If it be true, "that moist, foggy or cloudy air is not a conductor of electricity," [93, etc.] does it not follow that any "convective discharges" will seem to be confined solely to the vibratory or alternating motions of the air itself. It appears inconceivable, how the air, either in mass or atoms, can exhibit such movements of transfer and with all the power and velocity of a hurricane, either in *one* direction only, or in opposite directions, at a given time and place. Besides, an effective vibratory action between two distant surfaces with both which the vibrating body is in full contact, appears impossible. Nor would even such alternating action enable the convective discharge to pass through the vibrating stratum of air.—These passing remarks, however, as already suggested, are not needful for sustaining my views of whirlwind storms against the animadversions of my opponent.

Since the discoveries of Franklin, an electrical origin and character has often been conjecturally ascribed to storms. A want of originality in advancing this electrical hypothesis, will not weaken any evidence which shall be adduced in its favor; but, until it shall have been satisfactorily supported by observed phenomena, it will probably continue to be rejected by scientific inquirers.

There seems to be an evident improvement in Dr. Hare's views of whirlwind action, since entering upon this controversy. Nor do I doubt that the subjoined notices of the effects of the Providence tornado, as observed "on *terra firma* with the aid of a compass," will receive from my readers an impartial consideration.

On the Evidence of a general Whirling Action in the Providence Tornado.

On the 30th of August, 1838, between the hours of 3 and 4 P. M., a violent whirlwind or tornado visited the town of Providence, in the State of Rhode Island. It was preceded by a violent shower of rain of short duration, after which the tornado appeared, appended to another cloud, and passed through the southern part of the town nearly from west to east.

Its earliest ravages reported, were in Johnston, at the farm of Mr. Randall, about seven miles west from Providence. From this point it passed on through Cranston and Providence, where,

crossing the river into the State of Massachusetts, it passed through Seekonk, Rehoboth, Swansey, Somerset, and as far, at least, as Freetown, beyond Taunton river; a distance of twenty five miles from the point first mentioned.

The width of its visible track, as indicated by the prostration of trees, fences, and other objects, varied from a mere trace in its narrowest, to two hundred yards or upwards in its widest portions. Having, a few days after the occurrence of the tornado, carefully examined the track for the distance of about seven miles, on each side of Providence river, I propose to offer some of the results of this examination, together with such remarks as may seem justly deducible from the effects observed.

So far, however, as the impressions made on an accidental eye-witness of the tornado may be important, we have a valuable account furnished us in the letter of Zachariah Allen, Esq., of Providence, which is given in Dr. Hare's notice of this tornado. [This Journal, Vol. xxxviii, p. 74–77.] Mr. Allen had the advantage of viewing its progress from a point near its path. He calls it a "whirlwind," and describes its phenomena in a manner perfectly consistent with this appellation. "The circle formed by the tornado" on the river, he describes as "about three hundred feet in diameter," and mentions, that the "misty vapors" . . . "entering the whirling vortex, at times veiled from sight the center of the circle, and the lower extremity of the overhanging cone of dark vapor:" and that "Amid all the agitation of the water and the air about it, this cone continued unbroken," &c.

This "cone" of the tornado of which he so often speaks, it should be noted was an *inverted* one, the smaller end of which was sweeping on the earth's surface.* Thus he gives the instance, "when the point of the dark cone of cloud passed over the prostrate wreck of the building, the fragments seemed to be upheaved," &c. It will be seen here that the *prostration* of the building had preceded the arrival of the center or "point" of the

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* We may properly conceive of this "cone," in tornadoes or water-spouts, as including not only the visible clouded condensation here described, but also the invisible portion of the whirlwind which surrounds the narrow and depending portion of the visible cone, below the general line of condensation. This *entire* body of the whirlwind is generally a truncated cone; its smaller and most active end sweeping along the surface of the earth or sea.

"cone;" showing that the whirlwind often acts on a large area, with great force, *externally* to the lower part of the *visible* cone, or the column of vapor at its axis. Moreover, the substances which by the center of the tornado were "uplifted high in the air," were "left to fall from the OUTER EDGE of the black conical cloud."*

Mr. Allen says further, "The progress of the tornado was nearly in a straight line, following the direction of the wind, with a velocity of perhaps eight or ten miles per hour. Near as I was to the exterior edge of the circle of the tornado, I felt no extraordinary gust of wind; but noticed that the breeze continued to blow uninterruptedly from the same quarter from which it prevailed before the tornado occurred. I also particularly observed that there was no perceptible increase of temperature of the air adjacent to the edge of the whirlwind, which might have caused an ascending current by a rarefaction of a portion of the atmosphere."

Soliciting a careful attention to the observations of Mr. Allen, who is well known for his intelligence and his habits of correct observation, I proceed to give some account of my own examinations of the traces of this tornado.

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* Mr. Allen states that the form of the cloud and of the cone of vapor depending from it so nearly resembled the engraved pictures of 'water-spouts' above the ocean, that he should have come speedily to the conclusion that one of these 'water-spouts' was approaching, had he not been aware that "this phenomenon occupied a space in the heavens directly above a dry plain of land." Perhaps it might be inferred that Mr. A. had partaken of the too common notion, that the misnamed *water-spout* is, or should be, literally a *spout of water*. This phenomenon, so much talked of among mariners, proves to be nothing more nor less than the visible inverted "tapering cone of vapor" or condensation, noticed by him as "extending from the cloud to the surface of the earth," *at the axis or ascending portion of the whirl;* if we may at all rely on the results of extensive examinations and comparisons of the accounts of 'water-spouts' and their effects. The same appearance was observed in the New Brunswick tornado by experienced seamen navigating the Raritan river, who at once pronounced it to be a water-spout, and took their measures accordingly. It is probable, however, that most of the 'water-spouts' noticed at sea, are inferior in size and energy to these destructive tornadoes.

A 'water-spout' was seen by Messrs. Tyerman and Bennett near Borabora in the Pacific, which extended nearly horizontally from one cloud to another directly over their heads; and no harm done! The most credulous will hardly conceive this to have been *a column of water*, or even approximately such: besides, no sea-water has ever been known to fall from the clouds. Similar 'spouts' have been seen by others; and I once beheld a magnificent example of this kind, in one of the interior towns of Connecticut; which probably indicated an axis of rotation nearly horizontal.

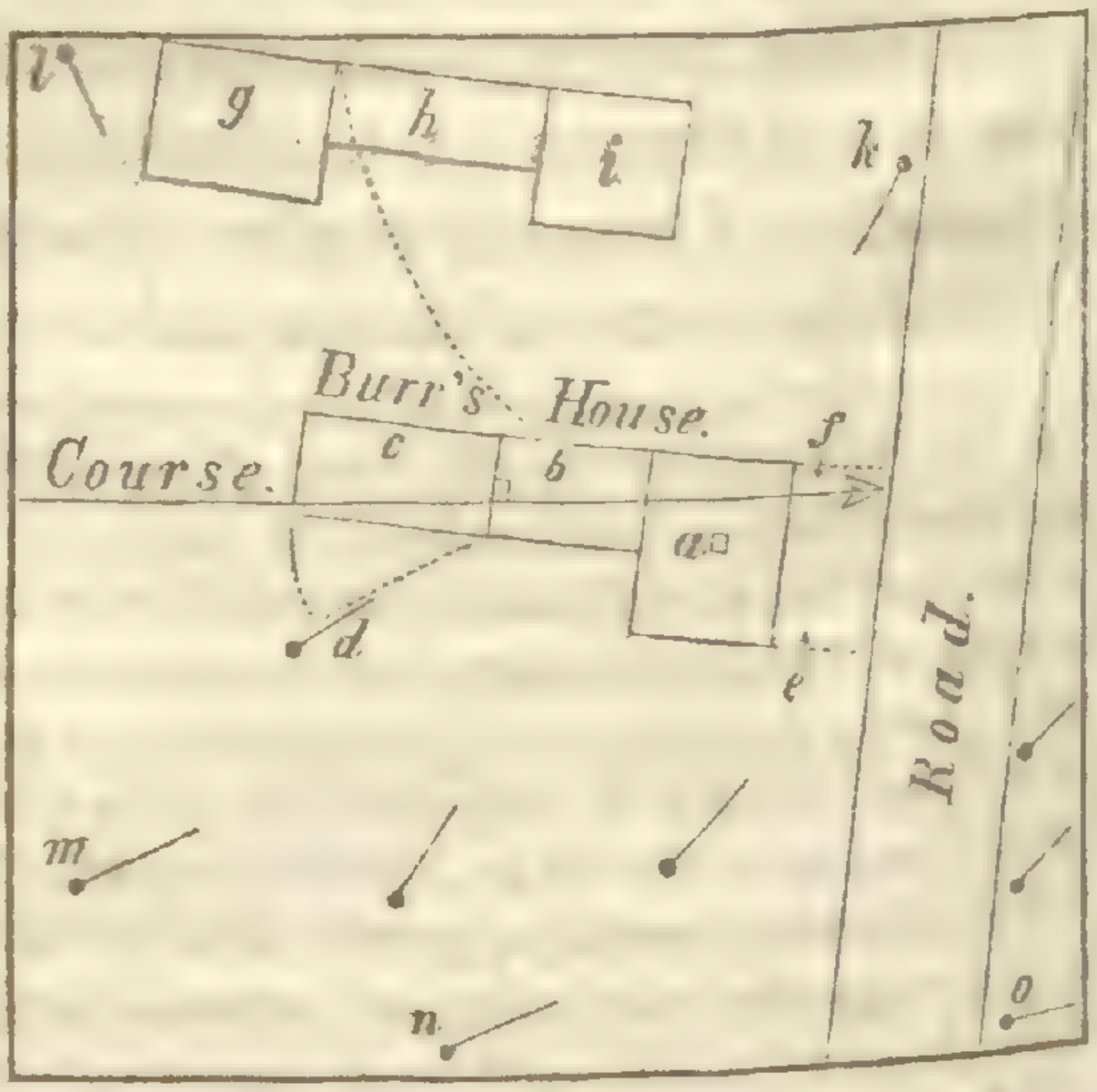
From a point on the rocky "ledge" north of the turnpike road and nearly three miles westerly from Providence, to the house of John Burr on the Cranston road, a distance of about one and a quarter miles, I found the course of the tornado to have been S. 86° E. by compass, over a plain country. The magnetic variation being here about 8° westerly, makes the true course E. 3° N. From this point to Providence river, a distance of about two miles, the course was five degrees more northerly.

I agree with Dr. Hare that the general effects observed on this track were "quite similar" to those of the New Brunswick tornado; and will give such of my sketches, formerly prepared, as will best illustrate this similarity and the general effects here mentioned.

The following is a sketch of some of the effects on the farm of Mr. Burr: His house is about one mile and a half from the Providence bridge.

In this figure, *a* represents a wooden dwelling-house of two stories with chimney at its center: *b* a dwelling added to *a* and extending to the rear: *c* a lighter building about 16 feet by 30, attached to the rear of *b*: *g* was a large wooden barn: *h* a long building or shed extending from the barn to the carriage-house *i*. The width of the visible track was here about five hundred feet, and the course of the center or axis of the tornado appeared to have passed somewhat diagonally over the three first named buildings.

Fig. I. *Providence Tornado.**



The house *a* withstood the shock, receiving some damage; the chimney top of *b* was thrown on the roof of *a*, perforating the same, while *b* was unroofed and greatly injured, and a long timber or *sill* from the shed *h* broke endwise into the upper part of the house *b* from a northwesterly direction. The building *c* was turned more than twenty feet to the *left about*, as regards the axis of the whirlwind, against the top of the prostrated pear tree *d*, and was there overturned upon it. There were twenty one persons in *a* and *b*, including a school of children, none of whom were seriously injured.

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* On these plans the large dot at the end of the several short lines, shows the original position of the root of the tree; the pointed end of the line shows the direction of its top.

The barn *g* and the shed *h* were destroyed, and the materials swept off toward the first named buildings. A corn-house, standing on the same side with the barn, is stated in the Providence papers to have been blown over to the *west*, but I can find no notes of my own respecting the direction of its fall.

The effects here exhibited appear to me to be due to a progressive whirlwind, revolving to the left; for we may notice, as in the New Brunswick tornado, a more onward direction in the trees prostrated on the *right* of the axis, *d*, *m*, *n*, *o*, &c., than on the left side; while the outermost prostrations on the right, *n*, *o*, point still more nearly than the average on this side, to the course of the tornado: And on the left side of the track we have the tree *k* in a direction inclined several degrees *backward* from the course of the storm. The value of these indications of whirling action I have endeavored to point out in my remarks on the New Brunswick case. [This Journal, Vol. XLI, p. 70–75.]

At the front of the house *a*, however, were two slatted door-yard fences, extending from the house to the road. The fence *e* was overthrown northward toward *f*, and the fence *f* in the contrary direction towards *e*: both directions being *transverse* to the line of the axis, which passes between them. Such cases have been adduced as supporting a directly inward course of the wind in the body of the tornado; or, as indicating two bodies of opposing wind meeting on a central line; but I draw a different conclusion.

Let Fig. II represent, horizontally, the directions of such center blowing winds in the body of the tornado, and let it be supposed as passing over the area of Fig. I, without revolving, so as the course of the center will coincide with the arrow which indicates the course of the axis on that figure. It may thus be seen that on this hypothesis the wind must strike the fences *e*, *f*, either parallel to their length, or but little oblique; a direction of wind which seldom or never

Fig. II.

prostrates fences, even in the path of a tornado. Besides, *near the center* of such an inward blowing tornado, where only it could act on these fences with *lateral* force, such winds must necessarily become neutralized both by blowing against each other and by turning upward to escape, thus having little effect at this point, within four feet of the ground. I say nothing here of the possibility of any winds blowing *with violence* in such central directions; which I could never conceive: For the entire spaces between the centripetal lines of arrows must be conceived as being filled by the affluent winds; the lines only indicating their directions.

But on the other hand, let us suppose a strong whirlwind passing in the same direction: the front half of which, both on and near the line pursued by its axis, must necessarily sweep laterally across this line, first *northwardly* towards *f*, if it be revolving to the left; and the last half of the whirl on its arrival will sweep *southwardly* towards *e*. That only the fence *e* was thus prostrated by the first wind of the tornado may be explained by the protection afforded to *f* by the house, against the *advancing* whirl, and perhaps here, also, by the spirally *upward* tendency towards the center, in the wind which thus came round the southeast corner of the house, prostrating *e* in its course. But on the passing of the axis of the whirl, the wind would recur with increased force from the opposite direction, upon the fence *f*, prostrating it towards *e*; while the latter, being already down, and in turn partially protected by the house, would remain as it first fell.

In passing over the track of the tornado between Burr's house and Providence river, several instances and groups of prostration were observed. But owing to the open character of the grounds throughout most of the track, the memorials afforded by the trees were less frequent than have been seen in other cases.

Near the Pawtuxet turnpike, the tornado encountered a new house belonging to Mr. Gardner. This house was in the southern portion of the track *on the right of the axis*, and was removed and turned several feet, *towards the left*.

It is proper to mention here that the *order of changes* in the wind's *direction*, viewing the tornado either as a whirlwind, or, as claimed by Mr. Espy and seen in figure II, would at any *fixed point* on this the right side of the track, be successively *towards*

the right, as relates to the center of the tornado. But this building having received its motion by yielding to the wind, shows the true course of the latter as whirling to the left.

Passing by the prostration of the range of buildings near the river, described by Mr. Allen, I proceed to notice the effects which appeared on crossing to the Massachusetts side.

From the bank of the river to the house of Abraham Tifts on the Lyon farm, three fourths of a mile, the grounds were open and unbroken, being mostly under cultivation and with few trees exposed to the tornado, excepting an orchard of scattered apple trees westward of Tifts' house. The traces of the wind in and adjacent to this orchard were very distinct in their character, and I subjoin here the sketch on which they are represented.

Fig. III. *Providence Tornado.*

North or left side.

South or right side.

Explanations of Fig. III.—The cases of prostration 4 to 14, were from a line of small locust trees on the west border of an old apple orchard, and are severally shifted a little out of line for the sake of a distinct exhibition of their directions.

From thence to near Tifts' house at *b*, the ground is but slightly foreshortened, and the relative positions of each tree, on the left of the centre, is approximately

shown. The figure was drawn from my field notes on account of the distinct phenomena which were exhibited on this part of the track, and which, in cases *a*, 14, 22, 21, 23, and 27, show conclusively the first action of the whirl *across the path of the axis*, and sweeping towards the northern border of the track. On the opposite or right side of the axis, southward of 15, there were no trees exposed, and the effects of the tornado were here visible only on the crops and fences. Therefore the cases shown on the figure south of the axis, and also westward of 22 on the left side, were brought in from the more western parts of the track between the orchard and the river, and include all the prostrations from the latter to Tifts' house; and their relative distances from the axis or center of the track are but approximated.

Case 14, represents a small locust tree broken off at an old wound near the root and carried *outward and backward* into the adjoining fallow field, having struck into the ground seven times in its course, leaving distinct traces. It was finally left at a point N. 57° W. from its stump, at the distance of forty yards, with its top turned southwardly, in conformity with its two last traces in the soft ground.

Case 10, a small locust tree was prostrated S. 25° W., leaving its mark in the fallow ground. It was subsequently shifted, by the progressive change in the whirlwind, to S. 11° E.

Case *a*, an old apple tree with but a single branch projecting southwardly from its trunk; this branch was taken off by the onset of the tornado and struck into the ground northwest from the trunk, depositing its apples at this spot. The limb itself was missing.—Case 21, apples deposited as in case *a*.

Case 22, a small wild cherry tree, was found lying on and against the stump of 14, having first been thrown *from the latter* by the onset of the wind and subsequently swung round by the south to its present position, as appeared by the impressions made in the ground. Its final position was such, as if occurring at the outset would have prevented 14 from being carried off northwesterly.—Case 23, the branch of an apple tree was thrown west.—At *b* is shown the relative position of Tifts' house.

Case 27, shows the original position of a large pear tree, the stem of which was broken off and first thrown northward, where it ploughed up the soft ground of the garden by its force, and continued its circuit to a point northwest of its original position, where it remained with its top turned toward the south.

For the purposes of a general comparison, the observed or first known directions of the prostrations on the two sides of the track may be summed up as follows.

Left or North side of the Track.

Case.	Direction of first prostration.	Inclination inw'rd and backw'rd fr'm course of tornado.
38	S. 74° E.	16 degr's.
39	S 70° E.	20
35	S. 67° E.	23
1	S. 10° E.	80
2	S. 23° E.	67
3	S. 45° E.	45
4	S. 12° E.	78
5	S. 35° W. (backw'rd)	125
6	S. 5° E.	85
7	S. 40° E.	50

Right or South side of the Track.

Case.	Direction of first prostration.	Inclination inw'rd and backw'rd fr'm course of tornado.
29	N. 65° E.	25 degr's.
32	N. 77° E.	13
30	N. 60° E.	30
33	N. 80° E.	10
34	N. 88° E.	2
36	East,	0
40	N. 65° E.	25
28	N. 63° E.	27
31	N. 75° E.	15
44	N. 63° E.	27

Left or North side of the Track.

Case.	Direction of first prostration.	Inclination inw'rd and backw'rd fr'm course of tornado.
8	S. 11° E.	79 degr's.
9	S. 10° E.	80
10	fell S. 25 W. turned to S. 11 E.	115
11	S. 26° E.	64
12	S. 55° E.	35
13	S. 55° E.	35
14	first thrown N. 23 W. (backward)	247
15	S. 45° E.	45
16	S. 30° E.	60
17	S. 55° E.	35
18	East,	0
19	S. 85° E.	5
20	S. 27° E.	63
21	N. 55° W. (backw'rd)	215
22	first fell N. W. turned to S. 37 E.	225
a	N. 45° W. (backw'rd)	225
23	Branch of apple tree thrown west	183
24	S. 20° W. (backw'rd)	110
25	S. 55° W. (backw'rd)	145
26	South,	90
27	first thrown N. 10 W.	260

Right or South side of the Track.

Case.	Direction of first prostration.	Inclination inw'rd and backw'rd fr'm course of tornado.
37	N. 87° E.	13 degr's.
43	N. 30° E.	60
41	S. 85° E.	– 5
42	East,	0

Mean direction of prostration on the right side of the track N. 73° E.: average inclination inward from course of tornado, *seventeen degrees*.

Mean direction of first prostrations on the *left side* of track, S. 4° W.: average inclination inward and backward from course of tornado, *ninety four degrees*.

Relative inclinations of the two sides to the line of axis, more than *five* to *one*.

It is proper to mention, that the average inward inclination of *all* the prostrations on the *right* side of the track for a distance of four miles east of the river was thirty degrees.* This however does not affect the conclusions in favor of rotation to the left.

These average results, on the two sides, together with the observations already adduced, appear to me to afford decisive evidence of whirlwind rotation in this tornado, in the direction from right to left or which is contrary to the hands of a watch. In reference to this evidence and that exhibited in my paper on the New Brunswick tornado, I add from my prepared sketches the following figure, as an approximate illustration of the whirling action in these tornadoes, so far as this may be shown *horizontally* and by a stationary figure.

Let the involuted lines or arrows on this figure be supposed to represent the motion of the wind at or near the bottom of a vertically cylindrical portion of the center of a tornado, comprising a length of radius equal to the greatest width of the prostrating power on the right of the axis of its path. Now if the tornado

* This larger average gives a relative degree of inclination on the two sides of *three* to *one*. Nearly the same difference is found in two outside bands of prostration, of equal widths, (Tables I and V,) shown in my survey of the New Brunswick Tornado. See this Journal, Vol. XLI, p. 78.

be considered as whirling in the manner here represented, but *without any change of location*, its action may be supposed as concentrically equal on all sides; the motion, however, becoming quickened towards the center in the *inverse ratio* of the successive concentric areas: that is, each particle of air as it revolves about the axis, *continuing to describe nearly equal areas in equal times*, in its progress towards the center, where it rises spirally in the direction of discharge; this direction being vertically at the center, the point or area of least atmospheric resistance or pressure. Thus, the course of a single particle, horizontally, may be *a b c d e f g h i k*;—and so on or between each of the four involuted lines which constitute the figure.

Fig. IV.

For further reference, we may divide this figure by the cross lines of arrow heads, into the four quadrants 1, 2, 3, 4.

We will now consider this whirl as having *a constant progressive motion* on the line of the long arrow *c c*, at a rate equal to one fourth or fifth of its average rotative velocity. It will then follow, that as the force of the whirl on the trees and other ob-

jects encountered by it, is *as the square* of the wind's velocity at the point of impingement, the relative effects on the two sides of the line of the axis, which before were equal, will now be greatly altered.

For, if at a given distance *on the right* of the advancing axis, the former velocity was 80, it will now, as relates to the earth's surface, have become 100; and at the same distance on the *left* side the velocity of the wind will be reduced to 60, as relates to the earth's surface. Thus the squares of these effective velocities will give a power relatively equal to 100 at the former point and only 36 at the latter; both being equally distant from the axis. Hence, although the *rotative* velocity of the whirl decreases rapidly as we recede from its axis, yet its *prostrating* power will, by its progressive motion, become greatly extended on the *right* side of the advancing axis, and proportionally contracted on the left side. Thus the respective boundaries of the prostrating power on the two sides of the tornado, when thus in motion, may be those indicated on the figure; which nearly correspond to the effects which have been observed in several cases.

It may be seen further, that *nearly all the prostrations* near the line of the axis and elsewhere, must, by the advancing motion of the tornado, receive a direction *more onward* than is represented by the arrows or lines in the figure, which can represent only a stationary rotation.

In further considering these effects, in different portions of the whirl, as it encounters objects in its advance, we shall find the maximum effects to be mainly on the line *a*, *i*, *o*, at the rear of the *first quadrant.* Hence, if a tree on this side the axis should fail to be prostrated till after the first quadrant had passed over, it would not be likely to fall in the fourth quadrant, on the further advance of the tornado, unless very near to its axis. Moreover, if one tree should fall when under the more advanced portion of the first quadrant, another if prostrated later in the same quadrant, must necessarily fall in a *more onward* direction than the first, and if sufficiently near will lie across the latter.

It may likewise be seen, that the wind of the whirl in passing into the *second quadrant*, on the left side of the track, is sweeping *backward*, and with its effective power thus greatly reduced, as regards fixed objects on the earth's surface. Thus the limits of prostration are not only narrowed, but the effective power is

here greatly reduced, and gives *fewer prostrations* than under either the first or third quadrants. The *minimum* of effect occurs on the arrival of the line *e k*, at the rear of the second quadrant.

But on the arrival of the *third quadrant*, the prostrating power on the left side becomes more and more efficient by the ceasing of the backward and the accession of the progressive movement; and at or near the line of *f m*, it again takes effect, with rapid increase. The destructive force is also much augmented here by the greater velocity of the heart of the whirl, near its axis, and the impetus must rapidly increase in energy to its maximum effect, as at *m n o*, taking off any tree which may here remain, and carrying aloft, or sweeping onward, the objects previously prostrated on the line *c x k*.

If a tree on the *left* side of the track falls on one previously thrown down by the tornado, the last fallen will also have the more onward direction, as on the other side: unless both have fallen in the second quadrant, where few prostrations occur.—The *fourth quadrant*, for causes noticed in considering the *first*, can have little prostrating effect, except perhaps on the small area near its axis.

If we now conceive of our figure as applied only to the limits of prostration or destruction which constitute the *visible path* of the tornado, it becomes apparently and relatively unequal, in its right and left hand quadrants, the axis appearing greatly eccentric, and in the same degree, at least, as the *left* band or belt of prostrations is found narrower than that on the right of the axis. This apparent, but illusive form of the whirl, may be illustrated by fig. V; which is drawn on the same lines with the preceding figure.

It will readily be seen that this eccentricity of the axis, on the visible track, will be in proportion to *the progressive velocity of the tornado;* other things being equal. Thus, if Mr. Allen be nearly right in his estimate of the rate of progress in the Providence tornado, the eccentricity shown in its path would be generally less than is shown in figures IV and V. On the other hand, if the progressive velocity should be as great as Professor Loomis informs me he ascribes to the tornado of February last, in Ohio, viz. about forty miles an hour, the eccentricity would in such a case be greatly increased, showing the axis as far out-

ward, perhaps, as would be in line with *m*, or *f l*, in these two figures.

Fig. V.

From this examination it appears to result, that an observer who follows the track of a tornado after its departure, will find on one side of the apparent axis of its path, *if it be a whirlwind*, a continued series of prostrations pointing almost invariably onward and inward, with various degrees of inclination to the course of the path. While on the other side of the axis, a narrower band or belt of prostrations will be found, which are also inclined mainly inward and onward, but showing greater inclinations from the line of progress, together with frequent cases which incline more or less backward and sometimes even outward from the course of the tornado.

It may also appear, that a want of proper attention to the necessary conditions of the prostrating power in a progressive whirlwind, can alone induce us to ascribe such effects to supposed antagonistic winds, blowing simultaneously in opposing directions.

Leaving, for a moment, the more tangible features of this inquiry, we may now take some notice of the more outward portions of the "cone" or whirlwind, which are supposed not to be comprised in figure IV. Assuming here the involuted and inward motion, with its upward discharge at the centre, it follows that the impulsive accession of air which is necessary for main-

taining a violent whirlwind action, must come in horizontally, and in the same gradually involuted courses; or, must descend in like manner from a higher region, in and around the outward parts of the whirling cone. I have long since been led to believe that this impulsive accession comes from *both* these sources, but *chiefly from the latter;* and that this motion of accession and support is spirally *downward* in the outward portions of the whirl. The latter being, in its higher portions, often greatly expanded, as noticed by Mr. Allen.

The evidence on which this opinion rests, can be but partially alluded to here; but I will suggest the following considerations:—1. The ascertained existence of a stratum of unusually cold air in the higher region of clouds, on some particular days remarkable for the occurrence of numerous thunder gusts and tornadoes:* 2. The observed descent of a portion of the clouds in front of the nucleus or body of a heavy squall or tornado, which may sometimes be traced by the eye as low as the existing limit of condensation will afford opportunity for observation: 3. The fact noticed by Mr. Allen and others, that adjacent "to the exterior edge of the circle of the tornado" or whirlwind, the previous breeze often continues "to blow uninterruptedly from the same quarter" as before:† 4. The last fact, when taken also in connexion with certain peculiar and striking effects in the outward portions or edge of the tornado, a knowledge of which I have gathered from various sources: 5. The coldness of the air which has been noticed at the edge of a whirlwind: 6. The instant penetration of the lower end of the whirlwind into thick forests, and into hollows and ravines, which has been frequently noticed: 7. The direct memorials of downward action in the outward portions of the whirl which I have myself met with, on the tracks of different tornadoes.

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* This change of upper temperature I think can be clearly made out on the day of the New Brunswick tornado, which was but one of many tornadoes and thunder gusts which appeared in this part of the United States on the same day; and on the preceding day in Illinois and other western states.

In the New Haven Gazette are accounts of *five* severe tornadoes which occurred in the states of New Jersey, Connecticut, Massachusetts and Rhode Island, on the afternoon of August 15, 1787. I can also refer to many more recent cases of this kind.

† The observation here quoted is one of many which show the error of the very hasty generalization which alleges a circuit or annulus of calm air to have been observed *on all sides* of tornadoes and hurricanes.

In most of the foregoing remarks it has been my design to view the tornado as it moves onward, in full action. Of the origin or incipient causes of the whirl, it is not necessary here to inquire: although some clue to these is perhaps afforded us in the considerations above noticed.

Recurring once more to the track of the Providence tornado, I have to state that eastward of Tift's house the course of the track soon became S. 65° E. magnetic, for more than two miles. It then took the course of S. 75° E., and further onward the tornado passed directly over the house of Solomon Peck, about four miles from Providence. This house was partly unroofed; chimney thrown down; windows broken *inward*, as in many other cases; and much other damage was also done to Mr. Peck's property. In passing onward towards Taunton river the tornado appears to have preserved an inclination to the south of east: the track, though slightly sinuous, appearing, like that of the New Brunswick tornado, to form part of a great curve, with its convex side to the northward.

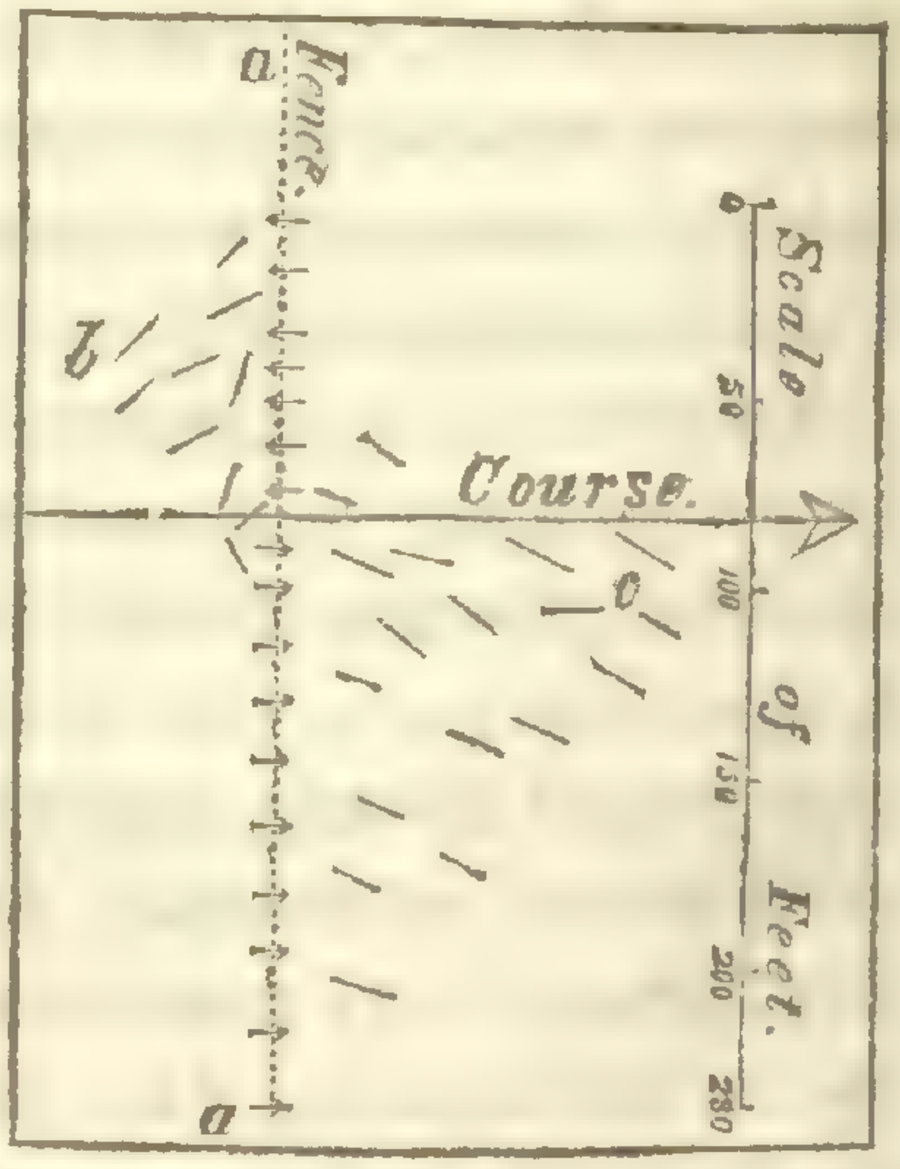
On the track from the Lyon farm to Peck's house there were many interesting memorials which might confirm the deductions already made. On some portions of the track, also, the tornado appeared to have risen almost entirely from the surface, its reversed apex leaving but a narrow trace, and on some fields, even no trace at all. But in these cases, as on the tracks of other tornadoes, the compass bearing did not fail to lead the explorer to new ravages, where, at times, the energy of the tornado appeared to be greater than before.*

Before we take leave of the traces of this tornado I would adduce another of my prepared sketches, which shows the rotative effects in a manner which I think should satisfy the most strenuous opposer of whirlwind action. In this sketch, Fig. VI, we have represented a portion of the track which crossed at right angles a line of weak post-and-rail fence, *a*, *a*. On the *right* of the axis, this fence was prostrated *eastwardly* or in the direction of the course of the tornado, as shown by the short arrows which may represent the posts of the fence; the rails also having been scattered onward and inward, towards *c*, in the general manner rep-

* This is not uncommon in tornadoes, and is especially noticed in the account of two "Trombes" which are given in Pouillet, Elemens de Physique et de Météorologie, § 655.

resented in the figure. On the *left* side, however, every post was prostrated *westwardly*, and the rails were likewise blown slightly backward toward *b*, in the same general direction. The scale of feet, which measures across the track, was obtained by estimating twelve feet to each length of the rails. The locality of this sketch was perhaps a mile eastward of the Lyon farm.—The application of the foregoing views of rotation to this case, it can hardly be necessary to point out.

Fig. VI. *Providence Tornado.*



I have noticed many effects of similar kind on fences; but that the *backward* prostration on the left side of the track should have taken full effect in this case, and mainly, perhaps, under the second quadrant, I ascribe to the age and general weakness of the fence.

Additional memorials might here be adduced in evidence, and of similar character to the foregoing; but having already occupied more space than I intended, I must now leave the question of a general whirlwind rotation in this and other tornadoes to the candid consideration of impartial inquirers.

New York, July 12, 1842.

ART. III.—*On a Tornado which passed over Mayfield, Ohio, February 4th*, 1842, *with some notices of other Tornadoes*; by ELIAS LOOMIS, Professor of Mathematics and Natural Philosophy in Western Reserve College.

(Communicated to the Conn. Acad. of Arts and Sciences, April 28, 1842.)

ON the 4th of February, 1842, between four and five o'clock, P. M., a tornado of destructive violence was experienced in the northeastern part of Ohio. It commenced near the south line of the township of Mayfield, in latitude 41° 31′ N., longitude 81° 27′ W., and pursued a course N. 33½° E. for about twenty four miles; when meeting Lake Erie, it left no further traces of its progress. A more distinct idea of its course may be formed