

VIII. *Experiments on local Heat. In a Letter from James Six, Esq. to the Rev. Francis Wollaston, LL.B. F. R. S.*

Read January 10, 1788.

DEAR SIR,

THE following experiments are a continuation of those I had the pleasure of communicating to you some time since, relating to the diversity of local heat in the atmosphere; and confirm, in a more particular manner, my former observations respecting a remarkable refrigeration, which, in clear weather, takes place near the earth; for, although its surface in the day-time is then most liable to be heated by the sun, yet after that is set, and during the night, the air is always found coldest near the ground, particularly in vallies. This phenomenon, for want of nocturnal observations, has been but lately noticed*; probably because in the day-time, especially when
the

* Within these few years.

Mr. WILSON, in the Philosophical Transactions, 1780, p 467. and 1781, p. 368. describing the effects of a severe frost at Glasgow, mentions a remarkable refrigeration, which he perceived to take place on the surface of the snow and hoar-frost, which sunk the mercury in a thermometer laid upon it many degrees lower than one suspended twenty-four feet above it. This phenomenon, he says, *had recently come under observation*; but supposing (I presume) the principle of refrigeration to operate only on the surface of the snow, or hoar-frost, when the cold was severe, it does not appear he made experiments at any other time.

In

the weather is still and warm, the difference of temperature is reversed, the reflection of the sun's rays from the earth heating the air more below than it does above.

The experiments in my former Paper * were made partly in autumn, and partly in winter; and, the local variations differing in some measure with the seasons, I was desirous of continuing a series of experiments throughout one entire year. To this end, therefore, I suspended proper thermometers † in a shady northern aspect, in the open air, at different heights; one in my garden at nine feet, and another in the Cathedral Tower 220 feet from the ground; continuing my journal, with the omission of a few days only, from July 1784 till July 1785.

In the summer of 1783, making experiments with thermometers, which I had constructed to shew the greatest degrees of heat and cold that happened in the observer's absence, *I first perceived* this nocturnal refrigeration in the lowest stratum of the atmosphere; for by suspending these thermometers at different altitudes, and viewing them only once in twenty-four hours, I found the true maximum and minimum of the heat and cold, which had happened during that time in their several stations.

A writer in the Gentleman's Magazine, for March 1785, p. 170, who did me the honour to mention my former Paper, containing *Experiments on Local Heat*, observed, that the effects of a sharp frost, which happened in *December of the preceding year*, appeared to be much more severe among the vegetables in the vallies than on the hills; and by taking the difference of temperature with thermometers at that time, he found them vary from 5 to 17 degrees, according to their several stations.

M. DE SAUSSURE, in his *Voyages dans les Alpes*, Vol. II. published 1786, says, "Quant à l'observation bien curieuse et bien nouvelle de M. PICTET, que pendant la nuit la couche d'air la plus basse depuis la terre jusques a 5 pieds au-dessus est plus froide que les couches suivantes depuis 5 pieds jusque a 50."

* Philosophical Transactions, Vol. LXXIV. p. 428.

† Constructed to give the true maximum and minimum that may happen in the observer's absence. See Philosophical Transactions, Vol. LXXII. p. 72.

The

Fig. 1.

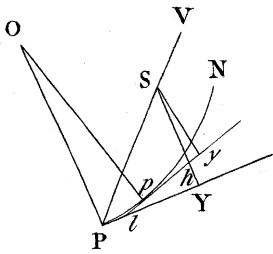


Fig. 2.

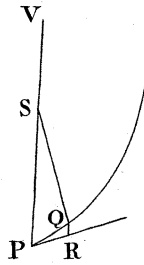


Fig. 3.

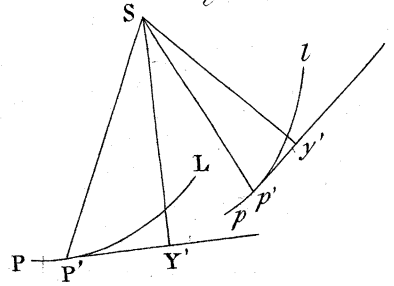


Fig. 5.

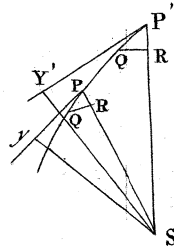
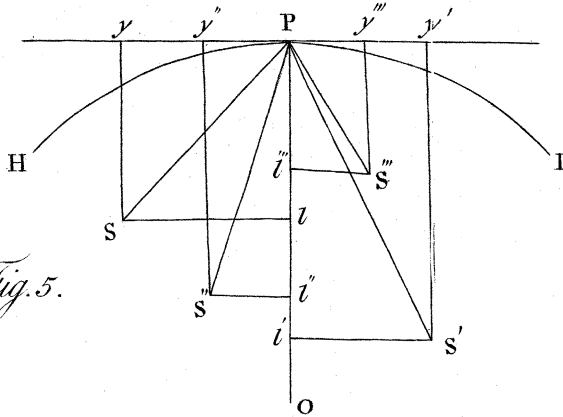


Fig. 6.

Fig. 7.

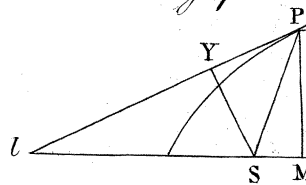


Fig. 9.

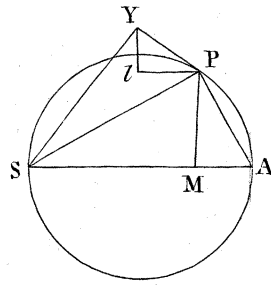
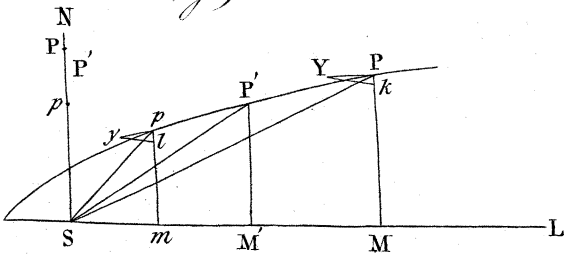


Fig. 10.

Fig. 11.

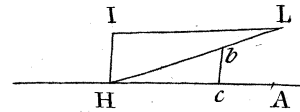


Fig. 4.

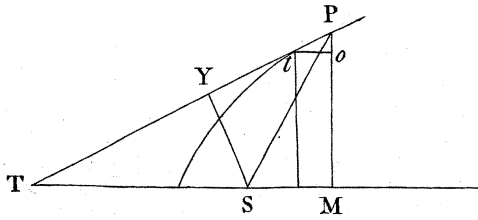


Fig. 8.

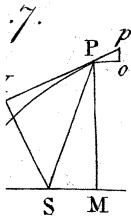
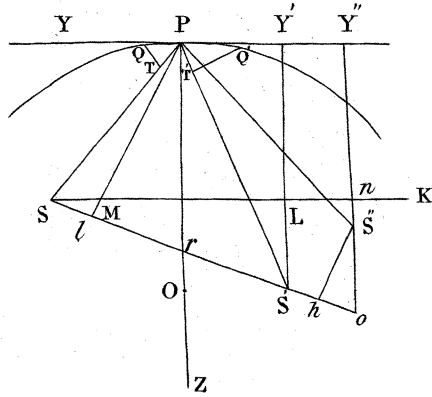


Fig. 11.

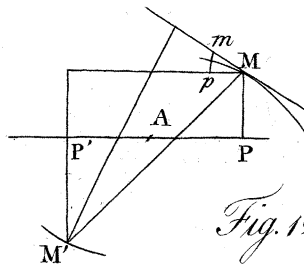
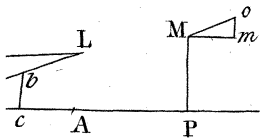


Fig. 12.

The result entirely corresponded with what I had before observed respecting the nocturnal diminution of heat, and the particular state of the atmosphere requisite to produce it. The greatest variations which happened within the year were in October and June; in the former month, the thermometers generally differed most in the night; in the latter, most in the day. From the 25th to the 28th of October, the heat below, in the night, exceeded, in a small degree, the heat above, at which time there was frequent rain, sometimes mingled with hail. From the 11th to the 14th, and also on the 31st, there was no variation at all; during which time likewise the weather was rainy; all the rest of the month proving clear, the air was found colder below than it was above, sometimes 9 or 10 degrees. In the month of June, the greatest nocturnal variations happened from the 11th to the 15th, and from the 25th to the 30th; at both which times there appeared to be two currents of wind, the upper current from the S.W., the lower from the N.E.*. On cloudy nights, the lowest thermometer sometimes shewed the heat to be a degree or two warmer than the upper one; but in the day time the heat below constantly exceeded the heat above more than in the month of October. See Tab. I. and II. †.

Being

* Sometimes these were rendered visible by clouds in different strata, moving in different directions, and at other times by clouds moving in a contrary direction to a very sensible current of air below.

† The observations of the wind and weather were taken at Canterbury. In all the tables, the nocturnal degrees of cold belong to the night immediately preceding the day to the date of which they are placed.—With my thermometer I have sometimes suspended hygrometers; but their movement, although as conformable as possible to the moisture of the air, had not a sufficiently regular correspondence with the variation of the thermometers to be inserted in the

Being desirous of knowing whether the nocturnal refrigeration increased on a nearer approach to the surface of the earth, I placed, in the midst of an open meadow, on the bank of the river, near this city, two thermometers; one on the ground, and the other six feet above it; with these, and the two others before mentioned, one on the tower, and the other in my garden, I made observations from the 10th to the 23d of October, 1786. See Tab. III. But as the thermometer six feet from the ground, in the meadow, nearly agreed with that in the garden at nine feet, I have omitted an account of the latter in this table of comparison. Here I found, as before, the nocturnal variations entirely regulated by the clearness, or the cloudiness, of the sky; and although they did not always happen in the same proportion to the respective altitudes, yet, when the thermometers differed at all, that on the ground was always the coldest.

Finding so considerable a difference as three degrees and a half, within six feet of the earth's surface, I increased the number of my thermometers in the meadow to four; one of them I sunk in the ground, another I placed just upon the ground, a third I suspended at three feet, and a fourth at six feet from the ground; at the same time I placed three thermometers in an open garden on St. Thomas's Hill, where the land is level with the Cathedral Tower, and about a mile distant from it; here I likewise put one in the ground, another just upon it, and suspended a third six feet above it.

tables of comparison. It is true, when the weather was clear and not too cold, the upper ones indicated dryness more than the lower; but in frosty weather, the contraction and expansion of the hygrometers being impeded by the frost, they did not in any regular manner agree with the variations of the thermometer.

With

With these seven thermometers and the two, before mentioned, in the city, I continued a diary for twenty days, taking also every morning the temperature of the water in the river; but the weather proving cloudy soon after, the thermometers hardly varied at all, seven or eight days only excepted. After this time I never rectified them but when the appearance of the weather gave me reason to expect that they would vary considerably. See the observations that were then taken Tab. IV.; by which it appears, that the cold in the night was generally greater in the valley than that on the hill; but that the variations between the thermometers on the ground, and those six feet above them, were often as great on the hill as in the valley.

Perceiving now, that a difference of temperature was frequently found within three feet from the ground, I resolved to try still nearer; but my thermometers being eighteen inches in height could not be applied so near to the surface of the earth as my experiment required; I therefore constructed two others for the particular purpose; and by bending down the large tube, the bulb or body of the thermometer, to an horizontal position, while the smaller tubes remained in a vertical one, I was enabled to ascertain the different degrees of heat from the ground to a single inch.

At certain times, when the weather was clear, I exposed these two horizontal thermometers in an open place, suspending one of them, so as to bring the body of it within an inch of the ground, and the other nine inches above it. When the variation among the other thermometers was considerable, I found also a difference between these; the lower one indicating sometimes more than two degrees less heat than the

upper one, although they were placed so near to each other. See Tab. V.

From the foregoing experiments it appears, that a greater diminution of heat frequently takes place near the earth in the night-time, than at any elevation in the atmosphere within the limits of my inquiry; and that the greatest degrees of cold are at such times always found nearest to the surface of the earth; that this is a constant and regular operation of nature, under certain circumstances and dispositions of the atmosphere, and takes place at all seasons of the year; that this difference never happens in any considerable degree but when the air is still, and the sky perfectly unclouded*; but the moistest vapour, such as dews and fogs †, did not, as far as I could perceive, at all impede, but rather increase the refrigeration. In very severe frosts, when the air frequently deposits a great quantity of frozen vapour, I have generally found it greatest ‡; but the excess of heat, which in day-time, in the summer season, was found at the lower station, in the winter diminished almost to nothing.

The foregoing experiments related to the difference of heat, which, at certain times, is found at different altitudes; the

* Free from clouds which float higher in the air than fogs, and are sufficiently opaque to hide the stars from our view even in the zenith.

† When fogs covered the valley, the refrigeration below was considerable; but they very seldom reached so high as the upper thermometer, and the sky was clear above. No variation during rain, except mingled with hail.

‡ This remarkable diminution of heat near the surface of the earth in clear weather, after the sun is set, and in the night, proceeds, I apprehend, partly from the coolness which the dews or vapours possibly may acquire in their descent, and partly from the evaporation which takes place at the same time from all moist or frozen bodies exposed to the open air, particularly from those on which the dew or hoar frost is deposited.

following to the different degrees of heat observed at different situations in respect to the sea-shore. Tab. VI. and VII. contain a set of corresponding observations; among which are those you were so obliging as to take for me at Chislehurst*; others at the same time were taken in my garden, and on the Cathedral Tower; and others on the sea-shore, about seven miles N.N.W. from Canterbury, where the thermometer was suspended about 40 feet above high-water mark, 14 from the ground, and about 100 yards from the sea†.

By Tab. VI. it appears, that every night, one only excepted, during that time, the air was coldest at Chislehurst; and that the mean heat at the sea-shore was equal to that on the tower at Canterbury. In the month of June (Tab. VII.) it is remarkable, that the cold was still greater in the night at Chislehurst than at any of the other places, excepting where there appeared two currents of wind, the upper current from the S.W. and the lower from the N.E.; at which time also there was the greatest difference between the thermometer in the garden and that on the tower.

Tab. VIII. contains observations taken only at particular times, when the weather was extremely cold; and shews how nearly at such times the temperature in the night, at the sea-shore, generally agreed with that on the Cathedral Tower; with this exception, however, that on the 18th, 21st, and 22d of February, 1784, a little snow falling at several times in the day, the evenings after being clear, and the wind at N.E., the thermometer on the sea-shore, contrary to what usually happened, gave the cold greater than the thermometer on the

* The thermometer at Chislehurst was suspended twelve feet from the ground.

† The thermometer on the Cathedral Tower was elevated about 200 above that on the sea-shore.

tower; but under similar circumstances I have since seen the same.

The following experiments relate to the variation of local heat in the earth itself; the diversity of which appears from the different heat of the water issuing from it at different places*. It has been conjectured, that the diversity of the temperature of springs may probably depend on their different elevations in the earth, with respect to the level of the sea.

Two remarkably deep wells, both near the sea-shore, and not far distant from Canterbury, gave me a favourable opportunity of making experimental inquiry into this matter; especially as the situation of the two springs differed considerably from each other in respect to the level of the sea. One of these is a well in Dover Castle, which is sunk 360 feet through the high cliff of chalk on which the Castle stands, and the depth of the well is nearly equal to the height of the cliff from the sea. The other is King's-Well at Sheerness†, which was sunk 330 feet through almost one entire stratum of firm clay, where the surface of the ground is only four feet above high water.

Supposing therefore the spring in Dover well to lie level with the sea, the spring of the well at Sheerness lies 326 feet below it; a circumstance extremely favourable to my experi-

* The temperature here meant is not that of the very hot springs which proceed from particular local causes, sometimes rising near the surface of the earth; nor of springs which are near enough to the surface of the earth to be affected by the change of temperature in the atmosphere; but that heat which being found at a great depth is more likely to be permanent, and may be supposed to originate from some general cause in the earth.

† See an account of sinking this curious well by Sir THOMAS PAGE, Phil. Transf. Vol. LXXIV. p. 6.

ment. The temperature of the springs I took in the following manner.

After fathoming each well with a line and plummet, I let one thermometer down to the bottom, and fixed another on the line, so as to reach to half the depth only, keeping a third to take the temperature of the air at the top.

Degrees of heat in the wells.

Sept. 28, 1784. Temperature of the water in the new well in Dover Castle.	Oct. 6, 1784. Temperature of the water in King's Well at Sheernefs.
By thermometer at the top 56°	By thermometer at the top 53
By ditto at the middle 52	By ditto at the middle 51
By ditto at the bottom 48½	By ditto at the bottom 56
Found the well 360 feet deep with 21 feet water.	Found the well 280 feet deep* with 180 feet water.

About noon was the time of day when I made the experiments at both places, and the top of the respective wells varying from each other depended wholly on the accidental temperature of the atmosphere at the time; but that the thermometer at half the depth of the well at Dover gave nearly the mean heat of the top and bottom, while that in a corresponding situation in the well at Sheernefs gave it colder than either top or bottom, I attribute to the following circumstance.

Over the well at Sheernefs a machine is erected, which raises the water by means of an horizontal windmill, working an endless chain. This chain, consisting of jointed double bars, with a number of buckets fixed thereon, at certain distances from each other, continually descending into, and ascending out of the water, to an elevation of eight or nine feet above

* The sand brought up from the bottom of the well by the force of the spring has reduced it to its present depth.

the top of the well, may be supposed to reduce the water as far as it reaches to the mean temperature of the air above ; and thus I found it ; for 51 degrees had been the mean temperature of the air near the sea-shore for several days before. At the bottom of the well, near to which the chain never descends, I found the temperature 56 degrees ; above 7 degrees warmer than that at Dover well.

The water at the bottom of these wells is, I presume, too deep beneath the surface of the earth ever to be affected by the temperature of the atmosphere ; for if the heat of the summer could have had any influence on either of them, that at Dover must have been most considerably affected by it, especially in the month of September ; and the air was something warmer when the experiment was made at Dover than at Sheerness. From the nature of the different kinds of strata in which these wells are dug, had they been in all other circumstances the same, one might reasonably expect to find the warmer spring in the chalk, and the colder in the clay ; but here the reverse is seen, without any apparent local cause, except the different elevations of the springs in respect to the level of the sea.

I am, &c.

JAMES SIX.

Canterbury,
August 1, 1787.

T A B L E I.

Thermometers at different stations compared together.

1784	Night.			Day.			Morning.	Afternoon.	Evening.	W nd.	Barometer.
	In the garden.	On the tower.	Differ-ence.	In the garden.	On the tower.	Differ-ence.					
Oct.											In.
1	40 ⁰ / ₂	45 ⁰	- 4 ¹ / ₂	50 ⁰	53 ⁰	+ 3 ⁰	Partly clear.	- -	- -	NE	30.2
2	42	40	- 4	58	56	+ 2	Cloudy.	- -	Clear.	E	30.3
3	40	45 ¹ / ₂	- 5 ¹ / ₂	55 ¹ / ₂	54	+ 1 ¹ / ₂	Partly clear.	- -	Cloudy.	E	30.4
4	40	46	- 6	55 ¹ / ₂	54	+ 1 ¹ / ₂	Partly clear.	- -	- -	E	30.2
5	41	51	- 10	57 ¹ / ₂	56	+ 1 ¹ / ₂	Partly clear.	- -	Clear.	E	29.9
6	41	47	- 6	56	55	+ 1	Clear.	- -	- -	E	30.1
7	40	46	- 6	54 ¹ / ₂	52 ¹ / ₂	+ 2	Clear.	- -	- -	E	30.1
8	40	46 ¹ / ₂	- 6 ¹ / ₂	55	53	+ 2	Clear.	- -	- -	E	29.9
9	39 ¹ / ₂	43	- 3 ¹ / ₂	53	51	+ 2	Cloudy.	- -	Partly clear.	E	29.9
10	44 ¹ / ₂	45	- 0 ¹ / ₂	50 ¹ / ₂	49	+ 1 ¹ / ₂	Cloudy.	- -	Rain.	E	29.9
11	44	44	-	54	51	+ 3	Showery.	- -	- -	NW	30.0
12	44	44	-	55 ¹ / ₂	53	+ 2 ¹ / ₂	Showery.	- -	Cloudy.	NE	30.2
13	45	46	- 1	56	55	+ 1	Showery.	- -	- -	NE	30.2
14	44	44	-	50	48 ¹ / ₂	+ 1 ¹ / ₂	Cloudy.	Clear.	- -	E	30.1
15	31 ¹ / ₂	41	- 9 ¹ / ₂	50 ¹ / ₂	49	+ 1 ¹ / ₂	Clear.	- -	- -	NE	30.0
16	28 ¹ / ₂	38 ¹ / ₂	- 10	53	51 ¹ / ₂	+ 1 ¹ / ₂	Clear.	- -	- -	E	30.0
17	28	38 ¹ / ₂	- 10 ¹ / ₂	54	52 ¹ / ₂	+ 1 ¹ / ₂	Partly clear.	- -	- -	E	30.0
18	29	38 ¹ / ₂	- 9 ¹ / ₂	56	53	+ 3	Clear.	- -	- -	E	29.9
19	34	40	- 6	58	54	+ 4	Partly clear.	- -	Clear.	NE	29.7
20	30 ¹ / ₂	37	- 6 ¹ / ₂	54 ¹ / ₂	51 ¹ / ₂	+ 3	Clear.	Cloudy.	Clear.	NE	29.9
21	33	35	- 2	51	52	- 1	Clear.	- -	- -	NE	30.1
22	43 ¹ / ₂	44	- 0 ¹ / ₂	55 ¹ / ₂	54	+ 1 ¹ / ₂	Cloudy.	- -	Partly clear.	SW	30.0
23	43	46	- 3	56	54	+ 2	Misty rain.	- -	Cloudy.	W	29.7
24	32 ¹ / ₂	34	- 1 ¹ / ₂	45 ¹ / ₂	43	+ 2 ¹ / ₂	Clear.	- -	Rain.	NW	29.4
25	31	30 ¹ / ₂	+ 0 ¹ / ₂	43	40 ¹ / ₂	+ 2 ¹ / ₂	Cloudy.	- -	- -	NW	29.7
26	35 ¹ / ₂	32 ¹ / ₂	+ 3	44	43 ¹ / ₂	+ 0 ¹ / ₂	Cloudy.	Rain with hail.	- -	NE	29.9
27	40	39	+ 1	47	46	+ 1	Rain.	- -	- -	NE	30.0
28	42	41	+ 1	47 ¹ / ₂	46	+ 1 ¹ / ₂	Rain.	- -	- -	NE	30.0
29	40	42	- 2	47	48	- 1	Cloudy.	- -	Rain.	NE	30.0
30	40	40	-	51	50	+ 1	Cloudy.	- -	Rain.	N	29.9
31	45	44	+ 1	50	49	+ 1	Cloudy.	- -	- -	W	29.8

TABLE II.

Thermometers at different stations compared together.

1785	Night.			Day.			Morning.	Afternoon.	Evening.	Wind.	Barometer.
	In the garden.	On the tower.	Differ- ence.	In the garden.	On the tower.	Differ- ence.					
June	°	°	+ °	°	°	°					In.
1	47	46	+ 1	65	59	+ 6	Showery.	- -	- -	W	29.8
2	47	48	- 1	65	61	+ 4	Clear.	Cloudy.	- -	N	29.8
3	46	47	+ 1	71	67	+ 4	Partly clear.	- -	Clear.	SW	29.9
4	42½	46	- 3½	70	66	+ 4	Partly clear.	- -	Clear.	SW.NE	29.8
5	54	54	—	68	60	+ 8	Partly clear.	Cloudy.	Rain.	W	29.7
6	51	49	+ 2	61	57	+ 4	Cloudy.	- -	- -	S	30.0
7	43	45	- 2	62	58	+ 4	Cloudy.	- -	Rain.	SE	30.0
8	53½	52½	+ 1	73	66	+ 7	Rain.	- -	Showery.	SSW	30.0
9	56	55	+ 1	75	70	+ 5	Partly clear.	- -	- -	SW	30.2
10	56	55	+ 1	78	74	+ 4	Clear.	- -	- -	W	30.3
11	54	57½	- 3½	84	74	+ 10	Clear.	- -	- -	SW	30.4
12	52	57	- 4	71	63	+ 8	Clear.	- -	- -	SW.NE	30.3
13	41	49	- 8	67½	64	+ 3½	Clear.	- -	- -	SW.NE	30.2
14	42½	50½	- 8	69	64	+ 5	Clear.	- -	- -	SW.NE	30.2
15	48	53	- 5	78	73	+ 5	Clear.	- -	Hazy.	SW.NE	30.0
16	54	54	—	68	60	+ 8	Clear.	- -	- -	W	29.9
17	48	46	+ 2	61	60	+ 1	Showery.	- -	Clear.	N	29.8
18	50	49	+ 1	64	61	+ 3	Cloudy.	Partly clear.	- -	N	30.2
19	48	48	—	61	57	+ 4	Cloudy.	- -	Clear.	NE	30.3
20	45	48	- 3	65	60	+ 5	Cloudy.	Clear.	Cloudy.	NE	30.3
21	51	49	+ 2	64	59	+ 5	Cloudy.	- -	- -	NE	30.3
22	47	45	+ 2	64½	60½	+ 4	Cloudy.	Clear.	- -	NEN	30.3
23	51	49½	+ 1½	61	57	+ 4	Mifty rain.	- -	Cloudy.	NE	30.3
24	52	51	+ 1	62	58	+ 4	Cloudy.	Clear.	- -	NE	30.4
25	40	48	- 8	63	60	+ 3	Cloudy.	- -	Clear.	SW.NE	30.3
26	44½	49	- 4½	68	63½	+ 4½	Cloudy.	- -	Clear.	SW.NE	30.2
27	43	52	- 9	67	61	+ 6	Clear.	Partly clear.	Cloudy.	SW.NE	30.0
28	56	55	+ 1	70	66½	+ 3½	Partly clear.	- -	Clear.	SW.NE	29.9
29	49½	55	- 5½	72	68	+ 4	Clear.	- -	- -	SW.NE	29.9
30	50	55	- 5	75	69	+ 6	Clear.	- -	- -	SW.NE	29.8

TABLE

T A B L E III.

Thermometers at different stations compared together.

1786	Night.				Day.				Morning.	After-noon.	Even-Ing.	Wind.	Barometer.
	In the meadow on the ground.	In the meadow at six feet.	On the tower.	Dif. between the ground and six feet.	Dif. between the ground and the tower.	In the meadow on the ground.	In the meadow at six feet.	On the tower.					
Oct. 10	52°	52°	52½°	—	—	62°	62°	58°	—	—	—	S	29.5
11	38	40	48	—2	—10	57	58	57	—1	—	—	S	29.5
12	51	51	51½	—	—	58	57	54	+1	+4	—	SW	29.5
13	36	37	38½	—1	—	52	51	47	+1	+5	—	NW	30.0
14	25½	28	32	—2½	—6½	51	51	48	—	+3	—	Clear.	30.1
15	31	33	40	—2	—9	52	50	42	+2	+10	—	Clear.	30.1
16	29	31½	36	—2½	—7	54	53	48	+1	+6	—	Clear.	30.1
17	33	36½	39	—3½	—6	50	50	50	—	+3	—	Partly clear.	30.2
18	31	34	34	—3	—3	53	53	50	—	+3	—	Clear.	30.2
19	26	29	36	—3	—10	50	49	47	+1	+3	—	Clear.	30.2
20	43	44	45	—1	—2	48	47	47	+1	+1	—	Cloudy.	30.3
21	43	44	45	—1	—2	49	49	48	+1	+1	—	Cloudy.	30.3
22	45	45	45	—	—	52	52	47	—	+5	—	Cloudy.	30.2
23	45	45	45	—	—	51	51	51	—	—	—	Cloudy.	30.2

T A B L E IV.
Thermometers at different Stations compared together.

1786	Night.						Day.						Greatest difference in the night.	Wind.	Weather.	Barometer.	In the ground in the meadow.	In the ground on the hill.	Temperature of the river.			
	In the meadow on the ground.	In the meadow at three feet.	In the meadow at six feet.	On the hill on the ground.	On the hill at six feet.	In the garden at nine feet.	On the tower at 220 feet.	In the meadow on the ground.	In the meadow at three feet.	In the meadow at six feet.	On the hill on the ground.	On the hill at six feet.								In the garden at nine feet.	On the tower at 220 feet.	
Nov. 12	23°	25½°	26°	25½°	28½°	27°	31°	43½°	43°	43½°	43½°	42°	43°	41½°	8½°	E	Clear.	29.3	42°	41°	42°	
13	21½	24	25	22	29	26	30	37	36½	37½	36	38	36	35	8½°	E	Clear.	29.7	42	41½	42	
14	23	24½	25	22½	28½	24	28½	34	33	33½	38	38	33	31½	3°	E	Clear.	29.8	42	41	42	
15	29	29	29	28	28½	29	28½	37	33	33	38	38	38	38	9°	E	Cloudy.	29.7	41½	39½	41½	
27	35	37	38	39½	42	39	44	48	47½	48	47	47	47	46	9°	S	Clear.	30.0	42	41	42	
28	44½	45	45	44½	45	45	45	51	51	51	49	49	51	50	9°	S	Rain.	29.7	47	45	47	
29	37½	38½	38	38	40	38	43	51	51	51½	48	45	51	51	10½°	S	Mistyrain.	29.7	44	43	44	
30	39	40	40½	39	40	39	40	49	50	50½	42	42	43	40	11°	S	Clear.	29.5	44	43	44	
Dec. 27	4	4	7	11	15	6½	21	43	43	42	42	42	42	44	7°	S	Clear.	29.5	44	43	44	
29	25	26	28	29	32	27	34	40	40	41	41	45	45	46	9°	S	Clear.	29.7	44	43	44	
31	28	29	28	30½	31	29	35	39	40½	43	42½	43	43	37	7°	WSW	Clear.	29.5	44	43	44	
1787																						
Jan. 2	25	27	29	26	28	28½	37	38	38	38	37	38	38	37	12°	E	Clear.	30.4	42	41	42	
4	34	35½	38½	35	36	38	37½	44	45	46	44	44	44	44	4½°	SW	Clear.	30.5	42	41	42	
7	24½	25½	28	27	27	38	30½	35½	34	37	44	45	43	44	6°	E	Clear.	30.5	42	41	42	
1	21	23	26	28	30	26½	31	41	42	44	43	43	43	38	10°	E	Clear.	29.8	42	41	42	
28	21	23	26	28	30	24½	31	41	42	44	43	43	43	38	10°	—	Clear.	29.8	42	41	42	
Feb. 6	28	29	32	31	33	31	36	45	45	48	44	44	43	43	8°	S	Clear.	29.9	42	41	42	

T A B L E V.

Thermometers at different stations compared together.

Greatest cold in the night.								
	Horizontal thermometers.		Difference.	Vertical thermometers.			Difference on the ground and three feet above.	Diff. on the ground and six feet above.
	One inch above the ground.	9 inches above the ground.		Meadow on the ground.	Meadow three feet above the ground.	Meadow six feet above the ground.		
1786								
Dec. 31	$27\frac{1}{2}^{\circ}$	29°	$1\frac{1}{2}^{\circ}$	28°	29°	31°	1°	3°
1787								
Jan. 3.	$33\frac{1}{2}$	34	$0\frac{1}{2}$	33	33	34	—	1
4	$37\frac{1}{2}$	38	$0\frac{1}{2}$	34	35	38	1	4
8	21	22	1	21	22	24	1	3
11	$24\frac{1}{2}$	27	$2\frac{1}{2}$	$27\frac{1}{2}$	28	31	$0\frac{1}{2}$	$3\frac{1}{2}$
12	21	23	2	21	$23\frac{1}{2}$	26	$2\frac{1}{2}$	5
13	$30\frac{1}{2}$	32	$1\frac{1}{2}$	34	$34\frac{1}{2}$	37	$0\frac{1}{2}$	3
14	$22\frac{1}{2}$	24	$1\frac{1}{2}$	23	25	28	2	5
Feb. 6	$27\frac{1}{2}$	$29\frac{1}{2}$	2	28	29	32	1	4
23	$18\frac{1}{2}$	20	$1\frac{1}{2}$	19	21	23	2	4

T A B L E VI.

Thermometers at different stations compared together.

1784	Night.				Day.			Morning.	Afternoon.	Evening.	Wind.	Barometer.	
	At Chiffchurt.	In the garden.	On the tower.	At the sea-shore.	At Chiffchurt.	In the garden.	On the tower.						At the sea-shore.
Oct.												In.	
22	38	43 $\frac{1}{2}$	44	47	52	55 $\frac{1}{2}$	54	55	Cloudy.	- -	- -	SW	30.0
23	44	43	46	46	52	56	54	50	Misty rain.	Partly clear.	Cloudy.	W	29.7
24	31	32 $\frac{1}{2}$	34	34	42	46 $\frac{1}{2}$	43	41	Clear.	- -	Rain.	NW	29.4
25	24	31	30 $\frac{1}{2}$	35	36	43	40	40	Partly clear. Hail	Clear.	Cloudy.	NW	29.7
26	29	35 $\frac{1}{2}$	32 $\frac{1}{2}$	36	45	44	43	45	Partly clear. Hail.	- -	Showery.	NE	29.9
27	31	40	39	40	44	47	46	40	Rain.	- -	Cloudy.	NE	30.0
28	33	42	41	42	46	47 $\frac{1}{2}$	46	47	Rain.	- -	- -	NNE	30.0
29	33	40	42	43	46	47	48	47	Cloudy.	Rain.	Showery.	NNE	30.0
30	33	42	40	41	49	49	50	50	Cloudy.	- -	Rain.	N	29.9
31	42	45	44	44	45	50	49	47	Cloudy.	Clear.	Cloudy.	NW	29.8
Nov.													
1	40	41	42	42	49	55	51	50	Rain.	Showery.	- -	SW	29.7
2	39	42	44	44	46	43 $\frac{1}{2}$	49	47	Clear.	- -	- -	W	29.8
3	-	32 $\frac{1}{2}$	35 $\frac{1}{2}$	34	49	50	48 $\frac{1}{2}$	51	Cloudy.	Clear.	- -	NW	29.9
4	34	34	38	37	48	48 $\frac{1}{2}$	48	51	Cloudy.	- -	- -	S	29.8
5	32	33	38	38	43	45 $\frac{1}{2}$	45	45	Misty rain.	- -	- -	E	29.6
6	39	42	42 $\frac{1}{2}$	44	44	46	43	45	Misty rain.	- -	- -	E	29.5
7	38	42	42	42	44	46	44	46	Misty rain.	- -	- -	E	29.8
8	27	35	36	41	39	45 $\frac{1}{2}$	42	45	Clear.	- -	- -	S	30.0
9	27	28 $\frac{1}{2}$	32	30	44	46	45	46	Cloudy.	Rain.	- -	S	29.7
10	37	38	40	41	51	54	54	-	Cloudy.	Clear.	Rain.	SW	29.6
11	41	49	50	-	56	54	51	57	Rain.	- -	- -	SW	29.3
12	45	50	50	48	49	56	48	56	Rain.	Clear.	- -	N	29.3
13	36	38	44	41	47	54 $\frac{1}{2}$	51	49	Cloudy.	- -	Clear.	NW	29.7
14	31	38	41	44	53	55 $\frac{1}{2}$	54	55	Cloudy.	Rain.	- -	NW	29.8
15	37	41	41	43	52	55	54	55	Rain.	- -	- -	NW	29.7
16	38	42	43	42	47	53 $\frac{1}{2}$	51	49	Clear.	- -	- -	SW	29.9
17	37	40	37	39	51 $\frac{1}{2}$	51	50	50	Rain. Hail.	- -	Clear.	NW	29.7
18	-	35	43	46	47	50	49	49	Showery.	- -	- -	NW	29.7
19	27	31	32	35	-	43 $\frac{1}{2}$	37	41	Partly clear.	Rain.	- -	NW	29.8
20	25	29 $\frac{1}{2}$	30	33	35	40	38	39	Clear.	Rain.	- -	NW	29.9
21	22	28	30	34	36	37	37	38	Clear.	- -	- -	NNW	30.2
22	25	27	29	29	40	40 $\frac{1}{2}$	45	43	Partly clear.	Showery.	Cloudy.	W	

T A B L E

T A B L E VII.

Thermometers at different stations compared together.

1785	Night.				Day.				Morning.	Afternoon.	Evening.	Wind.	Barometer.
	At Chiffelhurst.	In the garden.	On the tower.	At the sea-shore.	At Chiffelhurst.	In the garden.	On the tower.	At the sea-shore.					
June													In.
1	46°	47°	46°	47°	61°	65°	59°	61°	Showery.	- -	- -	W	29.8
2	47°	47°	48°	50°	61°	65°	61°	62°	Clear.	Cloudy.	- -	N	29.8
3	49°	46°	47°	46°	74°	71°	67°	69°	Partly clear.	- -	- -	SW	29.9
4	45°	42°	46°	44°	71°	70°	66°	69°	Partly clear.	- -	Clear.	SW.NE	29.8
5	52°	54°	54°	54°	64°	68°	60°	66°	Partly clear.	Cloudy.	Rain.	W	29.7
6	48°	51°	49°	51°	63°	67°	57°	61°	Cloudy.	- -	- -	S. N	30.0
7	43°	43°	45°	45°	63°	62°	58°	60°	Cloudy.	- -	Rain.	SES	30.0
8	53°	53°	52°	54°	67°	73°	66°	70°	Rain.	- -	Showery.	SSW	30.0
9	55°	56°	55°	55°	75°	75°	70°	73°	Partly clear.	- -	- -	SW	30.2
10	50°	56°	55°	52°	82°	78°	74°	86°	Clear.	- -	- -	W	30.3
11	54°	54°	57°	57°	78°	84°	74°	85°	Clear.	- -	- -	SW	30.4
12	56°	53°	57°	55°	76°	71°	63°	84°	Clear.	- -	- -	SW.NE	30.3
13	49°	41°	49°	—	77°	67½°	64°	—	Clear.	- -	- -	SW.NE	30.2
14	46°	42½°	50½°	47°	71°	69°	64°	68°	Clear.	- -	- -	SW.NE	30.2
15	51°	48°	53°	51°	79°	78°	73°	76°	Clear.	- -	Hazy.	SW.NE	30.0
16	51°	54°	54°	50°	63°	68°	60°	71°	Clear.	- -	Rain.	W	29.9
17	47°	48°	46°	47°	63°	61°	60°	61°	Showery.	- -	Clear.	N	29.8
18	48°	50°	49°	51°	66°	64°	61°	64°	Cloudy.	Partly clear.	- -	N	30.2
19	44°	48°	48°	50°	69°	61°	57°	63°	Cloudy.	- -	Clear.	NE	30.3
20	42°	45°	48°	51°	69°	65°	60°	61°	Cloudy.	Clear.	Cloudy.	NE	30.3
21	52°	51°	49°	50°	67°	64°	59°	60°	Cloudy.	- -	- -	NE	30.3
22	42°	47½°	44°	51°	70°	64°	60°	62°	Cloudy.	- -	- -	NEN	30.3
23	48°	51°	49°	50°	70°	61°	57°	63°	Misty rain.	- -	Cloudy.	NE	30.3
24	44°	52°	51°	54°	69°	62°	58°	60°	Cloudy.	Clear.	- -	NE	30.4
25	45°	40°	48°	53°	70°	63°	60°	65°	Cloudy.	- -	Clear.	NE	30.3
26	47°	44°	49°	52°	75°	68°	63½°	64°	Cloudy.	Clear.	- -	SW.NE	30.2
27	51°	43°	52°	51°	71°	67°	61°	63°	Clear.	Partly clear.	Cloudy.	SW.NE	30.0
28	53°	56°	55°	56°	72°	70°	66°	70°	Partly clear.	- -	Clear.	SW.NE	29.9
29	50°	49½°	55°	55°	75°	72°	68°	66°	Clear.	- -	- -	SW.NE	29.9
30	49°	50°	55°	57°	81°	75°	69°	67°	Clear.	- -	- -	SW.NE	29.8

T A B L E VIII.

Thermometers at different stations compared together.

	Night.				Day.		
	In the garden.	On the tower.	At the sea-shore.		In the garden.	On the tower.	At the sea-shore.
1784, Dec. 10	9°	15°	14°	} A little snow fell on these days. {	21°	20°	27°
11	5	12	12		25	22	29
25	17	21	21		33	32	33
26	23	27	27		36	35	32
1785, Feb. 7	25	28½	28		38	38	37
18	15	17	13		30	31	30
21	10	15	13		38	36	36
22	17	21	16		32	33	38
25	27	31	31		44	41	40
Mar. 1	18	21	20		32	31	32
3	23	25	25		36	35	36
6	25	30	30		38	39	38



Fig. 1.

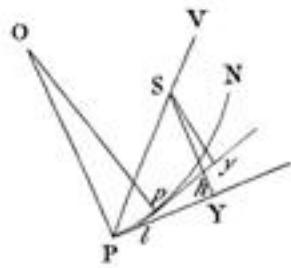


Fig. 2.



Fig. 3.

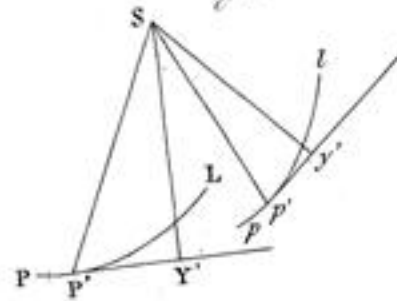


Fig. 4.

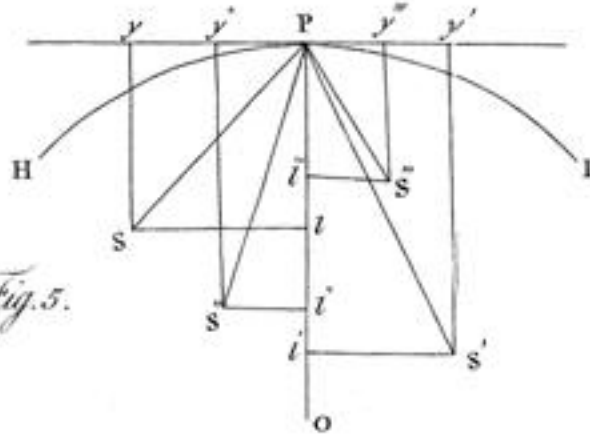
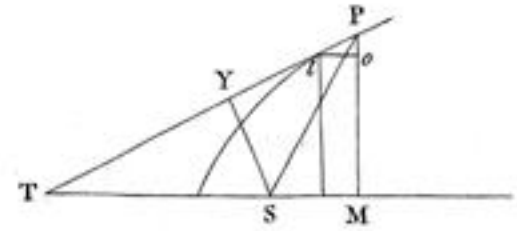


Fig. 5.

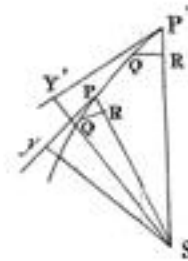


Fig. 6.

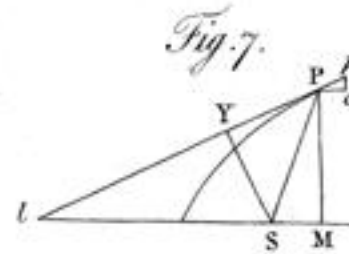


Fig. 7.

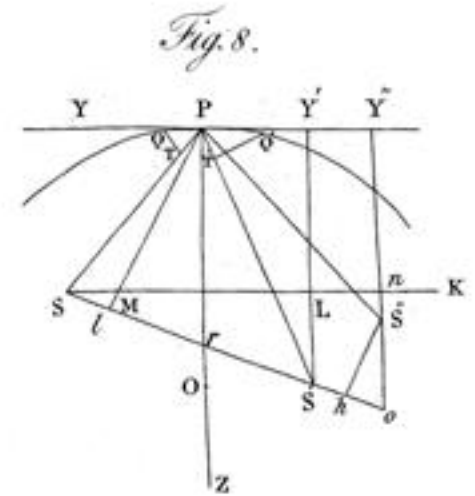


Fig. 8.

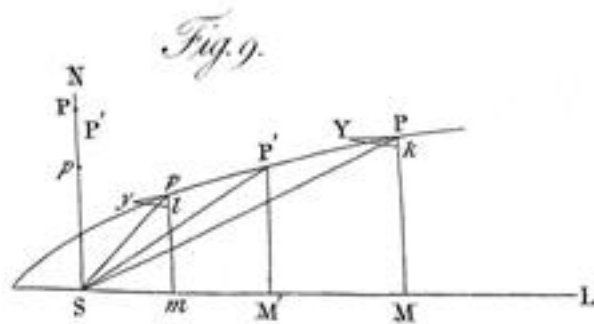


Fig. 9.

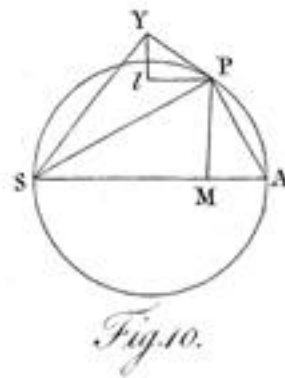


Fig. 10.

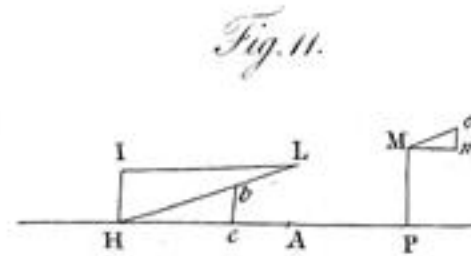


Fig. 11.

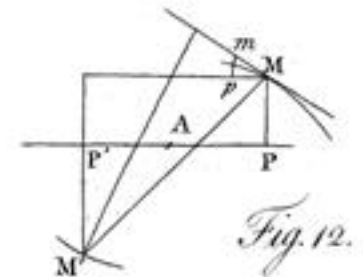


Fig. 12.