METEOROLOGY

How Storms Begin

"A Classic of Science"

Solution of One Weather Mystery Made Espy Famous When He Worked Out the Mechanism of the Whirling Storm

THE PHILOSOPHY OF STORMS. By James P. Espy. Boston: Charles C. Little and James Brown. MDCCCXLI (1841).

(Article 12)

SUPPOSE the dew point at 71°, when by article 1 the quantity of vapor in the air at the surface of the earth is 1/64 of the whole weight. Suppose also the temperature to be 75°, or 4° above the dew point; suppose a column to begin to rise either from superior heat or superior moisture: and suppose an extreme case, unfavorable to the theory that the column in ascending cools by expansion one and a half degrees for every hundred yards of ascent, while the atmosphere around the column is only one degree colder for a hundred yards; the effect will be, that the column will ascend only a little more than three hundred yards when some of its vapor will begin to condense. Now to ascertain what its temperature shall be at any particular height, sixty hundred yards for instance, we have only to find a point below 75°, at which sufficient vapor will be condensed to heat up the air as many degrees as this point wants of being one degree and a half below 75, for every hundred yards of ascent, or in the present case 90°. For as in this case the air is supposed to fall in temperature 90°, in ascending sixty hundred yards, there is nothing to prevent its falling this quantity but the latent caloric evolved in the condensation of the vapor. Now by examining a table of the dew point (129), according to Dalton, it will be found that if the temperature falls 48°, it will, after making allowance for the increased space it occupies, condense 20/38 of its vapor, sufficient to heat up the air 42°, which being added to 48° makes up the 90° which it would have fallen if there had been no latent caloric in the vapor condensed.

But as the atmosphere on the outside of the ascending column is 60° colder at the elevation of sixty hundred yards, and within the column only 48° colder, the specific gravity of the cloud will be at least 1/40 less than the outer air at the same elevation, even without allowing anything for the 140° of latent caloric given out by the congelation of the water. In this calculation, no allowance is made for the greater specific heat of rarefied air, but this will be fully compensated by the 140° given out by the congelation of the water and by the higher dew point in the column than in the surrounding air.

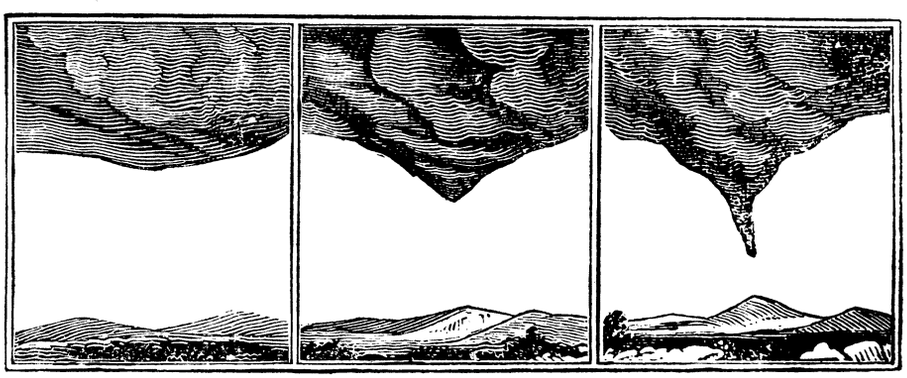
Vapor Condensed

13. If it had been assumed that air, in ascending, falls only one degree for a hundred yards, then, according to the same mode of calculation, it will be found that by falling 36°, making allowance for the greater space now occupied by the air, sufficient vapor would be condensed to raise the temperature of the air 24°, and then, 24° added to the 36°, will make up 60°, which would have been the actual depression of temperature in ascending sixty hundred yards, if the vapor had contained no latent caloric.

It is not at all probable that the actual depression of temperature of air on being rarefied by diminished pressure, would be greater than one degree and a half for every hundred yards of ascent; but even if it should be two degrees, it will be found that the latent caloric evolved when the dew point is high, would prevent it from falling one degree for every hundred yards of perpendicular ascent, and therefore, even in this case, its specific gravity would be constantly less than that of the atmosphere at its own elevation.

14. If we suppose a very narrow column of air to begin to rise, as mentioned in article 12, and a cloud to be formed in it reaching to a height where the barometer would stand only one-fourth of thirty inches, it will be then at a temperature of one degree at the upper end, and will have condensed two-thirds of its vapor capable of heating the containing air 50°, and then, according to article 13, it will be 50° warmer than the surrounding air at that height. And as the vapor condenses more rapidly in the lower part of the column than in the upper, the mean temperature of the whole column may safely be taken at 25° above the surrounding air; therefore, the mean temperature of the air being about 32°, the expansion of the columnar air will be about 25/480, which would cause the mercury in the barometer to be depressed about one inch and a fifth, and cause a velocity in the column upwards of two hundred and fifty-six feet per second.

15. The quantity of rain produced by the refrigeration of this ascending column, would be five inches in one minute and twenty seconds, if it were all to fall on a space equal in area to



HOW A TORNADO STARTS

The center of the storm within the cloud, descending from it, and marking its path upon the earth, from Espy's "Philosophy of Storms."

the area of the column. This, however, could seldom happen, as the drops of rain would be carried upwards to a height greatly beyond the region of perpetual congelation, and thrown off at the sides in the form of *hail.*

16. The dew point in the above calculation was assumed at 71°; if it had been taken at 80°, to which it sometimes rises at Philadelphia, it would have been found that the barometer would in that case descend one inch and nine-tenths, and all the other effects would be proportionately aggravated.

17. It will readily be perceived that the air will spread out more rapidly at the upper end of the column than it runs in below, and thus, at some distance from the column, especially in front of the storm at the surface of the earth, the barometer will rise, and the effect of this will be to increase the velocity of the ascending column, for which no allowance is made in the preceding calculation.

Air Thrown Inwards

18. It will also be perceived, that the air under the column being relieved from a pressure equal to an elevation of more than ten hundred yards, will fall in temperature more than 10°, and of course the cloud will reach the earth, unless the temperature of the air should be about 10° above the dew point, in which case it will reach very near to the earth.

19. In this case there will be a spout, and the air below the cloud reaching to the surface of the earth, the trees will be thrown inwards, and also forwards, if the spout has a motion along the surface of the earth.

20. The spout must have a motion on the surface of the earth, if there is a current of air at the upper end of the column, for this current will move the upper end of the column in its own direction, and the lower end will immediately advance with it. And as it is known that the uppermost stratum of air in which clouds appear, moves constantly at Philadelphia, and probably throughout the northern temperate zone, from a point a little south of west; and as it is certain that the upper end of the spout reaches far into this stratum, the motion of the spouts in this climate should be generally in this direction, or to a point a little north of east. Indeed, they will always move in this direction unless they meet with a middle stratum of air moving in a different direction.

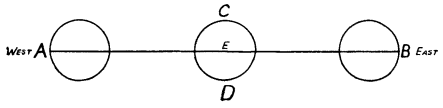
21. The narrower the spout is, the

more readily will the air at the upper end be able to spread out and leave the column below free from the pressure of accumulation, and the more violent will be its effects at the surface of the earth.

22. If the dew point should be much below the temperature of the air, the visible spout or cloud will not reach the surface of the earth, and then the rain falling through the lower atmosphere may, partly by its impulse and partly by its cooling influence, (thus increasing its specific gravity) cause the air at the surface of the earth to move *outwards* in all directions from the centre of the shower, especially in front, while all the time, the air at some distance above is running *inwards* from the circumference of the cloud at its lower borders, and of course upwards in the centre, and outwards in the upper parts. If we suppose a dew point 20° below the temperature of the air, we shall find, by calculating according to the law (article 3,) that the lower borders of the cloud will be a little more than twenty hundred yards high; and when the dew point is nearer the temperature of the air, the cloud will be nearer the earth at the lower extremity. This reasoning applies to clouds of moderate size.

23. But if the cloud is of great size, then the supply of air to keep up the ascending column cannot be afforded without reaching down to the surface of the earth, even when the lower part of the cloud may be at a considerable distance above the surface of the earth. Thus the law will become general, that *in all very great and widely extended rains or snows, the wind will blow towards the centre of the storm.*

24. From this law it will be easy to understand (when a round storm is in our neighborhood) not only the direction in which it is raging, but the course in which it is moving. For let



A E B be the direction in which the centre of a storm is moving, say from west to east, and C an observer to the north of that line, and D one to the south, when the storm comes within disturbing influence, as at A, the observer C will have the wind to begin to blow from a point north of east, and the observer D from a point south of east, and to the observer E, due east. When the storm shall have advanced to E, the wind to observer C will be changed round to north, and observer D to south, blowing at that time with its greatest violence; whilst to observe E, it will be calm, without having changed its direction, only having gradually increased in violence, as the borders of the storm approached, and gradually diminished in violence as the centre approached. Moreover, if the storm is very violent and not very wide, the barometer at E will be very low when the centre of the storm is there, and there will at that time be no rain; for the upward motion of the air will carry with it the drops of rain, and throw them off at the sides; but, in the mean time, it will continue there very dark and cloudy.

As the storm passes onwards towards B, the wind will suddenly commence blowing from the west at E, increasing in force there for some time after it begins to diminish its violence at C and D, where it is now changing round respectively to west of north, and west of south. In like manner it may be shown, if the storm moves in any other direction, that this direction may be ascertained by a single observer, provided the storm is round.

25. If the velocity with which storms travel along the surface of the earth shall be ascertained, then not only their direction but their distance from a single observer may be known from the angular velocity with which the wind changes.

Science News Letter, July 25, 1931

Spending a day with a razorback hog may not be an attractive enterprise, but such a procedure recently yielded some valuable information to the State Forest Commission of Mississippi.

Believing that the razorback was a serious destroyer of longleaf pines, and wanting to get irrefutable evidence on the subject, P. N. Howell, one of the commissioners, followed a hog for eight and one-quarter hours, from 8:00 o'clock in the morning to 4:15 that afternoon. In that time Mr. Howell counted 400 trees which the hog rooted out.

GEOLOGY

Studies on Mineral May Yield More Accurate Age of Earth

NEW MEASUREMENTS on a very old mineral have given the possibility of a new accurate determination of the time since the molten earth cooled sufficiently to form a solid crust. This new glimpse into the past of the earth comes as a result of the work of Dr. A. von Grosse and Dr. J. D. Kurbatow working at the Institute of Technology, Berlin.

That the earth is at least 1,800 million years old is one of the conclusions recently reached as a result of studies in physics and geology by the Committee of the National Research Council. A revision of previous calculations may be necessary, however, since the recent work. Physicists have grown accustomed to changing their estimates on this problem from time to time. During the last century, before the discovery of the radioactive atoms like radium, the noted British scientist, Lord Kelvin, was quite sure that the sun even could not be older than 50 million years; and of course the earth had to be younger than the sun.

The new research in Berlin indicates that the ratio of actinium to radium is four per cent. in the "Wilberforce uranite" examined. This fact gives a new check-up on the reliability of the most accurate clocks used by physicists in solving this problem. Those clocks are provided by the unchanging disintegration of heavy radioactive atoms into lighter atoms.

Uniform Rate of Disintegration

As this process has been going of for millions of years at the same rate as now, it is possible by measuring the amount of lighter atoms formed to know how long the break-up has been going on. These lighter atoms are very similar in nature to lead, and cannot be distinguished from it by ordinary chemical means. Separate clocks are given us by three different chains of elements which start from uranium, thorium and the yet-unknown parent of proto-actinium. The end of the uranium chain is radium "G," of the actinium chain is actinium "D." By measuring the amounts of lead, uranium and thorium and the relative amounts of