrometer from $8^{\circ}\cdot35$ C. to $12^{\circ}\cdot93$ C., *i.e.* $4^{\circ}\cdot58$ C.

The minute to minute readings made during the present investigations afford an even more valuable means of comparing the relative sensitivenesses of the dry and wet bulb thermometers in the aspiration-psychrometer and the Stevenson screen during rapidly changing conditions of temperature and humidity. Taking Ben Nevis, No. 161, as an

* Cf. J. Y. Buchanan, *Proc. R.S.E.*, lvi. 108; R. C. Mossman, *Proc. R.S.E.* lvi. 108.

example of one of the most notable records of rapid variation, the following table is obtained :—

Change per Minute.

Time	16 ^h 5 ^m	6	7	8	9	10	11	Average neglecting signs.
Dry Bulb—								
in Aspiration-Psychrometer	13·60	+0·25	−0·20	−0·60	±0·00	+0·45	+0·20	0·28
in Stevenson Screen	13·83	±0·00	−0·22	−0·17	+0·06	±0·00	+0·11	0·09
Wet Bulb—								
in Aspiration-Psychrometer	8·80	+0·20	±0·00	+0·45	+0·65	−2·30	−0·90	0·75
in Stevenson Screen	8·44	+0·17	+0·22	+0·23	+0·88	−1·55	−0·61	0·61
Departure of Wet Bulb from Dry—								
Aspiration-Psychrometer	4·80	+0·05	−0·20	−1·05	−0·65	+2·75	+1·10	0·97
Stevenson Screen	5·39	−0·17	−0·44	−0·40	−0·82	+1·55	+0·72	0·68

From this it is obvious that the instruments in the aspiration-psychrometer change more rapidly and to greater extremes. The change per minute in the dry bulb in the air current varies from -0.6 to $+0.45$, or, neglecting signs, averages 0.28 per minute, compared with a variation from -0.22 to $+0.11$ and an average of 0.09 per minute in the case of the dry bulb in the Stevenson screen. The wet bulb shows a similar variation in sensitiveness under these different conditions—in the aspiration-psychrometer its variation per minute ranges from -2.30 to $+0.65$, and averages 0.97 ; in the Stevenson screen only from -1.55 to $+0.88$, and averages 0.61 . The relative humidity, as evidenced by the departure of the wet bulb readings from those of the dry, shows even more marked changes—the aspiration variations being from $+2.75$ to -1.05 , and the average 0.97 per minute; the Stevenson variations being from $+1.55$ to -0.44 , and the average only 0.68 . The higher temperature of the Stevenson screen dry bulb is, as we have seen, a function of the time of day, and the lower humidity registered at the beginning of the observation in the Stevenson screen is probably part of a drier phase still actively affecting the Stevenson screen instruments.

Another instance of quicker response to changed atmospheric conditions on the part of the aspiration instrument may be cited. At 20 hours 4 minutes on 2nd September 1893 the aspiration dry bulb thermometer was at $8^{\circ}0$ C., and fell practically steadily to $6^{\circ}8$ C. during the next 12 minutes. The Stevenson screen dry bulb, on the other hand, began at $5^{\circ}94$ C., or ended at $6^{\circ}17$ C. That the former represented the true state of the atmosphere is confirmed by the changes of temperature in the large cylindrical aspirator used for drawing air through the drying tubes. The thermometer in this aspirator sank steadily from $11^{\circ}67$ C. to $8^{\circ}00$ C. in the same period.

The following table (page 542) shows the range of temperature on Ben Nevis in the minute to minute observations of three different days. The observations lasted, on an average, from 4 to 6 minutes on the first two days, and from 10 to 11 minutes during

MINUTE TO MINUTE OBSERVATIONS.

BEN NEVIS OBSERVATORY.

The Figures are those of the Aspiration-Psychrometer Readings ; but the Range of those made in the Stevenson Screen are given for Comparison.

No.	Date and Hour.	Dry.				Wet.				Notes. (See Tables for other weather.)
		Max. Asp. Psy.	Min. Asp. Psy.	Range. Asp. Psy.	Range. Stev. Scr.	Max. Asp. Psy.	Min. Asp. Psy.	Range. Asp. Psy.	Range. Stev. Scr.	
	1893. H. M.	C°	C°	C°	C°	C°	C°	C°	C°	
153	Sept. 4—8 6-13	11·10	10·60	0·50	0·06	5·20	4·45	0·75	0·44	Stones dry throughout. Sun, 2. Wind, 1.
154	9 1-4	11·80	11·60	0·20	0·06	4·10	3·65	0·45	0·06	Sun, 2, only 3 minutes. Wind, 0-1.
155	10 3-9	12·85	12·58	0·27	0·11	4·00	3·25	0·75	0·17	Sun, 2. Wind, 1.
156	11 1-6	13·00	12·70	0·30	0·17	5·10	4·20	0·90	0·50	Sun, 2-4. Wind, 1.
157	12 4-11	13·50	12·25	1·25	0·50	7·65	5·58	2·07	1·28	Sun, 4 (full). Wind, 0-1
158	13 4-10	13·00	12·20	0·80	0·22	9·20	7·00	2·20	1·39	Sun, no record. Wind, 0 or 0-1.
159	14 2-8	14·20	13·30	0·90	0·22	9·65	7·70	1·95	1·00	Sun, no record. Wind, 0 or 0-1.
160	15 1-10	14·10	13·20	0·90	0·50	9·90	6·30	3·60	1·61	Sun, no record. Wind, 1. No observation at 15H. 4M.
161	16 5-11	13·85	13·05	0·80	0·39	10·10	6·90	3·20	2·17	Sun, 4. Wind, 0-1.
162	17 3-7	14·00	13·40	0·60	0·33	6·80	6·40	0·40	0·22	Sun, 4, but low. Wind, 1.
163	18 2-8	11·85	11·40	0·45	0·06	7·20	6·20	1·00	0·17	Wind, 1-2.
164	19 3-8	11·20	11·05	0·15	0·11	7·05	6·85	0·20	0·11	Wind, 1-2.
	Mean Range	...	...	0·59	0·23	...	...	1·46	0·76	
172	Sept. 11—8 0-5	1·30	1·25	0·05	0·28	0·30	0·20	0·10	0·11	Stones $\frac{1}{2}$, dry $\frac{1}{2}$, hoar frost. Sun, 4. Wind, 1-2.
173	9 4-9	1·90	1·80	0·10	0·06	0·80	0·60	0·20	0·11	Stones dry. Sun, 4. Stevenson only 4 minutes. Wind, 1.
174	10 5-10	3·00	2·60	0·40	0·50	1·70	1·45	0·25	0·44	Stevenson only 4 minutes. Wind, 1.
175	11 0-6	3·85	2·60	1·25	0·56	2·45	1·50	0·95	0·39	f ^{oo} rising to s ^d and passing. Wind, 0.
176	12 4-10	3·40	2·70	0·70	0·11	3·10	2·45	0·65	0·11	f ^{oo} all round, and passing. Wind, 0 or 0-1.
177	13 2-8	4·70	3·50	1·20	0·67	3·40	2·50	0·90	0·72	Cum. 7, overhead. Sun, 1-2. Wind, 0-1.
178	13·59-14·6	4·70	3·20	1·50	0·61	4·20	2·60	0·60	0·56	f ^{oo} overhead and passing. Sun, 0. Wind, 1.
179	15 2-7	5·60	4·00	1·60	0·50	4·40	3·40	1·00	0·61	Sun, 0-2. Rise of 1°·3 in dry, and 0°·8 in wet, in last minute. Wind, 1.
180	16 4-12	3·90	3·25	0·65	0·28	3·50	2·65	0·85	0·28	f ^{oo} passing. Sun, 0. Stones dry. No observation at 16H. 7M. Wind, 1-2.
181	17 2-10	3·45	2·60	0·85	0·39	3·25	2·25	1·00	0·44	f ^{oo} passing. Wind 0 or 0-1.
182	18 1-5	3·80	3·45	0·35	0·17	2·60	2·20	0·40	0·11	No record of fog. Stones dry. Wind, 1.
183	19 4-9	3·25	3·20	0·05	0·11	1·85	1·80	0·05	0·06	Sun down. Wind, 1.
	Mean Range	...	...	0·72	0·35	...	...	0·66	0·33	
	1894.									
185	Sept. 10*—8 0-11	6·90	6·60	0·30	0·17	0·00	-0·40	0·40	0·11	Sun, 0. Wind, 2-3.
186	9 0-11	7·70	7·20	0·50	0·39	-0·90	-1·40	0·50	0·33	Sun, 2. Wind, 2-3.
187	10 30-39	9·35	8·95	0·40	0·22	-0·60	-0·80	0·20	0·06	Sun, 4. Wind, 1-2.
188	11 30-40	9·25	9·00	0·25	0·33	-0·40	-0·75	0·35	0·22	Sun, 4. Wind, 1-2. No observation at 11·36.
189	12 30-41	10·20	9·40	0·80	0·39	+0·40	-0·30	0·70	0·11	Sun, 24. Wind, 3.
190	13 30-40	10·20	9·30	0·90	0·33	+0·40	-0·20	0·60	0·22	Sun, 4. Wind, 3.
191	15 30-40	10·70	9·70	1·00	1·00	+0·40	-0·10	0·50	0·50	Sun, 4. Wind, 3.
192	16 30-39	6·90	9·00	0·60	0·56	-0·20	-0·60	0·40	0·11	Sun, 4. Wind, 4.
	Mean Range	...	...	0·40	0·32	...	...	0·30	0·14	

* Note:—Average duration of each set of Observations much longer at this date.

the third day. On the calm, sunny 4th September 1893 the range of dry bulb temperature was considerably greater in the case of the dry bulb and nearly five times as great in the case of the wet bulb than on the sunny but windy 10th September of the following year. The dry bulb range was greatest on the 11th September 1893, when fog was constantly passing, and the temperature conditions very variable, from foggy to the clear spells. The humidity on the 11th September, however, was great, and the range of wet bulb variations was less than half that of the 4th September.

The range of the thermometers in the Stevenson screen was roughly one-half that of the aspiration-thermometers, except in the case of the windy 10th September 1894, when it was as much as four-fifths.

From all these examples it is clear that in dry and almost calm weather, when the aerial conditions vary most, considerable differences of temperature are registered by a Stevenson screen and by a thermometer past which air is aspirated, and that the aspiration instrument responds more rapidly to changes in the temperature of the atmosphere.

In the case of the wet bulb thermometer, the same general law of the greater sensitiveness of the aspiration arrangement holds, but it has to be modified by a consideration of the influence of the passing air on evaporation. In the case of the aspiration instrument this is constant; in the case of the Stevenson screen it is variable. In the latter, in windy weather, the air is constantly renewed, and the conditions as far as regards this one factor resemble more closely those of the aspiration-psychrometer, and the results are comparable. They are all the more so, as we have seen, that the air is well mixed, and more uniform in its properties under such conditions, but an allowance must be made for the greater sensitiveness of the aspiration instrument. The value of the aspiration instrument in times of calm, clear weather, when atmospheric conditions may vary considerably both in space and time, is obvious. It indicates the humidity of the air in such a way that the results can be compared with those taken under windier conditions. Stevenson screen thermometers indicate in addition the influence of the wind, or want of wind, on the rate of evaporation from a moistened surface.

For physical determinations the aspiration instruments give much the more satisfactory results. It may be urged that the unventilated thermometers give nearer indications of the physiological effects of humidity in calm conditions, such as those by factories; but it would be better, both from the point of view of human health and of the behaviour of organic fibres under different temperatures and humidities, that the use of aspiration or sling-psychrometers should entirely replace that of stationary instruments. Any evaluations of the physiological effect can be deduced from these as adequately as from those of the fixed and unventilated thermometers.

Dry and Wet Bulb Thermometers, and Mass of Water Vapour.

Instead of determining the relationship between dry and wet bulb readings and those of a condensation-hygrometer in moving air, and thence deriving the vapour pressure, comparisons may be made directly between the dry and wet bulb temperatures and the mass of water vapour arrested by some desiccator through which the air is drawn; and this was carried out in the present research.

The ordinary meteorological elements were observed in the ordinary way during each experiment, and an Assmann aspiration-psychrometer was used to obtain dry and wet bulb readings, in addition to the stationary thermometer in a Stevenson screen. As a rule, temperature readings were taken every minute during each experiment.

A 6-inch U-tube, with a small bulb blown at the bend and an L piece of narrower tubing fused to one arm, was filled with granulated pumice, which had been washed with sulphuric acid and then heated until fumes ceased to be given off. A second piece of narrow tubing, shaped C, was next fused to the free arm (see fig. 2, *a*). Afterwards pure sulphuric acid was sucked in, and allowed to drain off; and the narrow

Fig. 2.

Fig. 3.

part of the tube was cleaned. After trying various expedients, the tubes were stopped by a glass cover held in its place by a narrow band of india-rubber, which prevented any leakage (see fig. 2, *b*). The tubes were joined by keeping the free ends close together by means of a piece of tightly fitting india-rubber tubing (see fig. 2, *c*).

Three capped tubes were weighed, one against weights, and each of the other two against this standard tube and weights combined. The standard tube went through the same experiences as the other tubes, except that the caps were never removed. The other two tubes were then joined in series, and a third tube attached which prevented any vapour from the aspirator reaching the weighed tubes. Whenever the second of the two tubes began to gain more than a few tenths of a milligramme in weight, the first tube was rejected and a new one inserted. It was found advisable to draw air through a new tube, or one which had not been in use for some time, before using it in any determination.

In the earliest experiments, Muencke's reversible aspirator or a 14-litre bottle were used as aspirators.*

* Cf. *Proceedings R.S.E.*, xx., p. 177 ff., where tables and account of preliminary experiments will also be found.

In most experiments the aspirators were iron cylinders with conical tops, through the bung of which a glass connection-tube and a thermometer were inserted. The volume of water run out was measured at first by noting the amount in the aspirator, which had been determined previously when filled to a mark on the glass tube, and either completely emptying the aspirator or measuring the water left; or, in later experiments, by running the water from the aspirator into another similarly-shaped vessel until it reached the level of a mark made on a glass tube projecting from it. In later experiments, the iron cylinder was wrapped in flannel to keep the temperature more equable.

The volume of water run from the aspirator does not precisely represent the volume of air drawn through the tubes. The air entering the tubes contains some water vapour, which is arrested in the tubes, and that entering the aspirator is dry air. The atmosphere inside the aspirator, however, is saturated with vapour from the water which was in the aspirator. The ordinary atmospheric pressure, p , is ultimately that inside the aspirator. In the free atmosphere the pressure of the dry air is $p - e$, where e is the vapour pressure calculated from the tables, from the dry and wet bulb temperatures t , t' ; whereas that of the dry air inside the aspirator is $p - E$, where E is the pressure of saturated vapour at the aspirator temperature T . Hence, to obtain the volume v of dry air drawn through the tube in the current atmospheric conditions, the volume of water V run from aspirator must be corrected as follows:—

$$v = V \cdot \frac{p - E}{p - e} \cdot \frac{273 + t}{273 + T}$$

The gain in mass of the drying tubes is divided by this corrected volume, and the mass of water vapour is expressed in grammes per cubic metre, or milligrammes per litre of space dried.

At the Ben Nevis Observatory the weight of the tubes used varied from about 3 to 25 grammes. The increase in the weight of the first tube during an experiment varied according to the humidity of the air and the volume of air dried from 0.2691 grammes to 0.0064 grammes. Except in the earlier experiments, when 23.6 litres of water were run from the aspirator, the volume of air dried varied from 26.3 to 29.5 litres. The water was run from the aspirator at the rate of from 1.7 to 4.2 litres per minute; the average rate being slightly over 3 litres per minute.

In the case of Fort-William the weight of the tubes used was from 9 to 25 grammes. The first tube gain varied from 0.2715 to 0.1080 gramme during an experiment, and, in the case of the experiments in January 1894, as low as 0.0597 gramme. The number of litres of air dried in an experiment varied from 21.9 to 24.5; in experiments 8 to 97 and after experiment 117, from 26.6 to 28.5. The rate at which the water ran from the aspirator was from 2.2 to 6.0 litres per minute; the average being about 4 litres per minute.

At Montpellier the apparatus was not quite so suitable for the work as that used at the Ben Nevis Observatories, and the aspirators were smaller. The tubes varied from

5·6 to 31·6 grammes in weight, and the increase during an experiment varied from 0·0316 to 0·2026 gramme for the first tube. The average rate of aspirations was 0·9 to 3·3 litres per minute. Here the average increase in weight of tube II., omitting cases where the gain was obviously due to the exhaustion of tube I., is 4·3 milligrammes. At Fort-William this was still lower than at Ben Nevis. At Montpellier the gain was much greater in tube II.; the tubes not retaining their drying properties nearly so long.

In the Ben Nevis experiments an error of 1 milligramme in the weighing would make an error of from 0·4 to 15·6 per cent. in the mass of water vapour measured, in Fort-William experiments one from 0·4 to 0·9 per cent., and in those at Montpellier an error of from 0·5 to 3·2 per cent. At Ben Nevis, however, the very dry conditions which made the first tube gain so little that a milligramme would have produced a large percentage error, were not common.

In the final results at Ben Nevis and Fort-William, when expressed in grammes of vapour per cubic metre of air aspirated, the percentage of error will be only about one-fiftieth of the values given above, supposing the column of air aspirated is correctly determined.

The various measurements of the capacity of the aspirators did not differ by 0·01 litre, giving a possible error of 0·04 per cent. in the measurement of the volume of water run out at Fort-William, and 0·03 per cent. at Ben Nevis. An error of 1° C. in estimating the temperature of the air inside the aspirator at Fort-William would lead to an error of less than 0·02 per cent. in the calculation of amount of air.

To study the results of the later determinations—314 in number—a diagram was constructed, the air temperatures being drawn along one axis, and the departure of the wet bulb from the dry along the perpendicular one and the mass of vapour in each cubic metre of the atmosphere written at each point thus fixed. The results are not numerous enough to permit curves connecting points of similar value being drawn with absolute precision.

On the same diagram there was drawn a series of lines derived from SPRUNG'S formula :—

$$f=f'-\frac{1}{2}(t-t')\frac{p}{755},$$

reckoning $p=755^{\text{mm}}$. The connection between the vapour pressures and the mass of vapour in a cubic metre of the atmosphere was derived from the latest *Smithsonian Tables* by finding the temperatures at which saturated vapour had a mass of 2, 4, 6 . . grammes per cubic metre, and then the pressures of saturated water vapour at these temperatures.

The experimental results, whether they were obtained at high or at low levels, agree with the general trend of these lines.

From the dry and wet bulb records the mass of water vapour has been calculated by the formula—

$$m = m' - \frac{1}{2} (t - t'),$$

where m is the mass per cubic metre required, m' that of saturated water vapour at t' .

The following table shows the differences between these calculated values and those directly determined at low levels :—

	Total Deviation, neglecting Signs.	
	No.	Amount. Grammes per cubic metre.
Fort-William	109	0·17
Montpellier	38	0·46

The differences are not much altered by a pressure correction, which is very much smaller than the fluctuations observed from hour to hour between calculated and determined values; *e.g.*, with no change of pressure, these fluctuations were at three successive experiments at Fort-William +0·17, +0·20, −0·04.

Theoretically, if the conception of an atmosphere of water vapour existing independently of an atmosphere of other gases be allowed, no such correction should appear in measuring the mass of vapour in a cubic metre of space; but there might be a small correction due to the slightly greater ease of vaporation in the lower pressures of higher levels. It has been shown by HANN and others that this conception is not tenable.

In order to reduce observations at Ben Nevis Observatory from dry and wet bulb readings of an aspiration-psychrometer and a table of masses of saturated water vapour at wet-bulb temperatures and standard pressures, the formula

$$m = m' - \left(\frac{t - t'}{2} \right) \frac{p}{755}$$

was employed. That a pressure correction is necessary is shown by such records as those of experiments 187–189, 191, 192, where $m' - \left(\frac{t - t'}{2} \right)$ is a negative quantity without. The following table shows the results then obtained, the values derived from the gravimetric determinations, and the differences between the two :—

BEN NEVIS OBSERVATORY.

Difference between the Mass of Water Vapour per cubic metre as determined by Gravimetric Methods,

$$\text{and as calculated from the formula } m = m' - \frac{t - t'}{2} \cdot \frac{p}{755}.$$

No. of Experiments.	C = Calculated Value.	O = Observed Value.	C - O.	No. of Experiments.	C = Calculated Value.	O = Observed Value.	C - O.	No. of Experiments.	C = Calculated Value.	O = Observed Value.	C - O.
133	7.42	7.48	- 0.06	165	5.98	6.30	- 0.32	195	1.36	1.33	+ 0.03
134	7.64	7.81	- 0.17	166	6.08	...	...	196	2.92	2.92	± 0.00
135	7.13	7.37	- 0.24	167	4.70	5.12	- 0.42	197	6.42	6.32	+ 0.10
136	7.38	7.74	- 0.36	168	4.37	4.46	- 0.09	198	6.34	5.97	+ 0.37
137	7.46	6.06	+ 1.40	169	5.04	3.96	+ 1.08	199	5.78	5.87	- 0.09
138	7.17	7.29	- 0.12	170	4.43	4.13	+ 0.30	200	5.99	5.94	+ 0.05
139	4.01	4.13	- 0.12	171	4.41	4.26	+ 0.15	201	6.47	6.37	+ 0.10
142	6.77	7.04	- 0.27	172	4.47	4.62	- 0.15	202	2.25	2.01	+ 0.24
143	6.96	6.71	+ 0.25	173	4.61	4.78	- 0.17	203	2.13	2.02	+ 0.11
144	6.62	7.02	- 0.40	174	4.85	4.96	- 0.11	204	6.86	6.78	+ 0.08
145	7.43	6.91	+ 0.52	175	5.09	5.32	- 0.23	205	7.48	7.37	+ 0.11
146	7.20	7.65	- 0.45	176	5.68	5.76	- 0.08	206	7.45	7.38	+ 0.07
147	7.60	7.91	- 0.31	177	5.50	5.73	- 0.23	207*	1.72	1.08	+ 0.64
148	7.64	7.87	- 0.23	178	5.82	6.01	- 0.19	208	1.63	1.53	+ 0.10
149	7.66	7.90	- 0.24	179	5.89	5.86	+ 0.03	209	2.20	1.98	+ 0.22
150	3.33	3.42	- 0.09	180	5.76	5.65	+ 0.11	210*	2.24	1.62	+ 0.62
151	3.99	4.01	- 0.02	181	5.76	5.78	- 0.02	211*	3.36	2.53	+ 0.83
152	3.74	3.83	- 0.09	182	5.12	5.13	- 0.01	212	6.00	5.87	+ 0.13
153	5.12	4.42	+ 0.70	183	4.86	4.92	- 0.06	213	4.58	4.39	+ 0.19
154	2.87	2.89	- 0.02	184	5.79	5.91	- 0.12	214	4.73	4.44	+ 0.29
155	2.26	2.38	- 0.12	185	1.69	1.44	+ 0.25	215	5.44	5.29	+ 0.15
156	3.13	3.20	- 0.07	186	0.66	0.48	+ 0.18	216	5.58	5.36	+ 0.22
157	4.87	4.94	- 0.07	187	0.40	0.40	± 0.00	217	5.56	5.14	+ 0.42
158	6.23	6.05	+ 0.18	188	0.42	0.23	+ 0.19	218	5.74	5.34	+ 0.40
159	6.55	6.61	- 0.06	189	0.38	0.36	+ 0.02	219	5.47	5.08	+ 0.39
160	6.19	5.81	+ 0.38	190	0.68	0.47	+ 0.21	220	5.49	5.06	+ 0.43
161	6.61	6.22	+ 0.39	191	0.43	0.26	+ 0.17	221	5.53	5.35	+ 0.18
162	4.48	4.21	+ 0.27	192	0.50	0.35	+ 0.15	222	5.51	5.05	+ 0.46
163	5.58	5.72	- 0.14	193	2.08	1.65	+ 0.43	223	5.54	5.32	+ 0.22
164	5.87	5.97	- 0.10	194	1.25	1.56	- 0.31				

The results may be summarized as follows:—

	Calculated value in excess.		Calculated value in defect.		No difference.
	No. of times.	Average excess.	No. of times.	Average defect.	
Experiments 133-183 recorded above .	13	0.45	35	0.16	0
Experiments 184-223 .	35	0.25	3	0.17	2
Total .	48	0.30	38	0.16	2

* These are all very doubtful values of O, as the gain in the second tube was such as to show that the first tube was not acting properly.

As a new series of experiments was begun with 184, the difference in sign of the larger number of deviations in the two series must be explained by some slight difference in the working. On the dry day of 4th September 1893, Nos. 153-164, the deviations varied from +0.70 to -0.14, and if the first experiment of the day, which has an abnormally large deviation, be eliminated, the deviations vary from +0.39 to -0.14.

The greatest variations occurred in the afternoon, when the calculated value for the water vapour exceeded that determined. On 10th September 1894, Nos. 185-192, another very dry day, the deviation varied from 0 to +0.25.

From the present determinations it is not possible to have any certain relationship between these deviations and the time of day. Some of the more excessive deviations are the first for that day, but this is not always the case; some may be due to the lessening of the drying power of a tube in its last experiment. The deviations have also been tabulated according to the departures of the wet bulb from the dry, and eliminating experiments 137, 153 and 169, and the doubtful results of 207, 210, 211, this gives the following table:—

Number and Mean Value of Deviations of Observed from Calculated Values of Means of Water Vapour arranged according to Differences between Dry and Wet Bulb Thermometers.

$t-t'$	Experiments 133-183.				Experiments 184-223.			
	+		-		+		-	
	No.	Mean value.	No.	Mean value.	No.	Mean value.	No.	Mean value.
Under 0.5	1	0.25	8	0.17	10	0.26	...	...
0.5 to 1.0	3	0.22	6	0.28	5	0.16	1	0.09
1.0 to 2.0	1	0.30	8	0.17	4	0.09	2	0.21
2.0 to 5.0	2	0.28	4	0.10	3	0.19	...	...
Over 5.0	3	0.27	7	0.07	13*	0.18	1	0.31

The greatest variations are in the cases where dry and wet bulb readings are closest, as the following table shows:—

$t'-t'$	133-183.				184-223.				133-223.			
	+		-		+		-		+		-	
Under 1	4	0.23	14	0.22	15	0.23	1	0.09	19	0.23	15	0.21
Over 1	6	0.28	19	0.12	20	0.16	3	0.24	26	0.19	22	0.13

* In addition two experiments gave the same results of calculation and by direct determination.

The difference between calculated and determined values is less under drier conditions, and, as far as the present experiments go, they indicate that the simple formula in the ordinary cases may be accepted as satisfactory.

Mass of Water Vapour (Absolute Humidity) under Different Weather Conditions.

The determinations made at Montpellier, at Fort-William, and on the summit of Ben Nevis, all agree remarkably—so much so as to give every confidence in the aspiration-psychrometer's action under very different conditions. As has just been remarked, there is no appreciable difference between the results of high and low level determinations, but more experiments are necessary,—especially in warm, dry weather at the top, and in cold, dry weather at the base of Ben Nevis.

In the autumn of 1893, simultaneous experiments were carried on at the two Ben Nevis Observatories. Two days may be chosen for the comparison of the water vapour at high and low levels, under very different conditions. The figures for dry and wet bulbs and mass of water vapour per cubic metre at both stations are plotted in the accompanying diagrams.

The following table shows the differences between the temperatures of the dry and of the wet bulb thermometers, and the mass of water vapour in a cubic metre of the atmosphere at Fort-William and Ben Nevis at different hours on the 4th and 11th of September 1893 :—

Hours.	8	9	10	11	12	13	14	15	16	17	18	19
<i>4th September 1893.</i>												
Dry Bulbs (F.W.—B.N.) C.°, . .	0·94	1·57	...	3·04	3·89	4·53	3·94	5·26	4·47	3·37	4·81	4·40
Wet Bulbs do. C.°, . .	4·99	8·30	...	8·83	7·50	6·55	5·95	6·92	6·52	8·55	7·84	7·45
Water Vapour do.												
Grammes per cubic metre, . .	4·83	6·66	...	7·38	5·65	5·25	4·57	5·52	5·48	7·08	5·83	5·70
<i>11th September 1893.</i>												
Dry Bulbs (F.W.—B.N.) C.°, . .	...	4·85	...	8·09	9·40	9·34	9·87	9·52	10·11	...	...	6·79
Wet Bulbs do. C.°, . .	...	4·71	...	6·57	6·12	6·56	6·76	6·54	7·20	...	...	6·34
Water Vapour do.												
Grammes per cubic metre, . .	...	1·58	...	2·07	1·16	1·20	1·63	1·91	2·26	...	...	2·54

On September 11th, the vertical temperature gradient was almost normal save in the early morning, the atmosphere at Fort-William dry, that at Ben Nevis nearly saturated. At Fort-William the amount of water vapour increased until 11 A.M., and fell at noon, rising steadily until 4 P.M. At Ben Nevis, except at noon, the water vapour increased until 2 P.M., and fell regularly thereafter except at 5 P.M. The bulges in the curve at noon, 2, and 5 P.M. are explained by the detached fog which appeared in the valleys around the Ben during the forenoon, and rose to the level of the hill top about noon, and just touched at these hours.

The weather at both stations was dry and warm on September 4th, but the air at the summit was relatively much warmer,—the difference between the two stations varying from $0^{\circ}\cdot9$ to $5^{\circ}\cdot3$. The vapour curve for the low level shows a slow but irregular increase in the mass of water in each cubic metre of air; that for the summit station curves in the same way as the movements of the wet bulb, showing a minimum at 10 A.M., two maxima at 2 and 4 P.M., and a marked minimum at 5 P.M., while at this hour the dry bulb reached a second maxima almost as high as the first at 2 P.M. The vapour present at 7 P.M. in the air at the summit was only $0\cdot41$ gramme per cubic metre more than at 8 A.M., but the range for the twelve hours was $2\cdot96$ grammes per cubic metre.

On both the 4th and 11th September 1893 there was a constant increase in the excess of water vapour at the base station compared with that at the summit until 11 A.M., and then a sudden drop at noon. On the more normal day there was a gradual increase in the amount of water vapour during the forenoon at both stations, but it was much more rapid at Fort-William; whereas, on September 4th, an increase of water vapour took place at the base, but a diminution of it at the summit of the mountain, until between 10 and 11 A.M. On the 11th, from noon onwards, there was a steady increase in this difference, which was very irregular on the afternoon of the 4th, due principally to the variations at the summit station already noted.

The atmospheric movements at the summit in radiation weather are very complex, and the mass of vapour is perhaps the most marked index of this variety of aerial samples, which appear to depend on the direction of the air current up or down the side of the mountain.

The difference between the mass of vapour per cubic metre at the two stations, under abnormal conditions, varies very much, the more humid atmosphere being pressed down by drier and warmer air flowing in from above, as Mr OMOND has shown, and this concentration of water vapour in the lower regions below the summit of Ben Nevis, acting as a screen, intensifies the abnormal temperature relations between the two stations. At Ben Nevis the boundary between such drier and moister layers must be often well marked, and an observer, in climbing or descending the mountain, might with advantage make observations with the aspiration-psychrometer at intervals of every few hundred feet. The variations are so great that it is obvious that the conception of an independent atmosphere of water vapour following Dalton's law for a gaseous atmosphere is untenable.

In the Montpellier experiments the vapour curve was very uniform, and sometimes remarkably constant.

With the aspiration-psychrometer it is possible to carry on work on the summit of Ben Nevis indoors in bad weather, but the observatory is so small that when the weather outside made work impossible, the apparatus could not be properly installed.

Mr RANKIN has suggested that the aspiration-psychrometer might be employed with advantage in foggy or frosty weather, the air being first drawn through a heated

worm before reaching the bulbs. Several experiments were tried, but a stronger fan and clockwork than those in the ordinary instruments are necessary to maintain a satisfactory current of air. By means of this, the amount of supersaturation of the air can be determined, and the humidity determined by a liquid and not an ice-coated bulb in frosty weather.

In conclusion, the writer was greatly impressed by the difference between the conditions of the laboratory and the open air. The changes observed in the conditions of the atmosphere increased with the delicacy of the instruments used for investigating its properties. It becomes a practical question what degree of refinement of investigation is most profitable, and the answer will obviously vary according to the problem to be solved. The aspiration-psychrometer gives the means of determining the pressure or mass of water vapour in the air much more accurately than the ordinary dry or wet bulb thermometer in a Stevenson screen. For an accurate determination of the mass or pressure of water vapour at any minute, undoubtedly the aspiration or sling psychrometer should be used. In calm weather the Stevenson screen thermometers, while indicating the conditions of the air surrounding them, may not give so reliable an indication of the general atmospheric conditions. On the other hand, when the air is changing very rapidly, as so often happens on mountain tops, the more sensitive aspiration-psychrometer responds practically instantaneously to those variations, and the difference of a minute or so in the time of observation may give a considerable difference in the temperatures and humidities, while the Stevenson screen instruments do not show these extremes so clearly, but at any one moment give a reading which is nearer the average. In the case of observations for the humidity of rooms or factories, the aspiration-psychrometer gives the more reliable observations for the determination of vapour mass or pressure, but the stationary thermometers probably yield truer indications of physiological effects; but, as has been pointed out before, the physiological influences can be best deduced from aspiration readings correlated with observations of movements of air.

The rapid variations of humidity are clearly shown in the records of the ordinary registering hair hygrometer. These are so great that it was found impossible to obtain precise values from the records of this hygrometer at the minutes of any psychrometer reading. In future experiments it might be profitable to use a hair hygrometer with a clock which turned the paper-covered drum in 24 hours or even in a shorter time.

TEMPERATURES AND WATER VAPOUR AT THE BEN NEVIS OBSERVATORIES.

11th September 1893.

4th September 1893.

TABLES OF OBSERVATIONS.*

I.—BEN NEVIS HIGH LEVEL OBSERVATORY.

No.	Time of Observation.		Aspiration Psychrometer.		Mass of Water Vapour in grammes.			Volume of Air aspirated (litres).			Mass of Vapour per cubic metre of Air (grammes).	Pressure in millimetres.	Wind (0-12).	Cloud. (0-10).	Dust Particles per cubic centimetre.	Rain-band. (0-8).	Remarks.
	Date.	Hour and Minute.	Dry.	Wet.	Tube 1.	Tube 2.	Total.	Volume of Water aspirated.	Temperature of Aspirator.	Corrected.							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
102	1893 Aug. 16	-	15.52	2.85	.1805	.0000	.1805	18.00	-	-	10.0†	650.13	-	Heavy drizzle	-	-	From 102 to 132 volume of air aspirated not corrected.
103	" 20	-	6.1	0.0	.1589	.0003	.1592	23.64	-	-	6.7†	642.51	-	-	-	-	-
104	" 23	17.20-27	8.41	1.98	.1532	.0019	.1532	23.64	-	-	6.5†	641.54	-	-	-	-	-
105	" "	19.20-27	7.41	1.68	.1396	.0002	.1398	23.64	-	-	5.9†	641.54	-	-	-	-	-
106	" 24	12.9-19	3.07	0.11	.1383	.0004	.1387	23.64	-	-	5.9†	644.34	N to NE 0-1	Fog ^o	2500	3.0	-
107	" "	13.12-20	3.70	0.10	.1386	.0009	.1386	23.64	-	-	5.9†	644.77	Nly 0-1	Fog ^{oo}	3200	1.3	-
108	" "	14.12-22	3.90	0.09	.1481	.0004	.1485	23.64	-	-	6.3†	645.35	Var. airs	Fog ^o	3800	3.0	-
109	" "	16.17-30	13.72	3.55	.1816	.0005	.1821	23.64	-	-	7.7†	645.91	-	-	-	-	-
110	" 25	8.50-59	13.78	3.67	.1799	.0007	.1806	23.64	-	-	7.6†	649.70	-	-	-	-	In tower
111	" "	10.58-67	13.72	3.60	.1845	.0008	.1853	23.64	-	-	7.8†	650.79	-	-	-	-	Do.
112	" "	12.58-64	14.53	3.86	.1845	.0002	.1847	23.64	-	-	7.8†	650.16	-	-	-	-	Do.
113	" "	14.0-10	13.42	3.90	.2691	.0004	.2695	23.64	-	-	7.2†	651.25	-	-	-	-	Do.
114	" "	16.10-17	14.11	3.89	.1850	.0003	.1853	23.64	-	-	7.8†	651.68	-	-	-	-	Do.
115	" "	18.6-14	12.68	3.68	.1619	.0003	.1622	23.64	-	-	6.9†	651.90	-	-	-	-	Do.
116	" 26	10.33-41	12.78	4.01	.1541	.0008	.1549	23.64	-	-	6.6†	652.39	-	-	-	-	Do.
117	" "	15.10-20	13.73	3.78	.1749	.0004	.1753	23.64	-	-	7.4†	652.21	-	-	-	-	Do.
118	" 27	11.8-24	2.70	0.13	.1627	.0009	.1636	23.64	-	-	5.5†	652.57	Nly 1	Overcast	600	6.0	Outside
119	" 28	12.49-61	11.07	2.30	.2110	.0005	.2110	29.64	-	-	7.1†	655.74	NNE 0-1	Dry mist	184	3.0	Do., air heated
120	" "	13.54-62	10.57	1.83	.2020	.0004	.2024	29.64	-	-	6.8†	655.76	Nly var. 0-1	Mist ^{oo}	100	3.4	Do. do.
121	" "	15.58-69	14.93	6.20	.1947	.0003	.1950	29.64	-	-	6.6†	655.61	Nely 0-1	Fog passing	550	-	Do. do.
122	" "	17.3-12	10.77	2.95	.1924	.0004	.1928	29.64	-	-	6.5†	655.51	N 0-1	Fog ^{oo}	1250	1.8	Do. do.
123	" "	17.57-69	12.71	7.60	.0843	.0005	.0848	29.64	-	-	2.9†	655.36	Calm—N 0-1	Cir. 2	300	1.2	Do. do.

* The tables expressed in F.^o and English measures will be found in the *Journal of Scot. Met. Soc.*, Third Series, vol. x. pp. 134-149, where the readings of the thermometers in the Stevenson Screen are also given.

† From uncorrected figures for volume.

I.—BEN NEVIS HIGH LEVEL OBSERVATORY—continued.

No.	Time of Observation.		Aspiration Psychrometer.		Mass of Water Vapour in grammes.			Volume of Air aspirated (litres).			Mass of Vapour per cubic metre of Air (grammes).	Pressure in millimetres.	Wind (0-12).	Cloud (0-10).	Dust Particles per cubic centimetre.	Rain-band (0-8).	
	Date.	Hour and Minute.	Dry.	Dry-Wet.	Tube 1.	Tube 2.	Total.	Volume of Water aspirated.	Temperature of Aspirator.	Corrected.							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	1893.																
124	Aug. 28	18.59-67	8.45	4.76	.0812	.0005	.0817	29.64	-	-	5.0†	655.61	NNW 1	Cir. 2	258	1.0	Outside, air heated
125	"	19.59-70	8.96	3.58	.1474	.0005	.1479	29.64	-	-	1.6†	655.69	Nly 2	Cir. 1	220	-	Do. do.
126	"	9.10-19	8.46	7.80	.0461	.0002	.0463	29.64	-	-	1.5†	655.44	NNW 2	Cir.-c. 1	167	3.0	
127	"	10.8-19	9.19	8.29	.0444	.0001	.0444	29.64	-	-	2.2†	655.66	N 1-2	F.° little cir.-c. 1	250	4.0	
128	"	10.59-67	9.15	7.43	.0633	.0006	.0639	29.64	-	-	5.6†	655.66	NNW 2	Cir.-c. 2	100	3.0	
129	"	11.56-66	6.34	1.47	.1644	.0000	.1644	29.64	-	-	7.0†	655.85	N 0 to calm	Cir.-c. 3	600	3.0	
130	"	13.56-65	7.29	0.39	.2073	.0000	.2073	29.64	-	-	7.6†	655.81	Calm to NW airs	Fog ⁰⁰⁰	650	2.6	
131	"	16.0-11	6.88	0.10	.2251	.0003	.2254	29.64	-	-	7.1†	655.33	N 1	Mist wet	25	4.0	
132	"	18.1-10	7.38	0.71	.2100	.0006	.2106	29.64	-	-	7.5†	655.06	N 1	Cir.-c. 2, f. passing	89	4.0	
133	Sept. 2	13.8-16	6.63	0.11	.2040	.0002	.2042	29.64	19.3	27.30	7.48	652.22	NE to N 0-1	Fog ⁰⁰⁰	122	1.0	
134	"	13.59-70	7.37	0.27	.2174	.0004	.2178	29.64	16.9	27.88	7.81	652.48	Calm to NE 0-1	Str. 10	275	1.2	
135	"	15.1-9	7.49	0.87	.1935	.0007	.1942	29.64	25.1	26.34	7.37	652.63	Calm to N 0	Cum. 7	165	1.0	
136	"	15.58-68	7.49	0.61	.2122	.0003	.2125	29.64	19.3	27.46	7.74	652.68	Calm to N 0	Fog ⁰ 7-10 overhd.	350	1.0	
137	"	17.3-11	6.79	0.15	.2139	.0003	.2142	29.59	14.1	28.28	6.06	652.81	Calm to various	Str. 10	283	2.0	
138	"	18.1-12	6.18	0.10	.2092	.0000	.2092	29.59	10.6	28.70	7.29	652.81	N 1	Fog ⁰⁰	417	3.0	
139	"	19.1-11	8.52	4.96	.1183	.0002	.1185	29.60	11.0	28.66	4.13	653.04	Calm to various	0	780	1.0	
140	"	20.3-14	7.23	1.87	-	-	-	-	-	-	-	653.39	Calm	0	-	-	
141	"	8.7-16	5.23	0.06	-	-	-	-	-	-	-	653.54	S 1	0, mist ⁰ passing	∞	-	
142	"	8.59-69	5.58	0.29	.1912	.0003	.1915	29.59	18.1	27.21	7.04	653.62	SSW 1-2	0 fog ⁰ passing	-	1.4	
143	"	10.5-14	6.02	0.25	.1052	.2847	.1795	29.59	21.7	26.75	6.71	653.72	SSW 0-1	Cir.-c. 1	600	2.5	
144	"	11.1-11	7.89	1.63	.1815	.0003	.1818	29.59	27.7	25.97	7.02	653.77	Calm to Sly-1	Cir.-c. 1	-	2.3	
145	"	11.58-67	7.66	0.65	.3023	.4942	.1919	29.60	17.2	27.76	6.91	653.88	S 1-2	0 or fog ⁰⁰⁰	-	-	
146	"	12.59-68	7.50	0.81	.2071	.0008	.2079	29.58	20.6	27.17	7.65	654.00	Southerly	Fog ⁰ passing	675	2.0	
147	"	14.2-8	7.58	0.42	.2167	.0001	.2167	29.60	19.2	27.41	7.91	654.02	W and S 1	Fog ⁰	-	1.0	
148	"	15.33-40	8.90	1.09	.2114	.0002	.2116	29.59	23.4	26.89	7.87	653.88	S 1	Soud 1	-	-	

† From uncorrected figures for volume.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	1893.																Air cleared during last minute
149	Sept. 3	16.2 -10	8.35	0.77	.2181	.0005	.2186	29.59	18.9	27.65	7.90	653.83	S 0 to calm	Cir.-c. 5, fog ⁰⁰	2000 ?	2.0	
150	"	16.59-68	12.93	7.92	.0923	.0009	.0932	29.59	23.0	27.27	3.42	653.67	Calm to Wly ains.	Cir.-c. 7	1000 ?	2.0	
151	"	17.59-67	12.01	6.68	.1156	.0005	.1161	29.60	14.2	28.92	4.01	653.67	W 1	Cir.-c. and str. 7	400	2.6	
152	"	19.0 -9	11.73	6.83	.1114	.0002	.1116	29.60	12.2	29.16	3.83	653.67	WNW 0	Cir.-c. and str. 6	550	1.0	
153	"	8.5 -14	10.75	4.77	.1233	.0001	.1234	29.59	18.3	27.88	4.42	652.30	W 1	Cir.-c. 7	500	2.5	
154	"	9.0 -8	11.68	7.86	.0811	.0007	.0818	29.60	16.8	28.25	2.89	652.40	Wly 0-1	Cir.-c. 8	Wind too var.	1.0	
155	"	10.2 -11	12.66	9.07	.0652	.0009	.0661	29.59	20.3	27.75	2.38	652.35	WSW 1	Cir.-c. 7	-	3.2	
156	Sept. 4	11.0 -7	12.85	8.13	.8882	.0003	.0885	29.59	21.5	27.61	3.20	652.27	SW 1	Cir. and cir.-c. 5	1000 ?	3.0	
157	"	12.2 -13	12.94	6.24	.1328	.0001	.1329	29.59	26.7	26.90	4.94	652.20	S 0-1	Cir. 1	1500	3.0	
158	"	13.2 -10	12.66	4.65	.1607	.0000	.1607	29.60	27.5	26.56	6.05	651.97	S 0-1 to calm	Cir. 2	490	3.0	
159	"	14.1 -11	13.71	4.89	.1733	.0007	.1740	29.58	28.9	26.31	6.61	651.85	Calm to S 0-1	Cir. and cir.-c. 4	375	3.0	
160	"	15.4 -11	13.43	5.15	.1597	.0006	.1603	29.60	22.8	27.60	5.81	651.48	S 1	Cir.-c. 3	475	3.0	
161	"	16.3 -12	13.49	4.77	.1633	.0005	.1638	29.58	25.2	27.11	6.22	651.13	S 0-1	Cir. 1	83	2.5	
162	"	17.0 -8	13.67	7.05	.1160	.0001	.1161	29.60	21.8	27.59	4.21	650.82	S x W 1	Cir. 2	275	3.5	
163	"	18.0 -9	11.65	4.78	.1613	.0000	.1613	29.58	17.8	28.20	5.72	650.57	SW 1-2	Cir. 1	-	3.0	
164	"	19.1 -9	11.16	4.20	.1731	.0005	.1736	29.58	12.5	29.04	5.97	650.42	SSW 1-2	Cir. 1	222	2.0	
165	"	10.59-73	3.79	0.31	.1739	.0007	.1746	29.59	13.5	27.72	6.30	636.80	N 0-1	Cum.-s. f. ⁰⁰	675	2.5	
166	"	11.58-65	3.52	0.15	.1748	.0007	.1765	29.60	11.3 ?	-	-	637.04	N 0-1	Fog ⁰⁰	2800	2.7	
167	"	16.59-68	-0.50	+0.38	.1488	.0013	.1501	29.48	0.4	29.32	5.12	644.45	NE var. 0-1	Nimbus 10, snow falling	800	1.0	
168	"	19.2 -13	-1.36	-0.08	.1293	.0007	.1300	29.58	1.2	29.12	4.46	644.88	E var. 0-2	Cum.-s. 10 ∞	-	-	
169	"	8.10-21	-2.83	+1.01	.1134	+0.002	.1136	29.59	4.7	28.66	3.96	645.70	N	Str. fog ⁰⁰	150	0.5	
170	"	9.0 -7	-2.58	+1.66	.1157	.0008	.1165	29.57	9.3	28.02	4.13	648.16	Nly 1	Fog ⁰⁰	89	-	
171	"	11.59-73	9.73	5.07	.1251	.0005	.1256	29.56	9.6	29.34	4.26	649.15	N 0-1	Cum.-s. 1; fog passing	200	-	Heated
172	"	7.58-67	1.27	1.03	.1294	-	.1294	29.60	13.3	27.99	4.62	652.40	N 1-2	0	1900	0.8	
173	"	9.2 -12	1.83	1.10	.1297	.0002	.1299	29.59	20.0	27.20	4.78	652.93	N 1	0	2200 ?	0.8	
174	"	10.3 -12	2.82	1.23	.1350	-	.0854	29.60	20.6	27.24	4.96	653.21	N 1	0	275	1.0	
175	"	10.59-69	3.16	1.09	.1438	-	.1439	29.58	21.9	27.06	5.32	653.39	S or SE var. 0	0; fog ⁰ passing	600	1.0	
176	"	12.3 -11	3.04	0.30	.1623	-	.1623	29.60	13.9	28.20	5.76	653.47	Calm var. 0-1	Fog ⁰⁰ passing	950	2.0	
177	"	13.1 -9	4.01	0.98	.1591	-	.1591	29.59	17.9	27.75	5.73	653.64	SE-E 0-1	Cum. 7	1400	1.0	
178	"	13.58-68	3.94	0.58	.1666	.0005	.1671	29.59	12.2	28.44	6.01	653.64	S-SE 1	Fog ⁰⁰ passing	2000	2.0	
179	"	15.0 -9	4.55	0.78	.1676	.0002	.1678	29.58	11.8	28.62	5.86	653.64	SSE 1	Cum. 8-10	-	1.0	

I.—BEN NEVIS HIGH LEVEL OBSERVATORY—continued.

No.	Time of Observation.		Aspiration Psychrometer.		Mass of Water Vapour in grammes.			Volume of Air aspirated (litres).			Mass of Vapour per cubic metre of Air (grammes).	Pressure in millimetres.	Wind (0-12).	Cloud (0-10).	Dust Particles per cubic centimetre.	Rain-band (0-8).	Remarks.
			Dry.	Dry-Wet.	Tube 1.	Tube 2.	Total.	Volume of Water aspirated.	Temperature of Aspirator.	Corrected.							
	Date.	Hour and Minute.															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1893																	
180	Sept. 11	16.7-14	3.73	0.54	.1638	.0828	.1638	29.59	8.3	28.98	5.65	653.64	S 1-2	Cum.-s. 10; fog ^{oo} passing	1800	2.0	
181	"	17.0-11	3.19	0.28	.1680	.0002	.1682	29.54	6.8	29.07	5.78	653.62	Calm, S 0-1	Str. 10; fog ^{oo}	2000	1.0	
182	"	17.59-66	3.61	1.25	.1500	.0001	.1501	29.59	6.6	29.23	5.13	653.47	S 1	Cir. 4	1800	2.0	
183	"	19.2-12	3.23	1.41	.1449	-.0170	.1449	29.60	3.3	29.46	4.92	653.63	S 1	Cir.-s. 4	1100		
1894																	
184	Sept. 9	20.47-15	6.46	1.82	.1629	.0000	.1629	29.64	21.3	27.57	5.91	656.68	ESE 0	Thin fog	-	1.5	
185	"	8.0-11½	6.80	7.04	.0420	.0000	.0420	29.64	8.2	29.17	1.44	655.82	NW 2-3	Cum. 10	-	1.8	
186	"	9.0-11½	7.43	8.70	.0136	-.0004	.0136	29.64	15.3	28.35	0.48	655.82	NW 2-3	Cum. 7	-	1.8	
187	"	10.30-40	9.05	9.71	.0107	.0003	.0110	29.64	20.9	27.62	0.40	656.10	NW 1-2	Cir.-c. 3	-	1.8	
188	"	11.30-40	9.10	9.72	.0064	-.0001	.0064	29.64	20.0	27.77	0.23	655.92	NW 1-2	0	-	1.8	
189	"	12.30-41½	9.85	10.07	.0101	-.0003	.0101	29.64	20.9	27.70	0.36	655.66	NW 3	0	-	1.8	
190	"	13.30-41½	9.70	9.60	.0130	.0004	.0134	29.64	19.5	27.90	0.47	655.46	WNW 3	Cir. 1	-	1.8	
191	"	15.30-41	10.39	10.22	.0073	.0002	.0075	29.64	16.8	28.34	0.26	654.93	WNW 3	Cir.-c. 5	-	1.8	
192	"	16.30-40½	9.36	9.76	.0099	.0002	.0101	29.64	14.2	28.59	0.35	654.53	NW 4	Cir. 2	-	2.0	
193	"	10.8-21	6.60	6.45	.0438	.0002	.0440	29.64	25.6	26.72	1.65	656.83	N 0	Cir.-c. and s. 3	-	1.0	
194	"	11.33-45	7.83	8.08	.0413	.0003	.0416	29.64	27.0	26.65	1.56	657.01	N 0	0	-	1.0	
195	"	12.30-41	7.98	7.98	.0350	.0004	.0354	29.64	28.0	26.57	1.33	657.27	N 0	0 ∞	-	1.0	
196	"	18.0-12½	6.54	5.34	.0840	.0005	.0845	29.64	10.1	28.96	2.92	657.42	Calm	Cir. 6	-	1.0	
197	"	11.0-14	5.63	0.76	.1811	.0007	.1818	29.59	10.3	28.76	6.32	657.78	ENE 0-1	Str. & cir.-st. 10	-	1.8	
198	"	12.5-18	5.69	0.82	.1699	.0001	.1700	29.16	10.5	28.46	5.97	657.83	NNE 0-1	Str. 10	-	1.8	
199	"	13.2-14	6.24	1.50	.1666	.0009	.1675	29.34	12.3	28.52	5.87	657.68	NNE 0-1	Str. 10∞	-	1.8	
200	"	15.2-16½	6.22	1.49	.1667	.0007	.1674	29.30	14.3	28.20	5.94	657.44	NNE 0	Str. 10∞	-	1.8	
201	"	16.36-45½	5.90	0.79	.1841	-.0007	.1841	29.46	9.9	28.90	6.37	657.27	NW 0-1	Fog	-	2.0	
202	"	10.35-48	11.83	8.63	.0549	.0004	.0553	29.64	24.5	27.47	2.01	656.43	SW 0-1	0	-	0.8	
203	"	11.35-47	12.89	9.28	.0550	.0005	.0555	29.64	25.4	27.41	2.02	656.43	S x W 1-2	0	-	0.8	

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	1894																
204	Sept. 17	13.0-14	9.41	2.18	.1878	.0006	.1879	29.53	22.0	27.70	6.78	656.51	SE 2-3	Cir. 1 [∞]	-	1.0	
205	"	15.0-15	9.90	1.88	.2034	.0008	.2042	29.26	20.6	27.72	7.37	656.35	SE 2-3	Cir. 3, Cum. 3	-	1.0	
206	"	16.3-17	9.63	1.69	.2121	.0003	.2124	29.59	14.8	28.77	7.38	656.25	SE x E 2-3 q	Cir. 1, Cum. 5 [∞]	-	1.0	
207	18	7.30-44	9.85	8.35	-.2001	.2309	.0808	29.59	15.9	28.41	1.08	655.26	E x S 1-2	0 [∞]	-	1.4	
208	"	8.32-46	10.64	3.82	.0418	.0010	.0428	29.59	19.4	28.00	1.53	655.26	E x S 1-2	0 [∞]	-	1.4	
209	"	10.31-44	11.52	8.63	.0542	.0007	.0549	29.60	21.8	27.79	1.98	655.19	E x S 1-2	0 [∞]	-	1.4	
210	"	11.34-49	12.53	8.85	-.4.0718	.4.1166	.0453	29.32	22.4	27.92	1.62	655.00	E x S 1-2	0 [∞]	-	1.4	
211	"	15.33-51	10.54	6.68	-.2.2277	2.2951	.0704	29.26	19.0	27.81	2.53	654.29	E x S 1-3	0 [∞]	-	1.4	
212	"	19 15.0-9	4.15	0.44	.1677	.0004	.1681	29.58	11.4	28.64	5.87	651.93	SE 0-1	Fog	-	2.0	
213	"	16.30-38	6.26	3.19	.1228	.0012	.1240	29.29	13.4	28.26	4.39	651.98	SE 0	Cir. & cir.-c. 9	-	1.8	
214	"	17.36-47	5.40	2.59	.1282	.0019	.1301	29.60	7.4	29.27	4.44	651.88	E x S 0	Cir. & cir.-c. 9	-	1.8	
215	"	11.30-39	3.10	0.61	.1509	.0029	.1538	29.59	7.1	29.06	5.29	651.25	S x E 0	Fog	-	2.0	
216	"	12.30-39	3.28	0.55	.1537	.0023	.1560	29.59	7.0	29.09	5.36	651.09	E x S 0	Fog	-	2.0	
217	"	13.30-40	3.09	0.48	.1418	.0013	.1493	29.60	6.7	29.04	5.14	650.94	S x E 0	Fog	-	2.0	
218	"	16.0-9	3.18	0.31	.1550	.0013	.1563	29.59	5.8	29.25	5.34	650.84	S x E 0	Fog	-	2.0	
219	"	18.30-40	2.94	0.51	.1485	.0002	.1485	29.60	5.5	29.26	5.08	650.61	Calm	Fog	-	2.0	
220	"	10.33-43	2.49	0.28	.1478	.0000	.1478	29.60	5.7	29.18	5.06	649.19	SE 1-2	Fog	-	-	
221	"	11.35-44	2.75	0.34	.1528	.0014	.1542	29.60	4.7	29.34	5.35	649.21	SE 1-2	Fog	-	-	
222	"	12.33-43	3.54	0.75	.1433	.0007	.1440	29.60	12.0	28.49	5.05	649.14	SE 2	Cum. 5 [∞]	-	-	
223	"	13.30-39	4.34	1.11	.1538	.0008	.1546	29.60	8.0	29.00	5.32	649.09	SE 1-2	Cum.-str. 10	-	-	

II.—FORT-WILLIAM LOW LEVEL OBSERVATORY.

No.	Time of Observation.		Aspiration Psychrometer		Mass of Water Vapour in grammes.			Volume of Air aspirated (litres).			Mass of Vapour per cubic metre of Air (grammes).	Pressure in milli-metres.	Wind (0-12).	Cloud (0-10).	Dust Particles per cubic centimetre.	Rain-band. (0-8).	Remarks.
	Date.	Hour and Minute.	Dry.	Wet.	Tube 1.	Tube 2.	Total.	Volume of Water aspirated.	Temperature of Aspirator.	Cor. rected.							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
8	1893 Aug. 22	19.42 -46½	12.85	1.55	.2173	.0004	.2177	23.86	12.78	23.85	9.12	757.79	-	-	-	-	
9	"	23 18.46 -53½	12.40	1.59	.2115	.0010	.2125	23.86	12.78	23.75	8.94	755.32	W 1-2	Cum. 5	-	-	
10	"	24 11.19 -29	14.14	2.43	.2054	.0000	.2054	23.86	16.67	23.45	8.78	753.27	W 0-1	Cum. 7	-	2	
11	"	" 12.15 -22	16.14	4.48	.1812	.0000	.1812	23.86	18.17	23.43	7.73	753.65	W 1-2	Cum. 3	-	2.5	
12	"	" 13.2 -12½	15.63	4.21	.1859	.0004	.1863	23.86	20.00	23.05	8.08	753.88	W 0-1	Cum. 3	-	2	
13	"	" 14.0½ -6½	15.66	3.85	.1919	.0000	.1919	23.86	19.44	23.10	8.30	759.53	W 1	Cum. 2	-	3	
14	"	" 16.3½ -10	16.33	4.63	.1811	.0005	.1816	23.86	20.56	23.07	7.87	760.50	W 1-2	Cum. 2	-	-	
15	"	" 19.40 -43½	11.97	1.80	.2005	.0000	.2005	23.86	18.89	22.72	8.81	761.85	W 0-1	Cum. cir.-c. 9	-	-	
16	"	" 8.56 -63½	13.60	2.92	.1930	.0002	.1932	23.86	13.33	23.83	8.11	765.75	W 0-1	Cum. 10	-	-	
17	"	" 10.51½ -56½	15.00	3.26	.2007	.0000	.2007	23.86	17.22	23.42	8.57	766.13	W 0-1	Cir.-c. 5	-	3	
18	"	" 12.0 -6½	14.85	3.50	.1945	.0000	.1945	23.86	18.89	23.05	8.44	766.31	Wly 1	Cir.-c. 3	-	3.5	
19	"	" 13.2 -8½	15.14	3.36	.1979	.0002	.1981	23.86	19.44	23.52	8.42	766.61	W 2	0	-	3.5	
20	"	" 14.2 -8½	14.76	3.16	.2020	.0006	.2026	23.86	20.56	23.09	8.81	767.07	Wly 1-2 q	Cum. 6	-	4.5	
21	"	" 16.1 -7½	14.72	3.74	.1900	.0005	.1905	23.86	19.44	23.03	8.27	767.40	Wly 1-2 q	Cum. 10	-	-	
22	"	" 18.3 -9	14.11	3.32	.1900	.0004	.1904	23.86	17.78	23.20	8.21	767.83	Wly 1-2	Cum. 9	-	3	
23	"	" 10.33 -39	14.68	3.63	.1923	.0003	.1926	23.86	18.33	23.28	8.27	768.57	NW 1	Cum. 9	-	3.5	
24	"	" 11.30 -36	14.58	3.14	.1986	.0001	.1987	23.86	17.78	23.28	8.54	768.32	NW 2	Cum. 9	-	4	
25	"	" 12.30 -35½	15.25	3.43	.2039	.0003	.2042	23.86	17.22	23.25	8.78	768.19	NW 0.1	Cum 10	-	3.7	
26	"	" 13.30 -35½	15.86	4.44	.1840	.0002	.1842	23.86	22.2	22.81	8.08	768.22	NW 0-1	Cir.-c. 9	-	7	
27	"	" 15.6½ -11½	15.34	3.62	.2031	.0004	.2035	23.86	17.8	23.38	8.71	767.86	NW 0-1 q	Cum. 10	-	4	
28	"	" 16.2 -8	16.92	4.48	.1937	.0002	.1939	23.86	27.2	22.14	8.76	770.83	W 0-1	Cir. 4	-	3	
29	"	" 17.1 -6½	15.48	3.50	.2003	.0003	.2006	23.86	21.7	22.80	8.79	770.88	W 0-2 q	Cir. 5	-	3.5	
30	"	" 18.0 -5½	14.82	3.66	.1896	.0004	.1900	23.86	19.4	23.18	8.19	770.96	NW 2	Cir. 3	-	4	
31	"	" 19.0 -6 ⁵⁰	14.07	3.13	.1981	.0002	.1983	23.86	14.4	24.52	8.09	771.23	0	Cir. 1	-	-	

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	1893																
32	Aug. 29	11.0 - 5	18.70	3.62	.2030	.0001	.2031	23.86	22.2	22.83	8.89	771.31	SW 0-1	Cum. 4	-	4	
33	"	12.0 - 4.6	16.69	4.47	.1896	.0003	.1899	23.86	22.2	23.74	8.00	771.29	SW calm	Cum. 2	-	5	
34	"	13.0 - 5.20	17.38	4.26	.2080	.0004	.2084	23.86	27.8	22.19	9.39	771.08	SW 0-1	Cum. 9	-	4.5	
35	"	14.3 - 8.60	17.08	3.70	.2247	.0001	.2248	23.86	22.2	23.03	9.76	770.81	W 1-2	Cum. 10	-	4	
36	"	17.1 - 7.5	15.96	2.80	.2314	.0002	.2310	23.86	23.3	22.61	10.24	770.30	W 1-2	Cum. 9	-	6	
37	"	19.4 - 10	14.68	2.05	.2368	.0002	.2370	23.86	15.6	23.66	10.02	770.14	W 1-2	Cum. 10	-	-	
38	"	11.0 - 5	16.00	3.09	.2237	.0003	.2240	23.86	20.6	23.12	9.69	766.25	SW calm	Cum. 10	-	5	
39	"	13.30 - 3.65	15.94	2.50	.2416	.0013	.2419	23.86	18.9	23.24	10.41	765.93	W 1-2	Cum.-s. 10	-	6	
40	"	17.0 - 6.20	15.80	2.89	.2282	.0002	.2284	23.86	18.3	23.38	9.77	764.01	WNW 0-1	Cum.-s. 10	-	6	
41	Sept. 2	13.11 ³⁰ -18	18.36	4.84	.2050	.0003	.2053	23.86	24.1	22.84	8.99	766.18	Wly 0-1	Cum. 3	-	2	
42	"	15.18 ¹⁵ -24	18.20	4.62	.2087	.0002	.2089	23.86	23.0	22.96	9.10	766.25	NWly 0	Cum. 4	-	1.5	
43	"	15.18 ¹⁵ -24	18.05	4.96	.2121	.0004	.2125	23.86	30.1	22.70	9.36	766.41	NNW 1	Cum. 3	-	-	
44	"	15.57 ³⁰ -62	18.77	4.82	.2156	.0001	.2157	23.86	26.6	22.43	9.64	766.46	NNW 1	Cum. 3	-	1.8	
45	"	16.58 - 63.00	18.25	4.80	.2092	.0003	.2095	23.86	25.6	22.53	9.30	766.65	NW 1-2	Cum. 1	-	2	
46	"	18.6 - 11.45	16.60	3.83	.2133	.0006	.2139	23.86	18.3	23.46	9.12	766.75	NW 1-2	Cir.-c. 1	-	2.5	
47	"	11.10 - 14.40	15.66	2.65	.2249	-	.2249	23.86	27.8	21.93	10.25	768.71	NWly 0	Cum. 8	900	4	
48	"	12.5 - 12.15	16.83	3.74	.2141	.0001	.2142	23.86	27.3	22.20	9.65	768.57	Nly 0	Cum. 6	2600	-	
49	"	13.1 - 6	16.81	3.54	.2221	.0002	.2221	23.86	24.0	22.65	9.80	768.61	Var. 0-1	Cum. 9	4200	3	
50	"	14.0 - 5.30	17.09	2.83	Broken	-	-	-	-	-	-	-	-	-	-	-	
51	"	15.12 ¹⁵ -17.30	16.92	2.71	.2435	.0000	.2435	23.86	26.5	23.01	10.53	768.25	SWly 0-1	Cir.-c. 6	1800	3.5	
52	"	16.34 - 39.30	15.42	2.23	.2556	.0001	.2557	23.86	23.1	23.10	11.04	768.10	SWly 0-1	Cir.-c. 9	6400	4	
53	"	19.8 ¹⁵ - 15.20	14.17	1.74	.2359	.0007	.2366	23.86	16.6	23.43	10.10	769.19	SWly 0	Cir.-st. 10	5200	2.5	
54	"	8.10 ³⁰ -15.00	11.69	0.72	.2210	.0003	.2210	23.86	15.1	23.34	9.25	766.67	Nly 0	Cir.-c. 10	5000	3	
55	"	9.1 - 6.40	13.25	1.13	.2184	.0001	.2184	23.86	19.6	22.86	9.55	766.54	Calm	Cir.-c. 9	36000	-	
56	"	11.0 - 6.15	15.69	2.34	.2394	.0003	.2397	23.86	23.1	22.66	10.53	766.00	Wly 0-1	Cir.-c. 3	2750	3.5	
57	"	12.0 - 5.20	16.93	2.63	.2408	.0002	.2410	23.86	23.9	22.75	10.69	765.61	Wly 0-1	Cir.-str. 5	5600	4	
58	"	13.0 - 5.15	17.19	2.63	.2542	.0003	.2545	23.86	25.6	22.52	11.30	765.10	SWly 1	Cir.-str. 8	11000	4	
59	"	14.1 - 6.15	17.65	2.88	.2517	.0005	.2519	23.86	25.4	22.52	11.18	764.72	SWly 1-2	Cir. 4	6400	4	
60	"	15.3 - 9	18.69	3.49	.2546	.0005	.2551	23.86	26.6	22.51	11.33	764.11	SWly 1-2	Cir.-c. 5	18000	5	
61	"	15.29 - 34.20	18.91	3.67	.2527	.0000	.2527	23.86	26.8	22.51	11.23	764.11	SWly 1-2q°	Cir.-c. & str. 5	6400	4	
62	"	16.0 - 5	17.96	2.78	.2612	.0001	.2612	23.86	27.5	22.32	11.70	763.86	SWly 1-2q°	0	8000	4	
63	"	17.0 - 5.10	17.54	2.83	.2542	.0006	.2548	23.86	25.5	22.57	11.29	763.61	SWly var. 1	0	8400	3.5	
64	"	18.0 - 5.30	16.46	2.05	.2650	.0003	.2653	23.86	21.7	23.02	11.55	763.37	SWly 0-1	0	12400	4	

II.—FORT-WILLIAM LOW LEVEL OBSERVATORY—continued.

No.	Time of Observation.		Aspiration Psychrometer.		Mass of Water Vapour in grammes.			Volume of Air aspirated (litres).			Mass of Vapour per cubic metre of Air (grammes).	Pressure in milli-metres.	Wind (0-12).	Cloud (0-10).	Dust particles per cubic centimetre.	Rain-band. (0-8).	Remarks.
	Date.	Hour and Minute.	Dry.	Dry-Wet.	Tube 1.	Tube 2.	Total.	Volume of Water aspirated.	Temperature of Aspirator.	Corrected.							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1898																	
65	Sept. 4	19.0 - 5 ³⁰	15.56	1.36	.2715	.0004	.2719	.23.86	18.3	23.39	11.67	763.15	SWly 0-1	0	2800	-	
66	" 5	10.10 - 15 ¹⁵	15.08	1.54	.2580	.0015	.2595	.23.86	16.2	23.67	10.96	759.55	SWly 1	Cum. 10	9200	4	
67	" "	16.30 - 36 ³⁵	16.72	2.62	.2512	.0001	.2513	.23.86	20.2	23.07	10.89	757.04	SW 1-2	Cum. 10	9600	4	
68	" 7	13.4 - 10 ³⁰	17.62	4.05	.2148	.0002	.2150	.23.86	29.3	21.93	9.80	750.54	Wly 1-2	Cum. 6	13500	4	
69	" "	15.22 - 29	15.72	2.74	.2289	.0003	.2292	.23.86	18.7	23.32	9.33	750.54	SWly 1-2	Cum. & str. 10	5600	-	
70	" 8	11.1 - 6 ¹⁵	13.42	2.75	.1883	-.0002	.1883	.23.86	20.6	22.78	8.23	750.44	Calm	Cum. 8	58000	2+	
71	" "	12.0 - 6 ¹⁵	14.64	3.48	.1876	.0004	.1880	.23.86	22.7	22.50	8.35	750.51	NW-NE 0	Cum. 9	34000	5	
72	" "	16.41 ³⁰ - 43 ³⁰	11.63	2.53	.1767	.0008	.1775	.23.86	13.3	23.54	7.54	754.17	NNE 0-1	Cum. 8	20000	3.5	
73	" "	17.24 - 30 ⁴⁰	11.73	2.55	.1796	.0000	.1796	.23.86	13.2	23.53	7.63	754.17	NNE 0-1	Cum. 8	39500	2	
74	" 9	8.11 - 17 ²⁰	9.29	2.23	.1577	.0001	.1578	.23.86	9.9	23.76	6.64	759.20	NWly 0	Cum. 9	3600	3 -	
75	" "	10.9 ¹⁵ - 14 ³⁰	9.91	2.65	.1527	.0002	.1529	.23.86	10.6	23.71	6.45	759.63	NWly 0-1	Cum. 9	3200	2	
76	" "	11.1 ³⁰ - 7 ³⁰	11.09	4.49	.1175	.0002	.1177	.23.86	19.9	22.43	5.25	759.88	Nly 1-2	Cum. 4	3000	2	
77	" "	12.0 - 5 ⁴⁵	11.36	3.77	.1377	.0000	.1377	.23.86	20.1	22.45	6.13	760.09	NNE 2	Cum.	1600	2	
78	" "	13.1 ³⁰ - 8 ³⁰	11.78	4.25	.1313	-.0001	.1313	.23.86	19.7	23.96	5.48	760.14	NNE 0	Cum. 4	5200	2	
79	" "	14.0 - 5 ⁴⁵	11.26	3.85	Broken	-	-	-	-	-	-	-	N 2	Cum. 2	3400	2	
80	" "	15.36 - 42 ⁴⁰	12.14	4.12	.1401	.0010	.1411	.23.86	21.9	22.26	6.34	760.14	N 2	Cum. 6	6000	2	
81	" "	16.26 - 31 ⁴⁰	12.46	4.49	.1330	.0000	.1330	.23.86	19.4	22.68	5.86	760.23	NNW 1-2	Cum. 6	4400	2 -	
82	" "	19.5 - 17	9.24	2.77	Balance-Tube Broken	-	-	-	-	-	-	-	NNE 1	Cum. 6	13000	-	
83	" 10	7.14 - 23	4.29	0.71	.1382	.0001	.1383	.23.86	7.0	23.50	5.88	764.98	Nly 0	Cum. 1	7200	-	
84	" "	8.1 - 7	5.97	1.50	.1353	.0000	.1353	.23.86	17.2	22.32	6.06	765.55	Calm	Cum. 3	20400	-	
85	" "	9.2 ³⁰ - 8 ³⁰	7.07	1.71	.1421	-.0001	.1421	.23.86	12.7	23.11	6.15	765.83	NE 0	Cum. 7	29000	2 -	
86	" 11	9.2 - 7	6.68	1.24	.1447	.0005	.1452	.23.86	13.8	22.84	6.36	770.23	NEly 0	0	11200	-	
87	" "	11.0 ³⁰ - 6 ³⁰	11.25	2.61	.1636	-.0001	.1636	.23.86	22.9	22.13	7.39	770.28	NWly 0	Cir. 1	32000	-	
88	" "	12.2 ³⁰ - 9	12.44	3.58	.1532	.0000	.1532	.23.86	23.6	22.15	6.92	770.08	SW var. 0-1	Cir. 2	22000	2	
89	" "	13.0 - 7 ¹⁵	13.35	3.76	.1636	-.0001	.1636	.23.86	25.1	23.61	6.93	770.03	SWly 0	Cum. 2	12800	3	

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
90	Sept. 11	14.0 - 6 ¹⁰	13.81	3.69	.1682	.0000	.1682	23.86	25.8	22.01	7.64	770.03	SWly var. 0-1	Cir. 3 cum. 1	32000	2.5	
91	"	15.2 - 9 ²⁰	14.07	3.76	.1701	.0005	.1701	23.86	26.5	21.94	7.77	769.72	SWly var. 0-1	Cum. 1	8400	3	
92	"	16.1 - 6 ⁰⁰	13.94	3.45	.1762	.0005	.1767	23.86	23.6	22.34	7.91	769.75	SWly 0-1	Cum. 1	18400	-	
93	"	19.3 - 10	10.02	1.86	.1744	.0001	.1745	23.86	12.8	23.39	7.46	769.83	Sly 1	Cir.-c.	8400	-	
94	"	9.7 ³⁰ - 13 ³⁰	11.61	2.08	.1869	.0001	.1869	23.86	14.9	23.32	8.01	768.88	SWly 1-2	Cum. 7	10000	-	
97	Dec. 31	15.35 - 46 ³⁰	8.28	1.11	.1977	.0011	.1988	29.65	8.2	-	-	771.57	W 1	Cum. 8	11600	2	The tempera- tures in ex- periments 95 to 117 are reduced from readings of thermometers in Stevenson Screen.
98	1894.																
99	Jan. 1	10.31 - 41 ⁴⁰	2.33	1.83	.1055	.0001	.1056	29.65	4.2	-	-	774.47	NE 0-1	Cum. 10	23600	1	
100	"	11.36 - 47 ¹⁵	2.72	1.89	.0913	.0002	.0915	29.65	5.5	-	-	774.33	N 0-1	Cum. 9	-	1	
101	"	13.0 - 11 ⁴⁵	2.72	2.22	.0988	.0004	.0980	29.65	4.8	-	-	774.33	N 0-1	Cum.-str. 10	-	1.5	
102	"	15.0 - 12 ⁴⁵	2.61	2.22	.1000	.0004	.1004	29.65	3.6	-	-	773.80	N 0-1	Cum. 7	-	1	
103	"	12.0 - 45.1	0.67	1.34	.1101	.0006	.1101	29.65	4.8	-	-	773.20	Calm	Cum. 7	12000	2	
104	"	10.40 - 51	1.61	1.61	.1187	.0003	.1146	29.65	6.6	-	-	773.20	Calm	Cum. 7	10000	2	
105	"	13.0 - 12 ³⁵	1.28	1.11	.1219	.0003	.1222	29.65	3.1	-	-	773.20	Calm	Cir.-cum. 1	13200	2	
106	"	14.0 - 10 ³⁰	1.84	1.17	.1166	.0000	.1166	29.65	3.2	-	-	773.15	Calm	Cum. 4	-	2	
107	"	15.31 - 43 ³⁰	2.89	2.06	.1027	.0001	.1027	29.65	2.6	-	-	773.17	NNW high air	Cum. 9	-	2	
108	"	10.35 - 46 ¹⁰	0.50	2.61	.0709	.0000	.0709	29.65	3.2	-	-	779.65	E 0-1	Cum. 4	6000	1	
109	"	12.0 - 12 ¹⁰	0.78	2.06	.0786	.0009	.0745	29.65	2.8	-	-	779.24	E 1	Cum. 3	-	2	
110	"	13.0 - 11 ³⁵	0.78	2.56	.0701	.0001	.0701	29.65	0.9	-	-	779.31	E 1	Cum. 3	-	2	
111	"	15.30 - 42 ⁴¹	0.72	2.11	.0716	.0003	.0719	29.65	4.4	-	-	779.36	E 2	0	-	2	
112	"	12.0 ¹⁰ - 11 ³⁵	2.28	2.22	.0783	.0003	.0786	29.65	8.5	-	-	775.48	Calm	Cum. 9	11200	1.5	
113	"	13.0 - 8 ³⁰	2.06	2.78	.0714	.0017	.0714	29.65	6.5	-	-	774.94	Calm	Cum. 7	-	2	
114	"	14.1 - 12 ³⁰	2.33	2.33	.0824	.0001	.0825	29.65	4.4	-	-	774.36	E 0-1	Cum. 9	-	1.5	
115	"	15.37 - 46 ⁵	2.06	2.17	.0955	.0005	.0955	29.65	3.5	-	-	773.15	NE 1-2	Cum. 10	-	1.5	
116	"	13.0 - 8 ¹⁵	1.73	2.90	.0692	.0015	.0692	29.65	7.9	-	-	760.21	NE 0-1	Cum.-str. 10	-	1	
117	"	11.25 - 34 ⁴⁵	-3.44	1.39	.0597	.0001	.0598	29.65	24.0	-	-	750.31	E 1-2	Cum.-str. 10	-	3.7	
118	"	7 11.15 - 23 ⁴⁰	0.83	2.22	.0743	.0000	.0743	29.65	1.2	-	-	752.67	E 2-3	Cum.-str. 10	-	3	
119	May 9	19.22 ³⁰ - 23 ³⁰	6.90	1.65	.1686	.0004	.1686	27.88	9.7	28.11	5.60	749.01	Nly 0-1	Cum. 5	4600	3	
120	"	17.25 - 31	10.27	3.16	.1700	.0005	.1700	27.88	14.0	27.94	6.08	755.21	SW to NE var. 0-1	Cum.-str. 10	1700	3	
121	"	19.14 - 20 ³⁰	9.88	3.09	.1234	.0002	.1236	27.88	13.0	28.02	4.41	756.33	SW 1	Cum.-str. 9	2200	3	
122	"	19.27 - 37	9.47	2.90	.1663	.0007	.1663	27.88	12.5	28.02	5.94	764.53	SW 1-2	Cum. 6	2800	2.5	
123	"	20.17 ³⁰ - 23 ³⁰	8.79	2.41	.1700	.0001	.1700	27.88	10.2	28.54	5.96	764.96	SW-W var. 1	Cum. 4	4600	-	

* 95 and 96—Tubes used too soon after being prepared.

II.—FORT-WILLIAM LOW LEVEL OBSERVATORY—continued.

No.	Time of Observation.		Aspiration Psychrometer.		Mass of Water Vapour in grammes.			Volume of Air Aspirated (litres).			Mass of Vapour per cubic metre of Air (grammes).	Pressure in millimetres.	Wind (0-12).	Cloud (0-10).	Dust Particles per cubic centimetre.	Rain-band (1-8).	Remarks.
	Date.	Hour and Minute.	Dry.	Wet.	Tube I.	Tube II.	Total.	Volume of Water aspirated.	Temperature of Aspirator.	Corrected.							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
123	1894																
May 14		16.20 -26	10.79	2.79	.1891	-.0002	.1891	27.88	11.8	28.29	6.68	760.41	ENE 1-2	Cum.-str. 10	17000	3.4	Much steamer smoke
"	"	20.33 -39+	9.57	2.01	.1936	.0002	.1938	27.88	9.8	28.42	6.82	760.77	ENE 1-2	Cir.-str. 5 Cir.-str. 10	35000?	4	
"	16	9.6 -12 ³⁰	8.97	2.68	.1637	-.0005	.1637	27.88	11.2	28.15	5.81	768.03	NNE 2-3	Cum.-str. 10	18000	3	
"	"	10.54 -61	9.65	2.13	.1865	.0003	.1868	27.88	15.4	27.73	6.74	768.27	NNE 3	Cum.-str. 9	15000	3	
"	17	14.6 -13 ¹⁵	12.31	3.73	.1766	-.0001	.1766	27.88	23.0	26.98	6.55	768.77	NE 2-3	Cum.	25000	4	
"	"	16.7 -14 ³⁰	11.46	3.54	.1685	.0001	.1686	27.88	20.8	27.19	6.20	768.85	NE 3	Cum. 5	17000	4	
"	"	20.38 -45 ¹⁵	7.38	2.77	.1434	.0002	.1436	27.88	9.6	28.16	5.10	770.27	NE 2-3	Cum. 10	18300?	-	
"	17	11.7 -14 ³⁰	11.16	3.75	.1622	-.0001	.1622	27.88	16.6	27.69	5.86	771.49	NE 2-3	Cir.-c. 9	9000	4	
"	"	15.10 -20 ³⁰	13.90	4.43	.1842	-.0001	.1842	27.88	18.0	27.81	6.62	770.73	NE 2	Cir.-c. 9	34000	-	
"	"	17.8 -17 ⁴⁵	12.36	3.41	.1927	Broken.	.1927	27.88	17.2	27.77	6.94	770.71	NE 2	Cir.-c. 10	22000	4	
"	"	19.10 -18 ¹⁵	11.11	2.88	.1902	-.0002	.1902	27.88	12.3	28.26	6.73	770.93	NE 1-2	Cir.-c. 10	31000	3 (?)	
"	18	12.6 -12 ⁴⁰	14.46	5.50	1620	-.0005	.1620	27.88	27.2	26.57	6.10	770.71	NE 2-3	0	21000	2.5	
"	"	14.3 ²⁰ -16 ¹⁵	15.06	5.01	.1834	.0000	.1834	27.88	17.9	27.93	6.57	770.35	NE 3	Cir. 1	48000	3	
"	"	15.6 ⁴⁵ -14	14.63	5.34	.1709	.0007	.1716	27.88	18.2	27.83	6.17	770.25	NE 3	0	29000	2.6	
"	"	16.58 ⁴⁵ -64 ⁴	13.55	4.58	.1748	-.0005	.1748	27.88	17.2	27.86	6.27	770.27	NE 3-4	Cum. 2	30000	3	
"	"	18.5 ⁴⁵ -13 ³⁰	11.61	3.88	1681	.0013	.1694	27.88	15.8	27.84	6.03	770.71	NE 3-4q	Cum. 4	22000	-	
"	19	9.4 ³⁰ -13	6.60	3.74	.1080	.0005	.1085	27.88	11.0	27.87	3.89	772.86	NE 1-2	Cum. 9	6800	2	
"	"	11.6 -12 ⁴⁵	6.51	3.55	.1122	-.0004	.1122	27.88	11.0	27.86	4.03	772.30	NE 0-1	Cum. & str. 10	2400	2	
"	21	12.5 -11	7.69	3.93	.1187	.0004	.1191	27.88	10.4	28.06	4.25	763.39	NE 1	Cum. & str. 9	700	-	Rain just after
"	"	16.20 ⁴⁰ -29 ²⁰	8.96	3.69	.1361	.0006	.1367	27.88	16.9	27.40	4.99	763.14	NW 1-2	Cum. 1	1500?	-	
"	"	20.15 ⁴⁵ -22 ⁴⁵	5.95	2.29	.1359	.0001	.1360	27.88	9.2	28.06	4.85	763.71	E 1	Cum. 3	1200	-	

III.—OBSERVATOIRE MÉTÉOROLOGIQUE DE L'ÉCOLE D'AGRICULTURE, MONTPELLIER.

No.	Time of Observation.		Aspiration Psychrometer.		Mass of Water Vapour in grammes.				Volume of Air aspirated (litres).			Mass of Vapour per cubic metre of Air (grammes).	Pressure in milli-metres.	Wind (0-12).	Cloud (0-10).	Dust particles per cubic centimetre.	Rain-band. (0-8).	Remarks.
	Date.	Hour and Minute.	Dry.	Dry-Wet.	Tube 1.	Tube 2.	Tube 3.	Total.	Volume of Water Aspirated.	Temperature of Aspirator.	Corrected.							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1894.																		
1	Mar. 10	11.1 -16	13.9	4.1	.2026	.0000	-	.2026	28.655	13.0	-	-	759.0	S 0-1	0	-	-	
2	"	12 16.42 -51	18.04	8.02	.1521	.0003	-	.1524	28.655	13.5	28.91	5.27	758.0	SSW 0-1	Cir. 10	?	-	
3	"	17.32 -41	16.39	6.85	.1591	.0003	-	.1594	28.655	13.8	28.02	5.69	758.0	W 1	Cir. 3	-	-	
4	"	18 15.23-44	12.22	1.96	.2060	.0375	-	.2435	28.655	12.8	28.49	8.55	751.9	S	Cum. 10	?	-	
5	14	11.0 -17	11.27	4.30	.1560	.0008	-	.1568	28.675	12.0	29.07	5.39	752.0	NNW 2-3	Cum. 3	?	-	
6	"	12.0 -9	11.83	4.71	.0797	.0102	-	.0899	17.544	-	-	-	752.0	NNW 2	Cum. 4	-	-	
7	"	12.57 -65	12.00	5.33	.1320	.0084	-	.1404	28.675	14.0	28.16	4.98	751.9	NW 2	Cum. 3	-	-	
8	20	17.3 -9	11.27	6.06	.0316	.0039	-	.0355	9.839	-	-	-	756.5	0	Cir.-cum. 9	?	-	
9	"	18.9 -19	8.82	4.48	.0431	.0006	-	.0437	10.074	-	-	-	756.5	0	-	?	-	
10	"	16.25 -31½	11.86	5.37	.0455	.0009	-	.0464	9.864	-	-	-	758.0	S 0-1	0	-	-	
11	"	16.47½-57½	11.56	5.22	.1207	.0016	-	.1223	25.943	-	-	-	758.0	S 0-1	0	?	-	
12	"	18.1 -4½	9.53	4.16	.0407	.0071	-	.0478	9.944	-	-	-	758.0	Calm	Cir.-cum. 3	-	-	
13	"	18.16 -28	9.00	4.08	.1146	.0057	-	.1203	25.943	-	-	-	758.0	S 0	Cir.-cum. 3	?	-	
14	"	10.6 -10	13.22	6.08	.0455	.0054	-	.0509	10.057	-	-	-	760.0	SSE 1	0	10000	-	
15	"	10.51½-55	15.22	7.28	.0472	.0022	-	.0494	9.989	-	-	-	760.0	SSE 1	0	10000	-	
16	"	11.28 -34½	15.24	7.27	.0879	.0076	-	.0465	10.017	-	-	-	760.0	SE var. 0-1 q	0	10400	-	
17	"	12.0 -6	17.09	7.28	.0535	.0057	-	.0572	10.070	-	-	-	760.0	S 0-1	0	?	-	
18	"	14.26½-33	16.68	7.53	.0462	.0033	-	.0495	10.011	-	-	-	780.0	-	-	?	-	
19	"	16.0 -6	15.16	6.39	.0465	.0038	-	.0563	10.046	-	-	-	759.5	S 1-2	0	?	-	
20	"	17.18 -25	13.79	4.56	.0617	-.0127	-	.0617	9.957	-	-	-	760.0	Sly airs	0	?	-	
21	"	11.46½-53	14.31	5.72	.0507	.0051	-	.0558	9.797	-	-	-	759.0	S 1-2	Cum. 1	?	-	
22	"	13.45 -55½	14.36	6.06	.0572	.0208	-	.0780	15.869	-	-	-	759.0	S 1-2	0	?	-	
23	"	15.38 -48	13.43	5.18	.0838	.0021	-	.0859	15.869	-	-	-	759.0	SWly 0-1	0	?	-	
24	"	16.53 -64	12.34	4.57	.0859	.0036	+.0003	.0898	15.875	21.3	15.14	5.93	759.0	Calm	0	?	-	
25	"	15.5 -18	14.38	4.85	.0974	.0041	.0018	.1033	15.872	19.4	15.39	6.71	760.0	SSW 1-2	0	?	-	
26	"	16.17½-30¼	13.38	4.14	.0507	.0419	.0093	.1019	15.880	19.8	15.31	6.65	760.0	SW 1-2	0	?	-	
27	"	17.42 -63	11.51	3.63	.0841	.0137	-.0003	.0978	15.869	17.0	15.36	6.37	760.5	SW light airs	0	?	-	
28	"	7.30 -43½	8.11	1.89	.0995	-.0005	-.0045	.0995	15.869	11.5	15.58	6.39	761.5	Sly airs	0	?	-	
29	"	8.44½-55½	12.06	3.31	.1105	-.0008	-.0007	.1105	15.877	11.9	15.02	7.36	761.0	Sly airs	Cir. 3	?	-	

III.—OBSERVATOIRE MÉTÉOROLOGIQUE DE L'ÉCOLE D'AGRICULTURE, MONTPELLIER—continued.

No.	Time of Observation.		Aspiration Psychrometer.		Mass of Water Vapour in grammes.				Volume of Air aspirated (litres).			Mass of Vapour per cubic metre of Air (grammes).	Pressure in millimetres.	Wind (0-12).	Cloud (0-10).	Dust Particles per cubic centimetre.	Rain-band (0-8).	Remarks.
	Date.	Hour and Minute.	Dry.	Wet.	Tube 1.	Tube 2.	Tube 3.	Total.	Volume of Water aspirated.	Temperature of aspirator.	Corrected.							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1894																		
30	Mar. 28	10.9 -21	14.52	4.54	.0962	.0175	-	.1137	15.871	13.5	14.86	7.65	761.0	Sly airs	Cum. 3	?	-	
31	"	11.20½-31½	14.95	5.33	.0918	.0108	-.0018	.1026	15.869	15.0	14.81	6.93	761.0	S 0-1	0	?	-	
32	"	16.16 -27	14.10	5.46	.0759	.0127	-.0007	.0886	15.869	19.8	14.77	6.00	761.0	SWly 0-2	0	?	-	
33	"	17.30 -41	12.11	3.94	.0889	.0108	.0000	.0997	15.869	18.3	14.90	6.69	761.0	SWly 0-2	0	?	-	
34	" 31	10.20 -31½	14.42	5.57	.1167	.0035	-	.1202	20.268	15.0	18.73	6.42	752.0	Calm	Cum. cur.-c. 10	?	-	
35	"	11.19 -27½	15.17	5.88	.0593	.0018	-	.0611	10.074	16.7	9.27	6.59	752.0	Calm	Cir.-c. 10	?	-	
36	April 2	14.51 -57	16.69	4.98	.0795	-.0005	-	.0795	10.078	21.8	9.17	8.67	753.0	SWly 0-2	0	?	-	
37	"	15.30 -36	15.66	3.95	.0798	.0002	-	.0800	10.078	22.0	9.20	8.70	753.0	SWly 0-2	0	?	-	
38	"	16.15 -21	14.76	3.48	.0811	.0009	-	.0820	10.132	22.3	9.27	8.84	753.0	SSW 0-1 & calm	Cir.-str. 2	?	-	
39	"	17.5 -11	14.36	3.17	.0813	.0009	-	.0822	10.074	22.3	9.24	8.89	754.0	Calm	Cir.-str. 6	?	-	
40	"	17.55 -61	13.19	2.52	.0825	-.0002	-	.0825	10.074	21.0	9.30	8.87	754.0	Slight airs	Cir.-c. and str. 8	?	-	
41	" 3	13.12 -18	16.10	3.95	.0851	-.0009	-	.0851	10.078	19.7	9.24	9.21	754.8	SE 1-2	Cum.-c. cir.-c. 4	?	-	
42	"	14.45 -49	14.85	2.98	.0900	+.0002	-	.0902	10.096	19.0	9.28	9.71	755.0	SE 1	Cum. 10	?	-	
43	"	16.0 -4	14.07	2.69	.0887	-.0009	-	.0887	10.162	17.7	9.41	9.43	755.0	SE-SSW 0-1	Cum. 10	?	-	
44	" 5	13.3 -7½	16.24	3.48	.0923	-.0002	-	.0925	10.080	22.5	9.25	10.00	759.0	Sly var. 0-1	Cir.-str. 10	?	-	
45	"	14.1 -8	16.45	4.38	.0781	-.0001	-.0072	.0781	10.082	22.8	9.21	8.48	759.0	SSE var. 1	Cir.-str. 10	?	-	
46	"	15.2 -8	15.14	3.77	.0612	.0007	-	.0619	10.121	22.0	9.32	6.64	758.0	Sly airs 0	Cir.-str. 10	?	-	
47	" 6	10.30 -45	19.11	8.02	.1164	.0000	-.0244	.1164	20.140	17.7	18.38	6.33	757.0	Calm to Sely light airs 0-1	Cir. 10	?	-	
48	"	11.41½-45½	20.19	9.08	.0559	.0017	-	.0576	10.090	20.5	9.14	6.30	757.0	SE 0-2 q	Cir. 10	?	-	
49	"	12.53 -57½	19.91	9.23	.0503	-.0006	-	.0503	10.092	23.5	9.10	5.83	757.0	SSEly 0-2	Cir. 10	?	-	
50	"	13.15 -30	19.47	8.87	.1232	.0068	-	.1300	20.454	20.7	18.60	6.99	757.0	Sely 1-2	Cir. 10	?	-	
51	"	14.30 -34½	18.90	7.84	.0576	.0012	-	.0588	9.964	25.5	8.98	6.54	757.0	SSEly to Sly 0-2	Cir. 9	?	-	
52	"	15.13½-18	18.72	7.71	-.0030	.0500	-	.0500	10.070	22.7	9.14	5.47	757.5	Calm to SSEly airs	Cir. 7	?	-	
53	"	16.18 -30	17.75	6.86	.1232	.0001	-	.1233	20.140	24.8	18.27	6.75	757.5	Light airs	Cir. 3	?	-	
54	"	16.40 -44	17.54	6.97	.0505	.0007?	-	.0512?	10.110	24.0	9.19	5.57	757.5	Calm	Cir. 3	?	-	
55	" 7	11.7½-14	18.47	6.02	.0665	-.0005	-	.0665	10.088	19.8	9.21	7.22	758.3	SSEly airs 0-1	Cir. 5	?	-	
56	"	12.8 -14	18.70	6.72	.0621	-.0018	-	.0621	10.070	20.2	9.18	6.76	758.3	SSE 0-1 q	Cir.-str. 2	?	-	