PROBLEMS IN PRACTICE

1 ● Determine the amount of sensible and latent heat given off by each person on a dance floor if the dry-bulb temperature is 75 F.

First select from Table 3 an occupation which would seem approximately as strenuous as dancing. Let us assume that the average dancer will have the same metabolic rate as a person walking 3 miles per hour. Then the total heat emission will be 1049 Btu per hour per person. If we assume that conditions in the dance hall are within the comfort zone, then we can locate our point with reference to the curves in Fig. 8. We find that 1049 Btu falls between curves A and B, and slightly closer to B.

Knowing this, the amounts of sensible and latent heat may be determined from Figs. 9 and 10, or the relative amounts may be determined from Fig. 11.

Using Fig. 11, we find that for a 75 F dry-bulb temperature, approximately 61 per cent of the heat will be by evaporation and 39 per cent will be sensible heat.

Latent heat = 1049 × 0.61 = 640 Btu per hour.

Sensible heat = 1049 × 0.39 = 409 Btu per hour.

2 ● What is the purpose and method of conditioning the air of occupied rooms?

Chiefly comfort, and the method is to control the temperature, humidity, and air distribution, and to prevent the accumulation of excessive body odors in the air. Other factors have yet to be studied.

3 ● What are the most comfortable air conditions?

Comfort standards are not absolute, but they are greatly affected by the physical condition of the individual, and the climate, season, age, sex, clothing, and physical activity. For the northeastern climate of the United States, the conditions which meet the requirements of the majority of people consist of temperatures between 68 and 72 F in winter and between 70 and 85 F in summer, the latter depending largely upon the prevailing outdoor temperature. The most desirable relative humidity range seems to be between 30 and 60 per cent.

4 ● Are the optimum conditions for comfort identical with those for health?

There are no absolute criteria of the prolonged effects of various air conditions on health. For the present it can be only inferred that bodily discomfort may be an indication of conditions that may produce poor health.

5 ● Given dry-bulb and wet-bulb temperatures of 75 and 68 F, respectively, first, what is the effective temperature? Second, is this condition warmer or cooler than 80 F dry-bulb and 60 F wet-bulb?

The first condition is given by the intersection of the 75 F dry-bulb line and the 68 F wet-bulb line (Fig. 5). The effective temperature of 72.1 deg is given by the numerical value of the effective temperature line passing through this point and indicated by the scale along the saturation curve. The second condition is given by the intersection of 80 F dry-bulb and 60 F wet-bulb and is 71.8 deg ET. It is therefore 0.3 deg ET cooler than the first condition.

6 ● Given 76 F dry-bulb and 61 F wet-bulb, how many degrees difference are there between this condition and the winter comfort line or 66 deg ET?

The effective temperature for this condition is given by the intersection of the 76-F dry-bulb and 61-F wet-bulb lines and is 70 deg ET, which is 4 deg ET warmer than the comfort line.

7 ● Assume that the design of an air conditioning system for a theater is to be based on an outdoor dry-bulb temperature of 95 F and a wet-bulb temperature of 78 F with an indoor relative humidity of 50 per cent. According to Table 2, the dry-bulb temperature in the auditorium should be 80 F. Estimate the sensible and latent heat given up per person.

The sensible heat given up per person per hour under this condition may be obtained from Fig. 9. With an abscissa value of 80 F, Curve *D* for men seated at rest gives a value

on the ordinate scale of 220 Btu per person per hour as the sensible heat loss. The latent heat given up by a person seated at rest per hour may be obtained from Fig. 10. With an abscissa value of 80 F, Curve *D* indicates a latent heat loss of 175 Btu per hour (left hand scale) or a moisture loss of 1190 grains per hour (right hand scale).

8 ● How much sensible heat, how much latent heat and how much water vapor will be added per hour to the atmosphere of an auditorium by an audience of 1000 adults, when the dry- and wet-bulb temperatures are 75 F and 63.5 F, respectively?

From Curve *D*, Fig. 9, find the sensible heat loss per person for a dry-bulb temperature of 75 F and still air to be 265 Btu per hour. From Fig. 10 find the latent heat loss per person for a dry-bulb temperature of 75 F to be 134 Btu per hour and the moisture added to be 905 grains per hour. Sensible heat = 1000 × 265 = 265,000 Btu. Latent heat = 1000 × 134 = 134,000 Btu. Water vapor added per hour to the air in the auditorium = 1000 × 905 = 905,000 grains or 129 lb.

The sensible and latent heat added to the air may also be found as follows: The effective temperature for dry- and wet-bulb temperatures of 75 F and 63.5 F, respectively, is 70.3 deg. From Curve *D*, Fig. 8, find 403 Btu as the total heat added to the air by a person for an effective temperature of 70.3 deg. From Fig. 11 find the percentage of sensible and latent heat at a dry-bulb temperature of 75 F to be 66.5 per cent and 33.5 per cent. The sensible heat added to the air in the auditorium is 1000 × 0.665 × 403 = 267,995 Btu per hour. The latent heat added is 1000 × 0.335 × 403 = 135,005 Btu per hour.

9 ● If the dry- and wet-bulb temperatures of the auditorium were 85 F and 63 F, respectively, how much heat and moisture would be dissipated to the atmosphere?

From Figs. 9 and 10, respectively, the sensible and latent heat losses per person for a dry-bulb temperature of 85 F are found to be 164 and 225 Btu per hour. The water vapor added to the atmosphere is 1520 grains per hour. The audience will then add 164,000 Btu sensible heat, 225,000 Btu latent heat and 1,520,000 grains or 217 lb of water vapor to the air in the auditorium per hour.

10 ● Neglecting the gain or loss of heat to an auditorium by transmission or infiltration through the walls, windows and doors, how many cubic feet of outside air, with dry- and wet-bulb temperatures of 65 F and 59 F, respectively, (63.1 deg ET) must be supplied per hour to an auditorium containing 1000 people in order that the inside shall not exceed 75 F (dry-bulb) and 65 F (wet-bulb), respectively?

Figs. 9 and 10 give 265 Btu sensible heat and 905 grains of moisture as the additions per person with a dry-bulb temperature of 75 F in the auditorium. Therefore, 265,000 Btu of sensible heat and 905,000 grains of moisture will be added to the air in the auditorium per hour.

Taking 0.24 as the specific heat of air, 2.4 Btu per pound of air will be required to raise the dry-bulb temperature from 65 to 75 F and $\frac{265{,}000}{2.4} = 110{,}400$ lb of air or 110,400 × 13.4 = 1,479,000 cfh of air will be required. This is equivalent to $\frac{1{,}479{,}000}{1000 \times 60} = 24.7$ cfm per person.

The moisture content of the inside air as taken from a psychrometric chart is 76 grains per pound of dry air and that of the outside condition is 65 grains. The increase in moisture content will therefore be 11 grains per pound of dry air. Hence $\frac{905{,}000}{11.0} =$ 82,300 lb of air at the specified condition will be required. This is equivalent to 82,300 × 13.4 = 1,103,000 cfh of air or $\frac{1{,}103{,}000}{1000 \times 60} = 18.4$ cfm of air per person.

The higher volume of 24.7 cfm per person will be required to keep the dry-bulb temperature from rising above the 75 F specified. The wet-bulb temperature will therefore not rise to the maximum of 65 F.