In submitting this device to your notice, I have made a little deviation in the figures from those forwarded to the Secretary of the Navy. Some modifications of the arrangement will be necessary, on board of each boat, according to circumstances.

The references and figures below will show the plan I have suggested. Suppose the vessel to be running ahead, and the commander wishes her to go in the contrary direction, he moves the index on A to the word "BACK," this changes the place of the frame B, and the engineer sees the direction to back by the motto, which is illuminated by the light of the lantern passing immediately through it; and so with any other direction that may be necessary, by simply moving the index. To make this plan as perfect as possible, there may be projections on the sliding frame which, when it is moved, causes the ringing of a bell to attract the notice of the engineer.

Respectfully yours,

A. C. JONES.

Progress of Physical Science.

Communication of Observations of the Solar Eclipse of May 15, 1836, and of an Aurora, on the evening of May 10th. By AMASA HOLCOMB, of Southwick, Mass.

TO THE COMMITTEE ON PUBLICATIONS.

GENTLEMEN:—The solar eclipse of May 15th, began at 7h. 17m. 52.22, mean time, and ended at 9h. 49m. 20.05, mean time, as observed at my residence, Southwick, Mass., latitude north $41^{\circ} 59'$; *longitude West 4h. 51m. 10s. The observation was very satisfactory.

On Sunday evening, May 10th, 1836, there was, at Southwick, a very splendid aurora. At half-past nine o'clock a stream of light rose in the east, passing through α Herculis to α Coronæ, and gradually extending to ϵ Bootis, through Ursa Major and Pollux. At forty-three minutes past nine it passed over Jupiter three degrees south, which was about twenty degrees above the western horizon. At fifty minutes past nine the whole arch had passed about six degrees south of Arcturus, and between Regulus and γ Leonis. At five minutes past ten it wholly disappeared.

It was very light in the north during the whole time of the visible aurora, and afterwards to a late hour. The arch was irregular in its width, being in some places not more than two degrees, in others four degrees. The waves passed from east to west, but not exactly in the direction of the arch. They appeared to begin on the north side, to run obliquely and pass off at the south side.

AMASA HOLCOMB.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Report on Hourly Observations of the Thermometer at Frankford Arsenal, Pennsylvania, by Captain Alfred Mordecai, of the United States Ordnance Department.

The observations which form the subject of this communication, were made at the suggestion of a friend, (Professor A. D. Bache,) who is a mem-

* Deduced by S. C. Walker from this observation.

ber of the Joint Committee on Meteorology of the American Philosophical Society, and the Franklin Institute, for the purpose of obtaining data for determining the laws of diurnal variations of temperature.

The observations were made during the day time, chiefly by Mr. William Pigott, the clerk in the office of the Arsenal, and at night by the guard: and I have reason to think that their correctness may be generally relied on, so far as the thermometer made use of will authorize. The instrument is one of Fishers', of Philadelphia, which was found to agree very well with a good French thermometer, with which I compared it for some days. As it would not have been convenient to use a screen which could have admitted of the thermometer being kept stationary at all times of the day and night, its place was changed in the morning and afternoon, so as to keep it protected from the direct rays of the sun, as well as from reflection; in the day time it was screened by a green venetian window blind, the window being kept always closed. There is no doubt that the influence of this change of place, and of the proximity of buildings, was felt by the thermometer, but from careful observation I do not find that the general results were materially affected by these causes, the effects of which having, moreover, extended over the whole period of time, would have little influence on the comparative results. I have, however, to regret that, being without any other aid than that of my private funds, I was not enabled, for want of the most suitable instruments, to conduct these observations in so satisfactory a manner as I might have done. I give them as the first attempt of the kind, so far as I know, on this side of the Atlantic, in hopes that they may be of some use for the purpose of comparison with such observations as have been made in Europe, and that they may perhaps afford a first guide for more full and correct observations at home.

Whilst I was engaged in drawing up this report, I received the Fifth Report of the meeting (in Dublin) of the British Association for the Advancement of Science, which contains the able paper of Mr. Snow Harris on this subject, and it will be perceived that I have availed myself of the knowledge thus obtained with respect to the most judicious method of presenting the results of my observations, although the observations do not extend over so much time as to entitle these results to the confidence that may be placed in those of Mr. Harris.

Frankford Arsenal, the place at which these observations were made, is about five miles in a north-easterly direction from the State House in Philadelphia, latitude 40° N., longitude $75^{\circ} 8'$ W. from Greenwich. The Arsenal is about a quarter of a mile from the west bank of the Delaware river, in an open, level country: the usual position of the thermometer is about twenty-four feet above ordinary low water in the Delaware.

My register was commenced on the 7th of May, 1835, and continued until the 31st of May, 1836, since which time it has not been convenient for me to have it carried on in such detail. I continued it through the month of May, 1836, because the register of that month in 1835, was not quite complete, and because I was apprehensive that the want of habit on the part of the observers, would make the observations of the first month less entitled to confidence than the others. In making up the mean results, it has been necessary, however, to use the observations of the month of May, 1835, as that is one of the six summer months of the period through which the observations extended; the results for the month of May, 1836, are therefore recorded only for preservation and comparison, and are not used in making up the mean results that we shall have under consideration,

except in taking the mean of the three spring months to which it belongs. The results of the observations in question oblige me, in making up the average of the several seasons, to consider May, June, July, August, September, and October, as the six summer months, being very distinctly those which give the highest range of the thermometer, as well as corresponding rates of variation. March, April, and May, are taken as the spring months: June, July, and August, as the summer months: September, October, and November, autumn months: December, January, and February, winter months: Tables I. and II. contain the numerical results of the observations, arranged in a manner which will be readily comprehended on inspection. Table I. shows the mean temperature of each day in the thirteen months, and also the mean of the highest and lowest temperature observed on each day, together with the general result for each month.

Table II. shows for each of the several periods of time, mentioned in the first column:

1. The mean temperature of each hour.
2. The general mean of the hourly observations, and of the diurnal extremes.
3. The days on which the highest and lowest temperatures were observed, and the amount of the maximum and minimum.
4. The difference of the maximum and minimum, or the extreme range of temperature.
5. The hours at which the mean maximum and minimum are respectively found.
6. The hours, before and after noon, at which the thermometer indicates the mean temperature of the day.
7. The relation between the mean temperature of each hour and that of the whole year.

In drawing general inferences from the results contained in these tables, it must be recollected that the observations extend over only *one* period of twelve months, and also, that the particular seasons embraced in that period were not such as we have usually had of late years; the summer was more temperate, and the winter colder, with more snow than usual.

The following results, deduced from the tables, are here stated, with a view of bringing them more distinctly under observation, viz.

Mean temperature of	10 days about the summer solstice, viz:—from June 16th to 25th, inclusive,	-	-	65.19
	10 days about the winter solstice, viz:—from December 16th to 25th, inclusive,	-	-	27.43
	Summer, viz. June, July, August,	-	-	69.40
	Autumn, viz. September, October, November,	-	-	53.54
	Winter, viz. December, January, February,	-	-	26.88
	Spring, viz. March, April, May, (1836.)	-	-	48.02
	6 summer months, viz. May to October, inclusive,	-	-	63.77
	6 winter months, viz. November to April, inclusive,	-	-	34.64
	12 months, viz. May to April, inclusive,	-	-	49.21
	April being nearest to that of the 12 months,	-	-	48.65
	Maximum temperature observed July 13th, at 3 and 4 P. M.			89.5
	Minimum temperature observed February 6th, at 5 and 6 A. M.			—7.
	Extreme range of temperature,			96.5
	Mean range between six summer and six winter months,			29.13

Table I. gives some idea of the fluctuations in the temperature of our climate, occurring within a short space of time: thus it will be seen that

there is in some parts of almost every month, a variation as great as 12° in the mean temperature of two consecutive days; and that, in the winter and spring, this variation often extends to 15° or 18° . In Mr. Harris' register of observations during two years at Plymouth, England, there is only *one* instance of a difference exceeding 8° in the mean temperature of two consecutive days, and but two other instances of a difference as great as 8° . The extreme range of temperature at Plymouth, in 1834, was 48° , just one half of the range at Frankford Arsenal in 1835-6.

In order to illustrate more clearly this peculiarity of our climate, I subjoin a table showing the extreme variation or range of the thermometer during the three days of each month on which the difference of extremes is greatest.

Table III. showing the extreme range of Temperature during three days of each month.

1835	Date	Interval of time between the extremes.	Difference of extremes.	1836	Date	Interval of time between the extremes.	Difference of extremes.
		Hours.				Hours.	
May	11th	$10\frac{1}{2}$	34.	January	2nd	$12\frac{1}{2}$	25.5
	17th	$9\frac{1}{2}$	31.		21st	13	27.5
	24th	10	29.		29th	10	26.5
June	2nd	11	28.	February	6th	8	28.5
	9th	12	31.		15th	9	23.5
	23rd	13	29.		19th	15	26.
July	2nd	11	26.5	March	3rd	$11\frac{1}{2}$	29.5
	11th	10	26.5		13th	11	26.5
	26th	12	26.		24th	10	26.5
August	3rd	11	25.	April	8th	8	28.
	8th	11	25.		26th	11	32.75
	24th	12	26.5		28th	10	27.
Sept.	3rd	11	28.5	May	2nd	13	33.5
	16th	10	29.		11th	11	30.
	27th	11	27.		16th	11	32.
October	4th	11	30.				
	14th	9	28.5				
	26th	8	27.				
Nov.	2nd	13	21.				
	14th	8	24.				
	30th	13	23.5				
Dec.	4th	12	22.5				
	9th	12	28.				
	24th	10	21.				

With the assistance of Table I. it will be easy to ascertain, if desirable, the degrees of extreme temperature on the days mentioned in table III., by taking from the former table the mean of extremes for the given day, and adding to it half their difference, from Table III., for the maximum, or subtracting the same half difference for the minimum.

Daily Progression of Temperature.

In order the more clearly to exhibit the changes of temperature during

the twenty-four hours, I have projected, in the form of curves, the temperature of each hour for each of the four seasons, and also for the two extreme months, July and February, and similar results for the six summer and the six winter months; also for the twelve months, and for the month of April, which approaches the nearest to the general mean. *See plate I., fig. 1 and 2.* From an examination of these registers, it appears that the minimum point is attained during the hour preceding the rising of the sun. This is observable with great regularity in the summer season; in the winter, when we might expect the thermometer to be more affected by accidental circumstances, the lowest point is often found about midnight; but taking the result of many days together, the same rule applies to both seasons. Thus the mean time of minimum temperature is, for the six summer months, at 4 A. M., for the five winter months at 6 A. M. For the twelve months, the lowest point is found at 4 A. M., but the difference between the mean temperature of that hour and of 5 A. M., which from analogy should give the lowest mean, is so small, being less than one-third of a degree, that further observations might establish the minimum at 5 A. M., where we should expect to find it.

From the lowest point the temperature increases rapidly until 1 P. M., when it has nearly attained its maximum, rising little more than half a degree during the next hour. The maximum point is found sometimes at 2, and sometimes at 3, P. M., and the temperature at those two hours is so nearly the same, not only for the whole year, but for any period of three or six months, as to warrant our assuming $2\frac{1}{2}$ P. M. for the true maximum point. At 4 P. M. the temperature is nearly the same as at 1 P. M., it then falls steadily until about an hour before attaining the minimum, after which, as at 1 P. M. in ascending, the change is very small.

In discussing the results with relation to the mean variation of temperature, we may assume 4 A. M. as the hour of minimum for the six summer months; 5 A. M. for the six winter months; and $4\frac{1}{2}$ A. M. for the twelve months; $2\frac{1}{2}$ P. M. being always the hour of maximum. The following tabular statement presents at one view, the principal results of this discussion.

	Six summer months.	Six winter months.	Twelve months.
Mean daily range of temperature,	17.23	11.81	14.36
Time of ascending temperature,	10h.	9 $\frac{1}{2}$ h.	10h.
Time of descending temperature,	13 $\frac{1}{2}$ h.	14 $\frac{1}{2}$ h.	14h.
Mean hourly rate of ascending temperature,	1.64	1.24	1.44
Mean hourly rate of descending temperature,	1.28	0.81	1.03
Ratio of mean rates of ascending and descending,	5 to 4	3 to 2	7 to 5
Greatest hourly variation in ascending,	(From 7 to 8) 3.10	(From 9 to 10) 2.13	(From 7 to 8) 2.53
Greatest hourly variation in descending,	(From 6 to 7) 3.05	(From 5 to 6) 2.17	(From 6 to 7) 2.50

I have not thought it advisable to increase the number of plates, or to encumber the annexed diagrams, by projecting the curves for each month separately, but I have done this for my own satisfaction, and it is gratify-

ing to observe the agreement, in general character, between each of these curves and the mean curve for the summer and winter period to which it belongs. This agreement is, without exception, in the six months from May to October inclusive; and in the other six months the only deviation, (and that not a remarkable one,) is in the month of April, the curve of which corresponds, as before observed, with that for the mean of the twelve months. November is the month whose mean temperature approaches nearest to that of April, but the flattened form of the curve, indicating a restricted range of temperature, marks it as belonging to the winter set, although the mean minimum of November exceeds the mean maximum of March, the nearest winter month.

The gradual diminution of temperature, uniformly observable on the approach to the minimum, shows that there is not, as some have imagined, any sudden increase of cold about the time of dawn; the opinion has doubtless originated in the feeling caused by the action of the greatest cold of the night, (which is found to be at the time referred to,) on the body previously chilled by exposure.

On the Hours of Daily Mean Temperature.

This may be regarded as the most interesting and useful part of the discussion of such observations as we are now considering, since the determination of the hours, before and after noon, at which the thermometer indicates the mean temperature of the day, will enable us to ascertain the mean temperature at any place, by two observations during the day, or even by one.

The hours of mean temperature are given in Table II., for each of the several periods of time embraced in the table, and need not be here repeated; it will be seen that with one exception, that of the morning mean for November, the results agree remarkably well with each other. The hours of mean temperature for the twelve months are 8h. 36m. A. M., and 7h. 35m. P. M., the interval between them being 11 hours. The interval of 11½ hours is found between the mean hours for the six summer months, and 10½ hours for six winter months.

It is worthy of remark, that the interval between the morning and evening means, as shown by these observations, agrees with that found by the results of similar observations, made during two years, by Sir David Brewster, at Leith, in Scotland, and by Mr. Snow Harris, at Plymouth, England, although the hours of mean temperature are very different in the three cases, viz:

	Leith.	Plymouth.	Frankford.
Time of morning mean,	9h. 13m.	8h. 9m.	8h. 36m.
Time of evening mean,	8h. 27m.	7h.	7h. 35m.
Interval,	11h. 14m.	10h. 51m.	10h. 59m.

As a guide for observations on the temperature during the year, in the vicinity of Philadelphia, the hours here stated might no doubt be safely used; but it would probably be better, (in the absence of more extended observations for the mean times,) to use the hours stated in table II., as obtained from the mean of observations during shorter periods, say for the six

Day.	May.		June.		July.		August.		September.		October.		November.		December.		January.		February.		March.		April.		May.	
	Mean.		Mean.		Mean.		Mean.		Mean.		Mean.		Mean.		Mean.		Mean.		Mean.		Mean.		Mean.		Mean.	
	Of hourly observations.	Of diurnal extremes.	Of hourly observations.	Of diurnal extremes.	Of hourly observations.	Of diurnal extremes.	Of hourly observations.	Of diurnal extremes.	Of hourly observations.	Of diurnal extremes.	Of hourly observations.	Of diurnal extremes.	Of hourly observations.	Of diurnal extremes.	Of hourly observations.	Of diurnal extremes.	Of hourly observations.	Of diurnal extremes.	Of hourly observations.	Of diurnal extremes.	Of hourly observations.	Of diurnal extremes.	Of hourly observations.	Of diurnal extremes.	Of hourly observations.	Of diurnal extremes.
1	.....	.....	68.75	66.50	50.52	61.75	73.52	71.50	57.66	59.00	49.87	47.00	42.12	43.00	30.64	30.75	28.81	30.00	13.54	13.00	34.85	34.50	41.23	40.25	55.56	55.00
2	.....	.....	67.52	66.00	63.83	62.00	66.77	66.50	59.50	60.00	56.00	56.50	47.81	46.50	23.58	21.50	35.66	35.75	4.04	5.25	23.22	22.75	47.54	48.25	65.41	66.75
3	.....	.....	73.20	73.00	70.58	70.50	67.21	65.50	61.85	60.25	48.02	47.50	54.29	56.50	20.52	20.52	36.69	37.50	5.92	7.00	27.40	26.25	48.79	48.25	71.27	72.75
4	.....	.....	75.62	76.50	72.48	72.50	60.52	61.25	64.50	64.00	52.31	49.50	55.75	58.25	32.93	33.25	36.85	36.75	8.23	7.75	34.00	35.25	44.00	44.25	65.12	63.75
5	.....	.....	73.00	72.25	73.92	73.50	62.23	61.50	70.00	70.50	62.23	63.75	57.27	57.50	30.46	29.75	37.94	37.75	4.04	5.00	31.46	32.75	43.67	44.00	58.09	59.00
6	.....	.....	75.30	70.00	69.58	70.75	60.94	59.00	75.58	76.25	59.85	57.00	53.94	53.50	27.00	26.00	33.12	32.50	7.40	7.25	29.06	30.25	34.06	33.50	58.74	58.50
7	55.25	52.50	63.30	62.50	73.94	72.25	63.31	63.25	64.00	60.25	49.27	49.00	52.58	51.75	26.85	26.50	32.35	31.50	24.79	23.00	33.34	33.38	38.17	38.50	59.23	60.00
8	52.00	55.50	60.00	60.00	77.42	76.75	66.10	65.50	59.00	58.50	44.85	45.50	57.16	49.25	25.31	26.50	35.50	35.75	33.67	33.00	32.01	29.75	46.20	45.00	58.65	57.75
9	45.50	45.75	63.16	61.50	70.16	70.50	68.41	67.75	64.00	63.00	47.17	48.00	56.37	57.50	32.37	31.00	34.21	34.25	30.19	30.00	30.67	29.50	61.54	62.00	55.40	55.75
10	50.00	49.50	72.66	72.25	70.04	70.00	70.00	68.75	68.35	69.00	48.79	49.25	48.33	49.00	29.54	27.25	31.56	31.50	32.65	31.75	38.22	38.25	50.60	46.25	57.84	57.13
11	55.50	54.00	71.30	71.50	68.56	68.25	71.25	71.00	62.70	61.50	57.19	57.00	52.52	53.00	26.33	26.00	33.46	33.75	27.78	27.25	35.00	33.00	36.73	36.75	61.91	61.00
12	60.00	60.25	74.45	75.00	73.33	74.00	73.64	74.25	62.54	64.50	54.77	56.50	46.35	43.50	33.70	32.00	35.29	35.50	29.04	29.75	19.79	20.00	35.90	37.00	67.75	68.25
13	55.50	57.25	75.92	76.25	79.10	78.75	76.27	76.50	64.73	64.50	56.27	56.50	36.27	34.00	33.73	33.00	39.33	40.00	34.71	36.00	27.28	25.50	41.94	42.50	60.56	57.75
14	48.50	49.75	70.33	73.50	78.46	78.50	75.95	77.25	60.29	56.50	56.10	58.25	37.64	37.00	34.56	35.75	32.92	33.25	24.13	21.00	42.17	43.25	49.88	50.75	51.42	52.00
15	50.50	51.50	62.25	62.00	70.89	73.25	71.95	72.75	52.00	52.50	58.00	59.25	50.56	50.75	31.85	30.75	27.73	26.00	22.31	20.25	30.52	29.50	44.69	44.00	55.71	55.75
16	50.66	48.50	63.29	62.75	68.52	69.00	75.41	74.75	53.46	52.50	63.19	65.75	60.00	60.00	14.61	14.37	14.29	15.25	23.52	24.00	30.53	29.25	43.61	44.13	66.57	65.00
17	55.86	53.50	63.40	63.00	69.72	69.50	73.18	74.25	58.77	57.00	62.00	61.00	48.77	50.00	14.46	13.50	19.00	16.25	18.85	16.50	37.16	37.25	44.77	45.50	71.54	71.75
18	61.00	62.00	65.58	63.75	71.06	70.75	74.85	75.50	63.29	62.75	67.52	69.00	48.80	48.25	23.41	22.75	28.04	29.50	9.58	8.50	38.67	36.50	55.90	55.00	72.86	72.75
19	69.00	66.75	73.45	70.75	72.69	71.50	71.02	71.00	67.14	58.00	67.13	68.00	50.73	51.00	28.64	28.25	22.58	23.00	13.72	8.75	29.52	28.50	50.83	50.25	67.13	67.00
20	72.00	73.75	63.83	63.00	71.53	74.00	68.10	68.50	60.60	59.50	66.29	67.25	57.46	58.75	34.11	34.25	18.58	20.00	30.26	29.13	32.63	32.50	51.77	52.50	65.02	64.00
21	60.80	61.00	57.37	58.00	70.94	72.75	62.90	63.00	59.46	60.00	65.73	68.50	50.98	49.25	37.63	39.00	21.39	20.00	36.12	37.00	33.82	34.00	54.56	55.75	70.94	73.50
22	56.70	56.00	59.83	58.00	69.52	68.50	60.00	60.50	54.31	54.50	63.81	66.25	37.21	37.00	32.98	32.50	35.66	36.25	37.31	38.50	34.11	33.63	44.41	43.38	75.42	74.50
23	52.80	53.50	68.00	67.00	72.10	71.00	61.35	61.00	54.10	55.00	59.35	59.50	35.58	34.75	22.94	23.75	20.96	18.50	36.81	36.25	30.48	31.75	48.51	46.75	79.90	76.00
24	52.75	50.50	72.14	71.75	75.02	75.00	62.90	62.75	50.81	51.25	56.90	54.25	36.45	36.50	25.79	25.50	18.96	16.75	38.91	39.75	39.60	39.25	50.77	51.00	61.81	61.00
25	62.66	62.00	65.00	64.50	77.29	76.50	69.73	69.00	52.83	51.25	46.90	46.25	33.48	34.50	40.25	39.25	27.85	26.00	31.60	32.25	33.65	32.50	47.45	47.00	59.46	59.25
26	71.33	72.50	67.10	67.00	75.41	75.50	69.06	67.50	54.62	54.50	46.75	47.50	31.23	32.75	45.33	46.75	22.75	24.75	21.76	22.75	30.10	30.75	61.77	60.58	56.22	56.00
27	65.46	65.00	71.10	71.25	67.33	67.25	70.42	69.50	52.58	52.50	52.29	54.00	32.27	32.25	35.21	35.00	14.18	15.25	22.48	23.00	40.42	40.75	62.34	61.25	50.05	49.75
28	70.40	67.50	65.12	68.75	67.12	65.50	74.04	75.00	57.31	58.25	52.83	54.50	34.85	35.25	30.19	32.00	9.48	11.00	20.21	20.25	43.65	45.25	58.21	57.50	57.41	57.75
29	71.66	72.50	68.48	67.75	69.40	72.00	73.66	73.50	51.56	50.75	56.42	56.75	33.44	23.25	33.16	34.50	15.29	15.75	25.63	25.13	40.52	40.25	63.17	64.00	59.02	57.50
30	67.83	66.50	63.85	61.50	72.27	73.50	66.08	65.50	45.48	45.00	62.87	64.25	28.23	27.25	36.85	37.50	27.00	27.75	.....	.....	36.01	35.50	56.40	53.25	50.16	49.75
31	67.33	65.50	.....	.....	76.44	76.00	61.71	61.50	.....	.....	52.80	52.75	.....	.....	32.80	30.25	32.83	31.75	.....	.....	41.25	41.25	.....	.....	50.78	50.25
Mean	59.18	58.71	67.78	67.16	71.58	71.65	68.46	68.20	59.43	59.10	56.20	56.60	44.98	45.05	29.90	29.36	27.68	27.72	23.07	22.72	33.58	33.54	48.65	48.30	61.83	61.51

Table II., Hourly Mean Temperature, &c.

MEAN TEMPERATURE OF EACH HOUR.																General Mean.		Extremes.					Hour of Daily Mean.					
																Of hourly observations.	Of diurnal extremes.	Minima.		Maxima.		Difference.	Minima.	Maxima.	Temperature.			
P. M.																		Date.	Degree.	Date.	Degree.		A. M.	P. M.	A. M.	P. M.		
9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12													
1.36	64.32	64.70	66.34	67.08	67.90	67.88	67.04	66.12	64.00	61.26	58.40	56.96	55.76	55.16	54.20	59.18	58.71	24th	36.	20th	86.5	50.5		4.	2.	5h. 18m.	7h. 44m.	
0.02	72.77	74.05	74.95	75.90	76.25	76.13	76.20	75.40	73.03	70.47	67.63	64.90	63.30	62.00	60.86	67.78	67.16	22nd	44.	4th	87.	43.		4.	2.	8	7 58	
4.06	76.01	77.37	78.71	79.90	80.48	80.20	79.60	78.58	76.34	73.61	70.77	68.74	67.58	66.84	65.90	71.58	71.65	2nd	48.	13th	89.5	41.5		4.	2.	8	7 43	
0.89	72.37	73.72	75.02	75.89	76.27	76.55	76.27	75.08	72.74	70.19	67.19	65.90	64.68	63.61	62.98	68.46	68.20	5th	49.	14th	85.5	36.5		4.	3.	7 53	7 35	
2.12	64.00	65.72	67.15	67.88	68.52	68.52	67.77	66.00	63.58	59.43	57.58	56.87	55.50	54.47	53.50	59.43	59.10	30th	36.	6th	86.	50.		4.	2 and 3.	8 12	7	
6.08	58.72	61.55	64.03	65.00	65.53	65.82	64.75	62.82	59.73	56.76	53.34	53.71	52.71	52.03	51.12	56.20	56.60	8th	33.	20th	76.50	43.5	4 and 5.	3.	9	3	7 24	
5.13	46.70	48.12	49.28	50.03	50.78	50.41	49.67	48.38	45.67	44.28	43.52	43.10	42.63	42.23	42.03	44.98	45.05	30th	15.50	15th	67.	51.5		6.	2.	8 51	6 30	
9.48	31.87	34.10	35.32	35.97	36.47	35.93	34.60	32.79	30.72	29.92	29.22	28.58	27.88	27.32	27.48	29.90	29.36	17th	6.5	25th	48.	41.5		5.	2.	9 10	7	
7.65	29.69	31.29	32.87	33.72	34.43	34.40	34.07	32.81	29.68	28.01	27.20	26.62	25.77	25.39	24.97	27.68	27.72	29th	2.5	2nd	48.5	46.		6.	2.	9	7 25	
2.53	25.12	26.66	29.95	29.31	29.75	29.63	29.21	27.85	25.62	23.57	22.64	22.00	21.14	20.48	20.38	23.07	22.72	6th	— 7.	22nd	48.	55.		6.	2.	9 12	7 32	
3.70	36.08	37.47	38.96	39.63	40.35	40.45	40.28	39.56	37.95	34.99	33.61	32.50	31.50	30.71	30.28	33.58	33.54	3rd&13th	11.5	27th	53.5	42.		6.	3.	8 56	8 02	
9.07	50.92	52.60	53.88	54.83	55.93	56.50	56.55	55.97	54.12	50.72	48.55	47.05	45.83	45.35	44.53	48.65	48.30	7th	26.	26th	77.25	51.25		5.	4.	8 48	7 57	
2.84	64.05	66.10	67.73	68.87	69.52	70.04	69.94	68.98	67.09	64.56	61.58	59.95	58.63	57.63	56.66	61.83	61.51	14th	39.	22nd	87.	48.		4.	3.	8 31	7 55	
1.66	73.72	75.05	76.22	77.23	77.67	77.63	77.36	76.35	74.04	71.42	68.53	66.51	65.19	64.15	63.25	69.40	69.00	June 22nd	44.	July 13th	89.5	45.5		4.	2.	8	7 45	
4.44	56.47	58.46	60.15	60.97	61.61	61.58	60.73	59.07	56.33	53.49	52.15	51.23	50.28	49.57	48.88	53.54	53.58	Nov. 30th	15.5	Sept. 6th	86.	70.5		5.	2.	8 38	7	
6.55	28.89	30.68	32.05	33.00	33.55	33.45	32.63	31.15	28.67	27.17	26.35	25.73	24.93	24.40	24.28	26.88	26.60	Feb. 6th	— 7.	January 2nd	48.5	55.5		6.	2.	9 8	7 21	
8.54	50.35	52.06	53.52	54.44	55.27	55.66	55.59	54.84	53.05	50.09	47.91	46.40	45.32	44.56	43.82	48.02	47.78	March 3rd&13th	11.5	May 22nd	87.	75.5		4.	3.	8 45	7 57	
5.75	68.03	69.52	71.03	71.94	72.49	72.52	71.94	70.67	68.24	65.19	62.82	61.18	59.92	59.02	58.01	63.77	63.57	Oct. 8th	33.	July 15th	89.5	56.5		4.	3.	8 16	7 30	
4.59	36.72	38.37	39.54	40.58	41.28	41.28	40.73	39.56	37.29	35.25	34.12	33.31	32.45	31.92	31.62	34.64	34.45	Feb. 6th	— 7.	April 26th	77.25	84.25		5.	2 and 3.	9	7 30	
10.18	51.91	53.94	55.29	56.26	56.89	56.87	56.33	55.11	52.77	50.27	48.47	47.24	46.19	45.47	44.85	49.21	49.01	Feb. 6th	— 7.	July 13th	89.5	96.5		4.	2 and 3.	8 36	7 35	
0.97	+ 2.70	+ 4.73	+ 6.08	+ 7.05	+ 7.68	+ 7.66	+ 7.12	+ 5.90	+ 3.56	+ 1.06	— 0.74	— 1.97	— 3.02	— 3.74	— 4.36													
9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12													

Table IV. shewing the relation of the Mean Temperature of each pair of Hours, to that of the whole year.

Pair of Hours.	1	2	3	4	5	6
Mean temperature.	50.19	50.24	49.94	49.43	48.98	48.20
Deviation,	+0.98	+1.03	+0.73	+0.22	-0.23	-1.01
Pair of Hours.	7	8	9	10	11	12
Mean temperature,	47.77	48.13	48.71	49.05	49.70	50.07
Deviation,	-1.44	-1.38	-0.50	-0.16	+0.49	+0.86

From this table it appears that the mean temperature of the six pairs of hours from 1h. to 4h. inclusive, exceeds the mean temperature of the year, the greatest difference being $1^{\circ}.03$; and the mean temperature of the six pairs, from 5h. to 10h. inclusive, is less than the mean of the year, the greatest difference being $1^{\circ}.44$. The mean temperatures of 4h. and 4h., and 10h. and 10h. approach nearest to the general mean of the year; therefore, according to these results, those would be the proper pairs of hours for making observations for the mean temperature.

Discussion of the curves of Mean Hourly Variation of Temperature.

The curve projected for the mean hourly temperature, during the twelve months, is that which will be first discussed. It naturally divides itself into four branches, viz:

1. The morning branch, ascending from the minimum to the line of mean temperature.
2. The noon branch ascending from the line of mean temperature to the maximum.
3. The afternoon branch descending from the maximum to the line of means.
4. The night branch, descending from the line of means to the minimum.

Sir David Brewster and Mr. Harris having discussed the curves given by their observations, on the supposition of their being parabolas, each branch having a distinct type, I have applied the same method to the curve under consideration.

Regarding then each of the four branches as an arc of a separate parabola, the vertex of which is at the point of maximum or minimum respectively, we have in each curve the abscissa and ordinate of the point in which it intersects the line of mean temperature, and therefore we can readily calculate the intermediate points, or the temperature of each hour, on the supposition of the curves being parabolas.

The following have been assumed as the data of the calculation, viz:

Minimum temperature	-	-	at $4\frac{1}{2}$ A. M.	42.5
Morning mean "	-	-	at $8\frac{1}{2}$ A. M.	49.2
Maximum "	-	-	at $2\frac{1}{2}$ P. M.	56.9
Evening mean "	-	-	at $7\frac{1}{2}$ P. M.	49.2

These terms, differing slightly from those given in Table II., are taken for greater convenience, as approximating sufficiently to the results of observations. Table V. gives the results of the calculated and observed temperature for each hour, together with the differences.

Table V. showing the Mean Hourly Temperature during twelve months as observed, and as calculated on the supposition that the curves are parabolas

	Hours.	Observed temperature.	Calculated temperature.	Differences.
Morning Branch.	5 A. M.	42.84	42.60	+ 0.24
	6	43.63	43.44	+ 0.19
	7	45.27	45.12	+ 0.15
	8	47.80	47.63	+ 0.17
Noon Branch.	9	50.18	50.43	— 0.25
	10	51.91	52.57	— 0.66
	11	53.94	54.28	— 0.34
	12	55.29	55.56	— 0.27
	1 P. M.	56.26	56.42	— 0.16
	2	56.89	56.85	+ 0.04
Afternoon Branch.	3	56.87	56.82	+ 0.05
	4	56.33	56.21	+ 0.12
	5	55.11	54.97	+ 0.14
	6	53.77	53.13	— 0.36
	7	50.27	50.66	— 0.39
Night Branch.	8	48.47	48.50	— 0.03
	9	47.24	47.17	+ 0.07
	10	46.19	46.01	+ 0.18
	11	45.47	45.01	+ 0.46
	12	44.85	44.18	+ 0.67
	1 A. M.	44.12	43.52	+ 0.60
	2	43.59	43.02	+ 0.57
	3	43.01	42.69	+ 0.32
	4	42.53	42.52	+ 0.01

By this table the general approximation of the curves to parabolic arcs is sufficiently shown, and the deviations seem to be nearly equal in the several branches. This result is different from that given by the observations at Leith, and at Plymouth, in both of which cases the deviations were greatest in the afternoon branch; indeed that branch in the Plymouth curve is almost exactly a right line, after 3 P. M.

But without more extended observations here, we cannot consider the difference in the rate of variation of temperature to be fully established. As there is a marked difference in the character of the summer and winter curves, caused by the difference in the daily range of temperature during the two seasons, I have been induced to calculate the hourly temperatures for the mean of the three warmest months, and for that of the three coldest, on the supposition of parabolic curves.

The results of the calculation, and a comparison with those of observation, are contained in Tables VI. and VII.

Table VI. showing the Mean Hourly Temperature during the three summer months, viz: June, July, and August, 1835, as observed, and as calculated on the supposition of parabolic curves.

	Hours.	Observed temperature.	Calculated temperature.	Differences.
Morning Branch.	4 A. M.	60.62	60.62	0.00
	5	62.43	61.17	+ 1.26
	6	64.00	62.82	+ 1.18
	7	66.39	65.57	+ 0.82
	8	69.37	69.42	- 6.05
Noon Branch.	9	71.66	71.77	- 0.11
	10	73.72	73.73	- 0.01
	11	75.05	75.30	- 0.2
	12	76.22	76.48	- 0.25
	1 P. M.	77.23	77.26	- 0.06
	2	77.67	77.65	+ 0.02
Afternoon Branch.	3	77.53	77.64	- 0.01
	4	77.36	77.02	+ 0.34
	5	76.35	75.82	+ 0.53
	6	74.04	74.02	+ 0.02
	7	71.42	71.62	- 0.22
Night Branch.	8	68.53	68.92	- 0.39
	9	66.51	66.99	- 0.48
	10	65.19	65.30	- 0.11
	11	64.15	63.87	+ 0.28
	12	63.25	62.70	+ 0.52
	1 A. M.	62.50	61.79	+ 0.71
	2	61.68	61.14	+ 0.54
	3	61.13	60.75	+ 0.28

From Table VII. it appears that the agreement of each branch of the winter curve to a parabola is, with one exception, sufficiently near to justify the supposition of the variations of temperature being represented by parabolic abscissæ, the single exception, (at 6 P. M.) results from an accidental anomaly in the mean results for the month of January; for the January and December curves meet at 5 P. M., although in the rest of their course they are nearly parallel to each other, and to the curve for February. I apprehend that this anomaly may arise from an error of observation, as the hour from 5 to 6 P. M. is that during which the thermometer was removed, in January, to the night station.

Table VII., showing the Mean Hourly Temperature during the three winter months, viz: December, January, and February, 1835-6, as observed, and as calculated on the supposition of parabolic curves.

	Hours.	Observed temperature.	Calculated temperature.	Differences.
Morning Branch.	6 A. M.	22.14	22.14	0.00
	7	22.49	22.62	- 0.13
	8	24.23	24.08	+ 0.15
	9	26.55	26.50	+ 0.05
Noon Branch.	10	28.89	28.88	+ 0.01
	11	30.63	30.75	- 0.07
	12	32.05	32.14	- 0.09
	1 P. M.	33.00	33.08	- 0.08
	2	33.55	33.54	+ 0.01
Afternoon Branch.	3	33.45	33.53	- 0.08
	4	32.63	32.95	- 0.32
	5	31.15	31.40	- 0.25
	6	28.67	30.07	- 1.40
	7	27.17	27.77	- 0.60
Night Branch.	8	26.35	26.30	+ 0.05
	9	25.73	25.51	+ 0.22
	10	24.93	24.80	+ 0.13
	11	24.40	24.18	+ 0.22
	12	24.28	23.64	+ 0.64
	1 A. M.	23.70	23.18	+ 0.52
	2	23.29	22.81	+ 0.48
	3	22.92	22.51	+ 0.42
	4	22.60	22.37	+ 0.23
	5	22.22	22.18	+ 0.04

The agreement of the observed and calculated temperatures in Table VI. also tends to confirm our supposition, except with regard to the morning branch. This exception might have been anticipated by inspection of the curve as projected, from which it is evident that the increments of temperature after sun-rise, in the summer, are too great to be represented by the abscissæ of equal parabolic arcs. As this branch of the subject requires, more than any other part of it, the application of more extended observations, I shall not pursue the investigation further at this time, in the hope that some persons favourably situated at one or more of our military or naval stations, may be induced to supply us with additional data for confirming or correcting the laws of variation of temperature, which have been laid down in this paper.

Frankford Arsenal, November, 1836.

Third Report of the Joint Committee on Meteorology, of the American Philosophical Society and the Franklin Institute of the State of Pennsylvania, for the Promotion of the Mechanic Arts.

In our two previous Reports we gave an account of nine storms, in all of which the wind blew towards the storm in its borders.

Two very remarkable storms have occurred since; one commenced on the 23rd of May, and continued to the 7th of June; the other occurred on the night of the 19th and the day of the 20th of June. Immediately after the

termination of these storms, the committee addressed circulars to a great many individuals throughout the United States, requesting an account of them, particularly with regard to the rain, and the strength and direction of the wind. Our inquiries were not in vain. We received very satisfactory replies from many in the region of the storms, and beyond their boundaries. It would be highly desirable to give the documents to the public, entire, but our present means will not permit.

It is hoped that when government shall become acquainted with the important discoveries already made, and the absolute necessity of combined and simultaneous exertions, beyond the reach of individuals, their liberality will be cheerfully extended to the promotion of this science, in our widely extended country.

In the mean time, we must content ourselves by giving a few general results, as we did in our previous reports.

In the first place, we remark a very striking difference between the first of the two storms mentioned above, and all the winter storms investigated before in our reports; all the winter storms as well as the tornados or land spouts in the summer, seem to travel from a point south of west, while this long continued storm was nearly stationary, inclining, indeed, a little towards the south-west, as it continued to rain in N. C. and S. C. some days after it ceased at Philadelphia. The Alleghany Mountains seem to have been near the centre of the rain, extending from the western parts of N. York to S. Carolina. The rain was copious as far west as Cincinnati and Lexington, Ky., and as far east as the shores of the Atlantic, hardly reaching Illinois, and extending but little way into the Atlantic, and not prevailing much as far N. E. as Massachusetts.

Now, in Massachusetts, Connecticut, and New York, the wind was constantly blowing from the N. E. during the whole period of the storm. In Charleston, S. C., constantly from the S. and S. E. In the interior parts of the storm, the wind was variable; the prevailing winds, however, in the northern parts of Ohio being from the N., in Illinois from the W., and in Alabama there seems to have been nothing remarkable—no N. E. storm occurred, but the direction of the wind is not given.

It also appears by the log books of several masters of vessels who left the Gulph of Mexico about the beginning of this storm, and arrived at Philadelphia about the end of it, that they had the wind constantly from the S. W. and S. and S. E. fresh the whole way, gradually passing the south and nearing the east as they approached to Philadelphia.

Thus it appears that on the N. E. and E., S. and S. W. the wind was constant, for at least fourteen days towards a great rain, and that on the other part of the circle, even within the boundaries of the rain, the wind, though variable, prevailed in a direction towards the centre of the storm.

In this storm then, as in the nine investigated before, the wind blew towards the centre, and consequently upwards in the middle—and outwards above—at least in Massachusetts. Mr. Daniel C. Sanders, of Medfield, 17 miles S. W. of Boston, says: "often there were three strata of clouds, the upper one very high, moving from the west, nearly opposite to the lower stratum. The middle one was very changeable in its direction."

And also at Bennington, Vermont, Mr. Jonathan Hunt says: "In almost all violent storms from the east, there is an upper current from the west."

There is therefore the strongest reason to believe that rain is caused by the cooling produced by the rarefaction of the air in its upward motion in the centre of the storm.

The storm which commenced on the night of the 19th June is not less remarkable than the one just described. It seems also to have traveled S. or S. W., for on the night of the 19th, and the next day, the rain was greatest at Silver Lake, in the northern part of Pennsylvania, and on the night of the 20th, and the next day, it was greatest at Baltimore, and it did not reach Hawsburg, Rappahannock county, Va., till the 21st, when it rained very heavily, the wind having veered round to the N. E. At Staunton, Va., it was clear all day the 21st and 22d, till evening, and the N. E. storm did not set in till the 24th.

In the wood cut we have given the direction of the wind by means of arrows at all the places from which we have any accounts. On the 20th of June, there fell nearly three inches of rain, including that of the preceding night, at Silver Lake. Much more rain fell here than at any of the surrounding places of observation. There was but little at Foxsburg, Gettysburg, and Harrisburg, and it did not commence at Baltimore till 7h. 30m. P. M., nor at Emmettsburg till 4 P. M., nor at Philadelphia till 5h. 10m. P. M.

By casting the eye on the wood-cut, it will be seen at a glance that the wind blew on all sides towards the point of greatest rain.

But what is not a little remarkable, the wind was much more violent all round the borders of the storm, than near the centre.* At Harrisburg and Gettysburg it was gentle, and at Emmettsburg it was tempestuous. It is true it did not begin to be tempestuous till 4 P. M., and at Philadelphia it did not begin to blow very hard at the surface of the earth, till about 11 A. M. At 7 A. M. it was very calm, though the low clouds were flying with great velocity from the S. E., exactly towards the region of the great rain. It is also worthy of particular remark, that the wind at Emmettsburg was N. W. on the 21st, blowing towards a region where it rained that morning and the preceding night, so much as to do great mischief, and even as near to Emmettsburg as Baltimore, it rained in that time 1-7 inches.

* It has since been ascertained that during the day of the 20th, the wind at Silver Lake was so variable that it was difficult to know from what point it prevailed most.

This rain reached Emmettsburg, but was small in quantity, viz. $\frac{26}{100}$ of an inch. The wind on this day, at Baltimore, varied from S. E. to N. E. It was, therefore, part of the time, exactly opposite to the wind at Emmettsburg.

Another remarkable feature of this storm is, that it was preceded the day before with thunder-gusts, on the N. E. N. and W., and probably on the S. E., as the temperature fell very suddenly at Philadelphia, as soon as the wind changed to south-east, about 11 A. M. The sudden depression of temperature can hardly be accounted for, except on the supposition that a thunder storm took place during the preceding night, S. E. of Philadelphia. The temperature had not changed at Harrisburg at 1 P. M., nor at Emmettsburg at 2 $\frac{1}{2}$, where the wind continued all day from the S. W.

Besides these two storms, we may mention one which took place on the night of the 10th March, 1836. The centre of greatest rain appears to have been at Providence, R. I., where it began at 6 P. M., and rained most violently till twelve at night. The papers of the day give accounts of great damage done by the floods near Providence; and they state that the wind sprung up and blew violently from the S. E. at Bristol, R. I., some time in the evening, and raged from that quarter till five next morning, and then changed round to S. W., and continued strong.

At Flushing, Long Island, the wind was almost calm at 5 $\frac{1}{2}$ P. M., but about seven it rose from S. W. and blew hard all night, and till ten next morning. At Philadelphia it was very calm and foggy all the evening, till about eleven, when the wind rose suddenly and violently from the S. W., and blew a hurricane nearly all night, changing round to N. W. at four next morning. It is worthy of particular remark, that at Flushing the wind began to blow towards the point of greatest rain about four hours sooner than it did at Philadelphia, about 100 miles more distant from the centre of the storm. This is in remarkable accordance with the fact detailed above, concerning the time the wind set in at Philadelphia from the S. E. on the morning of the 20th June, towards a very great rain which had been going on then for eleven or twelve hours at Silver Lake, and in that vicinity.

From all these facts, in connexion with those detailed in our previous reports, it is, we think, abundantly proven, that the air moves inwards towards the centre of great rains, and consequently upward in the region of the cloud. Nor is this inward motion difficult to account for. It has been long known that the barometer stands low in the middle of great storms, and nothing is more plain than that the air will run on all sides towards the point where the barometer stands lowest, with a velocity proportional to the square root of the depression. And as this air mounts upwards over the point where the barometer stands lowest, a condensation of the vapour must take place from the cold produced by diminishing pressure as it ascends. Now, the chairman of this committee has shown by calculation from acknowledged data, that for every pint of water which is formed by condensation of vapour, the cloud itself is expanded 7600 pints by the latent caloric given out at the moment of condensation. Thus will the upward motion in the cloud be continued as long as air highly charged with vapour runs in below.

It is also easy to explain why the base of the cloud, during this rapid motion of the air upwards, remains nearly at the same level. For so long as the dew-point of the air at the surface of the earth, which supplies the ascending column with vapour, remains the same, if the tempera-

ture of the air is the same also, it will have to ascend to the same height, before cold enough is produced by expansion to cause condensation of the vapour. This height is found to be about 100 yards for every degree between the temperature of the air and the dew-point, unless when the cloud becomes of great perpendicular depth, when the base sinks a little from the levity of the cloud.

The quantity of depression of the vapour as well as of the air, after due allowance is made for the fall of the dew-point from the expansion, is nearly 400 yards for a depression of the barometer one inch, on the supposition that the temperature of the air sinks 4° for a diminution of pressure equal to an inch of mercury.

A depression of near two and a half inches has been recorded in a spout accompanied with hail nine inches deep: hence the base of the cloud would descend in the centre near 1000 yards; and of course, if the dew-point and temperature of the air were not more than 10° apart, the cloud would reach the earth, and exhibit itself in the form of an inverted cone, expanding as it goes up, and by its rapid motion carrying up large drops of rain above the region of perpetual congelation, and throwing them out at the sides, in the form of *hail*.

From the principles here developed, it will be easy, when a great storm springs up, or comes within disturbing influence, to tell in what direction it is raging; for the direction of the wind points it out. An exception to this general principle was mentioned and explained in our last report. The connexion also between volcanos and rains is no longer mysterious: for an upward motion of the air is produced and kept up by the volcano, the result of which must be a condensation of vapour, unless the dew-point is very low. So powerful is this tendency, that in South America a dry season is sometimes changed into a rainy one, by the bursting out of a volcano. From these brief hints, we trust it will be acknowledged that something has been gained explanatory of the phenomena in question. But we must not stop here; it is not enough to know *where* it is raining at a given time; we must know *when* it will rain where we are. For this purpose it is of primary importance to know the direction in which storms move, and also their velocity in all the different seasons of the year.

We would suggest as the most effectual, and perhaps the only, means of obtaining this end, an appropriation by government for the purchase of meteorological instruments, to be presented to those academics, schools and colleges, that would pledge themselves to keep a journal of the weather, according to a prescribed plan, for five years; and send a monthly statement to a meteorologist, to be appointed by the government. If instruments were thus furnished for 100 observers, it is altogether probable 200 more would volunteer their services, knowing that their labours would be one hundred fold more valuable in combination with others than they had hitherto been.

With 300 observers, properly located, no storm could spring up within, or enter the United States, without being constantly under the eye of at least two observers. And thus its extent, its progress, and the direction of the wind in its borders, would be fully known. Until this shall have been effected by government, we entreat every gentleman to whom the report is sent, to consider it a patriotic duty to furnish the means of enabling at least one faithful observer of the weather, to transmit a series of observations monthly, to Wm. Hamilton, Esq., Actuary of the Franklin Institute, Philadelphia.