The following equation may be used to make corrections for temperature:

$$h = h_1 [1 - 0.000101 (t_1 - t)] \qquad (1)$$

where

h = height of mercury column corrected to temperature t, inches.
h_1 = actual height of mercury column, inches.
t_1 = actual temperature of mercury column, degrees Fahrenheit.
t = temperature to which column is to be corrected, degrees Fahrenheit.

Atmospheric pressure may also be measured by means of an *aneroid* barometer. In this instrument atmospheric pressure is made to move an indicating pointer either by bending the thin corrugated top of a partially exhausted metallic box, or by distorting a bent, thin-walled metal tube. The aneroid barometer contains no liquids, is portable but is less accurate than the mercurial barometer.

Pressures above or below atmospheric are usually measured by means of gages which indicate the difference between the pressure being measured and atmospheric pressure at the same time and place. A gage which indicates pressures higher than atmospheric is known as a *pressure gage*, and a gage which indicates pressures lower than atmospheric is known as a *vacuum gage*. The most common type of these gages contains a flexible hollow metal tube of oval cross section, known as a *Bourdon tube*. When subjected to unequal inside and outside pressures, this tube tends to straighten out, and a pointer motivated by this straightening indicates the pressure difference on a suitable graduated scale.

High vacuum readings such as are encountered in condenser and steam jet refrigeration practice are commonly obtained by the use of mercury column vacuum gages. When the readings obtained with the mercurial barometer and those with the mercury vacuum gage have both been corrected to 32 F, the difference in the two readings will give the absolute vacuum in inches of mercury. Equation 1 may be used to make corrections for temperature.

In the measurement of small pressure differences, the *U* tube in one of its many forms is convenient, inexpensive and it may be built for any desired degree of accuracy. *U* tube manometers may be fabricated from glass and rubber tubing or any of the numerous commercial forms may be used.

A gage which indicates pressures slightly above or below atmospheric is known as a *draft gage*. It is essentially a *U* tube containing either water, kerosene, alcohol, or mercury, with one leg exposed to the air and the other connected to a point where the pressure is to be determined. When the pressure being read is equal to atmospheric, the level of the liquid in the legs will be the same, indicating a zero gage pressure. When a pressure is applied to one leg, one side will fall and the other will rise an equal amount. The difference in height between the two liquid levels indicates the pressure expressed in inches of liquid used in the gage.

Various forms of high sensitivity draft gages[1] frequently called micromanometers[2] are available for the measurement of small pressure differentials and may be sensitive to pressures as small as 0.001 in. of water. These gages are often useful where measurements are to be made on pressure differentials less than 0.1 in. of water, although their total range may extend as high as 5 to 10 in. of water.

[1]Fluid Velocity and Pressure, by J. R. Pannell (Edward Arnold and Co., London, 1924).
[2]Illinois Micromanometer, University of Illinois (*Engineering Experiment Station Bulletin* No. 120, p. 91).

TEMPERATURE MEASUREMENT

In engineering work, thermometers are largely employed to measure the intensity of heat. Those most commonly used are *liquid-in-glass* thermometers. Mercury and alcohol are the liquids most frequently used.

Mercurial thermometers depend on the uniform expansion of mercury to indicate changes in temperature. An amount of mercury held in a sealed tube with a bulb at one end will rise to one definite level when immersed in melting ice, and to another definite level when immersed in boiling water. These two points are marked, and the space between them is divided into a number of equal portions, each of which is called a degree. In the Fahrenheit scale, there are 180 deg thus obtained, while the centigrade scale has 100 and the Reáumur has 80. Like divisions are marked off on the column above and below these two determined points in order that a greater range of temperature may be read.

Mercurial thermometers may be used in a temperature range from −40 to +932 F.

Alcohol thermometers are similar in construction to mercurial thermometers but are useful in a lower temperature range (−94 to +248 F).

Industrial thermometers in a large number of designs are available, but for test purposes etched stem thermometers are most frequently used. The etched stem thermometer has greater sensitivity and less lag than most industrial thermometers.

For precision temperature measurements, it is necessary to correct the thermometer reading for emergence of the stem if any part of the mercury column is exposed to a temperature other than that being measured (unless the thermometer has been calibrated under like conditions). The emergent stem correction may be calculated by the following equation:

$$K = 0.00009\, D\, (t_1 - t_2). \qquad (2)$$

where

K = correction to be added, degrees Fahrenheit.
D = length of emergent stem, degrees Fahrenheit on thermometer stem.
t_1 = temperature indicated on the thermometer, degrees Fahrenheit.
t_2 = temperature of exposed mercury stem, degrees Fahrenheit.

Thermocouples[3] may be used to measure any range of temperatures up to 2900 F. When two dissimilar metals are joined at two points and a temperature difference exists between these junctions, an electromotive force will be developed. Its magnitude depends on the character of the metals and the difference in temperature between the junctions. A potentiometer or sensitive galvanometer of high resistance connected to the thermocouple will give a deflection which is a function of the temperature difference between the hot and cold junctions. Thermocouples con-

[3]A.S.H.V.E. RESEARCH REPORT No. 943—Study of the Application of Thermocouples to the Measurement of Wall Surface Temperatures, by A. P. Kratz and E. L. Broderick (A.S.H.V.E. TRANSACTIONS, Vol. 39, 1933, p. 55).