

southwest of the city, while others assert that it can be traced to Carroll County, fifty miles farther southwest.

I am quite confident that it increased in size, fury, and speed after I first observed it. I estimated the speed of the wind at eighty miles an hour; but Professor Proctor, who studied the phenomena carefully and made an estimate of speed, says it was only sixty miles.

Within a few hours after the tornado, the mayor of the city organized a bureau of information, and took immediate steps for relief of the suffering. Kirksville is a city of between ten and twelve thousand inhabitants, and being a town of schools and colleges, there are always a large number of students from a distance in attendance at the various institutions of learning. It was heartrending next day to witness the search of parents for their children. Almost every train brought some anxious relative or friend.

Tornadoes generally travel toward the east, or in a northeastern course. This is not universal, but is the course more often taken than any other; consequently it is nearly always safe to fly northwestward

when you see the funnel-shaped cloud to the south or southwest of you. A strong cellar or a storm-cave of easy access is usually a safe retreat. It is better that the storm-cave should be placed a short distance southwest of the house, and connected with the cellar by a tunnel, as there is not so much danger of timbers falling upon the fugitives within, nor of death from fire. In the Western and Southern States the tornado period is usually from April to July, though it has been known to begin as early as March and extend to October.

There seems to be sometimes an unsettled condition of the atmosphere, and the tornado is the result of an effort of the atmosphere to regain its stability. Terrible as these storms are, destructive as the lightning may be, the peaceful, healthful calm which follows these convulsions of nature suggests that they may be essential to the perpetuity of the human race. Gail Hamilton says:

"When volcanoes close, and there are no more earthquakes, and the cyclone has ceased to sweep, and the freshets to overwhelm, it will be a settled earth, but it will be a dead earth."

TORNADOES.

BY CLEVELAND ABBE.



THE summer season annually brings to our attention a dreadful harvest of destructive local storms. From Massachusetts to Georgia, from the Atlantic westward to the one hundredth meridian, nearly every State occasionally sends a report of a cloud-burst, a tornado, or destructive lightning. The sum total of the lives and property destroyed by lightning undoubtedly exceeds that destroyed by cloud-bursts and tornadoes; but the damage done by the latter occurs in conspicuous disasters the number of which is relatively small, but which attract much attention. It is usual to speak of the tornado as the scourge of certain portions of our country, forgetting that nature provides many other methods of death and destruction, and that the least sensational is generally the most effective.

As the settlement of our country goes steadily forward, while its climatic peculiarities remain unchanged, the total destruction

of life and property must increase very nearly in proportion to the population and wealth of the nation. The completeness of our records will also increase in the same ratio. In the "Monthly Weather Review" for June, 1897, I published a table showing that during the eight years from 1889 to 1896 there was no appreciable increase in the record of tornadoes over the average for the period, between 1874 and 1881, except that depending upon the above-mentioned considerations; in fact, in many States the average per year had diminished. The area covered by the path of destruction attending a tornado is so exceedingly small that comparatively few houses or towns are affected by it. In a few States, such as Illinois, Indiana, Iowa, Kansas, Maryland, Massachusetts, Missouri, and New Jersey, the probability that a given spot one mile square will be struck by a tornado is about once in a thousand years. In fact, the chance that a specific person or house will be destroyed

by a tornado is much less than the chance that he or it will be destroyed by lightning, and far less than the danger from fire.

Many a person interested in the subject will stand on a favorable spot and, ignoring the slight personal danger to himself, become entirely absorbed in studying the approaching lightning, and in the photography of the flashes themselves. The time will doubtless come when such persons will also study a passing tornado with equal coolness and discretion. Photographs of tornadoes, sketches of the appearances of the clouds, and measurements of such phenomena as may give some idea of the force of the wind, are always welcome contributions to meteorology. Notwithstanding the fact that the United States Weather Bureau has many thousands of observers and correspondents scattered over the whole country, it is yet very rare that any one of them personally witnesses a tornado, so that the progress of our knowledge of these storms is necessarily slow. We can pick out of the ordinary popular reports, with all their gross exaggerations and sensational items, only very general conclusions as to the location and dimensions of the path; but the numerous questions that a scientist would ask remain unanswered.

The point about which there has, perhaps, been the most uncertainty relates to the rotatory motion of the wind at the center of the path of destruction. From all that I can gather, I conclude that generally a west or northwest wind is blowing over the country, with a front of many miles in length, which trends southwest and northeast. This cool northwest wind pushes aside a gentler southerly wind that had been prevailing over that same region during the previous twenty-four hours. In the long belt, or trough, where these two winds meet, the warmer southerly wind is suddenly elevated and cooled by expansion, as also by mixture with the undercurrent of cold northwest wind. A cloud is thus formed, or in fact rolls of clouds, along the whole front of the area of northwest wind. At certain favorable spots the cloud soon becomes so large as to form a special indraft upward through its center, and the ascending air must necessarily acquire a spiral ascending movement. The direction of rotation in this spiral is almost invariably the same as that of the hurricanes of the Atlantic Ocean, or the general storms attending the areas of low pressure that move eastward over the United States. This rotation is ordinarily spoken of as counter-clockwise; that is to say, a northwest wind

gradually changes to west, and then south-west, south, southeast, etc., as it whirls around the center. But this is not to say that the individual particles of air whirl about the tornado in a circular course. The tornado is *not* a cyclone. It is far more likely that a mass of southerly wind, when lifted up, becomes southeast and then northeast wind as it rises, and rarely describes more than half of its circuit before it has ascended so high that it is carried away by the westerly wind prevailing overhead. While this change of upper path occupies several minutes in description, the spot at the surface of the ground at which the southerly wind had prevailed is immediately occupied by a northwest wind. If all these winds were projected on the ground we should see an appearance of a whirl. One can easily observe something analogous by making little whirls in a basin of water. He will quickly find that a rapidly ascending column, which is also rapidly moving along, leaves behind it, on the bottom of the basin, only a very confused stream of particles, that give no sure basis for arguing backward as to what the motions of the wind were. Therefore the attempts to reconstruct the mechanics of a tornado from the study of the debris have hitherto proved very unsatisfactory. It is far more to be desired that we may have a series of photographs, and that prints of these may be submitted to the meteorologist for careful study before they have been touched up by the photographer for the purpose of producing beautiful and effective pictures.

It will surprise the reader to know that, although there are probably a hundred photographs of tornadoes to be obtained, or at least to be seen, among our collections, yet not one of these has any critical value for meteorological study. Every one "touched" by the artist's hand becomes useless to the student; for the artist, in his ignorance, invariably obscures the very fundamental points that we are interested in. Indeed, many of these photographs have had a conical tornado-cloud boldly but skilfully painted into them. These may make good pictures for the artistic public, but are simply curios for the meteorologist. There is no reason in the world why a photographer should not take a series of good photographs of a tornado at very close range. Owing to the darkness, he needs sensitive plates and a careful time exposure. For the purposes of subsequent measurement and study, he should record the hour, minute, and second

of each exposure; and, for the sake of meteorology, he should make a few prints before in any way retouching the first negatives.

Some beautiful photographs of the famous waterspout off Martha's Vineyard, in 1896, have proved valuable contributions to our knowledge of this phenomenon. The study of a dozen such photographs has been diligently pursued during the last three years. The results will undoubtedly apply, in part at least, to the tornadoes of our Western States, but similar work on a real tornado is greatly to be desired.

The question of protection from the death-dealing tornado is of great importance to us all. We need not dwell long upon the remarkable details; it is sufficient for us to know that when winds and clouds combine to form a tornado, no human device will prevent the storm. Neither high walls around a town (as recommended by one) nor the drawing off of electricity (as recommended by another) can have the least effect upon the tornado itself. The great mass of warm, moist air that is rising to form a cloud, the great evolution of heat within the cloud, and the action of the

sun's heat upon that cloud, represent a display of force beside which ten thousand great steam-engines shrink into insignificance. As Espy long since explained, the power of a tornado is the latent heat of its cloud of steam. There is no mystery as to this fundamental proposition in tornado lore. It would be folly to hold out to our citizens the hope that we may prevent or disperse a tornado. In 1885 Mr. John P. Finley prepared a number of good rules¹ to be followed by one who wishes to protect his life when he sees a tornado approaching. He showed that the south side of the tornado is the most dangerous, the north side is the safest. The observer should flee to the northwest if the cloud is coming from the southwest. His rule is: "Stand facing the advancing cloud when it is already half a mile or a mile away, and if it is moving straight toward you, flee to the right." Take refuge in some very low structure, preferably a cellar, cave, or "dugout." Throw yourself on the ground, and cling to a stake or stump. You may escape or survive, but you cannot prevent or destroy, a tornado.

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THE MISSOURI.

BY CAMERON MANN.

I.

BETWEEN low brinks of ragged clay
The rapid river takes its way.

Its heavy, tawny waters flow
As if their road they did not know;

Swirl off in loops, spread out in lakes,
Whose sandy shoals trail sluggish wakes.

They gnaw away the tumbling banks,
Mow down their leafy willow ranks;

They dwindle, till the dust blows round
Where fishes swam and men were drowned;

Then flood the bottoms miles away,
Fence, barn, and house their scattered prey:

But yet, far back, the hills remain,
Which all their wanderings restrain.

II.

O mighty river, we may see
Our new democracy in thee.

No Rhine art thou, by cliffs beset,
With castles on each parapet;

No Thames, of placid, even tide,
With grass lawns edging either side;

But strong, and turbid, and perplexed,
By frequent whirls and eddies vexed,—

At times an overwhelming fall
Of brute destruction,—yet through all

Large wealth bestowing—grain and woods
Upspringing where once swept thy floods.

And so we know, whate'er thy force,
God's hills will hold thee to his course.