show that this newly-developed scale of thermo-equivalent conditions not only indicates the sensation of warmth, but also determines the physiological *effects* on the body induced by heat and cold. For this reason, it is called the *Effective Temperature* scale or index.

Effective temperature is an index of warmth or cold. *It is not in itself* an index of comfort, as it is often assumed to be, nor are the effective temperature lines necessarily lines of equal comfort. This is true because, in determining this index, the subjects compared not the relative comfort, but rather the relative warmth or cold of various air conditions. Moist air at a comparatively low temperature, and dry air at a higher temperature may each feel as warm as air of an intermediate temperature and humidity, but the *comfort* experienced in the three air conditions would be quite different, although the effective temperature is the same. The intermediate condition may be entirely comfortable, but the other two would not necessarily be so.

Under extreme humidity conditions there seems to be a difference between sensations of absolute comfort and of the proper degree of warmth. In other words, human beings are not necessarily comfortable when the air is neither *too warm* nor *too cold*. Air of proper warmth may, for instance, contain excessive water vapor, and in this way interfere with the normal physiologic loss of moisture from the skin, leading to damp skin and clothing and producing more or less discomfort; or the air may be excessively dry, producing appreciable discomfort to the mucous membrane of the nose and to the skin which dries up and becomes chapped from too rapid loss of moisture. According to the comfort experiments first conducted at the A.S.H.V.E. Laboratory in the U. S. Bureau of Mines, Pittsburgh, and later studies at the Harvard School of Public Health in Boston, effective temperature appears to be a fair index of comfort also, but only within a humidity range of 30 to 60 per cent, approximately.

Definition of Effective Temperature

Briefly, *effective temperature* may be defined as an arbitrary index of the degree of warmth or cold felt by the human body in response to temperature, humidity, and movement of the air. Effective temperature is not a temperature at all; it is a composite index which combines the readings of temperature, humidity and air motion in a single value. The numerical value of the effective temperature index for any given air condition is fixed by the temperature of saturated air which, at a velocity or turbulence of 15 to 25 fpm, induces a sensation of warmth or cold like that of the given condition. Thus, an air condition has an effective temperature of 65 deg when it induces a sensation of warmth like that experienced in practically still air at 65 F saturated with moisture.

In all reports of the A.S.H.V.E. Research Laboratory, the term *still air* signifies the minimum air movement it was possible to obtain in the Laboratory's psychrometric chamber. Actually, the air motion was between 15 and 25 fpm in all experiments, without qualification, as measured by the Kata thermometer. This was not a linear movement of air but it represented the turbulence or eddy currents produced by the air change. Even in tightly sealed rooms, the natural air movement is not

likely to fall below 10 fpm so long as there is a temperature or pressure difference between the air inside and outside the room.

A series of tests has been carried out in the psychrometric rooms of the A.S.H.V.E. Research Laboratory, Pittsburgh, in order to determine the equivalent conditions met with in general air conditioning work. Reports of these studies for both still and moving air are given in A.S.H.V.E. TRANSACTIONS, Vols. 27 to 38, inclusive. Fig. 1 shows the results in a single chart, the so-called thermometric chart. The equivalent conditions or effective temperature lines are shown by the short cross-lines. The difference between the effective temperature for still air and for moving air, of any velocity, represents the cooling resulting from that air velocity.

The thermometric chart (Fig. 1) applies to average normal and healthy persons adapted to American living and working conditions. It is limited to sedentary or light muscular activity, and to rooms heated by the usual American convection methods (warm air, central fan and direct hot water and steam heating systems) in which the difference between the air and wall surface temperatures may not be great. The chart does not apply to rooms heated by radiant methods such as the British panel system, open coal fires, and the like. It will probably not apply with adequate accuracy to races other than the white or perhaps to inhabitants of other countries where the living conditions, climate, heating methods, and clothing are materially different from those of the subjects employed in experiments at the A.S.H.V.E. Research Laboratory at Pittsburgh.

The effective temperature index for persons doing medium or heavy muscular work, in still air, has also been determined at the A.S.H.V.E. Research Laboratory[10].

Example 1. Given dry-bulb and wet-bulb temperatures of 76 F and 62 F, respectively, and an air velocity of 100 fpm, determine: (1) effective temperature of the condition; (2) effective temperature with still air; (3) cooling produced by the movement of the air; (4) velocity necessary to reduce the condition to 66 deg effective temperature.

Solution. (1) In Fig. 1 draw line *AB* through given dry- and wet-bulb temperatures. Its intersection with the 100-ft velocity curve gives 69 deg for the effective temperature of the condition. (2) Follow line *AB* to the right to its intersection with the 20-fpm velocity line, and read 70.4 deg for the effective temperature for this velocity or so-called still air. (3) The cooling produced by the movement of the air is 70.4 − 69 = 1.4 deg effective temperature. (4) Follow line *AB* to the left until it crosses the 66 deg effective temperature line. Interpolate velocity value of 340 fpm, to which the movement of the air must be increased for maximum comfort.

OPTIMUM AIR CONDITIONS

No single comfort standard can be laid down which would meet every need. There is an inherent individual variation in the sensation of warmth or comfort felt by persons when exposed to an identical atmospheric condition. The state of health, age, sex, clothing, activity, and the degree of acquired adaptation seem to be the important factors affecting the comfort standards.

Since the prolonged effects of temperature, humidity and air movement on health are not known to the same extent as their effects on com-

[10]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).