such masses of air at different temperatures is to mix intimately and irregularly in order to restore the thermal equilibrium as rapidly as possible. The cold air is carried forward in the high levels, and like a sheet overflows the warmer lower layers, as is indicated by the first formation of clouds of the cirrus type, which later change into alto-cumulus and alto-stratus types.

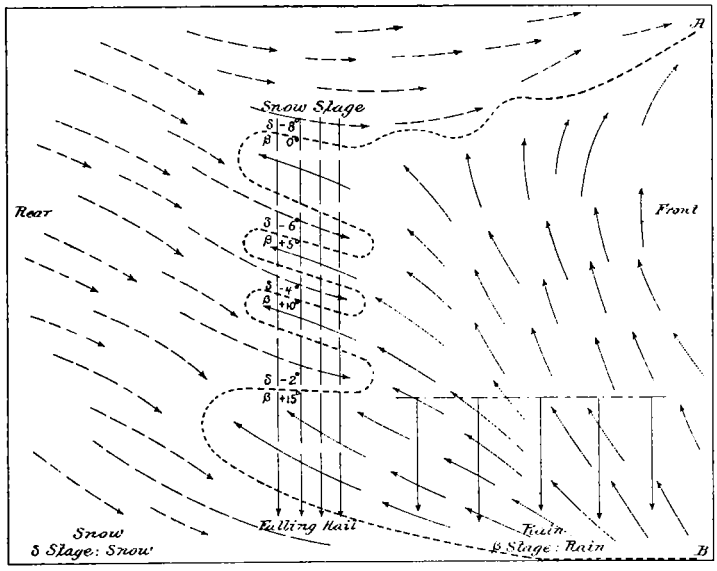

FIG. 40.—Stratification of β- and δ-stage in a cloud with hail.

The body of warm air tends to rise and interpenetrate the cold air in a congested circulation including numerous minor whirls and small vortices. On the western side of the column of rising warm air the tendency to stratification of the warm and cold layers in horizontal directions is very pronounced, the sheets of different temperatures penetrating strongly at a series of intervals in elevation, so that they lie over each other on a given vertical in succession which may be repeated many times. The boundary between the β-stage and the δ-stage, or the course of the γ-stage, is therefore folded upon itself several times in a vertical direction.

For example we may suppose that the temperatures are arranged in some such manner as the following:

Let $\beta = +15°$ C. and $\delta = -2°$ C. in the lowest fold;
let $\beta = +10°$ C. and $\delta = -4°$ C. in the second fold;
let $\beta = +5°$ C. and $\delta = -6°$ C. in the third fold;
let $\beta = +0°$ C. and $\delta = -8°$ C. in the fourth fold;

The temperatures in the β-stage fall off more rapidly than in the δ-stage, and the difference between them diminishes with the height.

The snow nucleus, starting from a great height, meets the water carried aloft in the warm strata, is coated with the drops, which are chilled by its lower temperature and frozen in irregular semicrystaline forms. The vertical current at even moderate velocities is able to carry up all the water contents in the form of drops, and they are injected as it were sideways from a fountain into the higher strata. The snow nucleus is therefore simply exposed to a spray of water drops, brought from the lower strata where high vapor contents prevail, because of the warm air occupying the lower levels before they were disturbed by the overflowing anticyclonic cold. The cold nucleus, therefore, suddenly condenses a layer of clear ice, or ice and snow when mixt by the minor vortices and horizontal rolling of the air. The small hailstone then falls by gravity thru successive stratifications of the snow and rain stages, it grows on the underside by special accumulations there, and finally reaches the ground, having received as many layers as there are distinct horizontal minor stratifications. The undercooling takes place chiefly in the highest stratifications, and ice or snow crystals are found deposited in the inner layers of the hailstone. The under cooling diminishes with the descent so that the outer layers are watery or simply opaque.

There evidently exists a series of small horizontal rolls produced by the dynamic action of the interflowing sheets, where the mixture of air at different temperatures is facilitated by drawing it out into thin ribbons, as in ordinary cyclonic circulations. The lowest cold stratum flows forward on the ground, producing the squall of cold air that precedes the rainfall. An examination of the isotherms and isobars on fig. 39 shows that this distribution of the air currents is the probable one, allowing for the minor configurations on the edges of the mixing masses. The isobars show that at the sea level the air flows forward, but in the upper levels it flows backward at the time of the hailstorm. The isotherms show that there is an excess of upward velocity at the line of separation, and also that the flow is backward in the higher levels. The production of lightning discharges under these conditions, especially in the region where the cloud is serrated as to temperatures, is evidently to be anticipated, in consequence of the rapid changes occurring in the thermal conditions and the water contents. The hailstones may therefore be heavily charged with positive electricity, or even with negative electricity, under these circumstances, and the fallen hailstones may exhibit electrical states by no means uniform from storm to storm.

It is desirable that numerous computations be made on the data that may be obtained from the surface observations in thunderstorms and in hailstorms, with the view of transforming our inferences regarding the thermal operations going on in the midst of such clouds into more definite knowledge. The formulas and the tables employed in this paper are satisfactory, and it is possible to accomplish much by using only our surface observations. It is, however, very important to supplement such studies with the actual observations in the clouds by balloons and kites.

CLIMATOLOGICAL REPORTS FROM THE PHILIPPINES.

The storm warnings, the publications, and other works that issue from the Philippine Weather Bureau show what an intense intellectual activity can be kept up by white men in a climate that is ordinarily supposed to be conducive to sluggishness and degeneracy. We never hear that the officials of the Manila Observatory need to leave their station occasionally in order to renew their mental and bodily vigor. They have been working on at the same rate for forty years past, and the great publications that they have lately issued seem to be due simply to the fact that more money has been put at their disposal for that purpose. The latest volume contains the complete record of two, four, or six observations daily of every ordinary meteorological element, in the year 1903, at forty-four stations, between the latitudes 6° 33′ and 20° 28′ N. and between the longitudes 119° 53′ and 126° 32′ E. All but one of these stations are near sea level, but that one, Baguio, is at 1456 meters elevation. Classified by orders we have: I, 7; II, 10; III, 20; IV, 7. With two exceptions, the observers seem to be Spaniards, and possibly members of the Jesuit order. The publications conform almost exactly to the requirements of the International Meteorological Committee. At the first and second class stations the hours of observation are 2, 6, and 10 a. m., 2, 6, and 10 p. m.; at the third and fourth class stations the hours are 6 a. m. and 2 p. m. At most stations the maximum and minimum temperatures are observed. The barometer readings are reduced to sea level, but the reduction to standard gravity seems to have been omitted, notwithstanding the advice of the International Committee and the general usage