XXIV. *Hourly Observations on the Barometer; with experimental investigations into the phenomena of its periodical oscillation.* *By* JAMES HUDSON, *Assistant Secretary and Librarian to the Royal Society. Communicated by* JOHN WILLIAM LUBBOCK, *Esq. M.A. Vice President and Treasurer.*

Read June 21, 1832.

WHEN Mr. LUBBOCK undertook, last year, an examination of the Meteorological Observations made daily at the Royal Society, during the preceding four years, he found that no satisfactory result connected with the diurnal variation of the barometer could be obtained from them, in consequence of the stated hours of observation not recurring after sufficiently small intervals of time. From the interesting nature of the phenomena of the barometer, and from the circumstance of no observations for determining the amount and peculiarities of its horary oscillation having been made at the Royal Society, I proposed to undertake as extensive a series of hourly observations on this instrument as my official duties and the state of my health would permit;—to prosecute such experimental investigations into collateral branches of the inquiry, as the anomalies presenting themselves might require;—and to institute, finally, a comparison between my own results and those derived from the labours of other observers, both in this country and on the Continent.

In endeavouring to accomplish these objects, I have been anxious in the first instance to present to the Society a series of observations, made at equal intervals of time,—in sufficient number,—through an extended period,—and with instruments, whose peculiarities of excellence or defect are well known and understood; and which, being conducted with every care, may furnish preliminary data for explaining the anomalies of its hourly and daily oscillation; determining, if possible, the laws which regulate its periodical changes; and ascertaining the circumstances which accelerate or retard the operation of these laws: being guided, in the progress of the inquiries,

by the strict inductive intimations only of the results themselves, and without reference to any particular theory or current hypothesis.

I have now the honour of laying before the Society the first portion of these hourly observations, amounting to about three thousand in number, and made in the months of April, May, June and July of 1831, and in those of January and February of 1832. The Standard Barometer of the Society has been observed for about sixteen or eighteen hours during the day, through a period of seventy-five days; and also at every hour through the whole twenty-four hours for thirty days; the Water Barometer every hour, day and night, for fifteen days; and the Mountain Barometer also every hour, day and night, for the same period. In making these observations, no pains have been spared to ensure their accuracy; and I was enabled to extend the series through the whole twenty-four hours, with three barometers for fifteen days, and afterwards with one barometer for the same period, through the assistance of Mrs. Hudson, who supplied my place as the observer for six hours of the night during these thirty days, and whose estimation in registering the instruments was found, on every comparison, to accord exactly with my own.

The Standard Barometer is fixed in the upper library, the Water Barometer within the public staircase, and the Mountain Barometer in the entrance-hall, of the Royal Society. Mr. Bevan, of Leighton Bussard, was, in 1827, requested by a Committee of the Royal Society, of which he was also appointed a member, to determine the levels of the barometers then in the possession of the Society, above a fixed mark on Waterloo-bridge. From Mr. Bevan's report on that occasion, and from the additional information with which he had subsequently the kindness to furnish me on my application to him, I am enabled to lay before the Society the relative altitudes of the three barometers employed in my observations.

Mr. Bevan adopted, as his bench-mark, the base of the columns of Waterloo-bridge, which base line, at that time, agreed nearly with the highest tide-line observed in the river, and was eleven feet six inches above the estimated mean level of the surface of the Thames at Greenwich. The presumed mean level above the sea at Sheerness was at the same time determined, from theoretical considerations, by the late Dr. Young; and with an accuracy which, I am informed, has been confirmed in a remarkable manner by actual measurement.

The following Table exhibits the relative levels of the surfaces of the fluids in the cisterns of the barometers.

	Above the bench-mark on Waterloo-bridge.		Above the mean level of the Thames at Greenwich.		Above the mean level of the Sea (presumed).	
	ft.	in.	ft.	in.	ft.	in.
Standard Barometer ..	83	$2\frac{1}{2}$	94	9	95	0
Water Barometer	42	11	54	$5\frac{1}{2}$	54	$8\frac{1}{2}$
Mountain Barometer..	41	$2\frac{1}{2}$	52	9	53	0

The Standard Barometer was made by NEWMAN, and placed in its present situation on December 12, 1822; and, at the request of a Committee of the Royal Society, it was constructed with great care under the direction of Mr. DANIELL, who has, in his Meteorological Essays, given a full account of the mode and principles of its construction*. Its peculiar advantages are, a tube of great diameter, a cistern of unusual extent of surface, and an apparatus for determining the height of the mercurial column, so delicate and perfect, that, with the unassisted eye, it may be determined, on successive trials, with a difference only in the ten-thousandths of an inch. The cistern is a cylinder of turned mahogany, with an internal diameter of 5·3 inches, and which terminates above, in a rectangular pillar of polished mahogany, encasing the tube, $1\frac{1}{4}$ inch wide, and $2\frac{1}{2}$ inches deep, rising $25\frac{1}{2}$ inches above the level of the mercury, and bearing on its upper surface, and firmly screwed into it, a metallic plate, on which rests the brass scale, with the divisions and vernier. The

* I have been informed by Sir JOHN HERSCHEL, that the Royal Society's barometer has been compared, intermediately, with almost every other standard barometer in Europe. A fine mountain barometer, belonging to him, and made by Mr. TROUGHTON, having being compared with it, previously to his setting out on an extensive tour on the Continent, in which it accompanied him, was found to give on his return, as Mr. HENDERSON related to me, exactly the same difference as that obtained before his leaving England, having been in the mean time the medium of comparison with a considerable number of Continental instruments. At his suggestion, I have opened a permanent registry for these standard comparisons. This barometer, with which Sir JOHN HERSCHEL had done me the honour of making some corresponding observations at Slough, is now entrusted to the care of Mr. HENDERSON, the Astronomer Royal at the Cape of Good Hope, who has promised to undertake with me a series of observations to be made simultaneously in that Colony and in London. Mr. DUNLOP, the Astronomer Royal at Paramatta, in New South Wales, and Mr. FORBES, now on a scientific tour in Italy and Greece, will each, I have reason to believe, be able to undertake with me similar correspondent observations.

tube has an internal diameter of 0·53 inch, and the neutral point of the instrument is 30·576 inches, at 54°.

The Water Barometer forms the subject of a paper by Mr. DANIELL, printed in the present volume of the Transactions, and containing a full statement of its peculiarities and the mode of its construction.

The Mountain Barometer is the property of Mr. DANIELL, and is considered by him as an almost perfect instrument. It has a tube of 0·15 inch and a cistern of 1·2 inch internal diameter, with a brass scale extending to the surface of the mercury in the cistern; and is the first barometer to which Mr. DANIELL applied the platina guard for preventing the insinuation of air into the vacuum chamber of the instrument. Its neutral point is 30·080, at 65°.

The regularity with which the barometer, in tropical climates, proceeds in its periodical rise and fall from day to day with almost uninterrupted progression, has long been observed by our travellers and philosophers. This periodical oscillation, as the parallel of observation becomes more remote from the equator, gradually ceases to be obvious in the observations of a single day; and in its place we have the violent and irregular movements of the mercurial column, so well known in our own and other extra-tropical climates, and in which the effect of no constant law is apparent. By classing, however, the observations made at the same hours on several successive days, and deriving from their union the hours of one mean day, it has been found that these accidental variations destroy or neutralize each other, and allow the constant, or equatorial, oscillation to become appreciable and subject to investigation *. The results now presented to the Society consist of eight such mean days, each of them derived from observations made on fifteen days, a period I have adopted as the standard, and which appears to be amply extensive for clearing the result from the interference of the accidental variations. In forming each mean day, all the observations made at a given hour, on successive days, have been collected together, their sum taken, and a mean result for the given hour obtained by dividing that sum by fifteen, the number of the observations. A mean hourly result for the temperature has been obtained in the same manner. Having thus derived a mean quantity for each

* The clear and striking statement of these phenomena, given by Sir JOHN HERSCHEL in his Preliminary Discourse, (§ 228.) suggested the original idea of the present observations.

hour of the mean day, a total mean of the whole of the observations made during the given period, has then been obtained, and each mean hourly quantity being referred to it, the hourly variations from this general mean have been determined. These hourly results are detailed in eleven Tables.

In the first five sets of fifteen days' observations the instruments were registered as nearly at the exact hour as was found to be practicable, and as few of the observations were omitted to be taken as circumstances would allow. The mean times of observation are therefore given in these five sets; and where an hour has passed unobserved, the place of a real observation has been supplied by a mean quantity derived from the two nearest observations. I have reason to believe, from a variety of trials which I have made, that when the interval of time elapsed is short, and the omission of an observation occurs only occasionally, and without periodical recurrence, that this mode of supplying the vacancy, not by an arbitrary quantity but a derived mean, is by far the simplest and best, and less injurious to the result than that of allowing the vacancy to remain unoccupied *. In the Tables the amount of such interpolations is stated; and from the number of the observations, and the small extent of possible error which could be made, it is probable that the mean result is little, if at all, different from that which an entirely unbroken series of observations during these five periods would have given. In the remaining three sets, the observations were made in every instance at the complete hour, and without the omission of a single observation.—The corrections have been applied to the mean results of the observations. Those of the Standard Barometer have been corrected for the relative superficial capacities of the cistern and the tube, for the constant amount of capillary depression (−·004), and for temperature. The Mountain Barometer, in addition to these, (the capillary depression being assumed as = −·044) has been corrected for its brass continuous scale. The Reduction Tables for the English Barometer, drawn up and published under the direction of Professor SCHUMACHER, first in his Sammlung von Hülfstafeln, and afterwards, with the brass scale referred, at Mr. BAILY's suggestion, to

* In the former case, the error is limited by the small extent of the *hourly* oscillation; in the latter, it extends to the mean *daily* variation at the particular hour for the given period. This daily mean, so widely remote in general from the single hourly observation, is, in effect, by this last process, made the substitute of it,—the mean of any set of quantities being equal to the mean of such quantities increased in number by the addition of the former mean.

the standard temperature of 62°, in the fifth volume of the Astronomische Nachrichten, have been employed to reduce the results of the observations to zero *. The first of these tables is intended for those instruments which are not supplied with a brass scale, and has reference only to the expansion of mercury. By this table the observations of the Standard Barometer have been reduced to 32° F. The second table is intended for those instruments which are furnished with a continuous brass scale, the temperature of which it reduces to 62° F., (the standard temperature of the English linear measures,) and the mercury to 32°, as before. The observations of the Mountain Barometer have been reduced by this second table. The observations with the Water Barometer have been corrected only for the expansive power of the vapour in its vacuum chamber at the temperature of the thermometer attached to the vernier, by Mr. DALTON's Table, given in Dr. HENRY's Elements of Chemistry, and adapted to the present purpose by assuming the mean specific gravity of mercury (that of the Standard Barometer) as 13·624.

First set of fifteen days' Observations. April 26th to May 10th, 1831.

Mean Times of Observation.		Number of Observations at each hour.	Number of Interpolations.	Barometer.	Attached Thermometer.	Barometer reduced to 32°.	Difference of Barometer from Mean.	Difference of Thermometer from Mean.
h	m			inches.	°	inches.		
A.M. 9	0	15	0	29·720	56·7	29·641	+·007	−0·5
10	4	10	5	29·718	57·6	29·636	+·002	+0·4
11	4	14	1	29·713	58·2	29·630	−·004	+1·0
12	3	9	6	29·710	58·6	29·625	−·009	+1·4
P.M. 1	6	12	3	29·708	58·8	29·623	−·011	+1·6
2	7	12	3	29·704	59·0	29·618	−·016	+1·8
3	0	15	0	29·694	58·9	29·608	−·026	+1·7
4	4	10	5	29·694	58·7	29·609	−·025	+1·5
5	2	11	4	29·696	58·2	29·613	−·021	+1·0
6	3	9	6	29·701	57·6	29·619	−·015	+0·4
7	2	7	8	29·708	56·9	29·628	−·006	−0·3
8	2	9	6	29·718	56·2	29·641	+·007	−1·0
9	2	9	6	29·725	55·7	29·649	+·015	−1·5
10	2	8	7	29·729	55·3	29·655	+·021	−1·9
11	2	8	7	29·733	54·6	29·661	+·027	−2·6
12	3	9	6	29·737	54·2	29·667	+·033	−3·0
Mean		10	5	29·713	57·2	29·634		

* I am indebted to the liberality and kindness of Professor SCHUMACHER for fifty copies of these valuable Tables, for distribution among such meteorological observers in this country as may feel desirous of possessing them.

Second set of fifteen days' Observations. May 11th to May 25th, 1831.

Mean Times of Observation.	Number of Observations at each hour.	Number of Interpolations.	Barometer.	Attached Thermometer.	Barometer reduced to 32°.	Difference of Barometer from Mean.	Difference of Thermometer from Mean.
h m			inches.	°	inches.		
A.M. 9 0	15	0	30·004	62·1	29·912	+·025	−0·2
10 5	15	0	30·000	62·5	29·907	+·020	+0·2
11 3	14	1	29·997	62·6	29·903	+·016	+0·3
12 3	12	3	29·994	62·9	29·900	+·013	+0·6
P.M. 1 3	12	3	29·989	63·2	29·894	+·007	+0·9
2 4	13	2	29·983	63·5	29·887	·000	+1·2
3 1	15	0	29·972	63·9	29·875	−·012	+1·6
4 1	12	3	29·970	63·9	29·873	−·014	+1·6
5 2	14	1	29·965	63·7	29·872	−·015	+1·4
6 2	10	5	29·965	63·2	29·870	−·017	+0·9
7 6	11	4	29·969	62·6	29·875	−·012	+0·3
8 6	9	6	29·972	61·9	29·881	−·006	−0·4
9 7	9	6	29·978	61·3	29·888	+·001	−1·0
10 3	8	7	29·980	60·8	29·892	+·005	−1·5
11 4	9	6	29·978	60·2	29·892	+·005	−2·1
12 1	8	7	29·963	59·6	29·878	−·009	−2·7
Mean	12	3	29·980	62·3	29·887		

Third set of fifteen days' Observations. May 26th to June 9th, 1831.

Mean Times of Observation.	Number of Observations at each hour.	Number of Interpolations.	Barometer.	Attached Thermometer.	Barometer reduced to 32°.	Difference of Barometer from Mean.	Difference of Thermometer from Mean.
h m			inches.	°	inches.		
A.M. 9 0	15	0	30·010	63·4	29·914	+·024	−0·8
10 2	14	1	30·010	63·7	29·913	+·023	−0·5
11 1	15	0	30·010	64·1	29·912	+·022	−0·1
12 2	13	2	30·005	64·3	29·906	+·016	+0·1
P.M. 1 3	14	1	29·993	65·2	29·892	+·002	+1·0
2 0	15	0	29·988	65·7	29·885	−·005	+1·5
3 0	15	0	29·982	66·0	29·878	−·012	+1·8
4 3	14	1	29·977	66·0	29·873	−·017	+1·8
5 1	14	1	29·973	65·6	29·870	−·020	+1·4
6 4	15	0	29·973	65·2	29·872	−·018	+1·0
7 0	14	1	29·971	64·6	29·871	−·019	+0·4
8 3	13	2	29·977	63·7	29·880	−·010	−0·5
9 3	14	1	29·985	63·0	29·890	·000	−1·2
10 2	12	3	29·985	62·6	29·891	+·001	−1·6
11 1	14	1	29·987	62·2	29·895	+·005	−2·0
11 49	14	1	29·982	62·0	29·890	·000	−2·2
Mean	14	1	29·988	64·2	29·890		

Fourth set of fifteen days' Observations. June 10th to June 24th, 1831.

Mean Times of Observation.	Number of Observations at each hour.	Number of Interpolations.	Barometer.	Attached Thermometer.	Barometer reduced to 32°.	Difference of Barometer from Mean.	Difference of Thermometer from Mean.
h m			inches.	°	inches.		
A.M. 6 4	6	9	29·996	69·3	29·882	—·002	+0·3
7 2	8	7	29·997	70·4	29·880	—·004	+1·4
8 4	10	5	29·994	70·2	29·878	—·006	+1·2
9 0	15	0	29·992	69·8	29·877	—·007	+0·8
10 1	14	1	29·992	69·5	29·878	—·006	+0·5
11 2	14	1	29·992	69·0	29·879	—·005	0·0
12 1	14	1	29·992	68·9	29·880	—·004	—0·1
P.M. 1 0	14	1	29·992	69·1	29·880	—·004	+0·1
2 0	14	1	29·996	68·7	29·884	·000	—0·3
3 0	15	0	29·997	69·5	29·883	—·001	+0·5
4 2	13	2	29·997	69·6	29·882	—·002	+0·6
5 3	14	1	29·994	69·5	29·880	—·004	+0·5
6 0	14	1	29·995	69·2	29·882	—·002	+0·2
7 2	14	1	29·997	68·7	29·885	+·001	—0·3
8 3	12	3	30·003	68·1	29·893	+·009	—0·9
9 5	14	1	30·008	67·5	29·900	+·016	—1·5
10 0	13	2	30·007	67·2	29·900	+·016	—1·8
11 2	12	3	30·003	66·7	29·897	+·013	—2·3
Mean	12	3	29·997	69·0	29·884		

Fifth set of fifteen days' Observations. June 24th to July 13th, 1831.

Mean Times of Observation.	Number of Observations at each hour.	Number of Interpolations.	Barometer.	Attached Thermometer.	Barometer reduced to 32°.	Difference of Barometer from mean.	Difference of Thermometer from mean.
h m			inches.	°	inches.		
A.M. 6 12	11	4	29·995	64·6	29·896	+·020	—2·9
7 2	15	0	30·000	65·8	29·897	+·021	—1·7
8 6	15	0	30·000	66·2	29·896	+·020	—1·3
9 0	15	0	29·998	66·7	29·892	+·016	—0·8
10 1	15	0	29·998	67·2	29·891	+·015	—0·3
11 2	15	0	29·993	67·7	29·884	+·008	+0·2
12 5	13	2	29·988	68·0	29·878	+·002	+0·5
P. M. 1 0	14	1	29·984	68·4	29·873	—·003	+0·9
2 3	15	0	29·979	68·7	29·867	—·009	+1·2
3 0	15	0	29·975	69·0	29·862	—·014	+1·5
4 5	15	0	29·970	69·2	29·857	—·019	+1·7
5 2	15	0	29·968	69·1	29·855	—·021	+1·6
6 2	14	1	29·968	68·9	29·856	—·020	+1·4
7 2	14	1	29·970	68·1	29·861	—·015	+0·6
8 3	15	0	29·974	67·9	29·864	—·012	+0·4
9 3	14	1	29·982	67·3	29·874	—·002	—0·2
10 7	10	5	29·986	66·8	29·880	+·004	—0·7
11 4	10	5	29·989	66·2	29·885	+·009	—1·3
Mean	14	1	29·984	67·5	29·876		

Sixth set of fifteen days' Observations. July 14th to July 28th, 1831.

I. Water Barometer.

Times of Observation.	Number of Observations at each hour.	Water Barometer.	Attached Thermometer.	Immersed Thermometer.	Subjacent Thermometer.	Water Barometer corrected for vapour.	Difference of Water Barometer from Mean.
h		inches.	°	°	°	inches.	
A.M. 1	15	392·979	64·3	64·4	63·9	401·194	−·114
2	15	392·985	64·1	64·3	63·9	401·146	−·162
3	15	393·019	63·9	64·3	63·9	401·125	−·183
4	15	393·055	63·9	63·9	63·8	401·161	−·147
5	15	393·198	63·6	63·6	63·8	401·223	−·085
6	15	393·348	63·3	63·3	63·8	401·304	−·004
7	15	393·464	63·1	63·0	63·8	401·366	+·058
8	15	393·469	63·0	62·9	63·8	401·344	+·036
9	15	393·384	63·4	62·9	63·8	401·368	+·060
10	15	393·255	63·8	62·8	63·8	401·334	+·026
11	15	393·081	64·4	63·0	63·8	401·324	+·016
12	15	392·901	65·2	63·4	63·9	401·348	+·040
P.M. 1	15	392·640	66·1	64·0	64·0	401·318	+·010
2	15	392·494	66·7	64·4	64·0	401·336	+·028
3	15	392·430	66·5	64·8	64·1	401·217	−·091
4	15	392·391	66·5	65·1	64·2	401·178	−·130
5	15	392·386	66·5	65·3	64·2	401·173	−·135
6	15	392·457	66·4	65·4	64·3	401·217	−·091
7	15	392·591	66·2	65·4	64·3	401·297	−·011
8	15	392·804	65·8	65·3	64·3	401·401	+·093
9	15	392·969	65·4	65·3	64·3	401·470	+·162
10	15	393·046	65·3	65·2	64·2	401·520	+·212
11	15	393·116	65·0	65·1	64·2	401·508	+·200
12	15	393·157	64·9	65·0	64·2	401·522	+·214
Mean		392·943	64·9	64·3	64·0	401·308	

The attached thermometer is let into the moveable brass cylinder connected with the vernier and encasing the outside of the glass tube.

The immersed thermometer is secured within the tube of the barometer, a few feet below the general surface of the column of the water.

The subjacent thermometer, by NEWMAN, was placed immediately under the cistern of the barometer, and, its variations being found so very inconsiderable, it was registered only at intervals of four or five hours during the day, and the series completed for each hour by interpolation.

Sixth set of fifteen days' Observations. July 14th to July 28th, 1831.

II. Royal Society's Standard Barometer.

Times of Observation.	Number of Observations at each hour.	Barometer.	Attached Thermometer.	Thermometer at Vacuum Chamber.	Barometer reduced to 32°.	Difference of Barometer from Mean.
h		inches.	°	°	inches.	
A.M. 1	15	29·917	65·9	65·0	29·812	—·004
2	15	29·913	65·6	64·7	29·809	—·007
3	15	29·911	65·4	64·5	29·808	—·008
4	15	29·902	65·5	64·4	29·799	—·017
5	15	29·907	65·3	64·5	29·804	—·012
6	15	29·915	65·6	65·3	29·811	—·005
7	15	29·924	66·3	66·3	29·818	+·002
8	15	29·928	67·0	66·7	29·821	+·005
9	15	29·931	68·3	67·7	29·820	+·004
10	15	29·932	68·6	68·0	29·820	+·004
11	15	29·931	69·6	68·2	29·816	·000
12	15	29·931	69·9	68·3	29·816	·000
P.M. 1	15	29·929	70·0	68·7	29·813	—·003
2	15	29·927	70·2	69·0	29·811	—·005
3	15	29·924	70·4	69·0	29·806	—·010
4	15	29·922	70·4	68·8	29·804	—·012
5	15	29·918	70·2	68·5	29·801	—·015
6	15	29·919	70·0	68·0	29·802	—·014
7	15	29·923	69·5	67·5	29·808	—·008
8	15	29·932	68·7	66·7	29·820	+·004
9	15	29·944	67·9	66·5	29·834	+·018
10	15	29·946	67·4	66·0	29·838	+·022
11	15	29·948	66·9	65·8	29·842	+·026
12	15	29·947	66·6	65·6	29·841	+·025
		29·926	68·0	66·8	29·816	

The thermometer placed in contact with that portion of the glass tube of the Standard Barometer forming its vacuum chamber, was a very delicate instrument, made by CRICHTON.

Sixth set of fifteen days' Observations. July 14th to July 28th, 1831.

III. Mountain Barometer.

Times of Observation.	Number of Observations at each hour.	Barometer.	Attached Thermometer.	Barometer reduced.	Difference of Barometer from Mean.
h		inches.	°	inches.	
A.M. 1	15	29·871	63·9	29·816	—·007
2	15	29·867	63.7	29·813	—·010
3	15	29·865	63·3	29·813	—·010
4	15	29·861	63·0	29·809	—·014
5	15	29·862	62·7	29·810	—·013
6	15	29·868	62·7	29·816	—·007
7	15	29·874	62·8	29·822	—·001
8	15	29·877	63·1	29·824	+·001
9	15	29·878	63·7	29·824	+·001
10	15	29·879	64·0	29·824	+·001
11	15	29·878	64·2	29·822	—·001
12	15	29·882	65·1	29·824	+·001
P.M. 1	15	29·883	65·4	29·824	+·001
2	15	29·879	65·7	29·819	—·004
3	15	29·877	65·8	29·817	—·006
4	15	29·874	65·9	29·814	—·009
5	15	29·872	65·6	29·813	—·010
6	15	29·873	66·0	29·813	—·010
7	15	29·878	65·8	29·818	—·005
8	15	29·887	65·6	29·828	+·005
9	15	29·896	65·4	29·838	+·015
10	15	29·899	65·1	29·842	+·019
11	15	29·902	64·9	29·845	+·022
12	15	29·901	64·6	29·845	+·022
Mean		29·879	64·5	29·823	

The direction of the wind and state of the sky were also registered every hour daily, from 3 A.M. to 9 P.M., and striking changes in the weather noted, during these fifteen days.

Corresponding Variations of the Water, Standard, and Mountain Barometers; and their Thermometers.

Times of Observation.	Water Barometer reduced to the standard of Mercury.	Attached Thermometer.	Immersed Thermometer.	Subjacent Thermometer.	Royal Society's Standard Barometer.	Attached Thermometer.	Thermometer at Vacuum Chamber.	Mountain Barometer.	Attached Thermometer.
h		°	°	°		°	°		°
A.M. 1	−·008	−0·6	+0·1	−0·1	−·004	−2·1	−1·8	−·007	−0·6
2	−·012	−0·8	0·0	−0·1	−·007	−2·4	−2·1	−·010	−0·8
3	−·013	−1·0	0·0	−0·1	−·008	−2·6	−2·3	−·010	−1·2
4	−·011	−1·0	−0·4	−0·2	−·017	−2·5	−2·4	−·014	−1·5
5	−·006	−1·3	−0·7	−0·2	−·012	−2·7	−2·3	−·013	−1·8
6	·000	−1·6	−1·0	−0·2	−·005	−2·4	−1·5	−·007	−1·8
7	+·004	−1·8	−1·3	−0·2	+·002	−1·7	−0·5	−·001	−1·7
8	+·003	−1·9	−1·4	−0·2	+·005	−1·0	−0·1	+·001	−1·4
9	+·004	−1·5	−1·4	−0·2	+·004	+0·3	+0·9	+·001	−0·8
10	+·002	−1·1	−1·5	−0·2	+·004	+0·6	+1·2	+·001	−0·5
11	+·001	−0·5	−1·3	−0·2	·000	+1·6	+1·4	−·001	−0·3
12	+·003	+0·3	−0·9	−0·1	·000	+1·9	+1·5	+·001	+0·6
P.M. 1	+·001	+1·2	−0·3	0·0	−·003	+2·0	+1·9	+·001	+0·9
2	+·002	+1·8	+0·1	0·0	−·005	+2·2	+2·2	−·004	+1·2
3	−·007	+1·6	+0·5	+0·1	−·010	+2·4	+2·2	−·006	+1·3
4	−·009	+1·6	+0·8	+0·2	−·012	+2·4	+2·0	−·009	+1·4
5	−·010	+1·6	+1·0	+0·2	−·015	+2·2	+1·7	−·010	+1·1
6	−·007	+1·5	+1·1	+0·3	−·014	+2·0	+1·2	−·010	+1·5
7	−·001	+1·3	+1·1	+0·3	−·008	+1·5	+0·7	−·005	+1·3
8	+·007	+0·9	+1·0	+0·3	+·004	+0·7	−0·1	+·005	+1·1
9	+·012	+0·5	+1·0	+0·3	+·018	−0·1	−0·3	+·015	+0·9
10	+·016	+0·4	+0·9	+0·2	+·022	−0·6	−0·8	+·019	+0·6
11	+·015	+0·1	+0·8	+0·2	+·026	−1·1	−1·0	+·022	+0·4
12	+·016	0·0	+0·7	+0·2	+·025	−1·4	−1·2	+·022	+0·1
Mean...	29·508	64·9	64·3	64·0	29·816	68·0	66·8	29·823	64·5

Seventh set of fifteen days' Observations. Jan. 17th to Jan. 31st, 1832 *.

Times of Observation.	Number of Observations at each hour.	Barometer.	Attached Thermometer.	Barometer reduced to 32°.	Difference of Barometer from mean.	Difference of Thermometer from mean.
h		inches.	°	inches.		
A.M. 1	15	30·190	44·0	30·154	+·018	0·0
2	15	30·185	44·1	30·149	+·013	+0·1
3	15	30·181	44·1	30·145	+·009	+0·1
4	15	30·178	44·0	30·142	+·006	0·0
5	15	30·173	44·0	30·137	+·001	0·0
6	15	30·172	43·9	30·136	·000	−0·1
7	15	30·173	43·8	30·138	+·002	−0·2
8	15	30·178	43·7	30·143	+·007	−0·3
9	15	30·185	43·6	30·150	+·014	−0·4
10	15	30·193	43·6	30·158	+·022	−0·4
11	15	30·194	43·6	30·159	+·023	−0·4
12	15	30·183	43·6	30·148	+·012	−0·4
P.M. 1	15	30·168	43·9	30·132	−·004	−0·1
2	15	30·160	44·1	30·124	−·012	+0·1
3	15	30·160	44·2	30·123	−·013	+0·2
4	15	30·159	44·2	30·122	−·014	+0·2
5	15	30·161	44·2	30·124	−·012	+0·2
6	15	30·163	44·3	30·126	−·010	+0·3
7	15	30·165	44·2	30·128	−·008	+0·2
8	15	30·167	44·1	30·131	−·005	+0·1
9	15	30·165	44·1	30·129	−·007	+0·1
10	15	30·163	44·2	30·126	−·010	+0·2
11	15	30·164	44·3	30·127	−·009	+0·3
12	15	30·156	44·2	30·119	−·017	+0·2
Mean....		30·172	44·0	30·136		

* The Rev. Mr. Hussey made, during this period, fifty-five corresponding observations at the Rectory at Chiselhurst, with one of Fortin's best barometers. I am indebted to his kindness for a copy of these observations, and, on a future occasion, I propose to compare them with my own.

Eighth set of fifteen days' Observations. Feb. 6th to Feb. 20th, 1832.

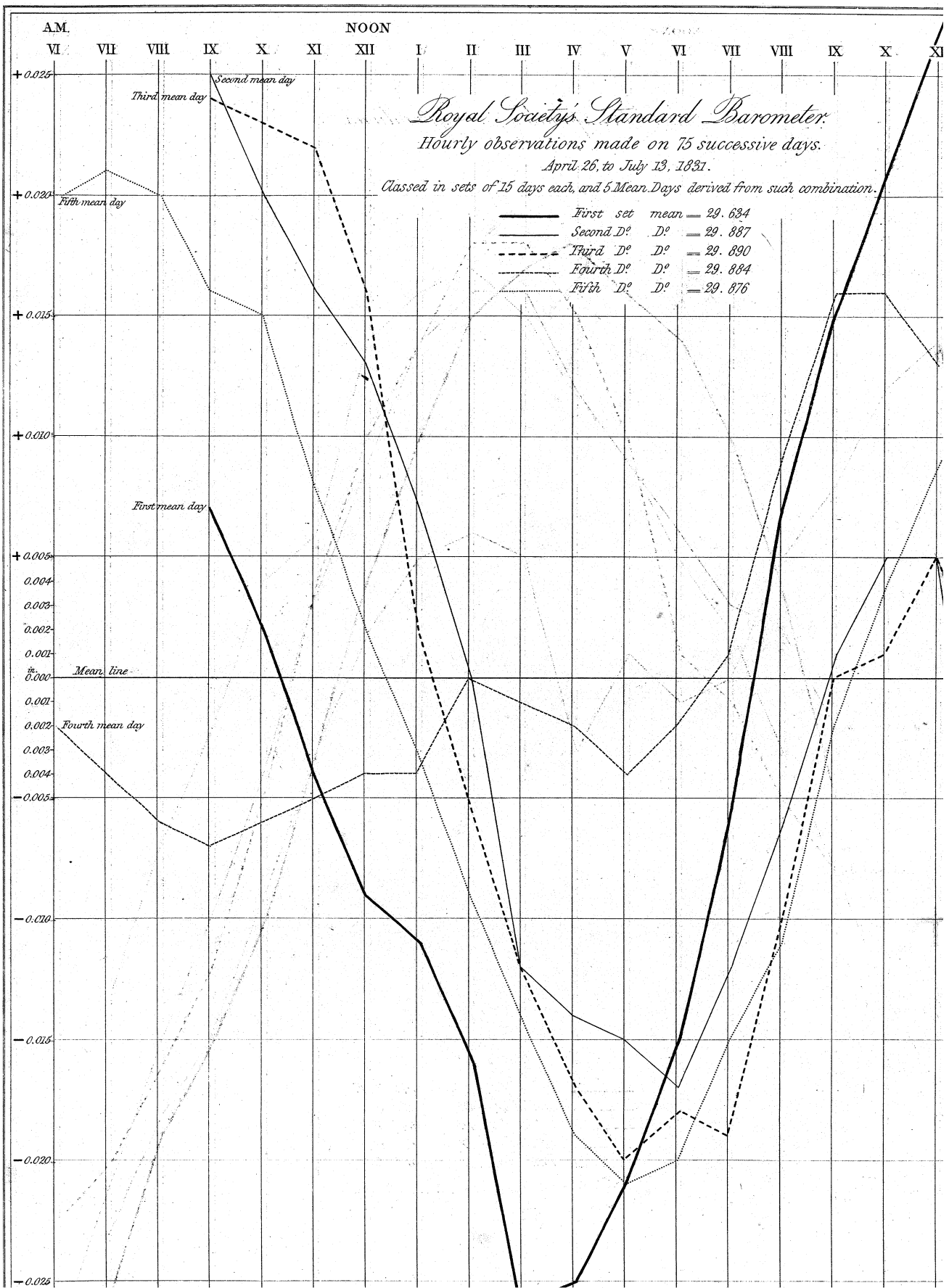
Times of Observation.	Number of Observations at each hour.	Barometer.	Attached Thermometer.	External Thermometer.	Barometer reduced to 32°.	Difference of Barometer from mean.	Difference of attached Thermometer from mean.	Difference of external Thermometer from mean.
h		inches.	°	°	inches.		°	°
A.M. 8	15	30·144	42·7	37·6	30·112	+·001	−1·4	−2·6
9	15	30·149	43·0	38·1	30·116	+·005	−1·1	−2·1
10	15	30·154	43·3	39·2	30·120	+·009	−0·8	−1·0
11	15	30·156	43·7	40·3	30·121	+·010	−0·4	+0·1
12	15	30·149	44·2	41·4	30·112	+·001	+0·1	+1·2
P.M. 1	15	30·141	44·6	42·1	30·103	−·008	+0·5	+1·9
2	15	30·132	45·0	41·8	30·093	−·018	+0·9	+1·6
3	15	30·131	45·1	42·4	30·092	−·019	+1·0	+2·2
4	15	30·132	45·0	41·8	30·093	−·018	+0·9	+1·6
5	15	30·138	44·8	41·3	30·100	−·011	+0·7	+1·1
6	15	30·147	44·4	40·8	30·110	−·001	+0·3	+0·6
7	15	30·152	44·2	40·3	30·115	+·004	+0·1	+0·1
8	15	30·153	43·9	39·9	30·117	+·006	−0·2	−0·3
9	15	30·154	43·8	39·6	30·119	+·008	−0·3	−0·6
10	15	30·155	43·8	39·2	30·120	+·009	−0·3	−1·0
11	15	30·155	43·7	38·8	30·120	+·009	−0·4	−1·4
12	15	30·156	43·6	38·4	30·121	+·010	−0·5	−1·8
Mean		30·147	44·1	40·2	30·111			

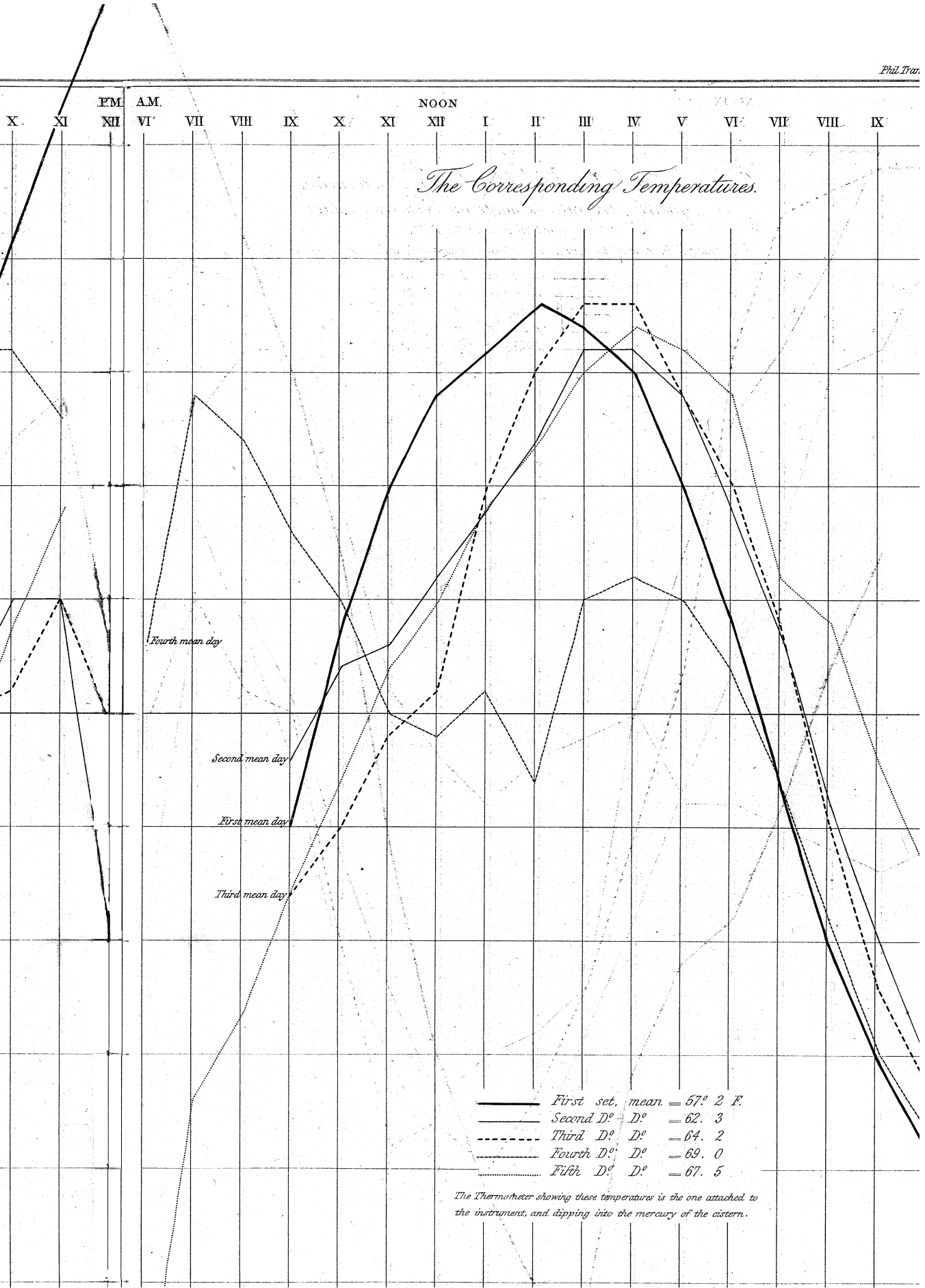
The external thermometer registered during this period was very accurate and sensible, and constructed many years ago by NAIRNE.

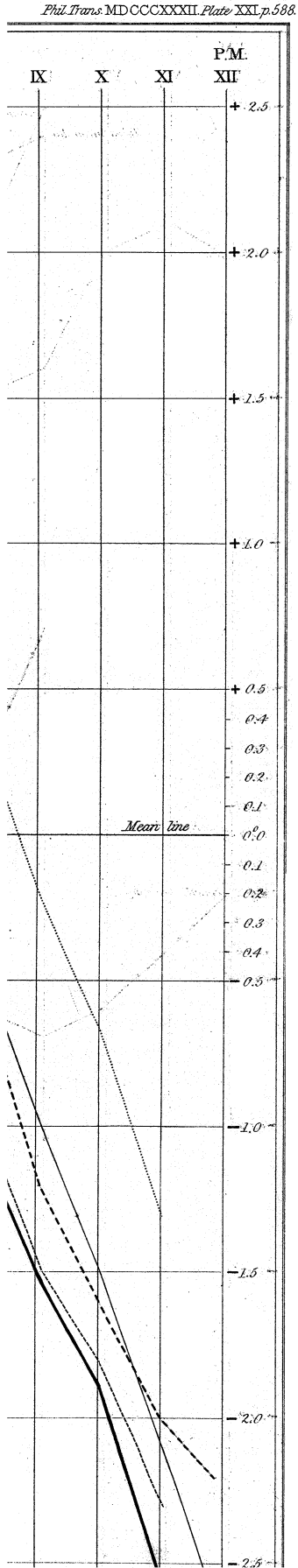
The most striking results which these observations have afforded, are exhibited, by means of linear representations, in the four Plates which accompany this paper. The respective variations from each general mean are referred, according to a given scale, to the mean line, and their points of distance from it, at each successive hour, are connected together by means of straight lines. The barometrical changes, and the variations of temperature, are each referred to the same scale, ·001 of an inch in the former case being equal to ·1 of a degree in the latter.

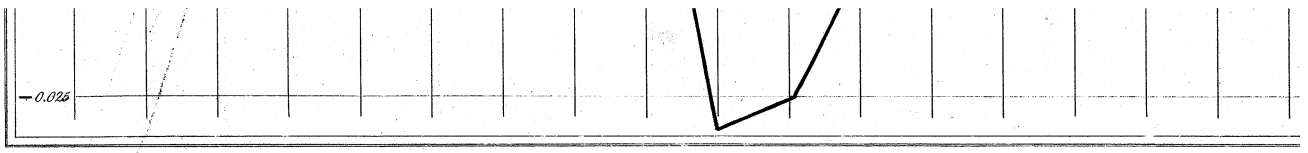
Plate XXI. represents the mean hourly variations of the Standard Barometer, and also those of the Attached Thermometer, in the first five sets of observations; and displays,—

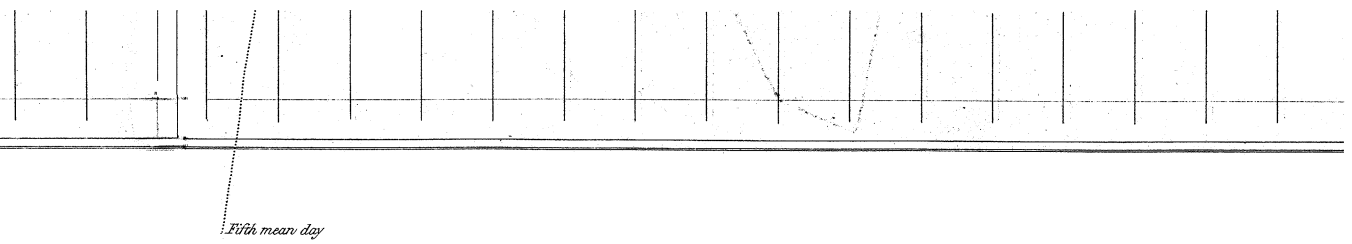
1. The general similarity of character, and of amount, in the mean variations, compared with the irregular changes of the barometer under ordinary circumstances.

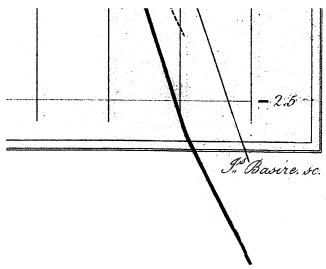

A.M.
NOON
VI VII VIII IX X XI XII I II III IV V VI VII VIII IX X XI
+0.025
+0.020
+0.015
+0.010
+0.005
0.004
0.003
0.002
0.001
in. 0.000
0.001
0.002
0.003
0.004
−0.005
−0.010
−0.015
−0.020
−0.025
Second mean day
Third mean day
Fifth mean day
First mean day
Mean line
Fourth mean day
Royal Society's Standard Barometer.
Hourly observations made on 75 successive days.
April 26, to July 13, 1831.
Classed in sets of 15 days each, and 5 Mean Days derived from such combination.
First set mean = 29. 634
Second Dº Dº = 29. 887
Third Dº Dº = 29. 890
Fourth Dº Dº = 29. 884
Fifth Dº Dº = 29. 876


P.M.
A.M.
NOON
X XI XII VI VII VIII IX X XI XII I II III IV V VI VII VIII IX
The Corresponding Temperatures.
Fourth mean day
Second mean day
First mean day
Third mean day
First set, mean = 57.° 2 F.
Second D.° D.° = 62. 3
Third D.° D.° = 64. 2
Fourth D.° D.° = 69. 0
Fifth D.° D.° = 67. 5
The Thermometer showing these temperatures is the one attached to the instrument, and dipping into the mercury of the cistern.


P.M.
IX
X
XI
XII
+ 2.5
+ 2.0
+ 1.5
+ 1.0
+ 0.5
0.4
0.3
0.2
0.1
Mean line
0.0
0.1
0.2
0.3
0.4
0.5
1.0
1.5
2.0
2.5


-0.025

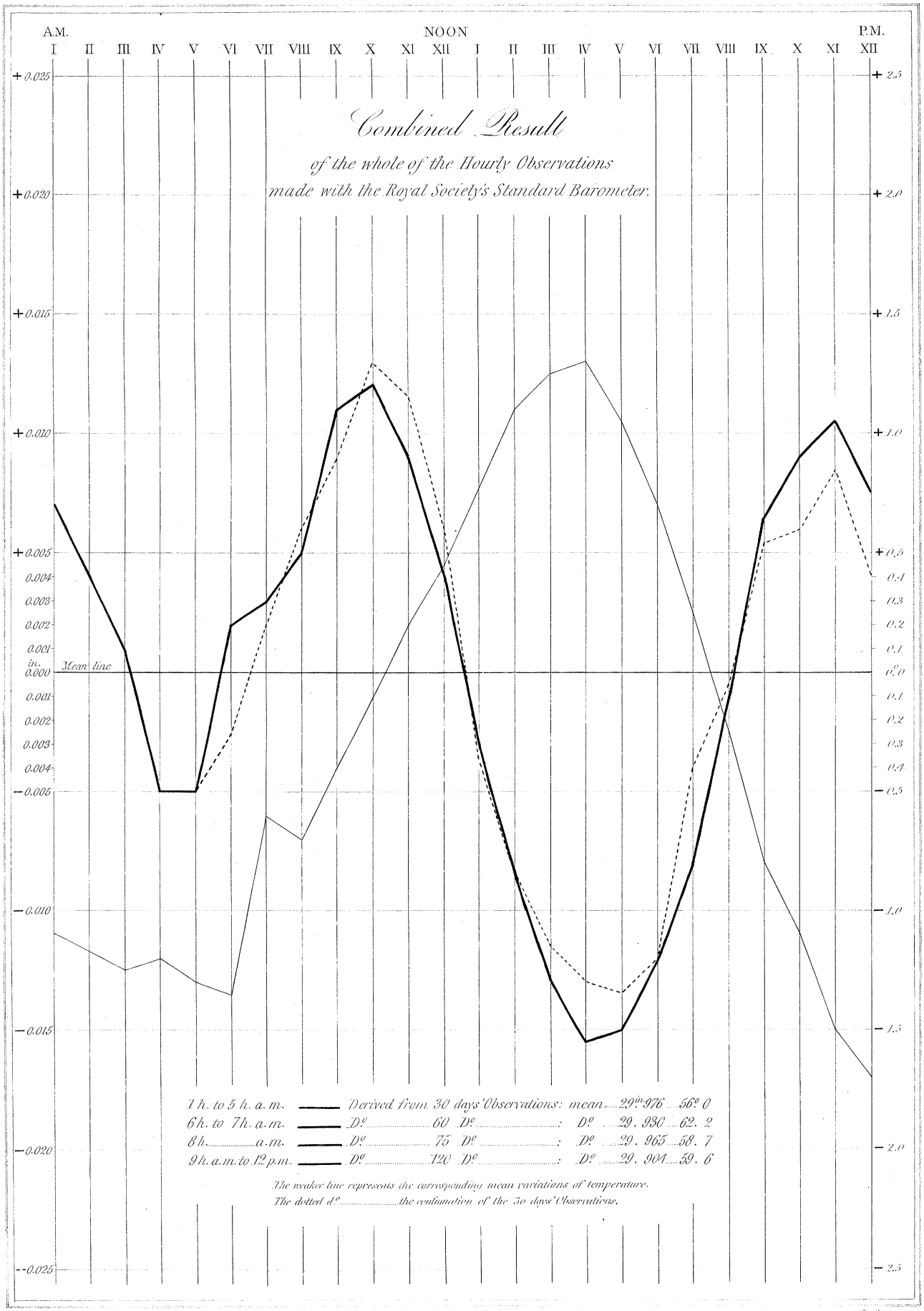

Fifth mean day


2.5
P. Basire, sc.


A.M.
NOON
P.M.
I II III IV V VI VII VIII IX X XI XII I II III IV V VI VII VIII IX X XI XII
+ 0.025
+ 0.020
+ 0.015
+ 0.010
+ 0.005
0.004
0.003
0.002
0.001
in. 0.000
0.001
0.002
0.003
0.004
− 0.005
− 0.010
− 0.015
− 0.020
− 0.025
Mean line
The Water Barometer, Standard Barometer and Mountain Barometer
observed simultaneously, every hour; for 15 days. July 14 to 28, 1831.
Represents the Mean Variations of the Water Barometer ..... Mean of the whole 29.508
Standard ..... D°. 29.816
Mountain ..... D°. 29.823
The variations of the Water Barometer are reduced to the standard of those of the Mercurial Barometers, by being divided by 13.6, the sp. gr. of the Mercury.

Phil. Trans. MDCCCXXXII. *Plate* XXIII. *p.* 389.

L.ᵗ Beare sc.


A.M.
NOON
P.M.
I II III IV V VI VII VIII IX X XI XII I II III IV V VI VII VIII IX X XI XII
Combined Result
of the whole of the Hourly Observations
made with the Royal Society's Standard Barometer.
+0.025
+0.020
+0.015
+0.010
+0.005
0.004
0.003
0.002
0.001
in.
0.000
Mean line
0.001
0.002
0.003
0.004
−0.005
−0.010
−0.015
−0.020
−0.025
+2.5
+2.0
+1.5
+1.0
+0.5
0.4
0.3
0.2
0.1
0°.0
0.1
0.2
0.3
0.4
−0.5
−1.0
−1.5
−2.0
−2.5
1 h. to 5 h. a. m. —— Derived from 30 days' Observations: mean ... 29in.976 ... 56°.0
6 h. to 7 h. a. m. —— Dº ... 60 Dº ... : Dº ... 29. 930 ... 62. 2
8 h. ... a. m. —— Dº ... 75 Dº ... : Dº ... 29. 965 ... 58. 7
9 h. a. m. to 12 p. m. —— Dº ... 120 Dº ... : Dº ... 29. 904 ... 59. 6
The weaker line represents the corresponding mean variations of temperature.
The dotted dº ... the continuation of the 30 days' Observations.

2. The striking connection between the barometrical changes and the variations of temperature.
3. The relation which appears to subsist between the variations before noon and those before midnight,—a great amount of variation before noon being followed, in the same mean day, by a corresponding small variation before midnight, and the contrary.

Plate XXII. exhibits the simultaneous movements of the Water Barometer, the Standard Barometer, and the Mountain Barometer; and points out,—

4. The general accordance in the mean variations of three instruments, so dissimilar in principle and construction; and the remarkable nature of those differences which their simultaneous observation has elicited.
5. The precession in time, by about an hour, of the mean motions of the Water Barometer over those of the Standard Barometer; and the precession, by the same interval, of the mean changes of this latter instrument, over those of the Mountain Barometer*.

Plate XXIII. exhibits a comparative view of a mean day's observations in summer, with one in winter, after an interval of exactly half a year; and displays,—

6. The influence which the season of the year, or the temperature of such season, appears to exercise over the hours of maximum and minimum, and over the amount of the mean variations. The minimum and maximum of the morning are earlier, and those of the evening later, in summer than in winter: and the variations in summer are small about noon, and great about midnight; those in winter, the reverse.

Plate XXIV. represents the mean result of the whole of the observations. The mean variations of the first five hours are referred to a general mean derived from all observations made continuously from 1 A.M. to midnight; those of the next two hours are referred to one derived from all observations made

* I am not aware that any series of observations has before exhibited this singular result, and developed the important influence which the diameter of the tube, and the nature of the fluid column exercise over the *changes* which the atmospheric pressure ought to produce in the barometer. Dr. PROUT has since informed me, that he has found a barometer made with sulphuric acid move with much greater freedom than the ordinary mercurial barometers,—a fact which he considers only to be explained by the greater mobility of the molecules of the liquid under these circumstances, and which strikingly corroborates this result of my observations.

from 6 A.M. to midnight; the mean variation at 8 A.M. is referred to a general mean derived from all observations made from that hour till midnight; and the variations at each of the subsequent hours are referred to a mean of all observations made from 9 A.M. till midnight*. It points out,—

7. That the greatest of all the mean variations is nearly ·016 inch in amount, and occurs in the afternoon minimum height of the barometer at four o'clock; the next ·012 inch, and found in the forenoon maximum at ten o'clock; after this the one of nearly ·011 inch in the evening maximum at eleven o'clock; and finally that of ·005 inch occurring in the morning minimum at half-past four.
8. That the general relation between the barometrical changes and the variations of temperature, appears to be direct during the morning hours, and inverse during those of the day and evening.
9. The singular fact, that while a period of fifteen days gives a mean day generally distinguished by its relative variations at noon and midnight, a period of one month, or a complete lunation, not only gives a gradual succession of variations, but, in all these observations, a result almost identical in character and amount with the combined result of the whole.

Among the investigations in which I am at present engaged, are those relating to the following inquiries: 1. To ascertain whether the mercurial vapour in the vacuum chamber of the barometer, sensibly influences the height of the column at the ordinary variations of the temperature of the atmosphere. 2. Whether the Tables for the reduction of the temperature of the mercury to zero are practically accurate. 3. A full investigation into the influence which the diameter of the tube exercises over the fluid column. 4. The relation between the mean daily variation of the magnetic needle and that of the barometer; and whether the former would be found to exhibit the same dependence upon changes of temperature as the present observations have shown the latter to have. 5. The connexion between the mean barometric height and the amount of the variations referred to it, and the influence

* I find that a mean derived from all the observations of the twenty-four hours, compared with one derived from all those of the sixteen hours, from 9 A.M. to 12 P.M., of the same period of observation, differs from it only by ·001 of an inch.

of altitude in the station of observation upon the variations. 6. A complete examination of the effect of temperature in influencing the changes of the barometer. 7. Whether, after the application of the ordinary corrections, the changes in the length of the mercurial column correspond accurately with those which take place in its absolute weight.

With regard to the first of these inquiries, Mr. DOLLOND has, at his own expense, furnished me with an instrument exhibiting the changes of atmospheric pressure without involving the agency of the mercurial vapour; and with which I propose to make a series of observations, simultaneously with the Standard Barometer. It is a Baroscope of considerable dimensions, and the same in principle as the well-known instrument of BOYLE, having a thin glass globe, of one foot and a quarter in diameter, counterpoised by a solid sphere of lead. From an abstract of a memoir by Signor AVOGADRO, contained in the fourth number of the Annales de Chimie for the present year, on the elastic force of mercurial vapour at different temperatures, it appears that the effect of this vapour in the vacuum chamber of a mercurial barometer would not be sensible at the ordinary temperatures of the atmosphere, as its tension at 212° F. appears to be equal to only ·001 inch of mercury; and Dr. PROUT has allowed me to state, that from his own investigations it appears to have no influence under common circumstances, he having, in summer when the temperature was unusually high, cooled down a mercurial barometer, by means of the evaporation of ether, to 32°, without detecting any such influence, after the requisite correction for the temperature of the mercury itself had been applied. Mr. SNOW HARRIS of Plymouth, having made a variety of experiments on the effects produced on barometers by the introduction of different gases into their vacuum chambers, has kindly offered to furnish me with the detail and results of his experiments, to lay before the Society in connexion with my own.—With regard to the second inquiry, I have compared two excellent and similar mountain barometers, for the use of which I was indebted to Mr. CARY,—first, under the same circumstances and temperature; and afterwards under the same circumstances in every respect excepting the temperature, which in the latter case was considerably raised. The mean difference obtained in one case was not sufficiently unequal to that obtained in the other to indicate any error or discrepancy in the Tables by which the ob-

servations were reduced. From Dr. PROUT's experiment also just named, these Tables of Professor SCHUMACHER, which he employed on that occasion, appear to be rigidly correct.—With respect to the third subject of investigation, the influence of the diameter of the tube, I am again indebted to the liberality of Mr. DOLLOND, who has, at his own expense, fitted up for my use a compound barometer, consisting of six tubes of different internal diameters, from 0·13 to 0·50 of an inch, all standing in the same cistern, and the heights read off by an index and scale common to them all. This instrument has already furnished some new and interesting results, and I hope to be able to make, and present to the Society, a complete series of observations by its means.—The fourth subject of inquiry, the connexion between the magnetic and barometrical variation, has been delayed, in consequence of the variation needles with which Mr. DOLLOND intended also to supply me, having, from the peculiarity of their construction, presented unusual anomalies, which he is at present investigating. When these magnetic needles are completed, the series of observations which I propose to make with them, will be rendered more interesting and valuable by the simultaneous observations, both on them and on the barometer, which Captain SMYTH has kindly undertaken to make at his Observatory at Bedford.—The fifth and sixth inquiries involve so many considerations, and require a still so much greater number of observations, that no conclusions can at present be drawn in reference to them: and in the seventh, the comparison of the Baroscope and the use of other instruments, different in principle, but all exhibiting changes in the atmospheric pressure, will be employed.

Among the comparisons which I propose to institute, those with the invaluable observations made at different stations, during the late Captain FOSTER's scientific voyage of discovery in the Chanticleer, by that lamented commander and the officers who accompanied him, and which the President and Council have, at Mr. LUBBOCK's request*, allowed me to make use of for this purpose, will be the first and most important; and their value will be enhanced by the comparison which, through the permission Captain BEAUFORT has kindly

* The interest taken by Mr. LUBBOCK in my inquiries, the encouragement he has so constantly afforded me in the prosecution of them, and the valuable advice which, on the occurrence of every anomalous result, he has been always so willing to give me, require my best acknowledgement.

granted me, I shall be allowed to make between the Royal Society's Standard, and the Mountain Barometers actually employed in those observations, and which are now deposited at the Admiralty. The barometer also just received from Germany, and made under the direction of Professor SCHUMACHER, at the request of the Royal Society, by BUZENGEIGER of Tübingen; and the barometer now in progress for the Society, under the direction of Dr. PROUT and Professor DANIELL, will, along with observations made both at home and abroad, furnish interesting data for future comparison.

In the present communication, I have laid before the Society the results of a classification of my observations according to the place of the sun;—on a future occasion, I propose to add those derived from arrangements made in reference to the position of the moon. I have also in this part of my paper presented data for investigating the constant horary oscillation of the barometer, and I hope to be enabled on a future occasion to submit to the Society the requisite data for examining the diurnal, monthly, and annual variations of that instrument, as well as to deduce results from inquiries made into the laws and nature of the ordinary and inconstant fluctuations exhibited by the mercurial column.

Mr. DANIELL having ascertained the deterioration of barometers in consequence of the insinuation of air between the glass and mercury into the vacuum, it became imperative upon me to ascertain if possible whether the Royal Society's Standard had become injured from this cause, and whether the results obtained from the observations made with it differed practically and in sensible amount, from those made with Mr. DANIELL's Mountain Barometer, an instrument considered by him as almost perfect, or with an instrument like the Water Barometer, widely distinct in its nature and in the corrections required for its reduction. I therefore carefully observed these three instruments simultaneously for 360 successive hours; and their results, already detailed, do not appear to differ essentially from each other in reference to the general accuracy of the Standard Barometer. The variations are nearly the same in amount as those of the Water Barometer, and both these and the mean of the observations, in reference to the Mountain Barometer, appear to be too nearly identical to allow of the supposition of a deterioration to any extent having taken place in the Standard Barometer. The two mercurial barometers give a dif-

ference of only ·007 of an inch in mean results derived from these 360 simultaneous observations; and as the Royal Society's Standard is placed at an elevation of forty-two feet above the Mountain Barometer, this small quantity by which it stands lower than the other, does not seem to indicate any of that undue depression of its mercurial column which ought to result from the insinuation of air into its vacuum. The mahogany pillar, also, which forms an intermediate portion of its scale, may be inferred, from the same simultaneous comparison with the Mountain Barometer, which is furnished with a continuous brass scale, as well as from the circumstances of the dimensions of the pillar, the polished surface of its sides, the brass plate on its upper surface, and the careful insertion of its lower end into the cistern of the instrument, not to be subject to the same hygrometric influence as instruments of less guarded construction. I may add that a gentleman, who has been for some time extensively engaged in the prosecution of barometric levelling, determined the elevation of this Standard Barometer above the level of the river, to within a very small extent of the estimated altitude, from the published observations only which had been made with it; and Mr. Richardson, of the Royal Observatory at Greenwich, has informed me, that in an extensive examination of barometrical observations which he was required, for particular astronomical reductions, to make, he found the published observations made with the Standard Barometer of the Royal Society to accord more accurately in their changes with the general result of those, made both in this country and on the Continent, which he had occasion to consult, than any of the other observations he made use of for that purpose.

A.M. VI VII VIII IX X XI XII NOON I II III IV V VI VII VIII IX X XI P.M. XII

Royal Society's Standard Barometer.

Hourly observations made on 75 successive days.

April 26. to July 13. 1831.

Classed in sets of 15 days each, and 5 Mean Days derived from such combination.

- First set mean — 29. 684
- Second D^{o} D^{o} — 29. 887
- Third D^{o} D^{o} — 29. 890
- Fourth D^{o} D^{o} — 29. 884
- Fifth D^{o} D^{o} — 29. 876

+0.035 +0.030 +0.025 +0.020

First mean day.

Second mean day.

Third mean day.

Fifth mean day.

Fourth mean day.

Mean line

0.000 0.001 0.002 0.003 0.004 0.005

−0.010 −0.015 −0.020 −0.025

The Corresponding Temperatures.

A.M. VI VII VIII IX X XI XII NOON I II III IV V VI VII VIII IX X XI P.M. XII

+2.5 +2.0 +1.5 +1.0 +0.5 0.0 −0.5 −1.0 −1.5 −2.0 −2.5

Mean line

Fourth mean day.

Second mean day.

First mean day.

Third mean day.

Fifth mean day.

- First set, mean — 57° 2 F.
- Second D^{o} D^{o} — 62. 3
- Third D^{o} D^{o} — 64. 2
- Fourth D^{o} D^{o} — 69. 0
- Fifth D^{o} D^{o} — 67. 5

The Thermometer shewing these temperatures is the one attached to the instrument, and dipping into the mercury of the cistern.

F. Baily sc.