Thermocouple psychrometers infer the water potential of the liquid phase of a soil sample from measurements within the vapor phase in equilibrium with it. The water potential, $\psi$, is related to the relative humidity, $p/p_o$, by

$$\psi = \text{energy/mass} = (RT/M) \ln (p/p_o) \quad [1]$$

where $M$ is the molecular weight of water (0.018 kg mol$^{-1}$), $R$ is the ideal gas constant (8.31 J K$^{-1}$ mol$^{-1}$), $T$ is the Kelvin temperature of the liquid phase, $p$ is the water vapor pressure in equilibrium with the liquid phase, and $p_o$ is the saturated water vapor pressure of the liquid phase. Within the range of water potentials commonly encountered in agricultural soils, $\ln(p/p_o)$ can be approximated by $(p/p_o) - 1$. Therefore the water potential, in J kg$^{-1}$, is

$$\psi \approx 461 \ T (p/p_o - 1). \quad [2]$$

The major difficulty in making this measurement stems from the fact that the relative humidity in the soil gas phase changes only slightly within the growth range of plants. For example, at a water potential of $-1500$ J kg$^{-1}$, a value often associated with the permanent wilting of plants, the relative humidity calculated from the above equation at 25°C, is still about 0.99. Thus, practically all measurements of interest to soil scientists lie in the narrow relative humidity range between 0.99 and 1.00.

The development of an instrument to measure relative humidity in equilibrium with a plant or soil sample within this range began with Spanner (1951). Major developments since then have been primarily