density. Most of these instruments make use of a photo-electric cell or a thermopile to measure the relative amount of light which has not been absorbed. Standard electrical instruments serve for indicating or recording.

MEASUREMENT OF RATE OF HEAT TRANSMISSION

The standard methods of testing built-up wall sections are by means of the *guarded hot-box*[6] and the *guarded hot-plate*[6]. The *Nicholls heat-flow meter*[7] may be used for testing actual walls of buildings.

It would be obviously impossible to determine the air-to-air heat transmission coefficients of every type of wall construction in use with the heat-flow meter, the guarded hot-box or the guarded hot-plate on account of the great amount of time involved. Hence, the method of computing the coefficients from the fundamental constants must be resorted to in most cases. The guarded hot-plate is used to determine the fundamental constants. The heat-flow meter, guarded hot-box and guarded hot-plate tests can be used to good advantage in checking the accuracy of the computed values.

If the hot-box or hot-plate methods are used, tests are usually run under still air conditions, which means there is no wind movement over the surfaces of the wall during the test. In the hot-plate method of test the inside surface coefficient is eliminated by the plate's being in direct contact with the wall. In practice, some wind movement over the exterior surface of the wall should always be allowed for; hence, still-air coefficients cannot be used over the outside of the building during the heating season. Moreover, still-air transmission coefficients cannot be corrected to provide for moving-air conditions by applying a single constant factor. Computed coefficients of transmission for various types of construction are given in Chapter 5.

EUPATHEOSCOPE

The eupatheoscope affords a means of evaluating the combined effect of radiation and convection in a given environment in terms of a standard environment and in some terms related to human comfort. See Chapter 37.

[6]See Standard Code for Heat Transmission through Walls (A.S.H.V.E. TRANSACTIONS, Vol. 34, 1928) and Report of the Committee on Heat Transmission, *National Research Council*.

[7]See Measuring Heat Transmission in Building Structures and a Heat Transmission Meter, by P. Nicholls (A.S.H.V.E. TRANSACTIONS, Vol. 30, 1924).

Chapter 41

PROPERTIES OF AIR, WATER, AND STEAM

Composition of Air, Specific Density, Boyle's Law, Charles' Law, Composition of Water, Density, Water Pressures, Boiling Point, Specific Heat, Sensible and Latent Heat, Saturated Steam, Superheated Steam, Quality, Tables

AIR is a mechanical mixture made up, by volume, of 20.91 per cent of oxygen and 79.09 per cent of nitrogen, or by weight, of 23.15 per cent of oxygen and 76.85 per cent of nitrogen. Air as found in nature always contains other constituents in varying amounts, such as carbon dioxide, ozone, water vapor, dust, and bacteria.

The *specific density* or weight per cubic foot of dry air decreases with an increase in temperature; and the specific volume, or volume per pound, increases with such increase. The *specific heat* of air at constant pressure, or the Btu required to raise the temperature of one pound one degree Fahrenheit, varies from 0.2375 to 0.2430 as determined by various investigators. The value 0.24 is recommended for engineering calculations. It has been found that a given volume of air expands when heated under constant pressure, and again that if the temperature of a given volume of air be kept constant and the pressure increased, contraction takes place. These changes follow definite laws, which apply to other gases as well as air, known as the *laws of perfect gases*. These laws do not generally apply to steam, since it is not a perfect gas, but superheated steam at high temperatures follows the laws approximately. (See Tables 1, 2 and 3).

Example 1. To show the use of table on air weights, Table 3: Given air at 83 F dry-bulb and 68 F wet-bulb (or a depression of 15 deg) with a barometric pressure of 29.40 in. of mercury. What will be the weight of this air in pounds per cubic foot?

Solution. From Table 3 the weight of saturated air at 80 F and 29.00 in. barometer is found to be 0.07034 lb per cubic foot. There is a decrease of 0.00015 lb per degree dry-bulb temperature above 80 F. There is an increase of 0.00025 lb for each 0.1 in. above 29.00 in. From the last column of Table 3 it is found that there is an increase of approximately 0.000035 lb per degree wet-bulb depression when the dry-bulb is 83 F. Tabulating the items:

0.07034	=	weight of saturated air at 80 F and 29.00 bar.
− 0.00045	=	decrement for 3 deg dry-bulb, 3 × 0.00015.
+ 0.00100	=	increment for 0.4 in. bar, 4 × 0.00025.
+ 0.00053	=	increment for 15 deg wet-bulb depression, 15 × 0.000035.
0.07142	=	weight in pounds per cubic foot of air at 83 F dry-bulb, 68 F wet-bulb, 29.40 in. bar.

Boyle's Law refers to the relation between the pressure and volume of a gas, and may be stated as follows: *With temperature constant, the volume of*