A Recording Digital Calorimeter.* (20801)

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The digital calorimeter, as originally described(1,2), consisted of an aluminum calorimeter cup, set in broken cork, and covered by a rubber membrane with apertures for the finger, a stirring device and a Beckmann thermometer. To measure the calories elaborated by the digit per unit of time, the calorimeter was usually set at 6 or 7°C below the temperature of the arterial blood. The rise in temperature produced by the digit, however, was modified by loss of heat from calorimeter to room because of the difference between their respective temperatures. This loss, therefore, was measured with a cork replacing the digit and was added to the temperature rise produced in the calorimeter by the digit. The total was considered representative of the total heat output of the finger or toe.

Although this procedure is sound for the measurement of calories within the error of the method as a whole, it involves 2 sets of measurements under slightly different conditions. Room temperature and the rate of stirring, for example, must be the same in the 2 phases of the procedure. Another objection has also been raised to the effect that a variable cooling lag might introduce error(3) although this is probably of more significance for the hand calorimeter than for the smaller digital calorimeter. To meet this objection, Greenfield *et al.*(4) introduced a calorimeter incorporating a stirred electrically heated water jacket, the temperature of which could be regulated to keep the temperature of the water within the calorimeter constant despite varying room temperature. Thus, the contribution made by the digit could be measured directly. This instrument, however, contained a liter of water and was therefore too large and unwieldy for practical digital calorimetry using one finger tip. Wilson(5) balanced heat lost from his calorimeter to the room by heating the outside of the cup with an electric bulb regulated by a rheostat. This simple device works well but has the disadvantage of bright lighting and a tendency to heat the hand or foot as well as the calorimeter cup.

Heat loss to the ambient air can also be balanced by a heating wire inserted into the cup.† This heating wire is connected to the secondary winding of a step-down transformer with an ammeter in series. The voltage of the primary winding of the transformer is controlled by a variable autotransformer, fed by a 120 volt, 60 cycles/sec. line. The heating wire is 2½ feet long and has a total resistance of 11.5 ohms. It is coiled and ensheathed in polyethylene tubing of appropriate size. The maximum voltage applied to the wire is 10 volts. This corresponds to a maximum heat input into the calorimeter by the wire of 120 g cal./min. By adjusting the voltage in the primary winding of the step-down transformer, the current in the wire and hence the heat input can be changed and the temperature of the stirred water in the calorimeter can be kept constant within 0.01°C. The actual heat input required to keep temperature constant varies from 0 to 5 g cal./min. depending on ambient temperature. The position of the wire must be adjusted to keep it free of the digit, the stirring bar and the thermometer itself.

Several other changes are incorporated in this calorimeter (Fig. 1) which increase ease of operation. The cup for the finger contains 125 cc, and for the toe, 250 cc of water. It consists of an evacuated silvered flask, the evacuation bulb being eccentric so that the bottom can be fairly flat. No other insulation is needed and the flask is held in place by a clamp on its metal jacket. Either a rotary or an electromagnetic stirrer may be used. Transfer of heat from the electromag-

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† This principle was used in a hand calorimeter by Greenfield and Scarborough(3).

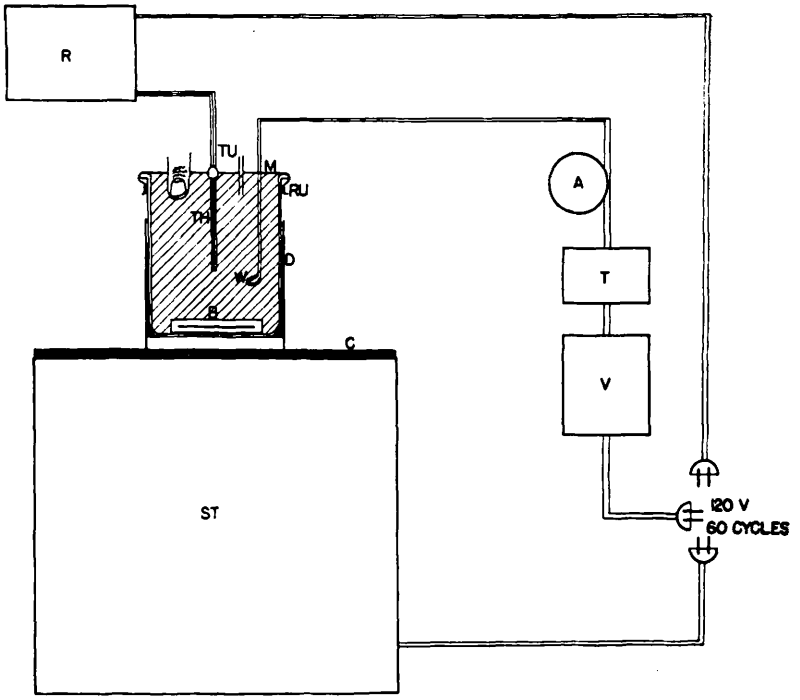

FIG. 1. Diagram of recording digital calorimeter. V, variable voltage control; T, step down transformer; A, milliammeter; R, recorder (Leeds-Northrup #61,452); Tu, glass tube; M, rubber membrane; Ru, rubber band; Th, platinum resistance thermometer (Beckmann thermometer can be substituted if no record is required); W, resistance wire ensheathed in polyethylene tubing; B, plastic stirring bar; D, silvered, evacuated, double-walled, glass calorimeter cup containing water. Cemented to the cup is a metal sheath, only the edge of which stands on the cork slab beneath. A clamp and ring stand (not shown in the diagram) hold the unit in place on the stirrer. C, cork slab; St, electro-magnetic stirrer (large).

net is prevented by a cork slab between the housing of the magnet and the edge of the metal jacket of the cup. This heat, as well as the heat of stirring produces no error, since adjustment is always made to near zero via the heating wire. In addition, a record is made with a cork before and after the digital record. Any deviation from zero is averaged and either added or subtracted from the digital slope. An air-vent which can be water-sealed is incorporated in order to make the insertion of the finger and the addition of water easier. A Beckmann thermometer or a non-adjustable mercury thermometer, registering with an accuracy of $\pm 0.01^{\circ}$C over the desired temperature range may be used with this apparatus. A platinum resistance thermometer and Leeds-Northrup recorder provide a permanent record of the temperature changes. A typical record, the slope of which is accurate to $\pm 0.01^{\circ}$C is demonstrated

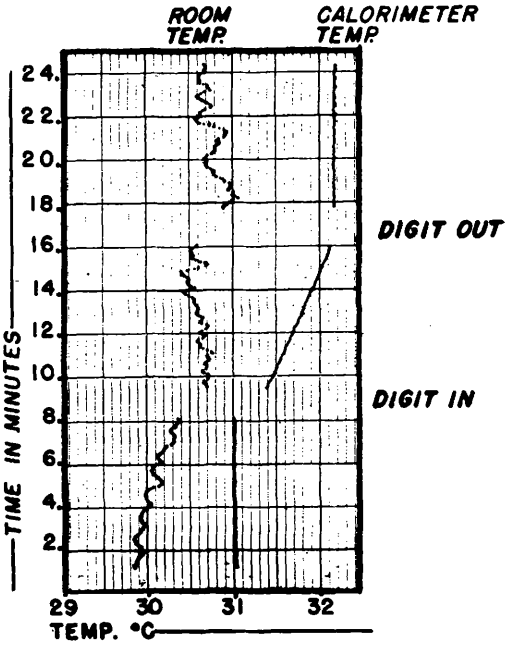

FIG. 2. A typical record of digital calorimetry.

in Fig. 2. With a constant heat input via the resistance wire, the rise in temperature as measured by the Beckmann thermometer is exactly the same as that measured by the corrected slope of the recorded temperature.

The hydrothermic equivalent of the apparatus was calculated as follows: With a constant heat input at a given calorimeter temperature under fixed room temperature conditions, the calories engendered in distilled water were equated with those engendered in potassium carbonate solution of known specific heat. The only unknown, the hydrothermic equivalent of the apparatus can be calculated(6). It was 5 ± 1 cc for the digital, and 14 ± 2 cc for the hallucal calorimeter.

Summary. A recording digital calorimeter is described.

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An Improved Technic for Liquid Emulsion Autoradiography.* (20802)

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The increasing application of radioactive elements as tracers in biological and medical problems and the necessity for more precise information regarding the effects of radioactive elements on tissues have resulted in continuous improvement in autoradiographic procedures for the detailed study of the distribution of these elements. It is generally recognized that autoradiographic resolution on a cytologic scale can be improved by the elimination of all space separating the emulsion from the tissue, the use of thin layers of emulsion, and the use of thin tissue sections (1-4). In the course of a study of the deposition of long-lived radioactive elements at the cellular level, it has been necessary to improve and modify existing technics for the preparation of liquid nuclear track emulsions for autoradiography. As a result, an autoradiographic procedure has been developed which eliminates all emulsion-tissue separation and allows the preparation of emulsions less than one-half micron in thickness.

Materials and methods. All tissues are fixed in acetone at room temperature to minimize migration of bone seeking radioisotopes and fogging of emulsions by chemical constituents. Tissue sections, 2 to 5 microns thick, are cut in an embedding medium such as celloidin, paraffin, or plasticized nitrocellulose(5), and mounted on glass slides with egg albumin or other fixatives. (For very hard tissues that tend to curl, *e.g.*, undecalcified bone, it is advisable to roll the damp section on a slide that has been previously coated with 1.5% gelatin, drained, and air-dried.) The embedding medium is then dissolved in a suitable solvent, *e.g.*, xylene for paraffin, ether alcohol for celloidin, and ether alcohol or acetone for the plasticized nitrocellulose, and the tissue section is dried. NTA and NTB liquid nuclear track emulsions in the solid state in air- and light-tight, Dewar flasks, and maintained at 5°C, were kindly supplied for

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