

*Divertissement 2*  
**From Thermodynamics**  
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**Why do we have winter heating?**

The layman will answer: "To make the room warmer." The student of thermodynamics will perhaps so express it: "To import the lacking (inner, thermal) energy." If so, then the layman's answer is right, the scientist's is wrong.

We suppose, to correspond to the actual state of affairs, that the pressure of the air in the room always equals that of the external air. In the usual notation, the (inner, thermal) energy is, per unit mass,\*

$$u = c_v T.$$

(An additive constant may be neglected.) Then the energy content is, per unit of volume,

$$u = c_v \rho T,$$

or, taking into account the equation of state, we have

$$\frac{P}{\rho} = RT,$$

we have

$$u = c_v P/R.$$

For air at atmospheric pressure,

$$u = 0.0604 \text{ cal/cm}^3.$$

*The energy content of the room is thus independent of the temperature, solely determined by the state of the barometer. The whole of the energy imported by the heating escapes through the pores of the walls of the room to the outside air.*

I fetch a bottle of claret from the cold cellar and put it to be tempered in the warm room. It becomes warmer, but the increased energy content is not borrowed from the air of the room but is brought in from outside. Then why do we have heating? For the same reason that life on the earth needs the radiation of the sun. But this does not exist on the incident energy, for the latter apart from a negligible amount is re-radiated, just as a man, in spite of continual absorption of

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\* The author has assumed that the specific heat of the gas is independent of temperature; a reasonable approximation for the oxygen and nitrogen around room temperature.

nourishment, maintains a constant body-weight. Our conditions of existence require a determinate degree of temperature, and for the maintenance of this there is needed not addition of energy but addition of entropy.

As a student, I read with advantage a small book by F. Wald entitled "The Mistress of the World and her Shadow". These meant energy and entropy. In the course of advancing knowledge the two seem to me to have exchanged places. In the huge manufactory of natural processes, the principle of entropy occupies the position of manager, for it dictates the manner and method of the whole business, whilst the principle of energy merely does the bookkeeping, balancing credits and debits.

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The above is a note published in *Nature* **141** (1938) 908. A. Sommerfeld found it so interesting that he cited it in his book *Thermodynamic und Statistik* (Vorlesungen uber theoretische Physik, Bd. 5, Dietrich'sche Verlag, Wiesbaden; English translation by F. Kestin, Academic Press Tic., New York, 1956). R. Emden is known by his work in astrophysics and meteorology as represented by an article in der Enzyklopadie der mathematischen Wissenschafte *Thermodynamik der Himmelskorper* (Teubner, Leipzig-Berlin, 1926).