

bulb depression) the rate of evaporation is also for case *two* substantially proportionate to the wet-bulb depression.

In case *two*, the rate of sensible heat transfer, from the air to the liquid to produce evaporation is substantially the same as the rate of heat transfer with the same type of surface, without moisture being present, but with the same temperature differences. In other words, the rate of heat transfer depends upon the temperature difference only, whether the surface is wet or not. For example, it has been shown that the rate of heat transfer with air flowing across staggered coils (transverse flow) may be represented by the formula:

$$U_t = \frac{1}{0.0447 + \frac{50.66}{v}} \quad (8)$$

where

U_t = heat transfer expressed in Btu per hour per square foot per degree difference in temperature between steam and air, for transverse flow.

At a velocity of 400 fpm, $U_t = 5.8$, at a velocity of 800 fpm, $U_t = 9.3$.

Referring to Fig. 3, showing the rate of heat transmission by evaporation for different air velocities, it will be noted that for transverse flow there are 560 Btu per hour per square foot transferred per inch difference of vapor pressure at a velocity of 400 fpm and 910 Btu per hour per square foot per inch difference in vapor pressure at a velocity of 800 fpm. One inch of vapor pressure difference corresponds approximately to 95 deg difference between the wet- and dry-bulb temperature. Dividing by 95, the value of 5.9 Btu per square foot per degree difference in temperature is obtained for a velocity of 400 fpm and 9.55 Btu per square foot for a velocity of 800 fpm.

It will be noted that for these two cases the heat transfer by evaporation per degree difference in temperature corresponds almost exactly with the heat transfer by convection coils. The similarity may be noted by comparing the formula for heat transfer in parallel flow, where

$$U_p = \frac{1}{0.026 + \frac{161}{v}} \quad (9)$$

with the heat transfer by evaporation with parallel flow. The relationship will be seen to be very close in both cases and would indicate that the heat transfer by evaporation is actually brought about by a process of convection.

The difference in form of the two formulae may be due in part to errors in observation at the higher and lower velocities.

In cooling air and condensing out the moisture therefrom the heat transfer is considerably more rapid than when the air is dry and no moisture is condensed. In general the rate of heat transmission on the air side is increased an amount which is proportionate to the latent heat removed as compared with the sensible heat removed. That is, if the latent heat removed was 50 per cent of the sensible heat removed, then the conductivity of the surface in contact with the air would be increased approximately 50 per cent.

Chapter 28

AIR CONDITIONING IN RELATION TO COMFORT AND HEALTH

Changes in Composition and Vitiating of Air; Heat Regulation in Man; Effects of Adverse Air Conditions; Acclimatization and the Psychologic Factor; Relation of Temperature, Humidity and Air Motion to Sensations of Warmth and Comfort; Optimum Air Conditions for Comfort and Health; Application of Comfort Charts to Air Cooling; Recirculation and the Use of Ozone; Ultra-Violet Radiation and Ionization; Heat and Moisture Given Up by Human Body; Air Pollution in Relation to Comfort and Health; Synthetic Air Chart.

FROM the standpoint of comfort and health, air conditioning may be regarded as the art of maintaining the atmosphere of occupied spaces at a condition best suited to the physiological requirements of the human body. According to the present knowledge of the problem, the requirements consist of maintaining simultaneously the proper temperature, humidity and air movement, and a reasonable air purity with regard to dusts, bacteria and odors.

CHANGES IN COMPOSITION AND VITIATION OF AIR

Under the artificial conditions of indoor life, the air undergoes certain chemical changes and a vitiating which are brought about by the occupants themselves. The oxygen content is somewhat reduced, and the carbon dioxide slightly increased by the respiratory processes. Organic matter, which is usually perceived as odors, is given off from the mouth, skin and clothing. The temperature of the air is increased by the metabolic processes, and the humidity raised by the moisture emitted from the skin and lungs. Moreover, according to latest researches¹, there is a marked decrease in both positive and negative ions in the air of occupied rooms.

Contrary to old theories, the usual changes in oxygen and carbon dioxide are of no physiological concern because they are much too small even under the worst conditions. The amount of carbon dioxide in air is often used in ventilation work as an index of odors of human origin, but the information it affords rarely justifies the labor involved in making the observation. Little is known of the identity and physiological effects of the organic matter given off in the process of respiration. The former belief that the discomfort experienced in confined spaces was due to some

¹Changes in Ionic Content in Occupied Rooms Ventilated by Natural and Mechanical Methods, by C. P. Yaglou, L. C. Benjamin and S. P. Choate (Heating, Piping and Air Conditioning, October, 1931).