turn, in 9 seconds, establishes a reverse course 2 R distant from the original course. If your bank angle changes, say from 45° to 30°, the turn radius changes by over 50%, so precision maneuvers must be carefully done. Gyro instruments are helpful. The total flight patterns you select will depend on what the variometer and other instruments are showing you. In most cases you will want a straight pass through the thermal so as to learn as much about it as possible — but this is only best if you interpret and utilize the information properly. Sharp turns are most efficiently done at slow speeds.

Another aid for visualizing exactly what is in a thermal is to mark it as you fly through. You can release paper, balloons, bubbles, or smoke. The bubbles and smoke can be released continuously by small special gadgets. The bubbles may be the best method because each bubble remains for a minute or two as a discrete entity, while smoke can quickly diffuse until it is invisible. To help preserve visible smoke, it can be released along the outer trailing edge of the wing where it is rolled up into the tip vortex and protected from diffusing until the tip vortices interact and break up.

Thermal Growth Measurements

If the air within a thermal is much warmer than the surrounding air at the same level, the thermal has buoyancy and will be accelerating, becoming better and better for the soaring pilot. Because water vapor is lighter than air, if the thermal has significantly higher humidity than the surrounding air at that level it will have buoyancy just as though it were warmer, and thus be accelerating (a thermal *is* more humid than the environment, and more so the higher it gets, reaching 100% at cloud base). The drag of the surrounding air slows down the upward acceleration, so the measurement of buoyancy is not a perfect predictor; also all the environment and thermal characteristics should be considered as they vary in height (perhaps in one minute the buoyant bubble will rise to an environment where it is no longer buoyant). Many of these factors are as yet the subject of considerable controversy in convection theory, but from the standpoint of the sailplane pilot one can summarize: a thermal with good buoyancy is likely to stay as strong or get stronger in the next minute or two, while a thermal with little buoyancy or even negative buoyancy is likely to weaken.

To summarize the acceleration due to buoyancy (neglecting drag, which has an unknown effect at the center of a thermal):

$$\text{Acceleration} = g\,[(Ti - To)/To + 0.6\,(Wi - Wo)],$$

where g is the acceleration of gravity, T is absolute temperature, W is the mass ratio of water vapor to air and the subscript "i" and "o" refer to inside and outside the thermal respectively. In a typical case, 1 °C of temperature excess will cause an upward acceleration of about 100 meters per minute velocity change in one minute, and near cloud base the water vapor buoyancy effect may be about as big.

Measuring the buoyancy terms requires measuring Ti, To, Wi and Wo, all at the same height. One can get useful information by measuring only Ti and To because one knows that the moisture buoyancy term is always positive; the humidity inside the thermal is always greater than outside, and the maximum amount can be predicted as a function of height reasonably well from previous knowledge of air mass characteristics and thermal theory. In temperature measurements dynamic heating of the probe should be corrected by means of a vortex housing. The big problem in measuring Ti vs To is that your height changes as you traverse a thermal, and so you encounter temperature changes due to the temperature gradient from adiabatic heating of the atmosphere. What you want is a "potential temperature" thermometer, one corrected for altitude by subtracting about 1 °C per 100 meters. One approximate way to provide this is to have a temperature difference sensor measuring the difference between outside air and air contained in an expandable balloon or envelope. As you ascend the balloon air expands or contracts and cools or heats adiabatically, providing a compensated reference temperature. Because of conductivity heating at the balloon walls, an error will slowly appear, so with this system one would adjust for zero difference just when entering a thermal, and the readings would be valid for perhaps a minute or so later. It is possible that the air capacity for the variometer would suffice as the balloon.