THEORY OF RAIN, HAIL, SNOW AND THE WATER SPOUT, DEDUCED FROM THE LATENT CALORIC OF VAPOUR AND THE SPECIFIC CALORIC OF ATMOSPHERIC AIR. By J. P. Espy, Esquire.

It is demonstrated by the air pump, that if air saturated with vapour is suddenly rarefied, some of the vapour is condensed by the refrigeration which is produced by the rarefaction.

It follows from this principle, that if air saturated with vapour should be made to ascend in the atmosphere, the vapour condensed in so ascending would in quantity be proportionate to the height to which it ascended; for the higher it ascended, the more it would be rarefied and cooled, and so more and more of its vapour would be condensed.

Now if any cause exists in nature to produce an upward motion of air highly charged with vapour, and to continue that motion for some considerable time, the quantity of vapour so condensed would be very great, and a rain would be thus produced which would continue as long as very moist air continued to ascend.

When it is recollected that air is lighter the more moisture it contains, it will readily be perceived that there is a cause to produce an upward motion of air, containing a large portion of vapour.

Indeed nothing is more certain than that a column of air lighter than surrounding columns would be forced to rise, and that with a velocity proportionate to the superior weight of surrounding columns.

It might be supposed that the equilibrium would soon be restored, more especially if upon the condensation of the vapour, the air containing it is condensed also, as is generally believed.

This latter, however, is not the fact: for I find by calculation that the quantity of latent caloric given out by the change of vapour to water or cloud, is sufficient to produce an expansion in the air six times greater than the contraction caused by the vapour turning to water. This calculation is founded on these three principles, which are all demonstrated by experiment. 1st. The latent and sensible heat of steam is a constant quantity, equal to 1212 of Fahrenheit. 2d. The capacity of atmospheric air is 250, that of water being 1000. 3d. The expansion of air by heat is 1-480th of the whole, for every degree of Fahrenheit above its bulk at 32°.

It follows from these facts, that whenever vapour, in an ascending current of air, begins to condense into cloud, there is an expansion of the whole mass of air as far as the cloud extends, caused by the evolution of the latent caloric of the vapour. Moreover, this evolution of caloric prevents the air in ascending from becoming cold as rapidly as it would by expanding if it was dry air.

It is known that if dry air should be made to ascend in the atmosphere, it would become one degree colder for every 100 yards of ascent, so that at the distance of ninety 100 yards high, it would be 90° colder than when it left the surface of the earth. But if saturated air should be made to ascend ninety 100 yards, it could not sink in temperature even 45° without condensing a large portion of its vapour; in some cases when the dew-point is high, more than enough to heat it 45° above what it would be by ascending to that height if no latent caloric had been given out.

It follows then, from these principles, that the higher this air ascends, the more will the equilibrium be disturbed, and that the equilibrium cannot be restored while very moist air, at the surface of the earth, continues to flow towards the ascending column.

For moist air in ascending will constantly have some of its vapour condensed and its latent caloric evolved; and thus its specific gravity diminished below that of the surrounding air. While this process is going on, the barometer will fall underneath the forming cloud, even before it begins to rain; for the air, as it expands in the region of the cloud, will spread outwards, and thus diminish the quantity of gravitating matter over the region below; and if the depression of the barometer is given, the velocity of the upward motion of the air may be calculated.

I find, if the barometer stands one inch lower under a forming cloud than it does in the surrounding regions, the velocity of the air upwards will be 230 feet per second.

This velocity will be sufficient to carry up large drops of rain after they are formed far above the region of perpetual congelation and freeze them there, and then carry them off to the sides of the ascending column and precipitate them in the form of hail.

When the dew-point is very high and the ascending column very narrow, the upward velocity will be very great, and thus water spouts, or what the French call trombes, both by sea and land, may be formed.

In short, it is believed that all the phenomena of rains, hails, snows and water spouts, change of winds and depressions of the barometer follow as easy and natural corollaries from the theory here advanced, that *there is an expansion of the air containing transparent vapour when that vapour is condensed into water.*

It is now more than three years since I formed this theory, and all the facts which I have been able to collect since, particularly with regard to water spouts and hail, have confirmed me in its correctness.

It is not my intention at present, however, to present all the coincidence in favour of this theory which I have collected; my object is to call the attention of the members of this Society, and meteorologists generally, to the importance of the subject, and to request them to turn their attention to the following queries, which are indicated by the theory :—

1st. Does the wind always blow towards the centre of a great rain in the lower part of the cloud, and from the centre of the rain in the upper part of the cloud, except as modified by the prevailing currents of wind?

2d. Do those storms which travel from the south west to the north east, always set in with the wind north east and also terminate with the wind south west, when the centre of the storm passes over the observer?

3d. If the wind does not change at the termination of one of these north east storms, is it because there is another not far distant in the south west?

4th. Is the direction of these storms determined by the uppermost current of air in our climate (which is known to be very uniform from the south west), carrying in that direction the air which rises into it, in the region of the storm?

5th. Is the prevailing direction of storms in the torrid zone towards the north west on the north of the equator, and towards the south west on the south of the equator, setting in with the wind in the opposite direction?

6th. If a storm passes to the south of us travelling eastwardly, does the wind change by the north towards the west; and if the storm passes to the north of us, does the wind change round by the south, blowing with a violence in proportion to the quantity of rain and its proximity combined?

7th. Is the direction in which a narrow storm travels, sometimes determined by a middle current moving in a different direction from the uppermost current?

8th. Do storms become more widely extended from the place of their commencement, as they travel eastwardly, or in any other direction?

9th. Does the depression of the barometer keep pace with the motion of the storm, accompanying it throughout its course?

10th. In case of a violent tornado, is the depression of the barometer very sudden and very great at the moment when the tornado passes; and at the moment of greatest depression is there no rain, the drops being carried upwards by the rapidly ascending air?

11th. Do violent tornadoes never occur only when the dew-point is very high, and are they always accompanied by violent rain or hail, more copious in the borders of the tornado than in the centre?

12th. In narrow storms or hard showers, does the air at the surface of the earth and at the upper part of the cloud move outwardly from the centre of the shower, while at the same time at the lower part of the cloud it moves towards the centre of the shower?

13th. Are there not sometimes two veins of hail at no great distance apart, both near the borders of the storm?

14th. Are hail storms always of very limited extent in width, occurring only when the dew-point is high; and more frequently in the afternoon than any other part of the day?

If these and such questions, plainly indicated by the theory, should be answered in the affirmative by observation, the theory will be established on a foundation which cannot be shaken. I hope I have shown plausibility enough in the theory, to excite the interest of observers to inquire of nature *whether these things are so.*