and air motion are most important. With dry-bulb temperature above body temperature, air motion facilitates evaporative heat loss by removing hot humid air from contact with the skin and replacing it with relatively drier air.

Heat regulation in man requires an intact set of sensory nerves, a normal sympathetic nerve supply to sweat glands and blood vessels, a great many sweat glands, and a circulatory system capable of carrying heat from muscles and viscera to the skin by circulation of the blood.

Some of the phenomena of body temperature control are shown graphically in Fig. 2. The dotted curves, from a study at the John B. Pierce Laboratory of Hygiene,[10] are for subjects lightly clothed in a semi-reclining position, and give the relation between the dry-bulb temperature of the environment (with about 45 percent relative humidity) and the metabolic

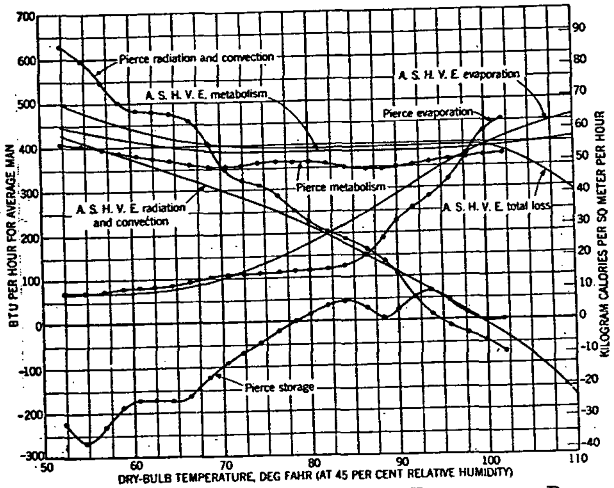

FIG. 2. RELATION BETWEEN METABOLISM, STORAGE, EVAPORATION, RADIATION PLUS CONVECTION, AND TEMPERATURE FOR THE CLOTHED SUBJECT

rate (heat production), the rate of heat dissipation by radiation and convection combined, and the latent heat loss due to evaporation from the skin and the respiratory tract. The smooth line curves from the work of the A.S.H.V.E. Research Laboratory[11] give the same relationships for healthy, male subjects (18 to 24 years of age), seated at rest and dressed in customary winter indoor clothing. The Pierce Laboratory data for the semi-reclining subjects also include the rate of heat storage (either positive or negative) due to a rise or fall in body temperature. For the normally clothed subjects, a curve gives the total heat loss (that is, the sum of the radiation, convection and evaporative losses). Here, storage is given by the difference between the metabolism and total heat loss.

The small difference between the metabolic rates for the two groups of subjects may be accounted for by difference in activity. Heat exchange between the body and the environment by radiation and convection is greater for the lightly clothed subject, both for cool conditions where there is excessive heat loss, and for very warm conditions where there is transfer of heat from the atmosphere to the body. The two curves for

evaporative loss serve to show how physiological control uses evaporation of sweat to maintain equilibrium at high temperatures. Below 75 F, for the normally clothed subject, and below 85 F for the lightly clothed subject, evaporation loss is minimal and constant. Burch[12] has shown that this insensible perspiration reflects the permeability of the skin to the moisture of the body. Above these temperatures, control is obtained by the availability of sweat for evaporation. The difference in the curves above 75 F is probably largely determined by the difference in clothing and activity.

In the zone of evaporative heat regulation, air movement facilitates heat loss if the temperature of the air is not above that of the skin.[13] Under hot, dry conditions air movement may be of little advantage, or even of disadvantage, if it increases the addition of heat to the skin by conduction more than it promotes the loss of heat from the skin by evaporation.

TABLE 2. PHYSIOLOGICAL RESPONSES TO HEAT OF MEN AT REST AND AT WORK[a]

Effective Temp	Actual Cheek Temp (Fahr Deg)	Men at Rest			Men at Work 90,000 ft-lb of Work per Hour			
		Rise in Rectal Temp (Fahr Deg per Hr)	Increase in Pulse Rate (Beats per Min per Hr)	Approximate Loss in Body Weight by Perspiration (Lb per Hr)	Total Work Accomplished (Ft-Lb)	Rise in Body Temp (Fahr Deg per Hr)	Increase in Pulse Rate (Beats per Min per Hr)	Approximate Loss in Body Wt by Perspiration (Lb per Hr)
60	......	......	......	....	225,000	0.0	6	0.5
70	......	0.0	0	0.2	225,000	0.1	7	0.6
80	96.1	0.0	0	0.3	209,000	0.3	11	0.8
85	96.6	0.1	1	0.4	190,000	0.6	17	1.1
90	97.0	0.3	4	0.5	153,000	1.2	31	1.5
95	97.6	0.9	15	0.9	102,000	2.3	61	2.0
100	99.6	2.2	40	1.7	67,000	4.0[b]	103[b]	2.7[b]
105	104.7	4.0	83	2.7	49,000	6.0[b]	158[b]	3.5[b]
110	....	5.9[b]	137[b]	4.0[b]	37,000	8.5[b]	237[b]	4.4[b]

[a] Data by A.S.H.V.E. Research Laboratory.
[b] Computed value from exposures lasting less than one hour.

HIGH TEMPERATURE HAZARDS

Studies at the A.S.H.V.E. Research Laboratory[14] and elsewhere during the past two decades have made available much information dealing with the physiological effects of hot atmospheres on workers, and means of alleviating the distress and hazards associated therewith. Table 2 gives some of the physiological responses of men, at rest and at work, to hot environments. Frequent and continued exposure of workers to hot environments results in physiological derangement affecting the leucocyte count of the blood, and other factors dealing with man's mechanism of defense against infection.

Wherever S (Equation 1) becomes strongly positive and body temperature rises progressively, men will continue to work until body temperature reaches 103 F. When these body temperatures are exceeded, men work with declining efficiency and may be subject to heat stroke.

Heat exhaustion is a circulatory failure in which the venous return to the heart is reduced so that fainting results.[15] Early symptoms of heat exhaustion may include fatigue, headache, dizziness when erect, loss of appetite, nausea, abdominal distress, vomiting, shortness of breath, flushing of face and neck, pulse rate above 150, glazed eyes, and mental dis-