colder."

The following statement is taken from Modern Meteorology, by Dr. Frank Waldo: "Where the addition of heat takes place too rapidly and the gradient exceeds the theoretical value, then the condition of unstable equilibrium ensues for a short time; such being the condition which Reye and others have assigned to tornadoes and thunderstorms."

In Elementary Meteorology, he says: "The principal condition for the formation of a tornado is the local unstable condition of the air, due to the abnormal heating of a mass of air either at the earth's surface or at some locality above it. The mass of air, being warmer than the surrounding air at the same level, is in unstable equilibrium, and when some slight disturbance frees it from its abnormal position it is forced upward by the pressure of the air below and around it." "Heat thunderstorms are the result of the local heating of the lower air, which makes its condition unstable."

The same author, commenting on the great Paris storm of September 10, 1896, says: "We know that when air is compressed it becomes warmer, and when it is expanded it becomes cooler, even though no heat be added or subtracted from the air mass. And the change, called adiabatic change, proceeds according to a regular law. The air pressure, and consequently the air density, decreases with the increase of altitude above the earth's surface, and so when air moves upward it expands and becomes cooler, at the rate of about 1 degree Fahrenheit for each 183 feet of ascent; and likewise it becomes warmer 1 degree for each 183 feet of descent in cases where it moves downward.

"So, then, if the temperature of a mass of air decreases 1° Fahrenheit for each 183 feet of increase in altitude, then the air is said to be in indifferent equilibrium, and any air carried upward or downward in it will remain in its new position, because its adiabatic change of temperature has been just such as to allow the air so moved to accommodate itself to the temperature of the surrounding air in its new position.

"If a mass of air decreases at a rate of less than 1° Fahrenheit for each 183 feet of increase in altitude, then the air is in stable equilibrium, and if any air is forced upward in it, it would gradually become denser than the air at its level and would sink back again to its starting place after the force which had caused it to move upward had ceased to act.

"If the mass of air decreases in temperature at a rate greater than 1° Fahrenheit for 183 feet of increase in altitude, then it is in unstable equilibrium, and if any of the air is started upward or downward it will continue so to move, as it will become lighter than the surrounding air with the upward, and heavier with the downward motion. It is on this condition of unstable equilibrium that most squalls depend for their origin and in great part for their maintenance."

Dr. Buchan, in the "Encyclopaedia Britannica," says: "Whirlwinds occur where for the time the air is unusually calm and moist, and where, consequently, temperature and humidity diminish with height at an abnormaly rapid rate. Whirlwinds and tornadoes have their origin in vertical disturbance of atmospheric equilibrium."

The following extracts are from the writings of Dr. Ferrel, whose theories of cyclones and tornadoes have perhaps met with more general acceptance than those of any other writer. Even Dr. Hann, who advocates a different theory of cyclones, seems to accept his theory of the formation of tornadoes, whirlwinds, and similar smaller disturbances in the air:

"The principal condition of a tornado is the unstable condition of the atmosphere, from which, with any very light disturbance, arises a bursting up of the air of the lower strata of the atmosphere through those above."

"The vertical circulation is the initial stage in the formation of a tornado, and so the tornado can not originate without the condition of unstable equilibrium which gives rise to a vertical circulation."

"In very hot, dry climates, where there is a sandy soil, sand spouts and whirlwinds are of frequent occurrence. The dry air of such climates, especially over a sandy soil, is often in a state of unstable equilibrium from the accumulation of heat on the earth's surface."

"Small waterspouts observed on seas and lakes in clear, calm, and hot weather usually arise from a state of unstable equilibrium in the lower strata of the atmosphere."

Mirage is defined by the Century Dictionary as "An optical illusion, due to the excessive bending of the light rays in traversing adjacent layers of air of widely different densities. * * * The heated earth rarifies the air in the lower strata faster than it can escape, so producing the mirage."

Professor Tait speaks of the mirage of the desert as formed by the refraction in the hot layer of air near the sand.

Deschanel says: "Mirage is explained by the heating and consequent rarefaction of the air in contact with the hot soil. The density within a certain distance of the ground increases upward, and rays traversing this portion are bent upward in accordance with the general rule that the concavity must be turned toward the denser side."

Guyot says: "The mirage is most frequent in arid plains where the soil, exposed to the burning rays of the sun, becomes intensely heated, and in consequence the strata near the ground are less dense than those above."

There thus seems to be abundant authority for the supposition that the air not infrequently exists in the condition of unstable equilibrium. And if the superheating of the lower strata of the air and the consequent unstable equilibrium which ensues is at times sufficient to produce thunderstorms, tornadoes, and mirages, it seems not unreasonable to suppose that a similar condition of unstable equilibrium, less intensified, may be of more frequent occurrence when the results are not so manifest. We are thus confronted with a question of fact about which recorded experiments give us but little information. We have been told so often that heated air will rise that it seems somewhat incredible to suppose that there are circumstances in which it will not do so. Laboratory experiments can have but little value in this connection, as it is next to impossible to reproduce the conditions as they exist in nature, nor have we the instruments for measuring with precision the small differences in temperature which suffice to produce unstable equilibrium within the walls of a laboratory. The following simple experiment, however, appears to indicate that a layer of heated air rises with difficulty from a surface. Let a quantity of tobacco smoke be gently exhaled upon the top of a table; instead of rising, as it would do if free of the table, it will remain a surprisingly long time as a dense layer upon

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