temperatures have varied from their respective normals. A similar chart covering the entire period of San Diego records was prepared, this being the only other regular Weather Bureau office in the coastal region of southern California.

Figure 1 shows that the precipitation for Los Angeles has been above normal when the preceding March temperature was above, and below when the March temperature was below, 74 per cent of the time. Figure 2 shows the same conditions 64 per cent of the time for San Diego with a record 27 years longer than that of Los Angeles.

This would tend to indicate that if the March temperature is above normal in the coastal region of southern California the chances would be considerably in favor of precipitation being above normal for the following season, and vice versa.

The temperature of March, 1926, equaled the highest mean for the month of March at the Los Angeles station and exceeded the highest mean for March at the San Diego station. At the close of March, 1927, both these stations had a total rainfall well above the normal for the entire season.

FORMULAE FOR THE VAPOUR PRESSURE OF ICE AND OF WATER BELOW 0 °C.

By F. J. W. WHIPPLE

[Kew Observatory, Richmond, Surrey, England, March 21, 1927]

In the MONTHLY WEATHER REVIEW, October, 1924 (pp. 488–490), Doctor Washburn published a valuable discussion of the vapour pressure of ice and of water below the freezing point. The formulae which he obtained from theoretical considerations are in beautiful agreement with observational data. In deriving his formulae, Doctor Washburn introduced two arbitrary constants, C and D, and evaluated these by reference to the experimental results. It appears, however, that simpler formulae can be written down which do not involve these arbitrary constants and which lead to the same numerical values. The agreement is really a demonstration that, over the range considered, the variation of specific heat with temperature can be ignored. The starting point is the Clausius-Clapeyron equation,

$$\frac{dp}{dT}=\frac{L}{(v-V)\,T},$$

in which p is the vapour pressure,
T is absolute temperature,
L is the latent heat of evaporation,
and $v-V$ is the change of volume on evaporation.

As Doctor Washburn mentions, V, the specific volume of water is negligible in comparison with v the specific volume of vapour.

We assume that the latent heat of evaporation at the centigrade temperature t is

$$L_v-(S_w-S_v)t$$

where L_v is the latent heat of evaporation at 0° C. and Sw and Sv are the specific heats of water and vapour at that temperature, and find (with Hertz) that the formula for vapour pressure over water is

$$\log_{10}\frac{p}{p_0}=\frac{J}{R}\left[\left(\frac{L_v}{T_0}+S_w-S_v\right)\log_{10}e\,\frac{t}{t+T_0}-(S_w-S_v)\log_{10}\frac{T_0+t}{T_0}\right]$$

Here p is the required vapour pressure,
p_0 is the vapour pressure at 0° C.,
J is the mechanical equivalent of heat,
R is the gas constant,
$t+T_0$ is the absolute temperature.

The formula for vapour pressure over ice is of the same type.

Using the numerical values,

$$L_v=597,\ L_F=79.8,\ T_0=273.1$$
$$S_w=1.009,\ S_1,=.5057,\ S_v=.457$$
$$\text{and } R/J=.1103\ \frac{\text{Cal}}{\text{deg. gm.}},$$

we get the following formulae:

(1) For vapour pressure over water

$$\log_{10}\frac{P}{P_0}=10.78\,\frac{t}{273.1+t}-5.01\,\log_{10}\frac{t+273.1}{273.1}$$

(2) For vapour pressure over ice

$$\log_{10}\frac{P}{P_0}=9.95\,\frac{t}{273.1+t}-0.445\,\log_{10}\frac{t+273.1}{273.1}$$

(3) For relative humidity of vapour over ice

$$\log_{10}\frac{r}{100}=4.56\,\log_{10}\frac{t+273.1}{273.1}-0.83\,\frac{t}{273.1+t}$$

I have verified that these formulae agree with Doctor Washburn's tables at −5°C., −10°C., −30°C., and −100°C. There is only a difference of 0.001 mm., which occurs systematically in the vapour over ice table (e. g. he gets 1.241 at −15°C., whereas I get 1.240).

The agreement with the laboratory results is very remarkable. I never appreciated before the wonderful power of the second law of thermodynamics, on which the Clausius-Clapeyron formula is based.