TORNADO FORMATION.

The Question Discussed in the Light of Scientific Facts.

A Few of the Most Important Theories Upon the Origin and Growth of Tornado Clouds—Fearful Manifestations of Nature's Forces.

H. Allen Hazen writing to the St. Louis *Globe-Democrat* concerning wind-storms says that, strictly speaking, a tornado is a funnel or balloon-shaped cloud, accompanied by a most violent wind, intense electric discharges, and usually by a peculiar greenish color and an indescribable roar. In fewer words, a tornado is the extremest development of a thunder-storm.

Space allows a presentation of only a few of the most important theories upon the origin and growth of these terrible outbursts. All are agreed that the "power" of the tornado is to be looked for at some distance above the earth's surface, probably not more than five thousand feet, however. As we have few observations at this height it is almost impossible to prove or controvert any theory that may be advanced, but for acceptance it is essential that a theory do no violence to any of the facts. It is thought by some that there is a condition called "unstable equilibrium" in the atmosphere, whereby, through an unequal heating of the air, there is started an upward movement which is augmented by the condensation of moisture and liberation of latent heat at the seat of the "power." Air is so mobile and nearly frictionless in its motion that it would seem as though such a state, if begun, would be immediately dissipated by the inflow of air. But even if we grant that such a state of instability is possible, we find a most serious, if not fatal, objection to its permanence, from the fact that the air stratum at five thousand feet is moving two to three times as fast as that near the earth. It is easy to see that any uprush of air would be entirely broken up in a few minutes from this cause.

Again, we are told that, while the lower warm current is from the south, the upper current is from the north and very much colder. The lower heated current has a tendency upward, but is hindered by the "cold cover," but at last it finds a vent and rushes through it, forming the fatal tornado. In the first place, conditions of equilibrium demand that the colder denser air underrun the lighter warm air, this is so plain that some have explained tornado formation in this way, but it is easy to see that there could be no instability in that case. In the second place, the idea of a colder upper current from the north is a myth, as any one can readily determine by studying the motion of the upper clouds in the tornado region, which are invariably from the south. In the third place, it is entirely incredible that such an instability once started could be carried forward at the rate of seventy or eighty miles per hour and maintained for more than three hundred miles.

One of the essentials to the formation of a tornado, according to generally accepted views, is the existence of a partial vacuum at the center. It seems probable that with a cloud not more than three hundred yards in diameter any vacuum would be almost instantly filled by the tremendous inrush of air. It is probable, moreover, that there is a rise of pressure at the center. No sudden fall has ever been observed, but a rise has, and, if we grant the tornado is a thunder-storm at its best, we now have hundreds of indisputable observations of a rise in pressure in the latter, and this rise is generally conceded by all investigators.

It is admitted that general storms move with the upper current, and it is thought that tornadoes may also be borne along in the same way. This seems hardly tenable, however, because the ordinary velocity of the tornado is double that of the accompanying storm, and, moreover, the upper current in the tornado region seems to blow toward the north, while the tornado moves northeast or east-northeast.

It has been generally accepted that in all atmospheric disturbances the presence of electricity is an effect and never a cause. All attempts to explain the presence of such large quantities of electricity have entirely failed. It is dangerous for any one to ascribe any unexplained phenomenon to electricity, but there seems to be no reason why it may not be concerned in the formation of the funnel-cloud. Dry air is almost a perfect non-conductor; if there be a supersaturated cloud it may be charged with electricity to an enormous potential. In 1857 Prof. Blodget wrote on tornadoes (see Climatology, p. 402): "The greatest difficulty exists in explaining the facts in regard to their narrow limits while the fullest measure of violence is retained, and this can only be done on the supposition that electric energy makes up a very large share of the force." We are just beginning to learn the possibilities in electric energy, and one can not well assert that it does not have much to do with tornado formation. I have space for a single illustration: The apparent explosion of a house, e. g., the house of Adolphus Isom, at Mount Vernon, is brought forward as a proof of the vacuum theory. In August, 1885, an analogous phenomenon came to my attention which was clearly due to electric action. A house having a tin roof and without lightning rods was struck by lightning. The electricity passing between the weather-boarding and the plastering, plowed a furrow in the ground at the base of the house and disappeared in a pool of water near by. The weather-boarding was violently burst off on the outside, while the plastering and clothes in the closet were thrown nearly across the room on the inside. There seems to be no reason why we may not explain other similar phenomena in this way.

While some form of electric energy seems an important factor in tornado action, yet this should serve to allay our fears of danger. If Franklin, by the simple device of the lightning-rod, secured immunity from lightning strokes, is it too much to expect that the genius of these later times will not discover some method of warding off or ameliorating the evils in this case. It may be that the time is not far distant when, owing to the gravity of the problem, we shall see experiments carried on at great cost looking to the dispersion of the funnel cloud by discharges of ordnance or explosives. It is of the utmost importance that we gain correct views of the manifestations, and in this many can help. It is customary to examine only the immediate havoc produced, but in order to study the question minutely we should have observations at points just before and after that of the greatest devastation. If it is admitted that tornadoes are analogous to thunder-storms, we have a most inviting field for research and one that is often present on warm summer days and frequently in many States.

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SALEM, Or., January, 1889.

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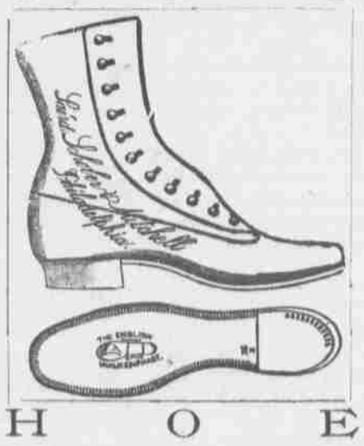

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