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LETTER TO THE EDITORS

COMMENTS ON PRATT'S TRANSIENT COOLING SOLUTION

IN 1963 Pratt and Ball [1] published a solution providing the temperature variation in a building following a step change in the outside air temperature. The model they considered consisted of six elements:

(a) an outside film transmittance between a wall and ambient air temperature;
(b) a homogeneous wall providing thermal resistance and thermal capacity;
(c) an inside film transmittance between this wall and the inside air;
(d) a film transmittance h_s between the inside air and the internal walls;
(e) internal walls having thermal capacity but no resistance; and
(f) a ventilation exchange between the inside and ambient air temperatures.

The solution, though too complicated for practical design use by architects and service engineers, enables a quantitative assessment to be made of the main factors upon which the thermal stability of a room depends. The authors gave a number of useful illustrations of the solution to buildings with heavy and light outer walls, with and without internal thermal capacity and with and without loss of heat by ventilation. The solution is reproduced and extended in Pratt's recent book [2].

We believe however, that the analysis contains some errors and attention is drawn to them in this letter.

In ref. [1], equation (19) reads

$$\phi(p) = [V(Cp+B_s)(B_i+B_o)+CpB_s(B_i+B_o) + B_iB_o(Cp+B_s)]\cosh\sqrt{(p)}+[(Cp+B_s) + B_sCp+CB_iB_oB_s]\sqrt{(p)}\sinh\sqrt{(p)} + V(Cp+B_s)(p-B_iB_o)(\sinh\sqrt{p})/\sqrt{p}. \quad (19)$$

On checking through the analyses leading to this equation, we find it requires the insertion of a term B_i and the alteration of a sign so as to give the amended equation

$$\phi(p) = [V(Cp+B_s)(B_i+B_o)+CpB_s(B_i+B_o) + B_iB_o(Cp+B_s)]\cosh\sqrt{(p)}+[(Cp+B_s)B_i + B_sCp+CB_iB_oB_s]\sqrt{(p)}\sinh\sqrt{(p)} + V(Cp+B_s)(p+B_iB_o)(\sinh\sqrt{p})/\sqrt{p}. \quad (19)$$

[In the book, the factor $\sqrt{(p)}\sinh\sqrt{(p)}$ appears without the term $\sqrt{(p)}$.] Equation (23) in ref. [1] and equation (1.23) in ref. [2] give an expression for the variation in room temperature. Equation (1.23) contains the term

$$T = V\left\{\frac{B_s\theta_o\,e^{-\beta\tau}}{(B_i+B_s+V)(B_i+V)} + B_iB_oB_s^3\theta_o \times \frac{[(B_i/B_o)\cos\sqrt{\beta}+(B_i/\sqrt{\beta})\sin\sqrt{\beta}]\,e^{-\beta\tau}}{[\phi(p)]_{p=-\beta}(B_i+B_s+V)^2(B_i+V)}\right\}.$$

In the version of this term as given in the original paper, the second component differs from that in the book by the factor $B_s/(B_i+B_s+V)$. A check on the derivation of the expression suggests that the book version is correct.

However, if the value for $\phi(p)$ as amended is inserted into the book expression for T, T becomes identically zero. This has the important consequence that the time dependence of air temperature in the enclosure is to be expressed solely in terms of the eigenvalues which appear as a consequence of the boundary conditions to which the wall is subjected; this dependence is expressed by the time-dependent factor $\exp(-\alpha_n^2\tau)$ in equation (1.23). There should be no dependence separately on the factor $\exp(-\beta\tau)$, and the term T is superfluous.

Later in the book [2, p. 138], the author provides simpler expressions for air temperature and $\phi(p)$ [equations (2.2) and (2.3)]. These forms follow from the assumption that the internal storage and the internal air have the same temperature (so that h_s is taken as infinite). Equation (2.3) for $\phi(p)$ is consistent with the amended form of equation (19). If it is inserted in equation (2.2) immediately above it, again the term in $e^{-\beta\tau}$ becomes identically zero.

The author evaluates the coefficient of $e^{-\beta\tau}$ [2, p. 147] and notes that it is small enough to be neglected.

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2. A. W. Pratt, *Heat Transmission in Buildings*. Wiley, Chichester (1981).