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A COMPARISON BETWEEN THE DRY BULB TEMPERATURE IN THE CLIMATOLOGICAL SCREEN AT VALENCIA OBSERVATORY, AND THAT IN A STEVENSON SCREEN exposed in an OPEN FIELD adjoining.

BY

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A COMPARISON BETWEEN THE DRY BULB TEMPERATURE IN THE CLIMATOLOGICAL SCREEN AT VALENCIA OBSERVATORY, AND THAT IN A STEVENSON SCREEN EXPOSED IN AN OPEN FIELD ADJOINING.

By L. H. G. Dines, M.A.

The Climatological screen to which these notes refer is that from which all the temperature readings at Valencia Observatory have been taken, which are published either in the Geophysical Journal, or Hourly Readings from the year 1893 onwards.* Details of its exposure and construction are given below.

The data for the comparison relate to a period of 8 years from 1909 to 1916, and a further period of 3 years from 1918 to 1920. For the former period the eye observations made in the Stevenson screen at 7h., 13h., and 18h. were used, and were compared with the published mean values from the climatological screen for the same hours. For the latter period several sets of observations were employed, obtained from records preserved at the Observatory, including a series of 3 years at 21h. Taking the former period first, monthly means of the Stevenson readings for each of the three hours were formed and the difference, Climatological *minus* Stevenson, determined in each case. This quantity is denoted by D in what follows; it is in every case given in Fahrenheit degrees. The monthly mean values of D so found were not large, hardly ever exceeding 1·0°F., as was to be expected in a locality where the diurnal range of temperature is small. This made it the more important that the index errors of the respective thermometers should be accurately known. As will appear later it has been possible to ensure that any uncertainty of this kind is negligible compared with the value of D.

The Stevenson screen which is of the usual pattern† stands on short grass in an open field with its base 4 feet 2 inches above the ground. The exposure is on a site open to sun and wind, about 40 yards from the Observatory, and can be classed as excellent in every way. As far as is known the state of the screen was good and the painting clean during the period covered. Until June, 1916, the legs and framing of the stand were painted black. Since then they have been white.

The Climatological screen is placed against the North wall of the Observatory near the North-East corner. It was formerly a comparatively crude structure which up to 1918 consisted in a single louvred wooden shelter backing against the wall, supported on two small concrete pillars 2½ feet high, and painted white.

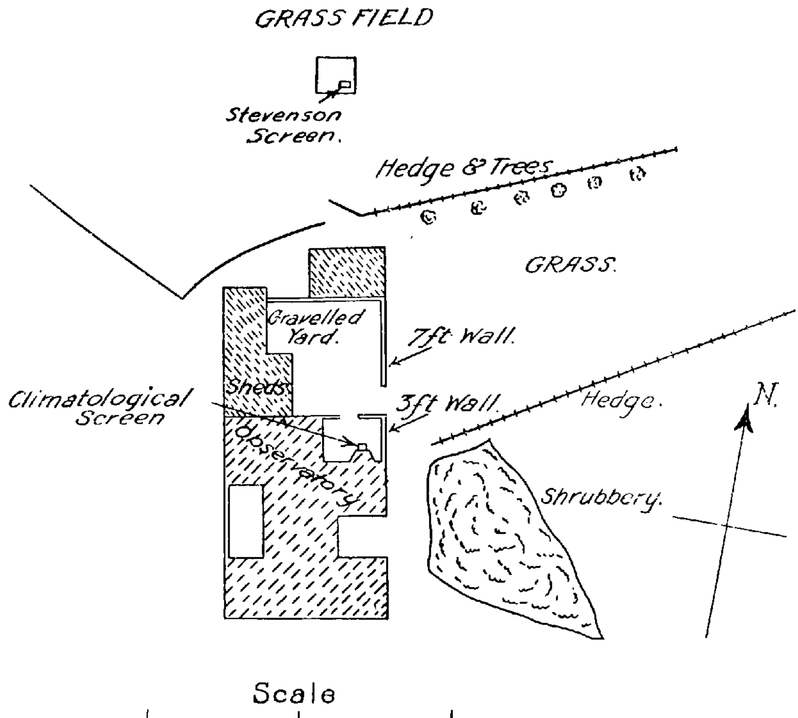
* Valencia Observatory was moved from Valencia Island to Cahirciveen in 1893.

† See note on page 40.

The bottom of the screen was partially open, the ground beneath being covered with gravel. The louvre boards at the two sides were not continued to the bottom of the screen, so that the direct rays of the sun could shine over the three foot wall into the lower part in the early morning in summer; in the evening, adjacent buildings shielded the screen from the sun. The bulbs of the thermometers were sufficiently high to be out of the direct rays of the sun at all times. The roof of the screen was single, and was painted red until the Summer of 1915, when it was whitened. In January, 1919, this screen was remodelled as detailed later.

Inside the screen, 4 feet 4 inches above the ground, the bulbs of two large thermometers are placed having their stems passing through the wall of the Observatory, from their inner ends photographic registration of dry and wet bulb is obtained; the source of illumination being two small paraffin lamp flames. Close beside these thermometers are placed two others with similar large bulbs, but adapted for direct eye readings. The latter are read thrice daily, and it is on them, as standard controls, that all the published Hourly Values are entirely based.

The positions of the two screens are shown on the plan, and it will be seen that the site of the climatological screen is very much shut in by walls and buildings standing round an open



Plan of Valencia Observatory shewing positions of thermometer screens.

Fig. 1.

(33208-12) Wt. 4178-6146 625 9/21 H. St. G. 3

gravelled yard. Close to the screen and overhanging it, there stood previous to the autumn of 1915 a young and fast growing sycamore tree, which was cut down at that date. Whatever effect this tree may have had on the exposure of the thermometers, it is clear that it must have been getting steadily worse as the tree increased in size and have come to an abrupt end in 1915. It is therefore satisfactory to notice that the yearly means do not show any recognisable signs of such changes, and it may be inferred that the effect of the tree was very small.

During the period 1909-1916 no change was made in the thermometers in either screen, and as both of them were old instruments their index errors may safely be assumed to have been constant throughout.* For the purpose of this comparison they were tested in water together in 1919 by taking a very large number of simultaneous readings over a wide range and plotting the results. By this means their comparative errors were determined to within about ·04°F. The corrections thus obtained were applied to all the monthly mean differences based on this particular pair of thermometers.

The following tables give the results of all the monthly mean differences determined during the two periods of the test. Also for reference a table of the monthly mean temperature in the Stevenson screen for the 8-year period 1909-1916 is included :

TABLE I.—MONTHLY MEAN VALUES OF *D* AT 7H., 13H., AND 18H.

The positive sign denotes that the temperature in the Climatological Screen is higher than in the Stevenson Screen.

7h.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
1909	−·38	−·23	−·18	−·04	−·07	− ·01	+ ·19	−·53	+·29	−·03	+ ·12	−·25	−·09
1910	−·27	−·35	+·14	−·21	+·09	+ ·15	− ·27	−·17	+·24	+·06	+ ·02	−·36	−·08
1911	−·12	+·13	−·65	+·00	−·20	− ·39	− ·11	−·23	+·25	+·44	+ ·06	−·29	−·09
1912	+·00	−·23	−·40	+·26	+·45	+ ·36	+ ·04	+·12	+·57	−·03	− ·21	−·25	+·06
1913	−·41	+·01	−·16	+·29	+·45	+ ·37	+ ·40	+·16	+·15	+·00	− ·31	−·11	+·07
1914	−·15	−·10	−·04	+·11	+·26	+ ·15	+ ·30	+·18	+·10	+·36	+ ·13	−·22	+·09
1915	−·54	−·52	+·09	+·05	+·36	+ ·39	+ ·23	+·31	+·08	+·09	+ ·10	−·43	+·02
1916	−·19	−·34	−·27	+·10	+·39	+ ·57	+ ·50	+·41	+·01	−·43	− ·24	−·26	+·02
Mean	−·26	−·20	−·18	+·07	+·22	+ ·20	+ ·16	+·03	+·21	+·06	− ·04	−·27	+·00

13h.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
1909	−·39	−·66	+·02	+·05	+·27	+ ·56	+1·31	+·60	−·76	−·31	−1·10	−·77	−·10
1910	−·31	−·33	−·35	+·24	+·40	+ ·60	+ ·07	+·31	+·18	−·44	− ·26	−·30	−·01
1911	−·42	−·66	−·35	+·17	+·26	+ ·23	+ ·61	−·15	−·27	−·47	− ·61	−·60	−·19
1912	−·24	−·48	+·14	+·27	+·94	+1·46	+ ·70	+·29	−·19	−·33	− ·08	−·27	+·18
1913	−·52	−·55	−·06	+·14	+·11	+ ·90	+ ·36	+·08	−·03	−·80	− ·32	−·30	−·08
1914	−·50	−·17	+·04	+·11	+·57	+ ·42	+ ·55	+·45	+·00	−·70	− ·58	−·72	−·04
1915	−·68	−·72	−·27	+·26	+·12	+ ·01	+ ·40	−·48	−·69	−·82	− ·85	−·68	−·37
1916	−·44	−·34	−·39	+·08	+·74	+ ·24	+ ·71	+·19	−·15	−·02	− ·33	−·72	−·04
Mean	−·44	−·49	−·15	+·16	+·43	+ ·55	+ ·59	+·16	−·24	−·49	− ·52	−·54	−·08

*** The numbers of the thermometers are 399 and M.O. 6280, the former being a very old instrument which was in regular use at Valencia Observatory for some 50 years.**

18h.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
1909	−·25	−·22	−·53	−·17	+·42	+ ·80	+ ·79	+·44	−·22	−·37	− ·42	−·38	−·01
1910	−·55	−·63	−·34	−·08	+·42	+ ·77	+ ·67	+·41	−·11	−·12	+ ·06	−·51	+·00
1911	−·11	−·07	−·36	+·12	+·28	+ ·85	+ ·86	+·21	−·48	+·01	− ·15	−·33	+·07
1912	−·34	−·16	−·20	+·06	+·86	+ ·95	+ ·78	+·20	+·21	−·25	− ·26	−·49	+·11
1913	−·39	−·20	−·26	+·11	+·40	+ ·91	+ ·27	+·21	+·09	−·47	− ·54	−·07	+·00
1914	+·00	−·43	−·27	−.37	+·53	+ ·73	+ ·39	+·19	−·19	−·32	− ·06	−·51	−·03
1915	−·39	−·92	−·43	−·04	+·28	+ ·48	+ ·38	−·08	−·45	−·23	− ·18	−·40	−·17
1916	−·43	−·38	−·31	−·09	+·48	+ ·34	+ ·80	+·20	+·03	−·10	− ·18	−·24	+·01
Mean	−·31	−·38	−·34	−·06	+·46	+ ·73	+ ·62	+·22	−·14	−·23	− ·22	−·37	+·00

Table II.—Various Monthly Mean Values of *D* from the Year 1918 Onwards.

7h.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
1918 1919 1920	−·26										−·11	−·38	

13h.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
1918 1919 1920	−·38	−·22	−·31	+·03	+·62	+·59	+·40	+·32	+·00	−·61	−·53	−·50	−·05

21h.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
1918	−·21	−·28	+·10	+·16	+·49	+·79	+·59	+·33	−·06	−·16	−·15	−·21	+·12
1919	−·18	+·08	+·03	+·06	+·44	+·45	+·63	+·50	+·02	+·04	+·17	−·22	+·17
1920	−·11	−·05	−·12	−·01	+·36	+·60	+·31	+·52	+·19	+·17	−·05	−·10	+·14
Mean	−·17	−·08	+·00	+·07	+·43	+·61	+·51	+·45	+·05	+·02	−·01	−·18	+·14

Table III.—Monthly Means of Temperature in the Stevenson Screen for the 8 years 1909-1916.

Hour.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept	Oct.	Nov.	Dec.
7	44·9	43·2	42·7	46·0	50·8	54·5	56·8	57·2	54·2	51·3	45·9	44·8
13	47·2	46·8	47·4	51·5	55·6	58·6	61·4	62·8	60·6	55·9	49·3	47·1
21	45·7	45·3	46·3	50·1	54·2	57·5	60·1	61·3	58·6	53·4	47·2	45·7

A noticeable feature of Tables I. and II. is that in the cases of 13h., 18h., and 21h. the figures vary from month to month in the same general manner every year; all show a rise in the summer and a fall in the winter. There is also a certain resemblance between the figures for 13h. and 18h. in any individual year.

The run of the 7h. values is much less marked than the others, and such seasonal variation as there is does not appear clearly except in the eight-year means.

In every case it appears that the grand mean of all the values for each hour has a small value, in general a very small value. The question arises as to whether the 24 hour means in the two screens would agree equally well. Had another series been available, made at 1h , a fair answer could have been given, but a great deal can be learnt from the values at 7h., which for five months in the year are obtained before sunrise, and at 21h. which are at or after sunset in every case.

It will be seen that under nocturnal conditions at 7h. and 21h. the values are small and generally negative, and it can probably be inferred that in the early hours of the day the mean value will likewise be small. If such be the case it is safe to say that the annual mean temperatures in the two screens do not differ by more than 1 or 2 tenths degrees Fahrenheit.

The graphs below for 7h., 13h., and 18h. are plotted from the monthly mean and annual values for the 8 years 1909-1916. That for 21h. refers to the three years 1918-1920.

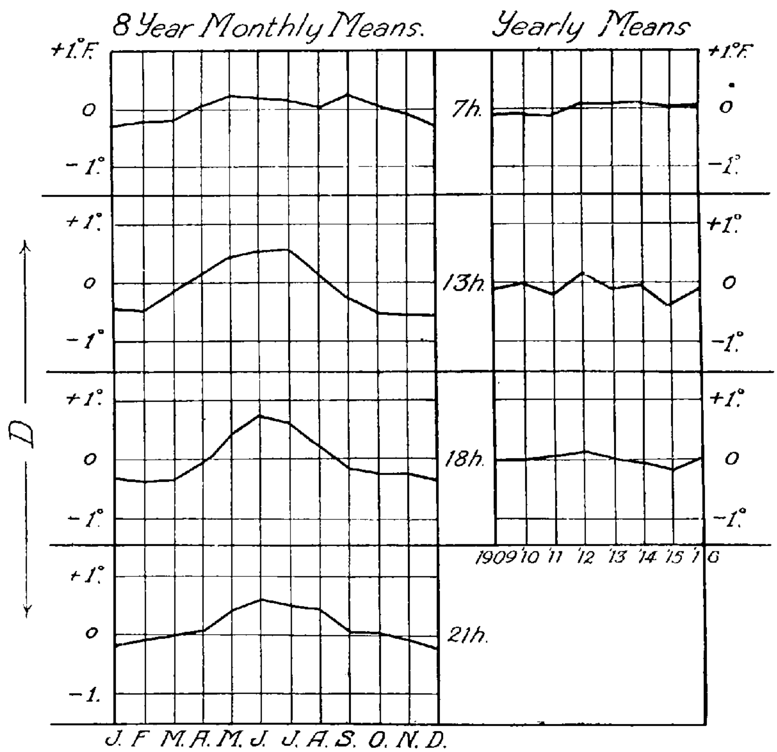


FIG. 2.

There seems, from an inspection of the yearly means, no reason to suppose that any gradual progressive change in exposure was taking place during the eight years. The year 1915 appears to be somewhat abnormal both at 18h. and at 13h., but as 1916 was normal, and there was nothing unusual noticeable about the mean at 13h. in 1920, it is probable that the weather conditions were the cause of the minima in 1915.

It will be seen that the means at every hour are positive in the summer and negative in the winter, and that there is no difference in this respect between the observations made in 1919-1920, after the climatological screen had been remodelled, and the earlier group. This is not the kind of variation which would have been expected; it has generally been found that a thermometer in the shade of a large building shows less variation in either direction than one in a freely exposed screen, and that accordingly *D* should be negative all the year round at 13h.

A very good detailed example is given by G. Hellmann in "Bericht über die Tätigkeit des Königlich Preussischen Meteorologischen Instituts," 1911, where he compares a Stevenson screen on a grass lawn with a shielded thermograph placed 13 feet above the ground in a window on the North side of the Potsdam Observatory.

Using *D* in the same sense as before, he found that at 7h. the monthly mean value of *D* was positive in the winter and negative in summer with a range between +·7°F. and −·2°F.; at 13h. it was always negative, ranging from −2·2°F. in summer to −·1°F. in winter; at 18h. it was positive in winter and negative in summer with a range between +·9°F. and −·5°F.; at 21h. it was always positive, ranging between +·6°F. in winter and +1·7°F. in summer.

One would expect greater differences at Potsdam as the diurnal range of temperature is more than twice what it is at Valencia, but the interesting point is that the character of the variation at 7h., 13h., and 18h. is diametrically opposite in the two cases. A friendly critic even suggested that the signs of all the Valencia differences were wrong, as the easiest way out of the difficulty.

The peculiarity being so marked, attempts were made to discover the reason by correlating *D* with various meteorological elements. First, the mean monthly values of duration of bright sunshine for the hour ending 13h. 10m. (approximately) G.M.T. were taken for the eight years 1909-1916 and correlated with monthly values of *D* at 13h., taken in all cases as differences from their eight year mean for the month.

There were found coefficients as follows:—

Spring.	Summer.	Autumn.	Winter.	Mean of the Four.
+·17	−·33	−·67	−·30	−·28

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There were found coefficients as follows :—

Spring.	Summer.	Autumn.	Winter.	Mean of the Four.
+·17	−·33	−·67	−·30	−·28

These coefficients are mostly too low to have much significance, but they do seem to show that sunshine has a tendency to cause negative values of *D*.

Next a set of individual daily readings at 13h. taken between December, 1919, and November, 1920, were utilised. At the beginning of 1919 the climatological screen had been modernised by the provision of a double roof, double louvres on all sides right to the bottom and a ventilated bottom, so that all direct radiation was excluded A new thermometer was also installed. *See* Table II. above for monthly means.

Correlation was made for certain months at 13h. between *D*, temperature, humidity, and sunshine; the coefficients are given in tabular form below :—

——	*D* with sunshine for the hour ending 13h. 10m.	*D* with Humidity at 13h.	*D* with Temperature at 13h.
December, 1919 ...	—·04	—	—
January, 1920	—·03	—	—
February, 1920 ...	—·44	—	—
March, 1920	—	—	—
April, 1920	—	—	—
May, 1920	+·27	·00	—·24
June, 1920	+·11	+·36	—·31
July, 1920	—·41	+·21	—·14

Sunshine appears quite inconclusive, but humidity and temperature seem to have a slight connection with *D*.

That, however, sunshine has a connection with *D* is shown from a consideration of all the days in the three months May, June, July, on which there was either a full hour's sunshine in the hour ending 13h. 10m. or none at all. Twenty-five days of the former gave a mean value of *D* of +·18 and 41 of the latter +·48.

The peculiar point about the correlation coefficients is that they indicate connections which all act in the wrong way to explain the seasonal variation of *D*.

There must be some other consideration which entirely outweighs them and to this end a classification with regard to wind direction was made, and definite results appeared at once.

The 12 months from December, 1919, to November, 1920, were chosen and grouped into four seasons. The daily wind direction and force on the Beaufort scale at 13h. for all months, and at 7h. for the three winter months, were taken out, and the values of *D* at the same hours classified with them.

The table on p. 37 gives mean values of D with each wind direction, further classified according to wind force. Figures in brackets indicate that there were in all less than four occasions of that particular wind direction, so that the bracketed means have less value than the others, they are not, however, in any way discordant.

TABLE IV.—MEAN VALUES OF D CLASSIFIED ACCORDING TO WIND DIRECTION AND FORCE; PERIOD DECEMBER, 1919, TO NOVEMBER, 1920.

—	7h.			13h.											
	Dec.-Jan.-Nov.			Dec.-Jan.-Nov.			Feb.-Mar.-Apr.			May-June-July.			Aug.-Sept.-Oct.		
	Force 1–3.	Force 4–8.	All Forces.	Force 1–3.	Force 4–8.	All Forces.	Force 1–3.	Force 4–8.	All Forces.	Force 1–3.	Force 4–8.	All Forces.	Force 1–3.	Force 4–8.	All Forces.
N. ...	—	—	(0·0)	—	—	(— ·7)	— ·8	— ·5	— ·6	0·0	— ·5	— ·4	—	—	(— ·7)
N.E. ...	+ ·7	— ·3	+ ·5	— ·4	— ·1	— ·2	— ·7	— ·4	— ·5	—	—	(— ·3)	— ·4	— ·8	— ·6
E. ...	+ ·3	+ ·4	+ ·3	—	—	(— ·4)	— ·3	0·0	— ·2	— ·4	— ·6	— ·5	— ·8	— ·4	— ·7
S.E. ...	— ·1	— ·3	— ·2	— ·5	— ·9	— ·8	—	— ·3	— ·3	—1·0	— ·7	— ·7	—1·0	— ·7	— ·7
S. ...	— ·6	— ·4	— ·5	— ·7	— ·4	— ·5	+ ·4	— ·3	— ·2	+ ·4	— ·1	0·0	— ·4	— ·2	— ·3
S.W. ...	— ·5	— ·3	— ·4	— ·5	— ·5	— ·5	+ ·8	0·0	+ ·1	+1·1	+ ·8	+ ·9	+ ·4	+ ·3	+ ·3
W. ...	— ·6	— ·5	— ·5	— ·3	— ·3	— ·3	+ ·6	+ ·1	+ ·3	+1·6	+ ·9	+1·3	+ ·5	+ ·6	+ ·5
N.W. ...	— ·2	— ·2	— ·2	—	—	(— ·6)	— ·4	— ·2	— ·3	+ ·3	— ·5	— ·1	— ·1	— ·2	— ·1

An examination of the columns of means of all forces bring out the remarkable fact that at 13h. in summer *D* is strongly positive for winds between SSW. and WNW. and negative for all other directions. The same thing holds good to a lesser extent in spring and autumn, but not in the winter. Also, the effect can be clearly traced both in high and light winds. Though the values from winds of force 4 and upwards are less than for light winds, the amount of difference which can exist with a wind of force 5 is surprising, sometimes reaching 1·0°F. A point which is not brought out by the mean values is the small amount of scatter in the individual observations with one particular wind direction; if the mean be decidedly positive, say, nearly all the individual items will be positive also.

As the frequency of Westerly winds is high, the tendency just noted in the summer is amply sufficient to outweigh all others and cause the consistent positive value of *D*. No doubt, the the same explanation holds good at 18h. also, but no investigation has been made at that hour.

At 7h. in the winter positive values occur with NE. and E. winds. This is associated, at least in part, with the cold clear mornings common with such winds. The peculiarity noted at 13h. in the summer with W. and SW. winds does not seem to have any counterpart at 7h. in the winter.

The reason for the dependence on wind direction is not known. A source of artificial heat in the building could produce systematic anomalies, but in this case they are of the wrong sign for such an explanation to be possible; we have to explain a low value on the North wall of the building at night in the winter and a high one at midday in summer.

If artificial heat in the building were the cause, it should act in the direction of warming the adjacent thermometer in winter, not of cooling it. It is clear, also, that the earlier faults in the climatological screen cannot be the cause, for no trace of any systematic change in *D* appears to have been introduced thereby, as between the mean values obtained between 1918 and 1920 and the earlier ones. The figures in Table II. for 7h. and 13h. are very similar to the eight-year means and show all their peculiarities both in type and magnitude. The annual means at 21h. show only infinitesimal variations in the three years 1918, 1919 and 1920.

A consideration of the geographical position of the Observatory shows that winds between SW. and WNW. come more immediately off the sea than in the case of other directions. In the three summer months, May, June and July, the mean temperature of the Atlantic is a few degrees below the mean air temperature at the Observatory at 13h. and 18h., in the winter it is a few degrees higher While this might perhaps have some connection with the high value of *D* in the summer, it does not fit with the winter values in Table IV. either at 7h. or 13h.

The fact, however, that the Observatory is situated about 200 yards from an estuary on the West and is but three or four miles from the open Atlantic in the same direction must introduce questions of horizontal temperature gradient different from what would prevail at an inland station, and this may have some effect on thermometers exposed near and away from large buildings.

The figures set out above represent nothing more than the attempt of a thermometer inside a screen to measure the air temperature outside it. No attempt has been made to compare either screen with an aspiration thermometer. Perhaps if this had been done some of the peculiarities found might have been explained more fully.

The general conclusions of the whole comparison seem to be :—

(1) Taking yearly means there is very little difference at any hour between the two screens. Whatever difference there is does not exceed 0·2°F. at any of the four hours tested, and it is probable that it does not exceed 0·3°F. at any hour.

(2) The modernisation of the climatological screen has made no recognisable difference in the readings relative to the Stevenson screen, and it may be inferred that crude though it was previous to 1915, the readings were very little affected thereby.

(3) The monthly mean differences between the two screens do not follow the law usually found to hold in such cases, that the temperature in a screen in the shade of a building will tend in general to depart less at any hour from the mean for the day than that in a freely exposed Stevenson screen will do, but why this is so has not been determined.

(4) The factor most intimately connected with the difference between the screens is wind-direction; wind-force has something to do with it, but in most cases only to this extent, that any peculiarity observable with a particular wind-direction for light winds will be somewhat reduced in extent when the wind is high from the same quarter.

There is a slight connection with sunshine in the direction that the temperature in the Stevenson screen will tend to be higher than in the other in bright sunny weather. A slight connection also noticed with temperature and humidity is probably not independent of the connection with sunshine.

On calm days in winter with a wind force of two or less the Stevenson tends to read low at 7h. and high at 13h., and this is especially the case when the sky is clear or nearly so.

Under these latter conditions the temperature in the Stevenson at 7h. is about ·5°F. lower than usual for the time of year in relation to the climatological; and at 13h. about 1·30°F. higher than usual. At 18h. there does not seem to be any difference.

(5) The individual values of the difference between the two screens range in general between ±2°F. About 20 per cent. of the total numerically exceed 1°F. and about 2 per cent. exceed 2°F.

NOTE ON THE STEVENSON SCREEN.

The Stevenson Screen* referred to in the foregoing paper is of the pattern described and illustrated in the *Observer's Handbook* (Editions 1908-1919). The specification was drawn up by a Committee of the Royal Meteorological Society in 1884 (*Q.J.R. Met. Soc.* 10, pp. 1 and 92, 1884).

In drawing up the revised specification the Committee had in mind the proposals of the Rev. F. W. Stow and the experiments made by the Rev. C. H. Griffith at Strathfield Turgiss in 1869. These experiments were discussed by Gaster, whose final report, dated 1880, was issued in 1889 as an appendix to the *Quarterly Weather Report* for 1879.

Some of the earliest screens had a ventilating chimney, but this seems to have been given up by the makers before 1884.

The principal modifications made by the Royal Meteorological Society Committee were :—

(*a*) The enlargement of the screen so as to give sufficient clearance for four thermometers.

(*b*) The provision of a double roof.

(*c*) The provision of boards at the bottom to cut off radiation from the ground.

In reading accounts of investigations on the subject, the likelihood of the Stevenson Screen being of the original pattern described in the *J. Scot. Met. Soc.* 1866, p. 122, is to be borne in mind. This caveat applies even to the most recent researches of Aitken (Edinburgh : Royal Society, 1920).

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* Reference may be made to an address by Edward Mawley, F.R.H.S., entitled *Shade Temperature* and published in the *Q. J. R. Met. Soc.* 1897, Vol. XXIII, in which readings of temperature taken in thermometer screens of various patterns are compared and the conditions necessary for a perfect thermometer screen are discussed.