pened and harvest was begun and gardens, pastures, and meadows did very well. The usual June crop of apples occurred, but it was for the most part not excessive, and an average crop was left on the trees.—*Edward A. Evans.*

Washington.—Although the mean temperature of the month was high and the precipitation somewhat above normal, yet both were so badly distributed that the effect on the crops was not so beneficial as it ought otherwise to have been. Burning winds injured wheat during the period from the 6th to the 11th. The first week of the month was cool, with severe frosts on the 3d; the last week was cool and showery, which was beneficial for filling wheat. The prospect is for a short wheat crop. Not much haying done yet.—*G. N. Salisbury.*

West Virginia.—Showery weather, with moderate temperature and ample sunshine, generally favorable for crop growth, except corn, for which the nights were rather too cool. At the close of June wheat and rye harvest were well advanced over the southern section, with fair to good yield; oats were greatly improved and meadows were making good growth, with prospect for better hay crop than expected; gardens and potatoes were doing finely and millet was promising; apples were generally a poor crop, except in some counties in the panhandle section, where they were promising.—*E. C. Vose.*

Wisconsin.—The month was deficient both in warmth and moisture, but mainly favorable for oats, barley, spring and winter wheat, and rye. Corn made very slow growth and at the end of the month was much below the normal condition. On the 11th and 12th a severe frost occurred generally over the State, except in the extreme southern counties and along Lake Michigan, doing considerable damage to winter rye, corn, and small fruits in exposed localities.—*W. M. Wilson.*

Wyoming.—The abundant and well distributed showers during the first two decades of the month were very beneficial to the ranges and meadows, which at the close of the month were generally in excellent condition. The prevailing cool weather during most of the month retarded rapid advancement of grain, gardens, and alfalfa, and those crops at the close of the month were nearly two weeks backward, although usually in good condition.—*W. S. Palmer.*

SPECIAL CONTRIBUTIONS.

"LA LUNE MANGE LES NUAGES." A NOTE ON THE THERMAL RELATIONS OF FLOATING CLOUDS.

By Mr. W. N. SHAW, F. R. S., F. R. Met. Soc.

[Reprinted from Quarterly Journal of the Royal Meteorological Society, 1902, pp. 95-100.]

It is always difficult to be sure that different persons are in agreement in identifying meteorological phenomena, and I will therefore state in a few words the conditions to which, according to my notions, the French proverb refers.

A single layer of drifting fleecy clouds—detached stratus—is rendered visible by the illumination of the moon not very long after sunset. The illumination not only shows the clouds, but shows that they are diminishing, and finally the moon is left in possession of an unusually clear sky. If this is not a correct description of the phenomena to which the proverb refers, it describes a state of things for which I desire to suggest a physical explanation which is not without interest.

I will put the matter in another way: A floating cloud, a finite mass of air carrying water particles, is losing heat by radiating into space through the clear air above it more heat than it receives from the earth beneath; the water globules will, in consequence of this loss of heat, evaporate, and the cloud will vanish. The converse of this proposition may be stated in slightly different form, thus: A floating cloud is receiving heat from the sun above and the earth beneath, and in consequence of this gain of heat condensation will take place, and the cloud become thicker.

These statements are paradoxical, and to exaggerate the apparent paradox it is only necessary to point out that, as the cloud consists of saturated air, evaporation means a rise of temperature, condensation a fall of temperature; for evaporation implies more vapor in the gaseous form, which is only possible at a higher temperature, and vice versa. So we may reduce the proposition from the meteorological form to a more conventionally physical one, and say that the abstraction of heat from a floating mixture of air and water will cause elevation of its temperature, or briefly, will warm the mixture, whereas the addition of heat will cool it.

The explanation of the apparent paradox is a simple one, as may be seen from the following consideration:

Suppose a mass of moist air at the surface of the earth to be warmed; it rises, and in consequence expands adiabatically and cools. Suppose that it rises just sufficiently high to form a cloud; then if it had been less warmed it would not have risen high enough for condensation to take place. If it had been more warmed it would have risen higher, and a cloud might have been formed even denser than in the first case. Supplying less heat before the condensation took place is, of course, equivalent to removing some after the first condensation occurred; one side of the proposition follows therefore at once, if we can assume that the cloud was formed by the adiabatic cooling of rising air. It is, of course, the changes of pressure incidental to differences of level (due to change of density) which produce the paradoxical thermal effects. But although this mode of treating the problem shows well enough that a cloud which is losing heat by radiation into space will grow warmer and disappear, it does not give any satisfactory proof that the cloud would grow thicker if the sun shone upon it.

The course of events for a floating cloud can, however, be very clearly followed out by means of Hertz's diagram of thermal lines for moist air, which is published in Vol. I of the Meteorologische Zeitschrift, and is reproduced in Waldo's Modern Meteorology.[1] The diagram represents the state of a mixture of air and water under varying conditions of pressure and temperature, the lines of reference being set out according to the logarithms of the pressure and of the temperature from absolute zero. Since the pressure scale is logarithmic, equal intervals along it correspond approximately to equal steps of height in the atmosphere. The adiabatic lines for different stadia and the lines of saturation for given percentage composition, enable all the changes in thickness of a cloud under varying quantities of heat to be followed. The diagram is approximate only, but sufficiently nearly accurate to indicate satisfactorily the changes that take place in floating cloud. For this purpose we must add to the diagram a line indicating the relation of temperature and height, or pressure, for the atmosphere in equilibrium, i. e., the line of temperature gradient. This, of course, is a variable line, depending on the condition of the upper atmosphere for the time being; but supposing, for example, the temperature gradient to be uniform and equal to 0.5° C. for every 100 meters (as given by Berson's figures for heights up to 2000 meters), we get a line across the diagram nearly straight, and dropping 1° in temperature for every 200 meters of height, as shown at the base of the diagram. The direction of the line being fixed, its position on the diagram must be defined by drawing it in the proper direction through a selected point representing the condition of a floating cloud. We may take a water cloud just above the freezing point, say at 5° C., at 1200 meters height. Through the point identified by these conditions we can draw the equilibrium line of temperature, and know that whatever be the initial state of a mass of air it will rise or sink, following the changes which Hertz's diagram represents, until the equilibrium line is reached. In fig. 1 certain parts of Hertz's diagram are reproduced and the equilibrium line is added. The point A represents the state of the floating cloud at 5° C. at 1200 meters, saturated with about 6.2 grams of water vapor per kilogram of mixture, as indicated by its position with reference to the saturation lines which are dotted in the figure. QAQ' is the adiabatic line for saturated air. SAS' is the saturation line for 6 grams of moisture per kilogram of mixture; the dotted lines parallel to this on either side represent the saturation lines for 7 grams and 5

[1] The complete memoir is given in Abbe's Mechanics of the Earth's Atmosphere.—ED.

grams, respectively. EAE' represents the equilibrium or temperature gradient line. This line is a little less steep than the adiabatic lines for saturated air, but decidedly more steep than the saturation lines. If we start from the point A on the equilibrium line, representing the condition of the floating cloud, the addition of heat (supposing the cloud always to rise until it recovers its equilibrium) means that the point will travel along the equilibrium line AE to the left; the temperature will fall, since the slope is downward; and, since the equilibrium line is steeper than the saturation line, the point will pass into the part of the diagram where saturation requires less moisture, in other words, condensation will take place. Abstracting heat, on the other hand, means traveling along the equilibrium line in the opposite direction, AE; the air passes into a region where more water is required for saturation. Hence, evaporation takes place. Since the slope of the equilibrium line is upward, the temperature rises.

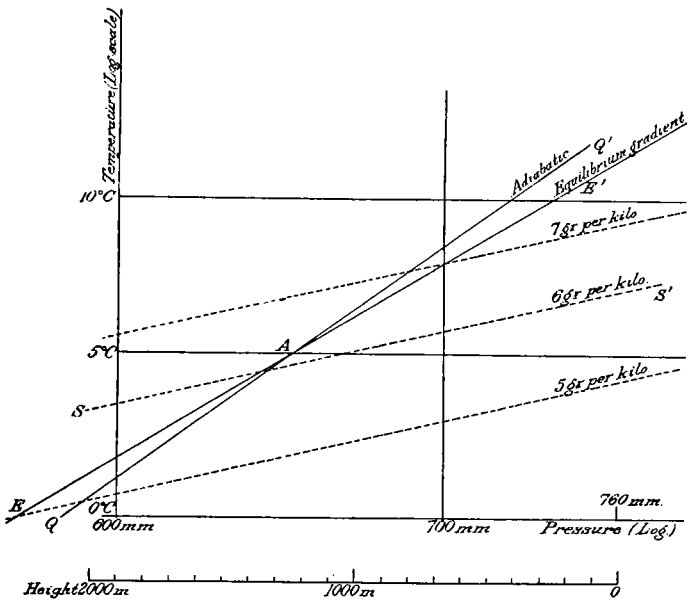

FIG. 1.

It is interesting to note that the result of warming a mass of floating air depends upon the temperature gradient for height of the air in which it floats. If the law of fall of temperature with height were the adiabatic law, a mass of air at the foot warmed ever so little above its surroundings would rise without limit. An inversion of temperature, on the other hand, would at once prevent any rise taking place, or speedily arrest it. A temperature gradient exactly parallel to the saturation line would indicate the conditions under which a cloud might receive or lose heat and change its temperature without any evaporation or condensation taking place.

It thus appears that, except in cases of an "inversion of temperature," or of a zero temperature gradient, meteorologists, in considering the properties of floating masses of air, have to consider that the ordinary relations between the increase of heat and increase of temperature must be reversed.

It is, of course, possible to suggest other physical explanations for the disappearance of clouds in accordance with the French proverb, and my excuse for suggesting one which may seem fanciful, is that it brings into prominence certain physical relations which are certainly real and are not generally noticed.

I ought to add a word with regard to the conveying of heat to a cloud by radiation. I have spoken as though the distribution took place throughout the cloud, and not, as would possibly appear more likely, at the upper or lower surface only. Although the confining of the addition of heat to the outer portions only would not affect the physical principles involved, I may mention a defence of these views that the clouds in question are generally very thin and very translucent, so that every part of the cloud is illuminated by the moon's rays, and consequently is exposed to other sources of radiation.

The extent to which clouds can absorb or emit radiation has not yet been ascertained, but there is no question that they are more effective radiators and absorbers than clear air.

It will be noticed that I have passed over any suggestion that the lunar radiation itself adds heat to the cloud. Possibly it does, but the amount of heat so gained must in any case be small compared with that lost by radiation to the rest of a clear sky, so that any effect of direct radiation from the moon may be quite properly disregarded.

The effect of difference of temperature gradient upon the increase or diminution of density of floating clouds with accession of heat, is one that may have many other applications than the one here referred to. It would seem, for example, to furnish a criterion for determining whether the action of the sun upon mist lying on the ground would result in dispersion of the mist, or the lifting of the mass as a cloud either directly upwards, or possibly creeping along a hillside till the top is reached.

The observations of temperature gradient by the ascent of kites would probably afford facilities for testing by observation the effects which have here been theoretically indicated.

ADDENDUM.

Since the above was written I have put together an arrangement of apparatus whereby the conditions applicable in the case of a floating cloud can be experimentally realized. The essential condition of the arrangement is, that the communication of heat to a limited mass of air shall result in a diminution of the pressure of the air, just as the communication of heat to a floating cloud results in the diminution of pressure as the cloud rises to a higher level. In the apparatus the necessary condition is secured by using a movable cistern of mercury to close the vessel containing the moist air. For this purpose the air is conveniently contained in a globe, G, fig. 2, surmounting a vertical tube open at the bottom. The globe with its vertical tube is fixed in a stand, and the open bottom of the tube dips into the mercury in the cistern C. The mercury cistern rests upon one end of a board, B, about 5 feet long, which is balanced upon a knife edge, E, the mercury and its containing vessel being counterpoised by suitable weights, P, (about 6 pounds) at the other end of the board. The mercury vessel is thus supported by one arm of a rough balance, and,

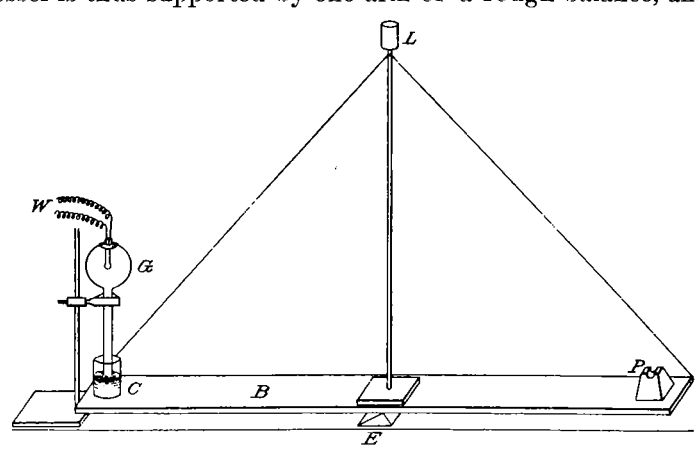

FIG. 2.

since all the weights on the balance are above the point of support, the balance, regarded apart from the effect of the elasticity of the air in the globe, is unstable. The instability is the essential feature of the arrangement, and is largely exaggerated by mounting a heavy mass of lead, L, on an iron

stand attached to the middle of the balancing board, so that the lead is about 5 feet above the board. The globe is provided with tubular apertures, not shown in the figure, to allow it to be filled with saturated and nucleus-laden air at pleasure; but during an experiment these apertures are closed. It is also provided with wires, *W*, led through an india rubber bung, and connected in the interior of the globe by means of a fine platinum wire, to allow heat to be supplied to the air at pleasure by passing an electric current through the fine wire.

When the globe has been filled with suitable air, and the apertures closed, any motion of the board diminishes or increases the pressure in the interior by the motion of the mercury vessel. The increase or diminution of pressure tends to resist the motion of the board, and by adjusting the positions of the counterpoise and the lead weight, the arrangement can be made to balance just within the limits of stability, when the elasticity of the enclosed air is taken into account. When this adjustment is made, it is clear that a slight motion of the board in the direction of increasing the volume of the enclosed air throws over the lead weight toward the same side as the globe, and brings to bear a largely increased moment of forces tending to continue the expansion; so that the ultimate expansion resulting from any cause tending to depress the balance on the globe side produces a rarefaction depending on the degree of dynamical instability of the balance. Such a cause arises when the air in the globe is slightly warmed by passing a current through the wire. If the mercury vessel were fixed, the heating would produce increase of pressure in the closed space, and consequently increase of pressure in the mercury surface supported by the board. As, however, the balanced vessel is movable, the balance comes over, and then the dynamical instability causes expansion, determined not solely by the amount of heat which originated the motion, but by the loads on the balance and their position.

The success of the experiment, for the demonstration of the production of a cloud—i. e. a diminution of temperature—on heating, depends upon the proper selection of the area of the tube in comparison with the volume of the globe. I have found a 4-inch globe with a $1\frac{1}{2}$-inch tube give completely satisfactory results. The counterpoising weights are about seven pounds on each side, and the lead weight with iron stand supporting it, perhaps fifteen pounds. Under these conditions, with the globe filled with saturated air and closed, and the mercury vessel properly counterpoised, the commencement of heating at once determines a depression of the board on the globe side, a rarefaction corresponding to about three-quarters of an inch of mercury and an abundant cloud. The experiment can be repeated with the same air, after readjusting the balance, until the exhaustion of nuclei for the deposit of globules makes the arrangement insensitive. Its activity can always be restored by refilling it with suitable air.

The degree of instability of the balance corresponds to the temperature gradient for height in nature. I have not yet formed an estimate of the temperature gradient to which my arrangement of the apparatus would correspond. But the analogy between the two is formally correct, and with a slight modification of the apparatus the equivalent temperature gradient could be determined. It would be still more strikingly clear to the eye if the globe and tube were attached to the balance and the mercury reservoir fixed. In that case the globe of air would indeed rise with increase of heat, and the arrangement would become simply an apparatus for multiplying the effect of the rise, a rise of 2 inches with my apparatus being equivalent to a rise of about five hundred feet in nature. It thus becomes a comparatively simple means of conducting in the laboratory, operations which really take place on a large scale in nature.

CLIMATOLOGICAL DATA FOR JAMAICA.

Through the kindness of Mr. H. H. Cousins, chemist to the government of Jamaica and now in charge of the meteorological service of that island, we have received the following table in advance of the regular monthly weather report for Jamaica:

Comparative table of rainfall for June, 1903.

Divisions.	Relative area.	Number of stations.	Rainfall.	
			1903.	Average.
	Per cent.		*Inches.*	*Inches.*
Northeastern division	25	24	6.32	9.86
Northern division	22	53	5.16	4.80
West-central division	26	26	8.53	9.08
Southern division	27	36	3.99	5.72
	100	139	6.00	7.36

The rainfall for June was therefore much below the average for the whole island. The heaviest rainfall was 17.93 inches at Brownsville in the west-central division, while 0.48 of an inch fell at Port Royal Naval Hospital in the southern division.

TORNADO AT GAINESVILLE, GA., JUNE 1, 1903.

By Mr. J. B. MARBURY, Section Director, Atlanta, Ga.

On the afternoon of June 1 one of the most destructive tornadoes in the history of Georgia struck the outskirts of the City of Gainesville, in Hall County, about 50 miles northeast of Atlanta. The track of the storm was about 4 miles in length and from 100 to 200 feet in width.

The course taken was from southwest to northeast along the southern outskirts of the city, and was marked by death, destruction, and desolation.

The city proper is situated on an elevated plateau about 1300 feet above sea level, but the section passed over by the tornado runs northeast and southwest around the town, and is over 100 feet lower, forming a miniature valley-like depression with hills on either side. The devastated territory was occupied by several large cotton mills and the homes of employees and the negro element of the city. The fearful death list is due to the crowding together of so many persons employed in the doomed mills. Most of the negroes were away on a large picnic excursion, or the loss of life would doubtless have been doubled.

The weather map for the morning of the 1st presented no abnormal features, certainly nothing heralding any severe storms. Cloudy and unsettled weather covered the major portion of the country, and thunderstorms occurred at numerous points in middle and northern Georgia during the preceding night. The pressure was highest over the Great Lakes with the barometer 30.40 inches at Marquette, Mich. The lowest pressure east of the Rockies was in Missouri where it was but little lower than normal. The temperature was below 70°, except in the southeastern portion of this State.

During the early hours of the day the weather was somewhat erratic, alternating between suushine and light showers with rather oppressive temperature. About noon heavy black clouds were seen forming in the southwest and soon continuous, though at first distant, thunder was heard. At the same time the wind blew briskly from the northeast, increasing in force as the clouds approached. A few moments later regular tornado clouds began forming, first in the southwest, and later in the west and northwest, in which was noticed what seemed to be a violent whirling motion; at the same time clouds were observed rushing in nearly all directions toward the tornadic disturbance. The tornado clouds were of the characteristic greenish hue, increasing in their horrible grandeur as they drew nearer. The clouds so closely resembled smoke that many thought it was smoke from an approaching locomotive; the cloud was approaching along the general direction of the Southern Railway. This appearance preceded by only a few seconds the development of the funnel-shaped cloud which