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

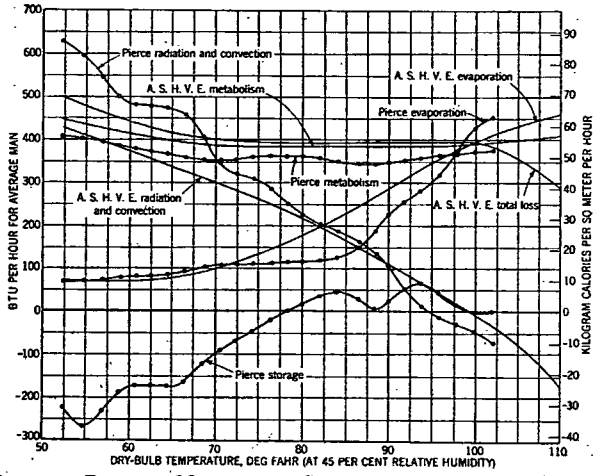

FIG. 2. RELATION BETWEEN METABOLISM, STORAGE, EVAPORATION, RADIATION PLUS CONVECTION, AND TEMPERATURE FOR THE CLOTHED SUBJECT

evaporative loss serve to show how physiological control uses evaporation of perspiration 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 perspiration 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 regulation air movement facilitates evaporation until the dry-bulb is above body temperature and convection and radiation heat gains interfere with heat regulation. Nelson et al[13] report much help from wind in enduring wet-bulb temperature of 88 to 91 F. The initial manifestation of failure of heat regulation is a rise in body temperature. Work is rarely possible with rectal temperatures over 102 F. Survival time is limited when the accelerated metabolic rate raises body temperature to 105 F.

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 101 to 103 F. When these body temperatures are exceeded men work with declining efficiency and are liable to heat exhaustion, heat cramps, or heat stroke.

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.

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, fever well above 102 F, glazed eyes, and mental disturbances as apathy, poor judgment, and irritability which usually precede fainting (syncope). Recovery is usually prompt when the man is removed to a cool place and kept lying down for a time, unless he has some other illness such as heart disease.

Heat cramps are painful muscle spasms in extremities, back and abdomen due, at least in part, to excessive loss of salt in sweating. Formerly common in hot industries, this manifestation of illness due to heat is now greatly reduced by drinking water containing 0.1 per cent salt, or by proper use of salt tablets. Heat cramps are readily alleviated by administration of salt solution intravenously.

Heat stroke or sun stroke is a serious effect of exposure to great heat. The body temperature climbs rapidly to excessive levels often above 105 F