any given instance must be determined by the air conditioning engineer after a study of conditions. In some hot industries where few workers are engaged in large spaces the worker himself, rather than the atmosphere, can be cooled by placing him in a small booth, and blowing cooled air over him, or by circulating cooled air through a loose-fitting suit [17].

The A.S.H.V.E. Laboratory has studied the effects of walls of higher temperature than the air [14]. The findings are in part shown in Fig. 4. Mean radiant temperatures up to 40 deg above the dry-bulb did not influence physiologic processes much. For example, at 84 deg ET and 40 deg elevation in MRT, 1 deg ET change was equivalent to a 4 deg rise in MRT. Similarly, at a constant ET of 90 deg and with MRT elevations of 0 and 40 deg, 1 deg increase in ET was equivalent to 7.5 deg and 11 deg rise in MRT respectively. Under ordinary *still air* conditions the effects of air temperature and MRT appear to be interdependent. Various authorities give 0.3 to 1 deg increase of room temperature to compensate for 1 deg depression of the MRT.

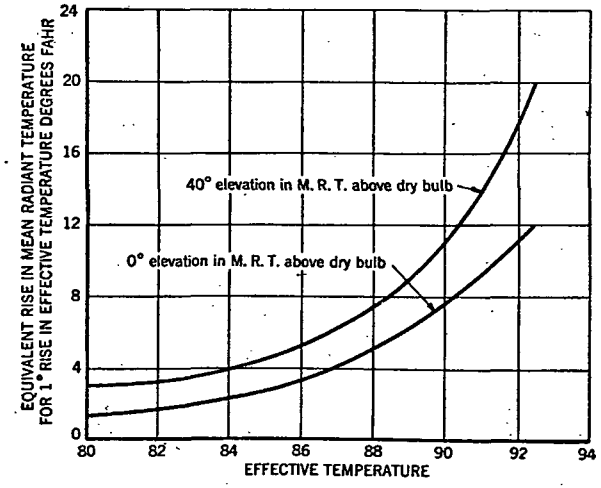

FIG. 4. EVALUATION OF EFFECT OF MRT ELEVATION IN TERMS OF EFFECTIVE TEMPERATURE

APPLICATION OF PHYSIOLOGIC PRINCIPLES TO AIR CONDITIONING PROBLEMS

In order to estimate cooling loads in occupied spaces it is necessary to know the metabolic rate (heat production) of man. This has been studied extensively and found to remain relatively constant per unit of body surface area in a subject fasting and resting quietly after a good night's sleep. The rate is high in children, and diminishes gradually with age; it increases in certain diseases and in the presence of fever. The metabolic rate is somewhat lower in women. Heat production goes up sharply with work and varies widely in different persons doing the same work. Table 4 and Figs. 5, 6, and 7 give sufficient basic data for estimating heat production and heat loss under various conditions.

EFFECTIVE TEMPERATURE INDEX AND COMFORT ZONES

There is no precise physiologic observation by which comfort can be evaluated. Mean skin temperature offers some promise. The zone of thermal neutrality differs with clothing, season, activity, and all the other factors controlling heat production (Table 5). The comfort zone is very similar to the zone of thermal neutrality.

Sensations of warmth or cold depend, not only on the temperature of the surrounding air as registered by a dry-bulb thermometer, but also

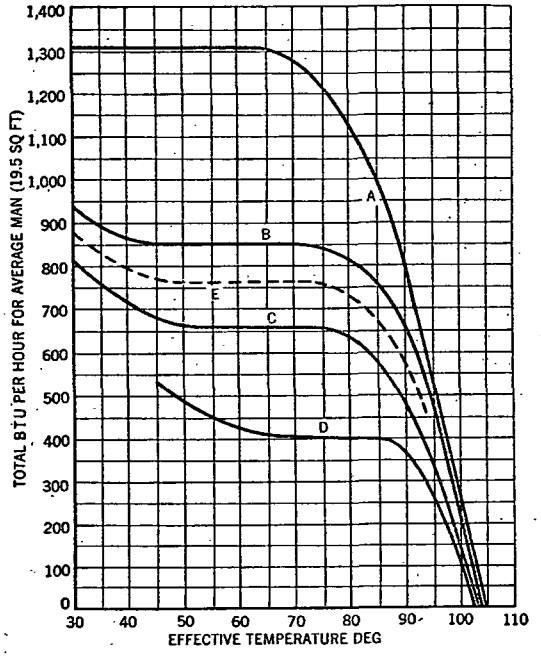

FIG. 5. RELATION BETWEEN TOTAL HEAT LOSS FROM THE HUMAN BODY AND EFFECTIVE TEMPERATURE FOR STILL AIR[a] [10]

[a]Curve *A*—Persons working, metabolic rate 1310 Btu per hour. Curve *B*—Persons working, metabolic rate 850 Btu per hour. Curve *C*—Persons working, metabolic rate 660 Btu per hour. Curve *D*—Persons seated at rest, metabolic rate of 400 Btu per hour. Curves *B* and *D* based on test data covering a wide temperature range. Curves *A* and *C* based on test data at an Effective Temperature of 70 deg and extrapolation of Curves *B* and *D*. All curves are averages of values for high and low relative humidities; variation due to humidity is small.

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 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 [18] at the A.S.H.V.E. Research Laboratory established the equivalent conditions for practical use. This scale of thermo-