tion of thermal anemometers requires consideration of the effects of temperature, humidity and pressure upon the air properties which influence convective heat transfer.[38] With sensing elements of simple shapes for which convection data are known, thermal anemometers may be designed, both thermally and electrically, for desired characteristics. Directional sensitivity is controllable. Thermal anemometers are convenient and practical for low velocities.

Infiltration or Air Change Measurement

The total air leakage into an existing building caused by wind and temperature difference forces can be determined with considerable accuracy by determining the decrease in concentration of a tracer gas. Hydrogen and helium have both been used rather successfully as tracer gases in conjunction with a sensitive thermal conductivity comparator.[39] About one percent of tracer gas by volume is introduced into the room or building, and the tracer gas is thoroughly mixed with the air. The decrease in concentration of the tracer gas is observed at regular time intervals with a thermal conductivity meter as infiltration dilutes the mixture. The following formula is used to calculate the infiltration from the observed concentration measurements:

$$C = C_o e^{-\frac{kt}{v}} \tag{7}$$

where

C_o = initial tracer gas concentration, percent.
C = concentration of tracer gas after t minutes, percent.
v = volume of room or building, cubic feet.
k = infiltration rate, cubic feet per minute.
e = 2.718, for natural logarithms.

Closets and cupboards should be left open during such infiltration tests so the entire space will have the same rate of change of tracer-gas concentration.

HUMIDITY MEASUREMENT

Psychrometers

Any instrument capable of measuring the humidity or hygrometric state of the air is a hygrometer. A psychrometer is a particular kind of hygrometer which consists of two mercury thermometers, one of which has a cloth wick or *sock* applied to its bulb. For use, the wick is wetted with water and ventilated with air moving at a recommended rate of 900 fpm or more, relative to the instrument.[40] In the simpler and more common type, known as the sling psychrometer, the two thermometers are mounted side by side on a frame fitted with a handle by which the device can be whirled through the air. The motion is arrested for reading the thermometers, and continued until the thermometer readings become steady. Due to evaporation, the wet-bulb thermometer will indicate a lower temperature than the dry-bulb thermometer, and the difference is known as the wet-bulb depression. Charts and tables are available showing the relation between the thermometer readings and the humidity.[19, 41] Data are usually based on a total pressure of one standard atmosphere. For precise work, a correction is necessary for barometric pressure and is usually made by multiplying the observed relative humidity by the ratio of the observed to the standard atmospheric pressure.

For air temperatures below 32 F, the water on the wick may either freeze or super-cool, and its state must be known and a proper table or chart used, since the wet-bulb temperature is different for ice and for water. Some operators remove the wick from the wet-bulb for freezing conditions and dip the bulb in water a few times, allowing the water to freeze on the bulb between dips and to form a film of ice. Since wet-bulb depression is slight at low temperatures, precise temperature readings are essential.

In the ventilated or aspirated psychrometer, the thermometers remain stationary, and a small fan or blower or a syringe is used to move the air across the thermometer bulbs. Various designs have been employed in the laboratories, and several commercial models are available.

The Dew-Point Hygrometer

In the usual form of these instruments, means are provided for cooling, and of observing the temperature of, a surface which is exposed to air. The temperature at which visible condensation occurs on the surface is considered the dew-point of the air. With the dew-point temperature known, the relative humidity and other properties of the air can be taken from tables and charts (See Chapter 3). A bright surface or metallic mirror is usually employed to improve the visibility of the dew deposit, and various means are used to cool the mirror from the back, including evaporating ether or another refrigerant, or a stream of air passed through dry ice. Dew-point temperatures, in some cases, are observed by means of thermometers in fluids in contact with the back of the mirror, but in modern instruments thermocouples are used, and are soldered or welded to the mirror itself. The dew-point apparatus is not so commonly used as the psychrometer, probably because it is less convenient. It is usable, however, for higher temperatures than the wet- and dry-bulb psychrometer, and should be considered for dew-points near or above the boiling point, as in the case of flue gases. Special apparatus for high precision has been constructed, in which the photronic cell and a light source are used for dew or frost detection instead of visual inspection.

Hair Hygrometers

Many materials, especially organic materials, change in dimensions with changes in humidity, and many devices have been designed in efforts to utilize this action in simple and effective humidity indicators, recorders and controllers. Unfortunately, no material has been found which can be relied upon to perfectly reproduce its action when exposed to repeated identical changes in humidity. The field has been well explored, and instrument and control manufacturers are practically unanimous in the selection of human hair for this service.

The hair hygrometer consists of from one to several strands of hair with a mechanism whereby changes in length of the strands, due to changes in humidity, cause an indicator to move across a dial. In the recording instrument, a pen is moved across and marks a moving paper ribbon, indexed in relative humidity. In a controller, or humidistat, the motion makes or breaks an electric contact governing the air conditioning equipment. Such devices require initial calibration and, for precise work, frequent recalibration or setting, especially if they are exposed to extremes of either high or low humidity. For continuous operation, with only slight changes in humidity, some operators report satisfactory reproducibility of results.

Electrolytic Hygrometers

The dampness, and therefore the electrical resistance of a salt film, varies with the humidity of the atmosphere to which the film is exposed, and at