Substituting in (1), we have

$$e''=\frac{Bs(t-t')}{\frac{w'}{w}DL_{t'}}$$

But $e''=e'-e$
where e' is the vapor pressure corresponding to saturation at the temperature t' and e the vapor pressure of the free air, the thing we are trying to evaluate.
Therefore

$$e=e'-\frac{Bs(t-t')}{\frac{w'}{w}DL_{t'}}$$

But as e is only a small fraction of B it follows that s is nearly the same as the specific heat, and w' approximately the equivalent molecular weight, of absolutely dry air and D a number but little greater than unity. We may therefore assume these limiting values for s, w' and D, and obtain the first approximation to the value of e. We then can correspondingly correct s, w' and D and find a closer value of e, and so on as far as we wish to go. Usually, however, the first approximation to the value of e is (theoretically) correct to less than 1 percent.

Therefore, closely enough for most purposes,

$$e=e'-AB(t-t')$$

where A is a numerical constant, of one value when the wet bulb is covered with liquid water and another when the coating is ice.

THE COLD POLE OF SOUTH AMERICA

By JULIO BUSTOS NAVARRETE, Director

[Observatorio del Salto, Santiago, Chile, October 1933]

(Translated by W. W. Reed)

On account of its géographic configuration, being surrounded by great oceans, South America does not offer conditions favorable for the occurrence of intensely cold weather such as is experienced in Siberia and North America. Nevertheless, the investigations made during 14 years by the Observatorio del Salto have shown that in South America, as in other regions, there exists a cold pole, which is well defined and from which there radiate cold waves every winter.

One naturally would suppose that the most intensely cold weather in South America occurs in Magallanes, the most southerly portion of the continent, but this is not the case. The observations made during many years at stations in Chile and Argentina have shown that the most intense cold occurs in a small zone situated in the interior of the continent, the region limited by the stations of Chos Malal, Lonquimay, Las Lajas, and Bariloche.

The occurrences of very low temperatures are always accompanied by mighty invasions of polar air loosed from the Antarctic front. These enormous air masses, indicated on the meteorological charts by anticyclonic systems of high pressure, often enter the continent between latitudes 40° and 50° S., lingering at times in the region of Aysen, Chiloe, and Llanquihue on account of the natural resistance offered to their advance by the cordillera of the Andes.

Under these conditions the anticyclonic centers usually remain for several days or even weeks over southern Chile, bringing generally fine weather with south or southwest winds, which keep the air clear during the long winter nights. Such meteorological conditions are extraordinarily favorable to rapid loss of heat at night by radiation. The land quickly loses its accumulated heat and for several consecutive nights the minimum temperatures in the open fall gradually and progressively. The masses of cold polar air and their calm and transparency during the long winter nights all favor the loss of heat from the earth. The snow is changed into compact ice, which the feeble rays of the sun of the next day are unable to melt. Hence it accumulates, layer upon layer, after each nocturnal freezing brought by an invasion of polar air.

For these reasons there have occurred in the region bounded by Chos Malal, Las Lajas, Lonquimay, and Bariloche minimum temperatures of −32° C. in standard shelters and −40° C. in the open with clear sky. This zone constitutes what is known as the cold pole of South America, and from this region there radiate the cold waves that in severe winters often invade the central valley of Chile and the pampas of Argentina.

As the cold pole in our hemisphere is always situated northeast of the center of high atmospheric pressure, or anticyclone, the diverging waves of icy air spread low temperatures to the remainder of the southern part of the continent. On the meteorological charts of South America it is possible to follow, day by day, the advance of these waves of cold air that moderate little by little until they reach the equatorial regions.

AN AID IN LOCATING AND STUDYING CLOUDS

By IRVING F. HAND

[Weather Bureau, Washington, November 1933]

In studies of solar radiation, it often is essential to know whether the ever-present haze is without form, or owing in part to definite clouds. A Nicol prism mounted at the eye end of a tube (the latter to cut off extraneous light) is not only of great help in locating clouds of indefinite form, but also resolves details of an intricate kind that ordinarily would remain undetected.

The writer recently made a simple instrument of this nature and tested it with the aid of several casual observers. Filters of various colors were tried in the optical train and while theoretically red should give the best results, the consensus of opinion was that the instrument worked better without any filter. In several instances clouds were rendered visible within the area of maximum polarization that could not be seen with the naked eye.

This "cloud finder" has its limitations as shown by the theory of skylight polarization. Generally speaking, maximum polarization occurs in a plane at right angles to the direction of the incident solar rays, but the percentage decreases as we get away from a point 90° from the sun. Thus with the sun on the horizon the maximum polarization occurs in the zenith. At that point it is plane-polarized vertically, while on the horizon at right angles to the sun's direction, that is, to the north or south at the time of the equinoxes, the skylight is plane polarized horizontally. Between the zenith and the horizon it is plane polarized at varying angles, except at two points which range from 15° to 25° above the horizon where the polarization is zero.

Therefore at noon during the summer season, the amount of polarization near the horizon to the west enables one to isolate from the haze incipient thunderheads considerably in advance of their detection with the naked eye. Near the sun, where polarization is slight and the diffused light intense, clouds are better detected with a dense red filter than with a Nicol prism.

In practice one does not *compute* the angle of polarization, but merely adjusts the Nicol by orientation until the sky appears darkest at which point the *plane* of the Nicol is at right angles to the plane of polarization. Through a perfect Nicol a cloud in a sky 100 percent polarized would appear snow-white against a jet-black background. Such contrasts never occur in nature, however, as the percentage of skylight polarization rarely exceeds 80. As even the inconsiderable amount of polarized light from the cloud is chiefly elliptical, the Nicol is of little use as an analyzer of its illumination.

SUPERSATURATION AGAIN

By W. J. HUMPHREYS

[Weather Bureau, Washington, November 1933]

Most of us well may wonder whether the persistent idea that a fourfold supersaturation can and does occur in the air is Truth, for crushed to earth it rises again, or a Hydra which every time its head is cut off sprouts two new ones in its stead. At any rate it keeps bobbing up here, there, and yonder, even in scientific literature—in the offhand explanation of a cloudburst (excessively heavy local rain), perhaps; the boiling of a large cumulus, or cumulo-nimbus, cloud; or some other such meteorological phenomenon which the author has not taken the trouble to understand.

By saturation is meant that degree of humidity, or mass of water vapor per unit volume (vapor density), that is, or would be, in equilibrium with a flat surface of pure water at the same temperature. Supersaturation is any higher degree of humidity, or greater vapor density, than that of saturation. Now from observation, and by experiment, we know that in ordinary air condensation, producing a fog of water droplets, starts when the humidity is in the neighborhood of saturation—more or less short of saturation when the condensation nuclei are particles of sea salt or other hygroscropic substance, and slightly beyond, perhaps, when they are nonhygroscopic. In well-filtered air, on the contrary, condensation does not begin until at least a fourfold supersaturation is attained and then only on such negative ions as may be present. A much greater supersaturation is necessary to cause condensation on positive ions, and a greater still in the case of neutral molecules. Therefore, in order that any considerable degree of supersaturation may occur in the atmosphere it must be freed from all ordinary condensation nuclei.

Our discussion, therefor, may be divided into two distinct parts—(1) a consideration of whether any large volume of the troposphere, or rainy region of the atmosphere, can be freed of condensation nuclei; and (2) what would happen if condensation should occur in a fourfold supersaturated space of considerable size. We need not concern ourselves about providing negative ions—they appear to be always and everywhere in the atmosphere.

Is, then, any considerable volume of the troposphere ever free from condensation nuclei? This much we can say: All the innumerable examinations for such nuclei, under various weather conditions and at many different levels, showed them to be present in great abundance. To be sure we can free a small volume of air from nuclei by filtering it, for example, through a tube filled with raw cotton, glass wool, or other finely divided suitable substance; and by inducing repeated condensations in it by expansions, say in a bell jar containing some water, and allowing the droplets to settle out carrying the nuclei with them. But the free air is not operated on very completely in either of these ways. The nearest approach to exhaustion of these nuclei in the open air presumably occurs in the midst of a large nimbus or cumulo-nimbus cloud. Here the ascending nucleus-laden air is partially filtered as it rises through the cloud, and partially cleaned by progressive condensation. Even if the air within any portion of the cumulus were freed from all nuclei there still would be droplets, or snow crystals, falling through it from its outer shell, as it were, which is in contact with unfreed air, and any considerable supersaturation thus prevented. And, of course, it could not pass out through this wall of dense cloud, every droplet of which is an efficient condensation nucleus, and still remain appreciably supersaturated. Presumably, therefore, marked supersaturation does not occur in the open atmosphere.

However, let us assume that sometimes a considerable volume of the air is cleared of all ordinary condensation nuclei, and that supersaturation has progressed to the fourfold value, at which stage condensation begins on the ever present negative ions. What would happen?

Condensation once begun would progress with great rapidity on the droplets thus formed until the vapor density had fallen to normal saturation. The freed heat of vaporization would increase the temperature of the air, expand it and induce convection, which in turn would cause the condensation of more vapor and further convection to a great but determinate height. Here a little calculation will be helpful, and rough approximations will suffice.

Let, then, the temperature of the air be 25° C., or 298° absolute, and the saturation fourfold, and let condensation start at this stage.

According to humidity tables the initial vapor density would be 91 grams per cubic meter. Density of the air, 1,200 grams per cubic meter, roughly. Specific heat of air at constant pressure, allowing for the water vapor present, 0.25, approximately. Latent heat of vaporization, say 600 calories per gram.

Hence to warm the 1,200 grams of air 1° C. would require 300 calories, which could be supplied by the condensation of 0.5 gram of vapor. But this warming would expand the air and correspondingly increase the volume to be occupied by the vapor.

Let the initial condensation from a fourfold supersaturation to normal saturation, and the consequent heating and expansion, occur at constant pressure, that is, be complete before convection sets in.

Let x° C. be the increase in temperature and y the grams of vapor condensed. Then