LETTERS TO THE EDITOR

PHYSICS

The Temperature Scale

THE proposal made by Prof. J. C. Georgian[1] is in my view unsatisfactory in so far as it involves not only a change of unit but a change in the definition of the quantity, temperature. Temperature is a macrophysical quantity and confusion arises if it be given a pseudo-microscopic redefinition.

It would, however, be possible and unobjectionable were there to be defined a new unit of temperature, say 'the Georgian' with the unit symbol Geo, such that the molar gas constant became 1 J/kmole Geo. This would achieve many of the aims of Prof. Georgian without involving a redefinition of the quantity.

One must, however, note that a system involving a new unit of temperature, say, the Boltzmann with a unit symbol Bol, such that the molar gas constant became 1 J/molecule Bol, might prove to be even more attractive.

In my view, however, a more radical reform should be made. It would be appropriate to make entropy a primary quantity and temperature a derived quantity. I would introduce a unit of entropy, say the carnot with a unit symbol Car, such that the molar gas constant became 1 Car/kmole. The unit of temperature would then be the J/Car.

This change would lead to relations between temperature and entropy which were symmetric relative to the relations between pressure and volume or force and distance. When considering pressure and volume it has long proved convenient to regard thermodynamic pressure as defined as minus the derivative of internal energy with respect to volume at constant entropy. According to my scheme, one would define (thermodynamic) temperature as the derivative of internal energy with respect to entropy at constant volume. This is indeed used in many presentations of thermodynamics, but the traditional scheme of units in which temperature is regarded as primary and entropy as derived militates against a clear understanding of this approach.

Whatever may eventually be done about changes in this field it cannot in my opinion be too strongly stressed that these macroscopic quantities should retain definitions which do not confuse them with related but non-identical microscopic quantities. It is from such a confusion that the controversy about certain electromagnetic quantities stemmed.

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[1] *Nature*, **201**, 695 (1964).

I BELIEVE Mr. Le Fevre's objections are due to the long-term habits of considering temperature measured by a degree (centigrade, Celsius, Kelvin, Fahrenheit, Rankine, etc.); hence, he feels it is necessary that the temperature should have some type of unit name. There is, of course, nothing wrong with this since, for example, we call the unit of energy, newton-metre, a joule, and power a newton-metre/second or joule/second, a watt. I am only proposing that the temperature be called by what it actually represents, that is a joule/kilomole, in the same manner that pressure is a newton/square metre.

While I appreciate Mr. Le Fevre proposing calling the new unit in my temperature scale a Georgian, I think that, if he feels it necessary to name this new unit, I suggest calling it a degree Joule, as it most closely names the temperature dimension of joule/kilomole. I maintain, however, that the molar gas constant can be dispensed with, as the temperature unit in the ideal gas law is determined from the fundamental M.K.S. units.

I suspect Mr. Le Fevre is also objecting to the idea that temperature has the dimensions of L^2/T^2 and feels that temperature needs a separate dimension. The ideal gas law shows from a macroscopic or phenomenological point of view that temperature is a measure of energy and on a specific energy basis has the units of L^2/T^2. On the other hand, from the microscopic or kinetic theory of gases it is shown that:

$$\overline{c^2} = \frac{3\theta}{M} \tag{1}$$

where $\overline{c^2}$ is the mean square velocity of the molecules; M is the molecular mass number (molecular weight) of the gas; θ is the absolute temperature.

Equation (1) indicates that the temperature is directly proportional to the mean square velocity of the molecules in an ideal gas. Consequently, either from the phenomenological or statistical theory of gases we find that temperature is indeed an energy unit with the dimensions of L^2/T^2.

Only by understanding clearly that temperature is a measure of energy do we see that entropy from its definition is nothing but a dimensionless quantity which, however, is of great convenience and utility in thermodynamics. In addition, the probability theory of entropy shows clearly that entropy is a dimensionless quantity. Entropy is given by the expression:

$$s = k \log_e W + s_0 \tag{2}$$

where now Boltzmann's constant, k, equals $1 \cdot 6604 \times 10^{-27}$ kilomole in the M.K.S. system with $\bar{R} = 1 \cdot 0$, and W is the probability. Therefore, Mr. Le Fevre's idea of introducing entropy as a primary quantity is extremely objectionable as he is attempting to force an essentially dimensionless quantity into some type of unit.

I believe that the real confusion has arisen from the fact that temperature has not been clearly defined as the energy unit it is, with the consequent proliferation of large numbers of extraneous units. Finally, the original proposal was to place temperature in the M.K.S. system of units and, hence, relieve scientific and engineering calculations of the unnecessary burdens of conversion factors.

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Stress Waves in a Liquid Column

EXPERIMENTS have been carried out in which stress waves are propagated upwards through a vertical liquid column. For this purpose the apparatus previously described by me[1] was used except that a piston of shorter length (3 cm) was used.

Briefly, the liquid under test was contained in a vertical steel cylindrical tube fitted with a steel piston at its lower end and the upper end open. A positive pressure wave was generated in the liquid by firing a lead bullet of 0·22-in. calibre so as to strike the lower end of the piston normally at its centre. When this pressure wave reached the upper free surface it was reflected as a wave of tension. The pressure changes in the liquid were recorded by means of a horizontal steel pressure bar inserted into a 'porthole' below the liquid surface.

Records using ordinary tap water showed that tensions of the order of 7 atm. could be generated in the liquid. It was then decided to introduce gas nuclei into the water in order to examine their effect on the wave propagation. This was first done by using fresh 'soda water' in the tube;