temperature became apparent only when the prevailing outdoor temperature fell to 66 F, which is below the customary room temperature in the United States for summer and winter.

Young men as a general rule prefer conditions in the cool region of the comfort zone, and women and older people in the warm region of the comfort zone. Crowding the experimental chamber lowered the optimum effective temperature from 70.8 deg when the gross floor area per occupant was 44 sq ft and the air space 380 cu ft, to 69.4 deg when the floor area was reduced to 14 sq ft and the air space to 120 cu ft per occupant.

Example 2. 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?

Solution. The first condition is given by the intersection of the 75 F dry-bulb line and the 68 F wet-bulb line (Fig. 2). 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.

Example 3. Given 76 F dry-bulb and 61 F wet-bulb, how many degrees difference between this condition and the winter comfort line or 66 deg ET?

Solution. 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.

In the comfort zone experiments of the A.S.H.V.E. Research Laboratory, the relative humidity was varied between the limits of 30 and 70 per cent approximately, but the most comfortable range has not been determined. In similar experiments at the Harvard School of Public Health, a relative humidity of 70 per cent was found to be *somewhat humid* in winter, by about half of the subjects who were stripped to the waist, even when the dry-bulb temperature was 70 F or less. In summer, a relative humidity of 30 per cent was pronounced as *a little too dry* by about a third of the subjects wearing warm-weather clothing. So long as the temperature was kept within proper limits, the majority of the subjects were unable to detect sensations of humidity (*i.e.*, too high, too low, or medium) when the relative humidity was between 30 and 60 per cent. This is in accord with studies by Howell[15], Miura[16] and others.

Dry air produces an excessive loss of moisture from the skin and respiratory tract. Owing to the cooling effect of evaporation, higher temperatures are necessary, and this condition leads to discomfort and lassitude. Moist air, on the other hand, interferes with the normal evaporation of moisture from the skin, and again may cause a feeling of oppression and lassitude, especially when the temperature is also high.

Just what the optimum range of humidity is, is a matter of conjecture. There seems to exist a general opinion, supported by some experimental and statistical data, that warm, dry air is less pleasant than air of a moderate humidity, and that it dries up the mucous membranes in such

[15]Humidity and Comfort, by W. H. Howell (*The Science Press*, April, 1931).

[16]Effect of Variation in Relative Humidity upon Skin Temperature and Sense of Comfort, by U. Miura (*American Journal of Hygiene*, Vol. 13, 1931, p. 432).

a way as to increase susceptibility to colds and other respiratory disorders[17, 18, 19].

For the premature infant, a high relative humidity of about 65 per cent is demonstrably beneficial to health and growth[20], and according to Huntington[21], this seems to be the case for adults also. All of these studies indicate that the optimum humidity must always be considered in combination with temperature.

Until more exact information is secured, it would be desirable to restrict the comfort zones to the range of relative humidity employed in the comfort zone experiments, namely, 30 to 70 per cent. Relative humidities below 30 per cent may prove satisfactory from the standpoint of comfort, so long as extremely low humidities are avoided. From the standpoint of health, however, the consensus seems to favor a relative humidity between 40 and 60 per cent. In mild weather such comparatively high relative humidities are entirely feasible, but in cold or sub-freezing weather they are objectionable on account of condensation and frosting on the windows. They may even cause serious damage to certain building materials of the exposed walls by condensation and freezing of the moisture accumulating inside these materials. Unless special precautions are taken to properly insulate the affected surfaces, it will be necessary to reduce the degree of artificial humidification in sub-freezing weather to less than 40 per cent, according to the outdoor temperature. Information on the prevention of condensation on building surfaces is given in Chapter 7. The principles underlying humidity requirements and limitations are discussed more fully elsewhere[22].

The comfort chart (Fig. 2) applies to adults between 20 and 70 years of age living in the northeastern parts of the United States. For prematurely born infants, the optimum temperature varies from 100 F to 75 F, depending upon the stage of development. The optimum relative humidity for these infants is placed at 65 per cent. No data are yet available on the optimum air conditions for full term infants and young children up to school age. Satisfactory air conditions for these age groups are assumed to vary from 75 F to 68 F with natural indoor humidities. For school children, the studies of the *New York State Commission on Ventilation* place the optimum air conditions at 66 F to 68 F temperature with a moderate humidity (not specified) and a moderate but not excessive amount of air movement (not specified)[23].

Satisfactory comfort conditions are found to vary from 40 deg to 70 deg ET, depending upon the rate of work and amount of clothing worn. The

[17]Reactions of the Nasal Cavity and Post-Nasal Space to Chilling of the Body Surface, by Mudd, Stuart, et al (*Journal Experimental Medicine*, 1921, Vol. 34, p. 11).

[18]Reactions of the Nasal Cavity and Post-Nasal Space to Chilling of the Body Surfaces, by A. Goldman, et al and Concurrent Study of Bacteriology of Nose and Throat (*Journal Infectious Diseases*, 1921, Vol. 29, p. 151).

[19]The Etiology of Acute Inflammations of the Nose, Pharynx and Tonsils, by Mudd, Stuart, et al (Am. Otol., Rinol., and Laryngol, 1921).

[20]Application of Air Conditioning to Premature Nurseries in Hospitals, by C. P. Yaglou, Philip Drinker and K. D. Blackfan (A.S.H.V.E. TRANSACTIONS, Vol. 36, 1930).

[21]Weather and Health, by Ellsworth Huntington (*Bulletin* of the National Research Council No. 75, The National Academy of Science, Washington, D. C., 1930).

[22]Humidification for Residences, by A. P. Kratz (*University of Illinois Engineering Experiment Station Bulletin* No. 230, July 28, 1931).

[23]Ventilation, Report of the New York State Commission on Ventilation, 1923.