thermal insulating tissues of women is almost double that of men, although the sensory responses to cold are similar. In the hot zone, the threshold of sweating and skin temperature levels are higher for women.

Finally, the thickness and insulating value of the clothing worn is an important factor in the determination of the comfort level.

EFFECTIVE TEMPERATURE INDEX

Sensations of warmth or cold depend, not only on the temperature of the surrounding air as registered by a dry-bulb thermometer, but also upon the temperature indicated by a wet-bulb thermometer, upon air movement and upon radiation effects. Dry air at a relatively high temperature may feel cooler than air of considerably lower temperature with a high moisture content. Air motion makes any moderate condition feel cooler. Radiation to cold or from warm surfaces is another important factor under certain conditions.

Combinations of temperature, humidity, and air movement which induce the same feeling of warmth are called thermo-equivalent conditions. A series of studies[30] at the A.S.H.V.E. Research Laboratory, Pittsburgh, established the equivalent conditions met with in general air conditioning work. This scale of thermo-equivalent conditions not only indicates the sensation of warmth, but also to a considerable degree determines the physiological *effects* on the body induced by heat or cold. For this reason, it is called the *effective temperature* scale or index, and it denotes sensory heat level.

Effective temperature is an empirically determined index of the degree of warmth perceived on exposure to different combinations of temperature, humidity, and air movement. It was determined by trained subjects who compared the relative warmth of various air conditions in two adjoining conditioned rooms by passing back and forth from one room to the other.

The numerical value of the index for any given air conditions is fixed by the temperature of slowly moving (15 to 25 fpm air movement) saturated air which induces a like sensation of warmth or cold. Thus, any air condition has an effective temperature of 60 deg, when it induces a sensation of warmth like that experienced in slowly moving air at 60 deg saturated with moisture. The *effective temperature index* cannot be measured directly but is determined by the dry- and wet-bulb temperature observations and by reference to the Comfort Chart (see Figs. 6, 8 and 9) or tables. The relation of winter and summer sensations of comfort to wet- and dry-bulb temperature at low air movement is shown in Fig. 6. This chart, published by an A.S.H.V.E. Technical Advisory Committee[31], is based on research prior to 1932. Later studies by the A.S.H.V.E. Research Laboratory indicate somewhat higher temperatures for winter comfort, while Fig. 7 shows some variation in the requirements for comfort in summer cooled and air conditioned space. Relations between moisture content and various dry-bulb temperatures to wet-bulb readings and effective temperatures are depicted in Fig. 8. Effective temperatures

[30] A.S.H.V.E. Research Report No. 673—Determination of the Comfort Zone, by F. C. Houghten and C. P. Yaglou (A.S.H.V.E. Transactions, Vol. 29, 1923, p. 361). A.S.H.V.E. Research Report No. 691—Cooling Effect on Human Beings Produced by Various Air Velocities, by F. C. Houghten and C. P. Yaglou (A.S.H.V.E. Transactions, Vol. 30, 1924, p. 193). A.S.H.V.E. Research Report No. 717—Effective Temperature with Clothing, by C. P. Yaglou and W. E. Miller (A.S.H.V.E. Transactions, Vol. 31, 1925, p. 89). A.S.H.V.E. Research Report No. 755—Effective Temperature for Persons Lightly Clothed and Working in Still Air, by F. C. Houghten, W. W. Teague and W. E. Miller (A.S.H.V.E. Transactions, Vol. 32, 1926, p. 315).

[31] How to Use the Effective Temperature Index and Comfort Charts, by C. P. Yaglou, W. H. Carrier, Dr. E. V. Hill, F. C. Houghten and J. H. Walker (A.S.H.V.E. Transactions, Vol. 38, 1932, p. 410).

for various combinations of wet- and dry-bulb temperatures and air movement are given in Fig. 9.

A long series of studies have been made to determine the optimum effective temperature for comfort of normal persons in both winter and summer air conditioned space, in different geographical regions and for different age groups of men and women. A group of these studies[32] was made between 1935 and 1940 by the A.S.H.V.E. Laboratory in Pittsburgh, and in several metropolitan districts of the United States in cooperation with the managements of offices employing large numbers of workers. Some of the results are shown in Fig. 7. Taking all of these studies together, women of all age groups studied indicate an average effective temperature for comfort 1.1 deg higher than for men. All men and

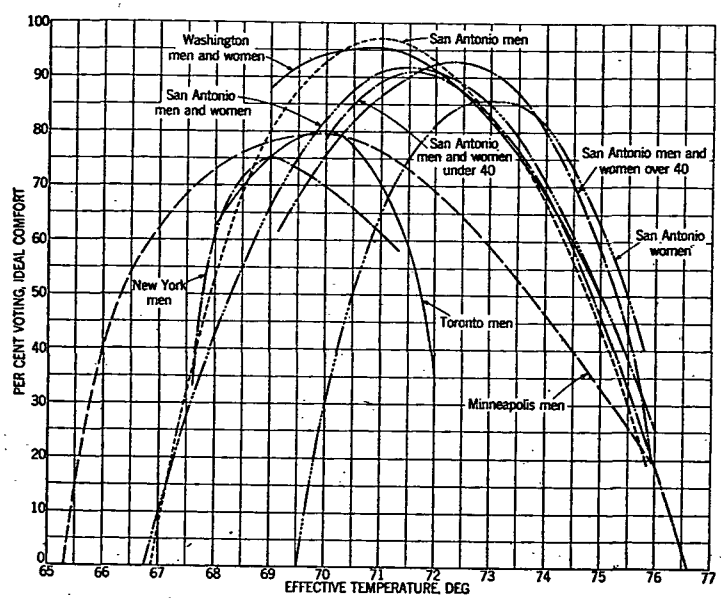

Fig. 7. Relation Between Effective Temperature and Percentage Observations Indicating Comfort

women, beyond the age of 40 years, show an average desire for 0.9 deg ET higher than those below this age; while the men and women, respectively, beyond 40 desired effective temperatures of 0.8 and 1.2 deg higher than those below 40. The persons serving in all of these studies were representative of office workers clothed for air conditioned space in the summer

[32] A.S.H.V.E. Research Report No. 1035—Comfort Standards for Summer Air Conditioning, by F. C. Houghten and Carl Gutberlet (A.S.H.V.E. Transactions, Vol. 42, 1936, p. 215). A.S.H.V.E. Research Report No. 1055—Cooling Requirements for Summer Comfort Air Conditioning, by F. C. Houghten, F. E. Giesecke, C. Tasker and Carl Gutberlet (A.S.H.V.E. Transactions, Vol. 43, 1937, p. 145). A.S.H.V.E. Research Report No. 1088—Summer Cooling Requirements of 275 Workers in an Air Conditioned Office, by A. B. Newton, F. C. Houghten, Carl Gutberlet and R. W. Qualley (A.S.H.V.E. Transactions, Vol. 44, 1938, p. 337). Cooling Requirements for Summer Comfort Air Conditioning in Toronto, by C. Tasker (A.S.H.V.E. Transactions, Vol. 44, 1938, p. 549). A.S.H.V.E. Research Report No. 1127—Reactions of Office Workers to Air Conditioning in South Texas, by A. J. Rummel, F. E. Giesecke, W. H. Badgett and A. T. Moses (A.S.H.V.E. Transactions, Vol. 45, 1939, p. 459). A.S.H.V.E. Research Report No. 1136—Summer Cooling Requirements in Washington, D. C., and Other Metropolitan Districts, by F. C. Houghten, Carl Gutberlet and Albert A. Rosenberg (A.S.H.V.E. Transactions, Vol. 45, 1939, p. 577). A.S.H.V.E. Research Report No. 1160—Reactions of 745 Clerks to Summer Air Conditioning, by W. J. McConnell and M. Spiegelman (A.S.H.V.E. Transactions, Vol. 46, 1940, p. 291).