The adaptive level changes somewhat with the season[27]. There are also marked differences between the sexes. In the cold zone the thickness of the 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 both higher for women.

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

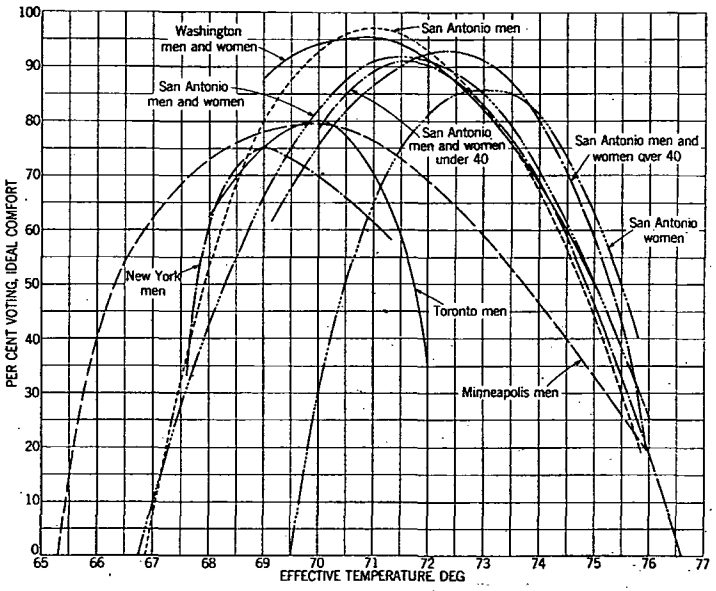

FIG. 7. RELATION BETWEEN EFFECTIVE TEMPERATURE AND PERCENTAGE OBSERVATIONS INDICATING COMFORT

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[28] 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.

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 calm (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 calm 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, 7 and 8) 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[29], is based on research prior to 1932. Later studies by the A.S.H.V.E. Research Laboratory indicates somewhat higher temperatures for winter comfort, while Fig. 7 shows considerable 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 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[30] was

[27]The Reactions of the Clothed Human Body to Variations in Atmospheric Humidity, by C.-E. A. Winslow, L. P. Herrington and A. P. Gagge (*American Journal of Physiology*, Vol. 124, December, 1938, p. 692).

[28]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 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).

[29]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).

[30]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. 1161—Reactions of 745 Clerks to Summer Air Conditioning, by W. J. McConnell and M. Spiegelman (A.S.H.V.E. TRANSACTIONS, Vol. 46, 1940,)