most accurate determination. At ordinary atmospheric temperatures the correction is negligibly small, but it usually is important when measuring high temperatures such as those of steam and flue gas. The emergent stem correction may be calculated by the equation:

$$K = 0.00009\ D\ (t_1 - t_2) \qquad (1)$$

where

K = correction to be added, degrees Fahrenheit.
D = number of degrees on the thermometer scale which are not immersed.
t_1 = temperature indicated on the thermometer, degrees Fahrenheit.
t_2 = temperature of the non-immersed mercury column, degrees Fahrenheit.
0.00009 = difference in the coefficient of expansion of the mercury and glass.

Since the bulb has considerable area, radiant energy may affect temperature readings[1]. In measuring room temperatures, care must be taken to locate thermometers away from hot surfaces such as radiators or cold surfaces such as walls or windows. Where this is impracticable, shields should be used to screen the bulb from the radiant energy.

Thermocouple

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 upon the metals used and the temperature difference of the two junctions. Often the cold junction is kept at 32 F by immersion in an ice bath. In other instances, a higher temperature such as that of the atmosphere is used for this junction. By proper selection of metals, any temperature up to 2900 F may be measured. Readings are obtained by means of a potentiometer or sensitive galvanometer which may be calibrated directly in degrees. A potentiometer balances the electromotive force against a known electromotive force with no current flowing, hence this method is independent of length and variations in resistance of leads. Calibration of thermocouples for high temperatures may be made against known melting points of metals. Radiation effects may be minimized by using the smallest size of wires consistent with mechanical strength. The use of small wires also makes the thermocouple sensitive to minute fluctuations in temperature.

Other advantages of thermocouples are: they are readable at remote points; they may be made recording; and an average temperature may be readily obtained by connecting several couples in parallel.

The temperature of a surface is at best difficult to obtain accurately.[2] In most cases the thermocouple is most adaptable for this purpose. In a metal surface, a common method is to peen the couple into a small drilled hole, bearing in mind that the temperature indicated is that existing at the last point of junction in the couple. Other methods involve fastening the couple to the surface with adhesive cellophane, or cementing the couple with litharge in a surface scratch, and grinding it flush with the surface. In any of these methods the leads should be of as fine wire as practicable, since conductance along the leads to the couple may be a source of considerable error.

Resistance thermometers depend for their operation upon the change of resistance of wire with change in temperature. Their use largely parallels

[1]Errors in the Measurement of the Temperature of Flue Gases, by P. Nicholls and W. E. Rice (A.S.H.V.E. TRANSACTIONS, Vol. 35, 1929, p. 473).

[2]Measurement of Surface Temperatures, by F. C. Houghten and H. T. Olson, In Temperature, Its Measurement and Control in Science and Industry (Reinhold Publishing Corp.).

that of thermocouples, although readings tend to be unstable above 950 F. Two-lead temperature elements are not recommended, since they do not permit correction for lead resistance. Three leads to each resistor are necessary to obtain consistent readings.

For measuring high temperatures, such as in furnaces, *pyrometers* are often used. Radiation pyrometers concentrate the radiant energy on a thermopile, and the reading is obtained on a galvanometer or potentiometer. Optical pyrometers match a narrow spectral band, usually red, emitted by the object with that from a standard electric lamp supplied with electric current.

Thermometer Wells

Where temperatures of fluids or gases in vessels or conduits must be read, it is often necessary to resort to thermometer wells. These are especially designed to contain thermometers and thermocouples. Since they separate the temperature sensitive element from the medium to be observed, large errors may result from their improper use.[3] These errors may be due both to poor heat transfer from the wall of the well to the sensitive element, and also to the tendency of heat to travel along the length of the well itself. To improve heat transfer in the case of thermometers, the void should be filled with a liquid of minimum practical viscosity. At the well mouth, the stem should be packed to check evaporation and heat transfer to the atmosphere. To reduce the temperature gradient over the length of the well, the wall of the conduit should be carefully insulated in the area surrounding the observation point.

PRESSURE MEASUREMENT

Barometer

The most accurate barometer for determining the atmospheric pressure is the mercurial type, consisting of a tube over 30 in. long closed at the top and standing in a mercury well. The barometric pressure is expressed as the height of the mercury column above the level of the mercury in the well. Such barometers are equipped with an adjustment to compensate for change in level of mercury in the well. The reading should be taken at the top of the meniscus and is obtained on a vernier scale.

Correction for variation of the density of the mercury column and for expansion of the brass scale, which are usually calibrated for 32 F mercury and 62 F scale temperature, should be made by subtracting from the observed height in inches the value of C determined by Equation 2.

$$C = \frac{h\ (t - 28.630)}{(1.1123\ t - 10978)} \qquad (2)$$

where

C = correction to be subtracted, inches of mercury.
h = observed height, inches of mercury.
t = observed temperature of the barometer, degrees Fahrenheit.

Standard atmospheric pressure at sea level is 29.921 in. Hg. Since normal atmospheric pressure decreases about 0.01 in. Hg for each 10 ft increase in elevation, it is important to make a correction if the elevation of the barometer is not that of the test apparatus. In many cases the barometric reading may be obtained from a nearby weather bureau station. Inquiry should be made as to whether the value is as observed or corrected to sea level.

[3]*A.S.M.E.* Power Test Code, Instruments, and Apparatus, Part 3.