We are continuing our studies of the hot atom effects on neutron irradiated cadmium phthalocyanine by the use of the "daughter-tracing technique". Details will be reported later.

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Received December 3, 1968.

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Heat Loss Compensated Calorimeter

I HAVE designed a calorimeter intended essentially to eliminate systematic errors caused by temperature gradients. It is a calorimetric body with the core completely surrounded by a thermally isolated jacket of equal heat capacity (Fig. 1). Thermistors imbedded in both body and jacket, to indicate temperatures, form opposite arms of a Wheatstone bridge that is initially balanced when the core and jacket temperatures are at equilibrium. Unbalanced output voltages for small changes in temperature are therefore proportional to the sum of the temperature changes of the core and jacket from equilibrium. The jacket is surrounded by a shield that either remains at a constant temperature, or follows the rising temperature of the jacket, depending on the mode of operation.

If power is applied to the core, first by an eccentrically located imbedded electric heater and then by a uniform absorption of energy produced from a radiation field, differences will be produced in temperature gradients throughout the core. If the gradients are large, as with an eccentrically located heater, the heat lost from the core during the application of power may be difficult to evaluate with satisfactory accuracy, especially if the core temperature is measured at only one point. The heat lost from the core that is retained in the jacket, however, contributes to the output of the Wheatstone bridge just as if it had been retained in the core. (A somewhat different method is described in ref. 1.) Compensation for heat lost from the core by this method is nearly independent of the temperature gradients produced in the core during power application. Hence this method would seem to reduce the systematic error when the calorimeter is used to compare power sources that produce different temperature distributions in the core. The relatively small jacket leakage correction that remains can be assumed to be made with good accuracy, in the case where the shield is maintained at constant temperature, because the rise of temperature in the jacket is smaller and more uniform than in the core. For the same reasons, in the adiabatic mode, the temperature of the shield can be caused to follow the rising temperature of the jacket more readily and accurately than that of an unjacketed core.

In a calorimeter used to measure the absorbed dose in a radiation field, it is assumed that the shield remains fixed at a temperature, and core and jacket are made of the same material and have equal heat capacities. The sensitivity of the calorimeter is determined from calibration runs in which measured power is supplied to and dissipated in the core by an imbedded electrical heater. No power is supplied to the jacket; its slight heating is the result of heat transferred from the core. The output voltage of the bridge circuit indicates $T_{1C}+T_{2C}$, where T_{1C} and T_{2C} are, respectively, the temperature changes of the core and the jacket from equilibrium, uncorrected for heat losses.

When radiation measurements are made the jacket's thermistor is replaced by a fixed resistor of equal ohmage external to the calorimeter. The output voltage of the bridge then indicates T_{1M}, the temperature change from equilibrium of the core. The energy, E_M, absorbed by the core from the radiation is

$$E_M = E_C \times T_1{}^1{}_M/(T_{1C} + T_{2C})^1$$

where E_C is the measured electrical energy, supplied during the calibration, and $T_1{}^1{}_M$ and $(T_{1C}+T_{2C})^1$ are the corrected temperature changes in the two runs.

I discovered, while calculating the ideal performance of the proposed single jacketed calorimeter design, that T_{1M} is identical to $T_{1C}+T_{2C}$, provided that (1) the absorbed radiation power converted to heat in the core and jacket are the same as the electrical power converted to heat in the core during a calibration run, (2) temperature changes are small enough that heat capacities and heat transfer coefficients can be considered constant, and (3) there are no temperature gradients within the core or jacket.

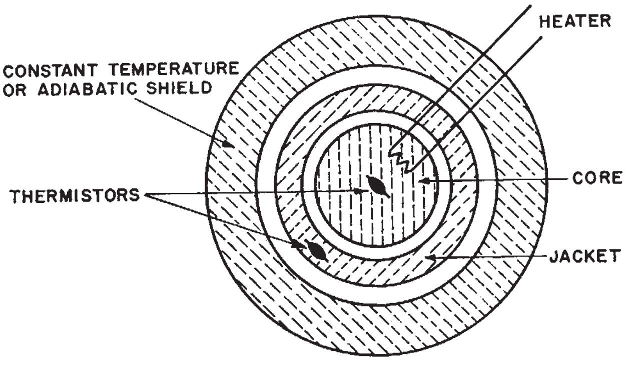

Fig. 1. Essential elements of the heat loss compensated calorimeter.

More generally, for a core surrounded by N-1 thermally isolated jackets,

$$T_{1M} \equiv T_{1C} + \alpha_2 T_{2C} + \alpha_3 T_{3C} + \ldots. + \alpha_N T_{NC}$$

if the same schedule of power, $P(t)$, is applied to the core during a calibration run and a measurement run, and if $\alpha_2 P(t), \alpha_3 P(t), \ldots., \alpha_N P(t)$ are the schedules of power applied during a measurement run to the first jacket, the second jacket and so on, respectively, where $\alpha_2, \alpha_3, \ldots., \alpha_N$ are constants. This expression is independent of the possibly different heat capacities of the core and jackets, and also independent of the time variation of $P(t)$, whether $P(t)$ acts as a heater or as a refrigerator.

I thank Dr Ben Petree for helpful comments. This work was supported by the National Cancer Institute, US National Institutes of Health, and by the Division of Biology and Medicine of the US Atomic Energy Commission, Washington. A calorimeter of the design described for measuring absorbed dose is nearing completion in the NBS Center for Radiation Research, and an experimental programme is under way.

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Received October 5, 1968; revised March 3, 1969.

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