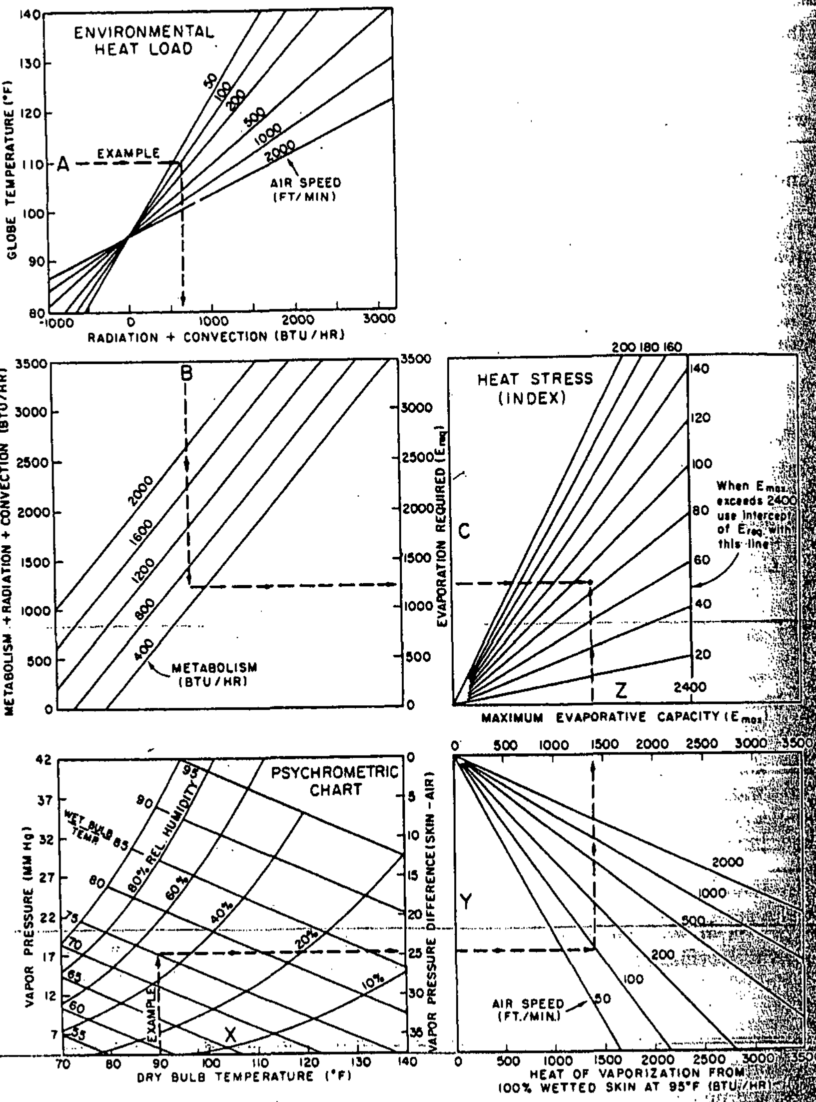

Figure 3. Flow charts for determining heat stress with example showing method of use. (After Belding and Hatch.[12])

(Explanation on facing page)

assumption of direct relationships of sufficient simplicity to cover practical situations adequately. It is therefore of interest to examine the proposed limit lines that purport to combine the several factors into a single index to determine the physical basis, if any, in their apparent physiological equivalence.

Haldane's original proposal to use the wet-bulb temperature as a single thermo-physiological index was based more upon physical reasoning than physiological consideration. The completely wetted surface of man, according to this reasoning, should assume a temperature directly related to the wet-bulb temperature of the air. The latter bears a direct relation to the dry-bulb and dew-point temperatures of the air such that the rate of heat flow into the thermometer bulb by convection and radiation just equals the rate of heat loss by evaporation from the wet bulb. For the ordinary thermometer with a $^1/_4$-inch bulb, the convection coefficient is given by: $K_c = 0.5\sqrt{V}$. The radiation coefficient (independent of bulb size) has a value of $K_r = \pm 1.0$ for temperatures around body temperature. Since the psychrometer is whirled at considerable velocity, K_c is many times greater than K_r, which can therefore be neglected. Consequently, the slope of the wet-bulb temperature line on the psychrometric chart is:

$$\frac{\Delta \mathrm{VP}_a}{\Delta t} = -\frac{K_c}{K_e} = -0.27 \text{ mm. Hg/° F.}$$

The convection coefficient of a cylindrical body varies (approximately) inversely with the square root of the diameter. For man, therefore, K_c is much smaller than for the thermometer and for a nude man has been shown experimentally to be: $K_c = 0.11\sqrt{V}$. For $V = 1000$ f.p.m., $K_c = 3.5$, which is not much greater than $K_r = 1.0$ and, hence, the latter cannot be neglected in considering the balance between heat input, $C + R$, and heat loss, E. With lower velocities K_c is even closer to K_r, and in still air it is actually smaller. In practical terms, this means that the line of thermal equivalence in man will have a steeper slope on the psychrometric chart than does the wet-bulb temperature line.

Using the coefficients of heat exchange given above and assuming an air velocity of 400 f.p.m., the line of thermal balance has a slope of −0.66 compared with −0.27 for the wet-bulb line. Eichna's lines of physiological equivalence have a slope of −0.44, which falls between the slopes of wet-bulb line and calculated

Procedure: *Enter A*; dropping vertical line from intercept of globe temperature with air speed; this gives combined heat loads of radiation and convection. Extend vertical line to *enter B*. At intercept with metabolism, draw horizontal line; obtain total heat load in terms of evaporation required for heat balance ($E_{req.}$). Extend horizontal line to *enter C*. *Enter X*. Draw horizontal line from intercept of dry- and wet-bulb temperature; obtain vapor pressure gradient between saturated skin at 95° F. and ambient air. Extend horizontal line to *enter Y*. At intercept with air speed draw vertical line; obtain maximum evaporation from wet skin at 95° F. ($E_{max.}$). Extend vertical line to *enter Z*. Proceed to intercept with horizontal line from C. (If $E_{max.}$ exceeds 2400, enter Z at 2400). *Read heat stress index value.*

Example: Globe 110, dry-bulb 90, wet-bulb 75, air speed 100, metabolism 600 (light arm work standing at bench). For solution follow broken lines: Heat stress = 90.