## THE TORNADO: APPEARANCES; LIEUT. FINLEY'S VIEWS.

WHILE it would appear that the most encouraging line of research is in determining the conditions leading up to a tornado, yet thus far the most time has been spent in studying the destruction, distribution of *débris*, violence of the wind, whirling of the clouds, etc., just at the tornado proper, and where investigation would be the most difficult. A tornado appears to be such a definite phenomenon, that it seems at first sight as though the testimony of different observers would be cumulative, and that there ought to be no difficulty in obtaining definite information regarding all its peculiarities. A very short research, however, dispels this view. The reasons for this are so well and concisely given by Dr. Wadsworth, who investigated the tornado of April 14, 1879, at Collinsville, Ill., that I quote from him.

"It must be borne in mind that this phenomenon came upon our people without warning, and passed before their vision with a probable speed of more than a mile a minute. The impression thus made would necessarily be far from complete. Of those in or near the path of the tornado, one would observe the lower, another a higher portion, very few noticing just the same features. It came to some with the shock of an explosion, or, if they were so fortunate as to have it lift as it passed over them, they might see that a lumber-yard was being poured down upon them, which would be equivalent to not seeing the real cause at all, only a secondary result. To others, again, personal preservation was the first law of nature. To those to the north or south, or some distance in advance, and so fortunate as to have their attention properly directed, are we most indebted for what little history we have been able to gather, otherwise than that to be obtained from the study of the destruction it left behind." To this may be added, (1) no two tornadoes ever had the same appearance; (2) in the same tornado the movements are so complex that it is practically impossible to grasp the whole scene; (3) it is believed that it is almost impossible to avoid preconceived opinions, which give an observer a bias one way or another (this is recognized by the most skilled physicists); (4) in many cases leading questions would tend to cloud the truth; (5) it is probable that sometimes a storm not a tornado is mistaken for one, and this serves to confuse the appearances. This was much more of a difficulty forty years ago than now. A good illustration of this (5) may be found in the so-called Natchez tornado.

### Natchez (Mississippi) Tornado.

This hurricane, for it was undoubtedly a West India cyclone or hurricane, occurred May 7, 1840. Mr. Tooley's description is quoted from. "At 12.45 P.M., the roar of the approaching storm began to be distinctly heard, the wind blowing a gale N. E., 6 (Beaufort). The roar and commotion of the storm grew more loud and terrific, attended with incessant coruscations and flashes of forked lightning. As the storm approached nearer, the wind veered to the E., 7. At 1.45 a blackness of darkness overspread the heavens; and when the annulus approached the city, the wind suddenly veered to the S. E., 8, attended with such crashing thunder as shook the solid earth. At 2 the tornado, 10, burst upon the city, attended with such murky darkness, roaring and crashing, that the citizens saw not, heard not, knew not, the wide-wasting destruction around them. At this moment the barometer fell to 29.37″ (it had been 29.49″ at noon). The wind that desolated Natchez was from the S. E. A brick house on the north side of Main Street had the leeward gable end thrown out, the windward end remaining uninjured. The windward gable end of a large house adjoining the Commercial Bank bursted outward against the face of the storm; the leeward end was uninjured." It is plain, from the veering of the wind and the steady fall of the barometer, that this storm was not a tornado, and we shall avoid a good deal of difficulty by throwing it out in our studies.

### Two Epochs of Study.

It is rather remarkable that between the years 1840 and 1850 there was most diligent attention paid to this subject by the most noted physicists and meteorologists of that day,—Joseph Henry, A. D. Bache, Loomis, Espy, Reid, Redfield, Hare, and others; and after that period for nearly twenty years, or till the Signal Service was established, there appear to have been very scanty studies of the phenomenon. In some respects this will be an advantage to us, as we can compare the later studies, having all the advantages of weather-maps, concerted action, simultaneous observations, etc., with the meagre data of the earlier explorers in this enchanting field. These appearances have been so differently described, and there seems to be so much confusion in some cases, that it is best to quote quite freely from the testimony of those who were eye-witnesses or personal investigators.

### New Brunswick, N.J., June 19, 1835.

One of the best studied of all tornadoes was this one in New Jersey. I quote from Professors Johnson and Henry. "In a few cases, in which the ridge of a building lay north and south, the eastern slope of roof was observed to be removed, or at least stripped of its shingles, while the western slope remained entire. I do not recollect to have encountered a single case in which the top of a tree, with its roots in the ground, was lying towards the west, though I cannot say that none occurred. None were seen with the tops fron the centre of the path. A lad of eight or nine years was carried upward and onward with the wind a distance of several hundred yards, and afterwards descended in safety, being prevented from a violent fall by the upward forces. Rafters which penetrated buildings south of the track, entered them on the north side. Their descent, in some instances, was with great violence, contrary to what happened in the range of the upward motions, where a lad, already referred to, was deposited in safety after a journey of one-fourth of a mile." Professor Bache also investigated this tornado. He says, "I think it entirely made out that there was a rush of air in all directions at the surface of the ground towards the moving meteor, this rush of air carrying objects with it. The effects all indicate a moving column of rarefied air, without any whirling motion at or near the surface of the earth."

### New Haven, Conn., July 31, 1839.

A short time before this tornado the wind blew fresh south-east. It changed suddenly south, and in a moment west, where it continued. Professor Olmstead says, "Accompa-

nying these changes, a heavy rumbling noise was heard, not unlike the passing of a long train of cars, which was audible in every part of the city. All describe it as a strange cloud of terrific aspect, white, like a driving snow-storm or light fog, and agitated by the most violent intestine motions. It came suddenly upon them with torrents of water. Trees and other objects that mark the direction of the wind which prostrated them are, with a very few exceptions, turned inwards on both sides towards the centre of the track; while near the centre the direction of the prostrate bodies is coincident with that of the storm. A barn was demolished, and a dove-cote scattered in fragments, while a hen-roost which stood feebly on blocks was unharmed. In a barn that was blown down, a boy that was on a load of hay in the barn was transported across the street and deposited in a neighboring field unharmed. In other cases, however, forces seem to have acted with great violence upon the individual parts of bodies. Numerous instances occurred where hens were completely stripped of their feathers. Trees and other heavy bodies, that were raised into the air and transported to a distance, did not generally appear to have fallen with the ordinary force of falling bodies. Forces appear to have acted in contrary directions. The legs of the same table were found deposited at the distance of many feet from each other in different directions."

**Pine Plains, N.Y., June 19, 1835.**

The day had been very sultry. Clouds highly charged with electricity darkened the horizon at 3 P.M. At 6 P.M. "our attention was arrested by the peculiar manœuvring of dark and heavy clouds a little south of west. As the black cloud arose (it had the appearance and commotion of dense volumes of smoke bursting from a burning building), light and windy clouds from all that part of the heavens veered toward it with unspeakable confusion and velocity. Mr. Anthony Simmons, near Best's, was on the road with his team loaded with a hogshead of sugar (1,250 pounds). Horses, wagon, and sugar were hurled over a stone wall into a perfect wreck; himself blown in an opposite direction about fifteen rods."

**Stow, O., Oct. 20, 1837.**

Professor Loomis gives a graphic account of this tornado. There was a tremendous roar heard. "Several of the fowls were picked almost clean of their feathers, as if it had been done carefully by hand. There were two powerful currents of wind blowing from opposite sides of the track,—that is, within a few rods of each other,—and with such violence that the stoutest oaks fell before it. What then became of the air thus accumulated in the centre? That there was a powerful current upward from the surface of the earth, near the middle of the track, is proved by the objects which were elevated. A tree which was levelled as this whirl was approaching it, would be turned to the right; and another, which fell as the whirl was receding, would be inclined to the left."

**Mayfield, O., Feb. 4, 1842.**

Professor Loomis has given us a description of this tornado also. "The lightning was quite sharp just before the blow came on, and thunder was distinctly heard above the roar of the tornado. This roar was almost deafening, and was compared to a heavy surf upon the seashore, or to the Falls of Niagara." Professor Loomis loaded a six-pounder with a pound and a quarter of powder and with pieces of board. These were fired into a side hill, and from the penetration he decided that some of the boards in this tornado were driven into the earth with a velocity of 682 miles per hour. The stripping of fowls attracted much attention in this and other tornadoes. In order to determine the velocity needed to strip these feathers, the above six-pounder was loaded with five ounces of powder, and for a ball a chicken just killed. Professor Loomis says, "The gun was pointed vertically upwards and fired. The feathers rose twenty or thirty feet, and were scattered by the wind. On examination, they were found to be pulled out clean, the skin seldom adhering to them. The body was torn into small fragments, only a part of which could be found. The velocity was 341 miles per hour. A fowl, then, forced through the air with this velocity is torn entirely to pieces; with a less velocity, it is probable most of the feathers might be pulled out without mutilating the body."

Professor Loomis gives a list of twenty-one tornadoes down to March, 1842, and the following *résumé* of all the appearances: "1. No season of the year is exempt, but they are most numerous in May and June. 2. They occur chiefly between noon and sunset. 3. The temperature at the time is unusually elevated. 4. They are invariably accompanied by lightning and rain, and frequently by hail. 5. Their progress in this country is invariably eastwardly, the mean being twelve degrees north of east. 6. Their average breadth is about 120 rods; length, 15 miles; velocity of progress when violent, about 30 miles per hour; duration of destructive violence, 45 seconds. 7. Light objects are frequently transported 3 to 20 miles. 8. Very few human lives are lost, about one to a tornado. 9. Leeward roofs are generally taken in preference to windward (Professor Loomis thought the windward side of a roof would be pressed down on the rafters, while the wind would cause a partial vacuum on the leeward side, which would suffice to throw that off). 10. Fowls are frequently picked of most of their feathers. 11. In passing over ponds or rivers, water is invariably raised in considerable quantity."

The omissions in this summary of any ascending motion in the centre of the tornado, any whirling from right to left or left to right, and any evidence of a partial vacuum, are most extraordinary and well-nigh inexplicable. Professor Loomis also adds several significant facts. The Morgan (Ohio) tornado of June 19, 1823, is thus described: "At 9.30 P.M the observer heard a roaring as of heavy thunder, which called him to the door. Upon opening it, he immediately discovered a bright cloud, having precisely the color of a glowing oven, apparently of the size of a half-acre of ground, lower than the dark canopy which remained unbroken above, and moving rapidly in the direction of his house. The brightness of the cloud made the face of things light above the brightness of a full moon. There was neither hail nor rain during the passage of the tornado, neither flashes of lightning nor distinguishable peals of thunder, but an intense brightness of the cloud and a continual and tremendous roar." Such descriptions as these might be given for hundreds of pages; but the above is a

fair sample of them, and must suffice. Before remarking upon these quotations, it will be of interest to bring down such descriptions thirty years later.

**Signal Office Notes.**

In making investigations of tornadoes, the observer was furnished with fifteen to twenty topics of search, and usually framed a number of questions to be asked each person. It is also probable that in these answers all classes of replies by the more interested and by those less so are mingled together. Oftentimes the localities were visited some weeks after the tornado, and when many valuable facts could not be ascertained. To any one desiring a more connected account of these tornadoes, they will find them in the annual reports of the chief signal officer for 1873 and 1875. I will here simply make quotations without giving names.

**Iowa and Illinois Tornadoes of May 22, 1873.**

"Saw two clouds—one in the south-west, and the other in the north-west—which appeared to rush together in the west."

"Saw tornado approaching like two dark clouds, with an intervening lighter-colored space between them. These two clouds presented a funnel-shaped appearance. It whirled contrary to the hands of a watch. Heard some thunder previous to tornado, but saw no lightning."

"Heard it roaring a long time before it arrived. As it approached, saw two funnels distinctly. Saw funnel on the south side, which was the smaller, swing around in a half-circle and join the larger one. When it struck the ground it seemed to smoke, the smoke surging up like spray upon a wave-beaten rock. Saw lightning during the tornado."

"Saw lightning during the tornado, and heard thunder above its roar."

"Saw the funnel whirling contrary to the sun. Saw lightning flash up and down the funnel. Saw a tree thrown out from the top of the funnel about one foot in diameter."

"The roaring was terrific. It resembled the sounds of machinery magnified a million times. It was a combined 'woo-oo-oo' and 'whir-r-r-r.' When the funnel came near, it grew as dark as midnight."

"Observed sheet lightning in the tornado several times. When the tornado had passed about a mile and a half, it appeared to stand still; and a strong gale, with rain, blew directly from it, so that I thought the storm was coming back."

"The tornado first appeared as two clouds—one from the south-west, and the other from the west—rushing to one point."

"Heard roaring about half an hour before it came."

"Heard roaring an hour before the storm came. Did not hear it after it passed. Saw a cloud rushing from the south, and another rushing to meet it from the north."

"The roaring was very loud for an hour previous to its arrival. Did not hear it after it passed. Saw no lightning."

"It was impossible to hear thunder, owing to the noise of the storm, which was terrific."

"Noticed a very black cloud in the west, with a lighter space on each side of it. Did not hear the roaring very distinctly until it was nearly opposite. Then it was an awful ocean-like roaring."

"Saw two clouds—one in the north-west, and one in the south-west—rushing together with great rapidity. A whirling began right where they met, assuming the form of a funnel. Saw it whirling with the hands of a watch at the distance of about two miles."

"There seemed to be a dark cloud to the south-west, another to the north-west. The roaring, like the whirring of a thousand threshing-machines, was so loud that I could not hear the breaking of the buildings."

**Georgia and South Carolina Tornadoes, March 20, 1875.**

"The cloud was very black, with a reddish appearance beneath. Approached with a rising and falling motion, and sometimes bursting upward, like dense, black smoke from a furnace."

"The cloud was fiery in appearance, throwing up, at times, what looked like tongues of flame."

"The form of the cloud was that of an inverted cone, and its appearance luminous. The red cloud moved with great velocity."

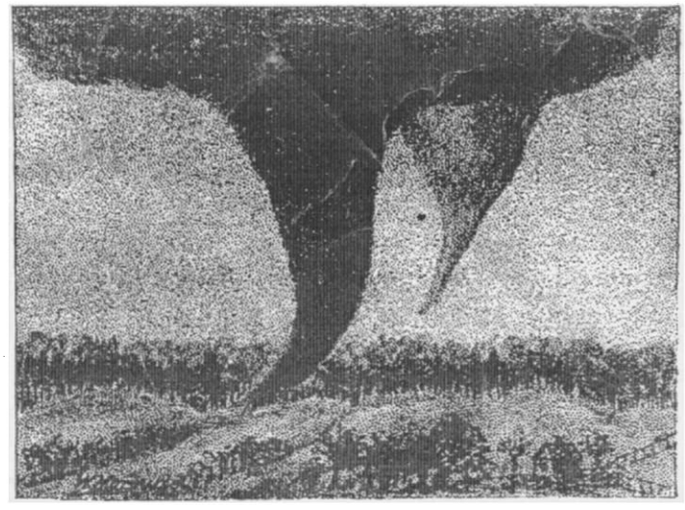

FIG. 1.—TORNADO-CLOUD.

"The roar of the tornado was terrific, as if a thousand locomotives were racing across the country at full speed."

"Saw a bright column reaching from the ground to a height of nearly a hundred yards."

This tornado occurred just about noon, and it is not a little strange that many of the observers saw a more or less bright light connected with the funnel. A photograph of the ruins of Massey's house, near Sparta, Ga., shows a remarkable parallelism in the distribution of the *débris* The house stood directly in the path of the tornado, and was built of heavy hewn timbers dovetailed together at the corners. The south-east side was first crushed in; then the whole house was moved ten feet east, and torn to fragments. The present writer saw precisely the same lines of *débris* parallel to the tornado track in the Wallingford (Connecticut) tornado of Aug 9, 1878. This illustration (Fig. 1) of a tornado-cloud is given as a good representation of the phenomenon. It will be found that nearly every picture has waving lines upon it, as though the funnel were whirling, but the amorphous appearance here given is probably more accurate. Dr. McPherson gives this description: "The horizontal whirl, con-

trary to watch-hands, was plainly visible, together with a rolling motion inward and upward, giving the appearance of dense volumes of black smoke ascending from a tar-kiln. Coruscations were observed shooting out on the right or south side of the cloud. A light funnel-shaped cloud, looking much like white steam, immediately preceded the black cloud."

**Summary.**

I have read over about a thousand pages of tornado literature in making these quotations. They are extremely disjointed, as must be necessarily the case in the scope of this paper. I have had no theory to support, and in consequence the quotations are without bias. It is hardly probable, however, that any one person can read such a mass of matter and make the best selections to give the more prominent appearances; and it is much to be hoped that some one will go over this ground and make independent selections of the salient points. I think the omissions in these appearances are oftentimes more suggestive than the positive statements.

*The Loud Roar.*

The well-nigh universal testimony is, that there was an indescribable roaring in connection with the tornado. It is probable that this was heard in the earlier cases, but was not regarded of enough importance to note. It is hardly probable that the loudest of this roar could be heard more than a few minutes before the outburst. Little weight can be attached to the observations of a few, that it was *not* heard after the passage. It is entirely improbable that this can be caused by the wind, or by the tornado whirling in the air. We very much need more careful observations. Attention should be directed especially to a comparison of the sound with a continuous rumble of thunder.

The ascending current has also been largely commented on. The attempt to show an updraught by the fact that some persons were let down gently is more than counterbalanced by the fact that pieces of board and timber were driven into the ground many inches. The evidence on this point of an ascending current is very contradictory, and it is highly probable that a fierce blast from two directions, together with the assistance of the topography, will account for most of the phenomena. There is almost overwhelming evidence that air rushing into a partial vacuum does not produce this updraught. The evidence shows that the direction of the path of the tornado is pre eminently toward the north-east.

*Whirling of Tornado-Cloud.*

Perhaps the least satisfactory testimony is regarding this appearance. We may set down at once the uselessness of any one trying to determine this whirling if he is more than a thousand feet away, and probably the limit should be five hundred feet. Attention should be directed to the ground, and most careful observations made of the whirling fragments. The distribution of the *débris* is markedly against any whirling. It is impossible to see how a whirl of a hundred feet diameter could throw down one tree to the north-east, and its neighbor to the south-east on top of the other. Some one has well suggested, that, if the cloud is whirling, the trees on the edges of the tornado should lie parallel to the track, while those in the centre should lie at right angles; but we know that precisely the contrary is the appearance. The writer once made an observation which may help to elucidate this problem. In the streets of Washington, during the laying of the cable-road, there were employed furnaces for heating tar, and in these furnaces it was customary to consume the remains of the tar-barrels for fuel. The smoke from these furnaces was most dense and black. The draught was so strong that the smoke issued from the chimney at a velocity fully equal to the wind that was blowing. The top of the chimney was not more than three feet from the eye, thus giving a most excellent opportunity for noting the slightest movement. When it was nearly calm, the smoke ascended perfectly straight, and with no whirling motion. The moment the wind blew, an extraordinary phenomenon was seen. Taking a vertical plane in the direction of the wind, and looking with the wind at the back, it was found that on the right of the plane the smoke whirled from right to left, while on the left it whirled from left to right. The appearance of this smoke thus doubling upon itself was most interesting, and invariably occurred when the wind blew. It seems as though most of the contradictions in the testimony would disappear if some such action as this took place. We may be certain that there is no uniform whirl in tornadoes in either direction.

*Stripping Feathers from Fowls.*

This is undoubtedly a true phenomenon. The attempts to prove that this could be caused by the expansion of air in the quills, due to the passage of a vacuum, have signally failed. Fowls under an air-pump could not be deplumed by exhausting the air. We must also regard Professor Loomis's experiment of shooting a fowl out of a cannon as an entire failure, I mean for elucidating this phenomenon. He thought, that, if the fowl could have been fired at a hundred miles per hour instead of three hundred and forty, the result would have been very different; but this certainly is very doubtful. A wind of a hundred miles per hour would have carried along the fowl, feathers and all. It would be an interesting experiment to fire a fowl at a hundred miles per hour; but it is entirely probable that no fowl could live under such a shock as that, and the feathers would not be driven off until the velocity became enough to dismember the fowl. It would also be interesting to hold a fowl before a blast, and determine, if possible, the velocity needed for depluming. The most singular fact is, that the fowl lives under the depluming process. In some cases roosters have been seen walking around, days after the tornado, crowing, and without a feather on their backs. The appearance can be readily accounted for on the supposition that an electric charge threw off the feathers, and this seems the only way of explaining the stripping of clothes from a person.

The conclusion seems forced upon us that we need, more than all else, much more accurate observations by persons accustomed to note physical phenomena. It will be seen that in later days the appearance of clouds from the north-west and south-west is attracting great attention. That this fact was not emphasized before, may be due, in part, to the fact that it was not regarded as of any special importance in accounting for the phenomena. It seems that these appearances certainly attend the tornado, and are seen all along its

course of a hundred or two hundred miles; so that they cannot be regarded as individual clouds, whose meeting produces the funnel.

[Continued on p. 316.]

## NOTES AND NEWS.

ANY one interested in the sick benefit, funeral aid, and death-beneficiary associations of the United States can help make the statistics of their organizations for the forthcoming census more complete, and disseminate the knowledge of the good work they are doing, by sending the names of such societies as they may know of, and the addresses of their principal officers, to Mr. Charles A. Jenney, special agent of the Eleventh Census, 58 William Street, New York City.

— Professor S. T. Maynard, in the April bulletin of the Hatch Experiment Station of the Massachusetts Agricultural College at Amherst, states that the fact that healthy and vigorous peach-trees can be grown to the age of six to ten years in New England needs no demonstration, but that we seldom find healthy trees of a greater age on account of the destruction resulting from the cold and by the disease called the "yellows." While we do not know the exact nature of the disease called the "yellows," and cannot wholly control the atmospheric causes, the other causes, says Professor Maynard, we can largely control; and by careful cultivation in the spring and early summer only, by the use of complete fertilizers in the fall or early in the spring, we can largely prevent this destructive disease. It may not be profitable to try to save diseased trees, and it would be advisable to destroy them as a matter of safety, although there is no evidence that the disease is contagious: for upon the college grounds more or less diseased trees may be found at all times; and young trees are planted where old trees have died, and, with an abundance of plant-food, have grown in perfect health for six years.

— Experiments in the cutting of seed-potatoes after various methods have been carried on each season since the organization of the Ohio Agricultural Station. In 1889 the work was carried on upon a larger scale than formerly, and with a greater number of varieties, the object being to test the validity of conclusions drawn from the results of former experiments, also to compare varieties. There is sufficient uniformity in the results of different seasons to warrant the following conclusions, says Professor W. J. Green, the horticulturist: 1. Other conditions being the same, the larger the cutting, the greater the total product; i.e., the total product varies in about the same ratio as the size of the cutting. 2. The marketable product also increases as the size of the cutting is increased, but does not follow the same ratio as the total product, the rate of gain being less. 3. The increase is found in both the large and small potatoes, the greater portion being in the latter. 4. A crop grown from whole potatoes matures at an earlier date than one from small cuttings. 5. Small cuttings require soil that is more highly enriched and thoroughly prepared than large cuttings and whole potatoes, in order to secure a good stand and to produce a profitable crop. 6. The question of relative profit, as between the use of small cuttings and whole potatoes, depends upon the cost of seed-potatoes, the date at which the crop is to be harvested and sold, and the condition of the soil at planting-time. 7. In ordinary practice it will usually be found that neither extreme, as to quantity of seed used, will be found to be profitable. The safest plan is to use large, well-matured, healthy potatoes, and cut to two and three eyes.

— Much discussion having been provoked relative to the results of experiments at the Massachusetts Agricultural College, Amherst, Mass., with steam and hot water for heating greenhouses (reported in Bulletins Nos. 4 and 6), especially as to the accuracy of the results, Professor S. T. Maynard has the past winter made a careful repetition of the experiments to correct any errors that might be found, and to verify previous results. The boilers having been run with the greatest care possible from Dec. 1, 1889, to March, 1890, and every precaution having been taken that no error should occur, he finds the total coal consumed between those dates, for the hot-water boiler, to be 6,598 pounds, the average daily temperature for the time being 49.74°; and for the steam-boiler the total coal consumed in the same time was 9 734 pounds, the average daily temperature for the time being 48.39°. The following criticisms have been made by parties not conversant with the facts of the case: 1. That the piping and check-valve were not arranged so as to get the most perfect circulation of steam without a great loss of fuel. 2. That the flues from the two boilers entered the chimney in such a way as to give a better draught to the hot-water boiler. 3. That the exposure of the two houses was such that the house heated by hot water received more sun-heat than the one heated by steam. These criticisms Professor Maynard thinks can be answered to the entire satisfaction of all fair-minded readers. By numerous test examinations he found that the circulation of steam through all the pipes, above the water-line of the boiler, is perfect whenever there is fire enough to create steam in the boiler; that the check-valve must consequently work easily; and that there is never any standing water in the return-pipes above the water line of the boiler. The flues are arranged so as to give as nearly equal draught to the boilers as is possible and have them enter the same chimney, and enter at the same point; and if there is any difference in the draught of the two, it is in favor of the steam-boiler. It was suggested by the late Mr. George Hills of Arlington, that perhaps from their location the steam-heated house received less sun-heat than that heated by hot water. To test this matter, two standard thermometers were placed in each house, so that the sun's rays should fall upon them equally in both houses at the same time, — one on the eastern, and one on the western exposure. Records were made three times each day for twenty days, ending March 18. Of these twenty days, about eleven days were cloudy and nine clear, and probably the period of time under observation was long enough to show that the amount of sun-heat received by each house is so nearly equal as to in no way change the results given in the temperatures of each house.

— In the *American Chemical Journal* (vol. xii. No. 4) Mr. H. J. Patterson of the Maryland Agricultural Experiment Station, Agricultural College, has an article on "The Use of Animal Charcoal in the Determination of Fat (Ether Extract) in Feeding-Stuffs." His conclusions are, that the use of charcoal results in a closer approximation to the truth than any other method in use, though absolute accuracy is not claimed. The following points may be claimed in favor of the use of animal charcoal in the determination of fat (ether extract) in feeding-stuffs: 1. That the product obtained is nearly pure fat or vegetable oil. 2. That the product obtained gives a more correct idea of the physical nature of the fats from various substances. 3. That slight quantities of water that may exist in the substance and pass out with the extract will be removed by the charcoal. 4. That soluble acids of the plant, or acid which may be formed by the continuous distillation of ether, in connection with some constituents of plants, will be partially, if not wholly, removed by the animal charcoal. 5. That the animal charcoal will partially obviate, if not wholly remove, the difficulty of change in the amount of ether extract (which generally increases) with the aging of the sample.

— The April bulletin of the Michigan Agricultural Experiment Station is on "Foul Brood," by A. J. Cook. By special request of several bee-keepers, Professor Cook issues the bulletin upon the most serious malady that ever attacks bees in this or any other country. The problem of safe wintering, once so important, is now solved, and the intelligent apiarist feels no longer any dread of winter's cold. Foul brood is now the bee-keeper's terror. Like the cholera — a disease which is close akin to foul brood — among our own kind, so this disease comes into the bee community like a terrible scourge; and if the bee-keeper is ignorant, incautious, or indifferent, it abides with him till it starves for want of bees on which to feed. Terrible, and terribly fatal, as this disease is known to be, experience has proved, certainly, that with full knowledge, and as great care, it can be kept in check and wholly cured, and that with not very serious labor and expense. The minute ovoid spores are brought to the hive probably in honey fed to or brought in by the bees. It is easy to see how honey in a diseased colony of bees would receive these spores. It is diffi-

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### Lieut. Finley's Views.

For the past ten years Lieut. Finley has devoted a great deal of attention to this subject, and has received reports of tornadoes from thousands of observers. His views, then, should have much weight as being a *résumé* of all the facts reported. Quotations will be made from his book entitled "Tornadoes," published in 1887 by the *Insurance Monitor*. No attempt has been made to classify these, but I have given them in the order in which they occur in the book. Speaking of the flow of air on either side of a large storm, we find, "As these conditions continue to prevail, there is a growing contrast of temperature to the north and south of the major axis (of the depression), owing to the long-continued movement of the atmosphere from opposite directions; such movement eventually affecting the disposition of air in the warmer regions of the extreme south, and likewise the colder regions of the extreme north. The contrast of temperature now naturally increases with marked rapidity, and the formation of clouds commences in earnest. Huge masses of dark and portentous appearance bank up in the north-west and south-west with amazing rapidity, and soon the scene becomes one of awful grandeur. The struggle for mastery in the opposing currents is thus indicated by the gathering cloud-formations. The condensation of vapor from the extremely humid southerly currents by contact with the augmenting cold of their struggling opponents continues. It increases rapidly. Finally, when resistance to the unstable equilibrium can no longer be maintained (controlled by the rate of temperature change and rapidity of condensation), the opposing forces are, as it were, broken asunder, followed by the upward rush of huge volumes of air. The outward indication of this event is first shown in the whirling, dashing clouds over the broken surface of the heavy bank of condensed vapor, forming the background,—a scene not easily depicted or realized by one who has not witnessed it, but never to be effaced from the memory of the actual observer. There is an awful terror in the majesty of the power here represented, and in the unnatural movement of the clouds, which affects animals as well as human beings. The next stage in the further development of this atmospheric disturbance is the gradual descent of the funnel-shaped cloud from a point apparently just beneath the position of the enactment of the first scene. The tornado is now before us, not fully developed, but soon to acquire that condition when the terrible violence of its power will make the earth tremble, animals terror-stricken, and men's hearts quake with fear."

"There seems to be some strange connection between the almost simultaneous appearance of clouds in the south-west and north-west, possessing as they do such unusually threatening forms. As they approach from opposite directions, they are suddenly thrown into the greatest confusion, breaking up, as it were, into small portions, which dash pell-mell over each other and in every direction; now darting toward the earth; now rushing upward to considerable heights like sky-rockets, or at moderate elevations rolling over each other in a well-developed whirl. An observer, in describing the approach of the clouds from the south-west and north-west, stated that they came together with a terrific crash, as if thrown from the mouths of cannons. Generally, following closely upon the existence of this condition, the funnel-shaped tornado-cloud appears against the western sky, moving boldly to the front from without this confused mass of flying clouds." Lieut. Finley describes four motions of the tornado: "No. I. is called the whirling or gyratory motion, which is invariably from right to left. Above all other motions, this is attended with the greatest violence. This gyratory motion forms what is termed the 'vortex' of the tornado-cloud, within which the velocity of the centripetal currents of air is almost beyond conception. No. II. is called the progressive motion of the tornado,—the motion which determines the cloud's track from one point to another. No. III. is termed the rising and falling motion of the tornado. No. IV. is called the zigzag motion, or swaying from side to side of the central line of cloud-movement. This movement is sometimes quite suddenly performed, but generally it is a moderately slow movement, and one that can be watched and easily identified. In completing the extent of a single act of this motion, the tornado-cloud will diverge about an equal distance on either side of

the central line of movement, though these tangents to the major axis are not necessarily of equal length."

Lieut. Finley summarizes his study of the relations of a tornado to general atmospheric conditions as follows: "There is a definite portion of an area of low pressure within which the conditions for the development of tornadoes are most favorable, and this is called the dangerous octant. Tornado regions are to the south and east of the region of high contrasts in temperature (temperature gradient) and in dew-points. The area of tornadic action is to the south and east of the region of high contrasts of cool northerly and warm southerly winds,—a rule that seems to follow from the preceding, and is of use when observations of temperature and dew-point are not accessible. The relation of tornado regions to the movement of upper and lower clouds shows that the former indicate the presence of the cold north-west current, and the latter the warm south-west current of air, which ultimately lead to the development of the high contrasts of temperature so essential to the birth of tornadic action. The study of the relations of tornado regions to the form of barometric depressions shows that tornadoes are more frequent when the major axis of the barometric trough trends north and south, or north-east and south-west, than when it trends east and west."

From Lieut. Finley's "Scientific Résumé of Tornado Characteristics," I have selected the following as touching upon points not already mentioned.

"The time of day, the time of year, and the peculiar hot and stifling condition, indicate that heat is the physical agent developing the tornado. By the rotary action of the tornado-cloud the condensed vapor is whirled into a fine mist, giving it the appearance of steam, and lighting the interior of the cloud. The tornado is accompanied by a rumbling noise (very peculiar), which never ceases while the funnel-shaped cloud is upon the earth or a short distance above it. The funnel form of the cloud is due to the peculiar ascensional movement of air-currents, the vapor being condensed along the central line of movement by the cold of elevation. The motive power of a tornado, and the agency which lifts objects or carries them long distances, is that motion of the air in the cloud set up by the variable heat conditions of large masses of air over adjacent regions.

"The tornado vortex may be formed either by an ascensional movement of a mass of heated air, giving rise to unstable equilibrium, or by the meeting of opposite currents with high temperature gradients, or by a combination of these. Two currents of air approaching each other from opposite directions will not come directly together, because of the influence of the relative motion of the earth. The mass of air coming from the south would have a greater velocity eastward than that coming from the north: therefore, instead of meeting each other in a direct line, the two currents will form an angle at their intersection, and the combination of the two masses will give rise to a rotation in a direction contrary to the hands of a watch with its face upwards. These conditions account for the spiral movement of the air-currents and the formation of the vortex in the tornado. The cold air from the northward will under-run the warmer air from the southward, because of the difference in density of the two masses, and as a result will aid in the formation of the whirl.

"The electrical tension of the air cannot, under the most favorable atmospheric conditions, cause the movement of oppositely electrified air masses, because of the excellent conductivity of free air, which always tends to equalize electric potential. The presence of ozone is usually detected in the wake of the tornado. People are stripped of clothing, fowls and birds denuded of feathers. The peculiar roaring noise which accompanies the progress of the tornado cannot be ascribed to the intervention of electrical forces: it is far more reasonable to assert that the noise is produced by the resistance which the rapid and violent indraughts of air encounter while passing into the tornado's vortex. The vortex approximates a vacuum, and the air rushes into it at the spout end near the earth with great violence, attended by a hollow, sucking sound of marked intensity.

"The peculiar sensations of what are termed 'burning,' 'scorching,' or 'stifling' heat, which are reported by those who experience the violence of the tornado, must be due to the latent heat of vaporization, which is given off in great quantities by the extremely rapid condensation that attends the tornado as a constant feature."

A very interesting comparison may be made between these later views and the appearances noted earlier. Lieut. Finley seems to have slightly confused the conditions which prevail at the centre of the general storm with those at the tornado. Great contrasts of temperature and dew-point, meeting of hot south with cold north winds, etc., can only occur at the centre of the general storm, but that point is four hundred miles from the tornado. It seems probable that altogether too much emphasis has been given to the two clouds,—one in the north-west, and the other south-west—which are described as gathering themselves together as two giants eager for the coming contest. We have already seen that these clouds are an accompaniment of the tornado. They are probably never more than one or two miles apart. They seem to rush together, because, when first seen, a cloud of dust hides the true tornado, and these appendages appear prominently on either side. In a minute or two the observer is enveloped in the dust, and the next instant he sees the death-dealing funnel, and his heated imagination at once leads him to the conclusion that the funnel is produced by the forcible meeting of the clouds.

### Contrasts of Temperature.

Lieut. Finley especially insists on such contrasts as a *vera causa* in the formation of a tornado, but it would seem as though he has entirely mistaken the mode of action generally ascribed to an unstable equilibrium. We are impressed with the fact that the clouds and resulting contrasts are on the same level, whereas, in order to have a contrast capable of causing an upsetting in the atmosphere, it is absolutely essential that the cold air be *above* the hot. Lieut. Finley expressly declares against this disposition by stating that the colder air, by its density, under-runs the warmer. It is a matter of deep regret that other writers on this subject have not seen that such a condition as the last mentioned entirely negatives their theories of tornado formation.

### Tornado Whirls.

No one who has read all that precedes can be more astonished than the present writer to find that the evidence proving a whirl is so inconclusive and conflicting. I had fully made

up my mind that there must be a whirl, though in doubt as to its direction. In fact, the best testimony we have, scattering of *débris*, is strongly in favor of the view that there is no whirl. Figs. 2 and 3 will show better than pages of text the nature of this testimony. Let us ask what would be the effect of a whirl, in a direction counter-clockwise, passing through an orchard (see Fig 2). Facing the tornado as it approaches, we would see trees passing our eyes at right angles to the track, or leaning over to the right. After the tornado passes, we would see trees on the south side lying

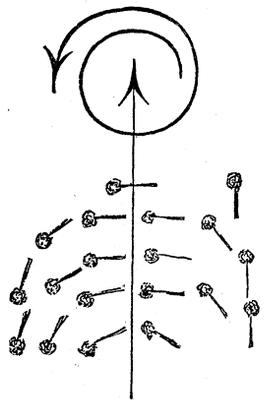

FIG. 2.—ORCHARD BLOWN DOWN BY A WHIRL FROM RIGHT TO LEFT.

parallel to the track, with tops to east, while on the north side their tops would lie to the west. Fig. 3 shows the true conditions which are found. The *débris* and trees in the centre all lie parallel to the track, while on the north and south sides the trees point inward and forward toward the centre. The writer made a most careful investigation of the conditions at the Wallingford (Connecticut) tornado; and these appearances were repeatedly met with, though the

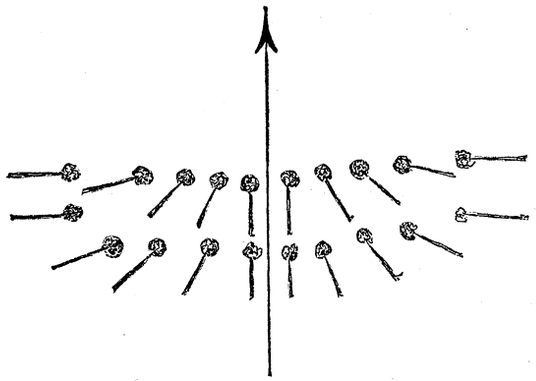

FIG. 3.—ORCHARD AFTER ACTUAL TORNADO HAS PASSED.

true significance of the facts was not fathomed. The strongest argument that has been advanced in favor of a whirl has been the position of tall trees which have crossed each other. Almost invariably the under tree is the one pointing north or north-east, while those above point south-east or south. The proof is very unsatisfactory. If there is a steady whirl in a mass of air, why would it not break down neighboring trees in the same direction?

### Further Research.

We are impressed with the imperfection of the evidence regarding the true mechanism of a tornado. Even the apparent drawing-up of water from a pond cannot be regarded as evidence of an uprush. We know, that, even if there were a perfect vacuum, water could not possibly be raised more than thirty-four feet. It is probable that the depression noted as the tornado passes is due to the wind, and the apparent rising of a mass of water is simply fine water-particles or mist borne on the wind. The fact of the existence of a whirl is one of the most important that can be established. While we can never expect that an observer would remain near enough to a very severe tornado to make accurate observations, yet it seems as though this fact might be established by skilled observations in a less severe tornado. If you are on the south side of a tornado, there is little use in looking for a whirl; but attention should be given to the starting of objects into the air. See whether, when a tree starts, it goes suddenly, as if shot from the ground, or is swayed violently at the top first; see whether the *débris* that rises goes up in great confusion, whirling over and over, or whether it is carried lengthwise, as in a stream; etc. If you are on the north side, get as near as you dare, and cling to a large tree, or, better, to a post; note whether a single object near the ground or up in the funnel has any motion whatever toward your right hand as you look at the funnel. The moment the tornado has passed, run with the greatest possible speed to its rear, and, if possible before the dust has enveloped you, see if a single object on the ground or up in the air is moving to your right. If the tornado has moved through an orchard, establish as near as you can the centre line, and then pace off one hundred, two hundred, three hundred feet to north and south, examine trees at the same distance on either side, and see if those on the south are uprooted or broken more than those on the north. If the tornado is moving at the rate of eighty miles per hour, and the whirl a hundred and twenty, on the south side the resultant velocity would be two hundred, while on the north side it would be only forty miles per hour. The greatest care must be taken that we do not blind our eyes with preconceived notions. When some observer who has a barometer has been so fortunate as to take it to a dug-out, and has kept his eye upon it rather than upon the more absorbing tornado, we may hope from his testimony, if the funnel goes over his head, to clear up more doubtful points, and establish more certainties, than can ever be done by any other means. Finally, as the West becomes more thickly populated by skilled observers, we may hope to some time establish many points now very uncertain.

H. A. HAZEN.

## LETTERS TO THE EDITOR.

*** Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.*

*The editor will be glad to publish any queries consonant with the character of the journal.*

*On request, twenty copies of the number containing his communication will be furnished free to any correspondent.*

### To Discuss Meteorological Topics.

A PRELIMINARY survey is being made to discover if available material enough exists in and near this city to form a society to study and discuss meteorological topics. Such an organization should include physicians, civil engineers, and other professionals, and amateurs who have studied the weather in a scientific way, or the relations of any of its phases to important human interests, like health, construction of dams, bridges, and buildings, navigation for commerce and pleasure, horse and steam car local traffic,