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ART. XII.—*Barometric Indications of a Resisting Aether;*[1] by PLINY EARLE CHASE, M.A., S.P.A.S.

IN a recent communication to the American Philosophical Society, I stated that there are indications in the hourly barometric means, of disturbances which may, perhaps, be owing to a resisting medium. As the proper interpretation of those disturbances seems, in my opinion, to involve a consideration of the principal laws that govern molecular force, I desire to present some of the evidences on which my statement was based, and to invite an investigation of the subject by mathematicians and physicists.

The contrast between the light, volatile atmosphere, and the sluggish, ponderous mercury, is so great, that few persons would expect any slight variations of one to be accurately recorded by the other. But that such is the case, has been shown by my barometric investigations; and so minute is the apparent correspondence between the two fluids, that it does not seem unreasonable to look even for traces of æthereal disturbance in the mercurial column.

I believe no attempt was ever made to represent the daily ærobaric tides by general algebraic expression, prior to the one to which I was led by an *a priori* consideration of the effects of rotation.[2] The remarkable correspondence between the theoretical formula and the results of observation, being, as it is, far

[1] I prefer this spelling for the fluid which is supposed to pervade all space, to distinguish it from the liquid Ether of the chemists.

[2] Proc. Am. Phil. Soc., vol. ix, p. 285; and Sill. Jour. for May. 1864, p. 410.

within the limits of probable error, lends strong confirmation to my original hypothesis, and seems to require a revision of the reasoning which has led to the prevalent belief that all the influence of rotation must be constantly uniform, and therefore incapable of producing any tidal action.

Perhaps the error of that reasoning, as applied to the earth, has arisen from considering the joint action of rotation and orbital revolution, and making undue allowance for the mutual compensation of their mutual disturbances. That such compensation must be effected at every instant, I have no reason to doubt, but how is it modified by the stress of gravity and the stretch of molecular elasticity? That stress, at the surface of the earth, is nearly three hundred times as great as would be necessary to retain the particles in orbits at the same mean distance from the earth's centre; and since it probably follows a different law from the countervailing elasticity, it seems to me that each of the forces must be constantly accomplishing work. The value of this work must form an important element in all calculations of the effects of the earth's rotation, and, if it were properly ascertained, I have little doubt that it might be represented by a formula analogous to the one which I have deduced from the relative motions of the air and the earth's centre.[3]

I am inclined to believe, as I have intimated elsewhere, that a due consideration of these relative motions may help to explain other compensations, such as the variations in temperature and the deposition of dew during the night, the fluctuations of magnetic force, &c. I content myself, for the present, with a simple statement of the belief, because its confirmation or refutation will depend principally upon the results of the investigation that I am now inviting.

The following table is constructed from data furnished by Gen. Sabine's summary of three years' hourly observations at St. Helena,—a work of great value, on account of the number and accuracy of the observations, and the proximity of the station to the Equator. The 4th column, (B), represents the averages of the observed heights of the barometer at 0, 1, 2, and 3^h from each high and low ærobaric tide; the fifth column, (C), is the theoretical height, computed by the formula,

$$B = M\left(\frac{1 + \sin\theta\cos\theta\cos l}{R^3} \cdot \frac{2C}{gt^2}\right);$$

the other columns require no explanation.

[3] It willl be readily seen that the sun's attraction is in the same direction as the earth's, and opposed to the molecular elasticity, at midnight; but at noon it acts with the elasticity, and against terrestrial gravity.

TABLE OF HOURLY THERMOMETRIC AND BAROMETRIC MEANS.

Astronomical time.	Temperature Fahrenheit.	(A) Observed height of barometer.	(B) Observed barometric averages.	(C) Theoretical height of barometer.	A—B.	A—C.	B—C.
h.	°	28 in. +	28 in. +	28 in. +	in.	in	in.
0	64·392	·2985	·296125	·2970	·002375	·0015	−·000875
1	64·731	·2819	·28145	·2821	·00045	−·0002	−·00065
2	64·946	·2660	·267125	·2672	−·001125	−·0012	−·000075
3	64·639	·2553	·2572	·2563	−·0019	−·0010	·0009
4	64·108	·2521	·25355	·2523	−·00145	−·0002	·00125
5	63·174	·2562	·2572	·2563	−·001	−·0001	·0009
6	62·120	·2642	·267125	·2672	−·002925	−·0030	−·000075
7	61·403	·2764	·28145	·2821	−·00505	−·0057	−·00065
8	61·067	·2899	·296125	·2970	−·006225	−·0071	−·000875
9	60·828	·3003	·3077	·3079	−·0074	−·0076	−·0002
10	60·666	·3061	·31225	·3119	−·00615	−·0058	·00035
11	60·491	·3025	·3077	·3079	−·0052	−·0054	−·0002
12	60·330	·2913	·296125	·2970	−·004825	−·0057	−·000875
13	60·184	·2777	·28145	·2821	−·00375	−·0044	−·00065
14	60·002	·2646	·267125	·2672	−·002525	−·0026	−·000075
15	59·868	·2562	·2572	·2563	−·001	−·0001	·0009
16	59·779	·2550	·25355	·2523	·00145	·0027	·00125
17	59·691	·2611	·2572	·2563	·0039	·0048	·0009
18	59·664	·2737	·267125	·2672	·006575	·0065	−·000075
19	59·868	·2898	·28145	·2821	·00835	·0077	−·00065
20	60·575	·3048	·296125	·2970	·008675	·0078	−·000875
21	61·692	·3163	·3077	·3079	·0086	·0084	−·0002
22	62·635	·3184	·31225	·3119	·00615	·0065	·00035
23	63·578	·3117	·3077	·3079	·004	·0038	−·0002

The greatest theoretical error, (A–C,) is only ·0084 in. at 21^h, or ·000297 of the entire height, and ·127 of the daily range; the least error is at 5^h and 15^h, ·000004 of the height, or ·00151 of the range; and the average error ·0042 in., which is ·000147 of the height, or ·063 of the range.

The greatest difference between the observed height and the observed average, (A–B,) is at 20^h, when it is ·131 of the daily range; the least difference is ·0068 of the range, at 1^h; the average difference, ·0639 of the range.

The greatest difference between the observed averages and the theoretical height, (B–C,) is at low tide, or at 4^h and 16^h, when the difference is less than ·02 (say ·0189) of the daily range; the least difference is at 2^h from low tide, or at 2^h, 6^h, 14^h and 18^h, when it is but little more than ·001 (·00113) of the range; the average difference is only ·00926 of the range.

Both A–B and A–C show that some cause is operating from 1 or 2^h to 15^h inclusive, (say 2 P. M. to 3 A. M.,) to reduce the barometric pressure, while for the rest of the day the normal pressure is increased. That this cause is not to be found in differences of temperature, I think is evident, because the observations are already corrected for *known* effects of temperature, and because the average height of the thermometer from 2^h to 15^h ($61^{\circ}{\cdot}7$) corresponds very closely with the average from 16^h to 1^h ($61^{\circ}{\cdot}66$).

The greatest unexplained reduction of barometric pressure is at 9^h; the greatest increase, at 20^h or 21^h. All these facts appear to me to admit of a ready explanation, on the hypothesis that the disturbances are caused by the resistance of an æther, which is condensed, as Fresnel supposes, by planetary attraction, and I can imagine no other hypothesis by which they could be satisfactorily accounted for.[4]

Mr. Colburn's inquiry into the nature of heat suggests some interesting speculations concerning other effects of rotation than those that can be measured by the barometer. Recognizing the impossibility that the sun should warm the whole solar system, as a simple incandescent body,—the improbability that its heat should result from continuous combustion, and the probable approximate uniformity of temperature in the upper regions of the atmosphere, in summer and in winter, by day and by night —Mr. Colburn looks for the principal sources of heat in the earth itself. He supposes, 1, that the solar attraction tends to draw into closer proximity the particles of air on the heated side, and to separate them on the night side of the earth, thus producing heat of compression, and cold of expansion: 2, that the change of eastward velocity from 69,000 miles per hour at midnight, to 67,000 miles at noon, (*sic*) necessarily produces a conversion of motion into heat, and of heat into motion: and 3, that if the earth is moving in a resisting medium, by which it is so retarded that it approaches the sun at the rate of 1,000,000 miles in 3,000,000 years, its "lift" involves the annual abstraction of a heat-force equivalent to 752,665,108,390,000 horse-power!

The third hypothesis has been often broached; the indications of a resisting ether, which, as we have seen, are furnished by the hourly barometric means, may, perhaps, yield the data for its final verification or rejection. The supposed separating effect of the sun's action in the most remote portions of the atmosphere, is so problematical that it seems hardly deserving of any consideration, and even if it existed, it is difficult to understand how it could produce a difference of more than a fraction of a degree in the range of the thermometer. The alternate acceleration and retardation of orbital velocity can produce no *accumulation* of heat to supply any loss that may arise from radiation into space, but it must modify the *distribution* of heat throughout the day in a manner that may be readily calculated. The available data are not sufficient to furnish us with complete results,

[4] The remainder of this article is taken from my communication to the American Philosophical Society.

but they give curious approximations that seem to open a wide field for profitable investigation.

"Sir John Herschel finds the direct heating effect of a vertical sun at the sea level to be competent to melt ·00754 of an inch of ice per minute, while according to M. Pouillet, the quantity is ·00703 of an inch."[5] Taking the mean of these two estimates (·00728 in.), multiplying by the latent heat of water (142·6° F.), and dividing by the number of cubic inches in 1 lb. of water (28), we obtain $\frac{\cdot 00728 \times 142 \cdot 6}{28} = \cdot 037076$ units of heat received per minute on each square inch of the earth's surface that is exposed to a vertical sun. The weight of the aërial column being 15 lb., and its ratio of specific heat 25, the maximum effect of the direct solar rays is sufficient to heat the whole atmosphere $\frac{\cdot 0371}{15 \times \cdot 25}$ per minute, or 7·12° F. in 12 hours.

Now, in consequence of the earth's rotation, the difference of atmospheric "lift" between noon and midnight, is 182,336 ft. per minute. The average difference for the twelve hours is one-half as great. "Rapid rotation, without friction or resistance, cannot in itself alone be regarded as a cause of light and heat;"[6] but we have found in our barometric investigations, that the ratio of the half-daily velocity of rotation to that which would be conferred by twelve hours' action of terrestrial gravity, is ·00109, which may be regarded as the modulus of heat-producing resistance. If we multiply the average difference of lift by the weight of the atmosphere and by the effective resistance, dividing the product by the ratio of specific atmospheric heat, and the number of foot-pounds raised by a unit of heat, we obtain $\frac{91168 \times 15 \times \cdot 00109}{770 \times \cdot 25} = 7 \cdot 74°$ F. as the amount of heat communicated to the air by rotation between midnight and noon, and abstracted between noon and midnight.

The theoretical barometric lift is, as we have seen, ·00219 of the entire weight of the atmosphere. Estimating the height of the aërial column when reduced to uniform surface density, at 24,000 feet, the heat-producing disturbance that is indicated by the barometer is represented by a lift of 15 lb. on each square inch to a height of ·00219 × 24000 feet. The quarter-daily disturbance from this cause is, therefore, $\frac{24000 \times 15 \times \cdot 00219}{770 \times \cdot 25} =$ 4·1° F.

It is more than likely that each of these results will require important modifications when the entire influence of the several

[5] Tyndall, Heat considered as a Mode of Motion. N. Y. edit., p. 431.

[6] Dr. J. R. Mayer.

conditions of the problem is better understood. I have thought it proper to present them in their present crudity, in order to show the true points of departure, and to prepare the way for some further considerations.

Whatever other heat-disturbing causes there may be, there can be little doubt that the three we have just been considering are the most important. Dividing the astronomical day into four quadrants, and representing the solar effect by S., rotation by R., and barometric by B., it will be readily seen that the several positive and negative influences must be distributed as follows:

	S.	R.	B.
From 0^h to 6^h,	+	−	−
" 6^h to 12^h,	−	−	+
" 12^h to 18^h,	−	+	−
" 18^h to 0^h,	+	+	+

The tables of average temperature at any given place would therefore furnish us with four equations for determining the value of each of the disturbing elements, providing those that are unknown were so insignificant as to be safely neglected. The effects of these unknown disturbances are confined within certain limits that can be pretty satisfactorily determined.

Our discussion of the barometric fluctuations demonstrated a tendency of inertia to retard the effects of rotation, so that the mean daily altitudes are found nearer to 1^h, 7^h, 13^h, and 19^h, than to 0^h, 6^h, 12^h, and 18^h. A like tendency is discernible in the thermometer.

There are three, and only three, quadrantal divisions of the day, commencing respectively at 0^h, at 1^h, and at 2^h, for which we could obtain approximate positive values of S., R., and B. The maximum solar effect is deduced from the first, and the minimum from the third of these divisions; while the maximum rotative and barometric effects are exhibited in the third, and the minimum in the first division.

The nearest average temperatures are found in the third division, as is shown below.

Average of temperature at 2^h, 8^h, 14^h, and 20^h, and of the entire day.

Station.	Mean of the four hours.	Daily mean.
At Girard College,........	52°·1	52°·1
At St. Helena,...........	61·65	61·69

The following table presents all the coördinate positive values of S., R., and B., that can be obtained from the Girard College and St. Helena means.

Station.	Dividing at								
	0, 6, 12, 18h.			1, 7, 13, 19h			2, 8, 14, 20h.		
	S.	R.	B.	S.	R.	B.	S.	R.	B.
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Girard College,	45·92	41·32	12·76	31·3	49·5	19·2	13·8	63·2	23·0
St. Helena,	25·97	42·96	31·07	15·8	46·7	37·5	5·6	56·6	37·8

The percentages of the calculated values correspond very nearly with the means of the earliest Girard College and St. Helena values.

	Calculated values.	Percentage.	Mean Percentage.	Limits.	
S., - - - - - -	7°·12	37·6	35·95	5·6	45·92
R., - - - - - -	7°·74	40·8	42·14	40·8	63·2
B., - - - - - -	4°·1	21·6	21·91	12·76	37·8

It may be inferred from this comparison that the rotation element of daily heat is least affected, and the solar element most affected, by extraneous causes (of which moisture is probably the chief); that the first division gives the best, and the third division the poorest, results; that the proportion of thermometric variation which is attributable to rotation is between ·4 and ·5 of the average total daily variation, and that the most difficult element to determine satisfactorily is S., which is modified by many local disturbing influences, such as the nature of the soil, amount of vapor, clouds, altitude of the sun, &c.

Philadelphia, May, 1864.