STUDIES ON THE PHYSIOLOGICAL EFFECTS OF FEVER TEMPERATURES

I. A Description of a Series of Constant Temperature Water Baths for the Determination of the Thermal Death Time of Bacteria*

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In order to study the *in vitro* thermal death time of bacteria as well as that of tissue and tumor cells, it was necessary to have a series of constant temperature water baths to cover the range of fever temperature in man from 37–42°C. The purchase of many single units would have been expensive. The construction of such baths also seemed difficult and expensive, but after a consultation with the various members of the Departments of Bacteriology, Physiology, and Vital Economics of this school, it was decided to construct six baths as a unit in one table. This would enable us to use a single counter-shaft and motor for the stirrers and make the controlling equipment compact and simple.

Construction

Six ordinary galvanized iron boxes were obtained from the Rochester Can Co. These were 55 x 41 cm. at the top, tapering to 49 x 34 cm. at the bottom, and 25 cm. deep. They were thoroughly painted inside with aluminum bronze lacquer. A solid trough-like table (Fig. 1) was built to support these boxes flush with its upper surface. Each was separated from the other by a thin board partition. A space of 2 cm. was left between the top of the metal boxes and the surrounding walls, and the space filled with ground cork. The bottom of the metal boxes

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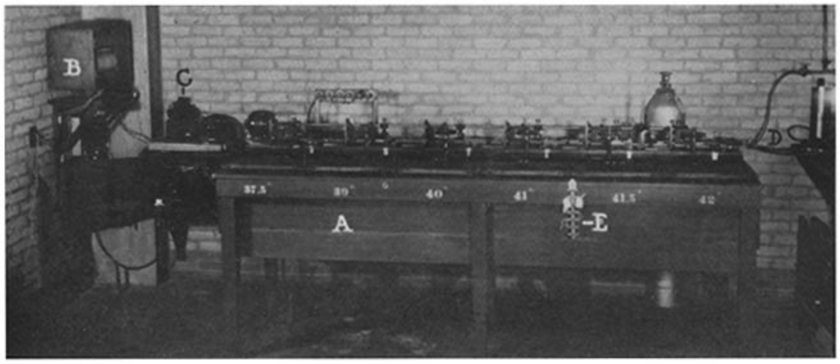

FIG. 1. Series of six constant temperature baths for studying the thermal death time of bacteria. *A*, table supporting baths; *B*, recording galvanometer; *C*, rotating switch; *D*, siphon arrangement to maintain water levels; *E*, dental film holders to which are attached the labelled, sealed vials. Used to immerse vials in baths.

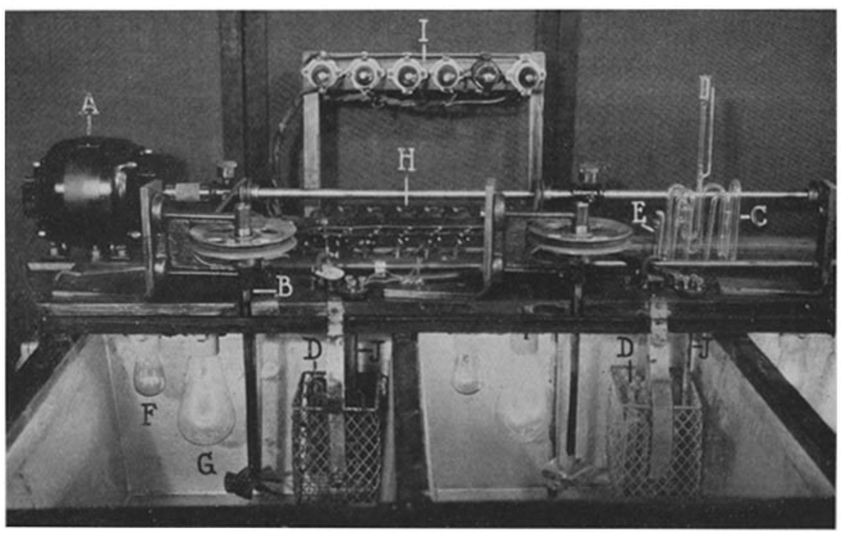

FIG. 2. Detail of two of the series of six baths. *A*, motor; *B*, stirrer; *C*, thermoregulator—disconnected showing type and construction; *D*, thermoregulator—installed within basket that affords it protection; *E*, adjuster screw for thermoregulator; *F*, continuous heater lamp; *G*, intermittent heater lamp; *H*, series of relays that operate heater lamps; *I*, neon pilot lamps; *J*, resistance thermometer.

rested directly on the tight 2 cm. (3/4 inch) flooring of the table, it being found unnecessary to insulate further the under surface of the metal boxes. Wooden strips were then placed over the metal box edges to hold them and the cork packing in place. A 4 cm. plank about 25 cm. (10 inches) wide was then fitted the full length of the back of the table so that its center rested on the posterior rim of the metal boxes. It thus projected over the back edge of the table, as well as some 8 cm. over the baths. This plank supported the motor, the bearings and shaft, the bearings and support for the stirrers, the thermoregulators and their relays, all wiring, the heater lamps, the resistance thermometers, and a water-levelling device (Fig. 1). The next and most important step at this point was to waterproof all wooden surfaces and joints with hot paraffin to prevent warping. The hot paraffin was spread on quickly with a large brush until the wood was well saturated

The stirrer supports and bearings were mounted so that a 12 cm. paddle wheel occupied about the middle third of each bath. The paddle wheel was cut from a brass disc about 1 mm. thick. This was mounted on the end of a 13 mm. (1/2 inch) brass shaft between two washers. The shaft passes up through the bearings and a pulley wheel, which is held in place vertically by a bushing and set screw. The pulley wheel and bearings were stock products, common in laboratory supplies. The bearings for the pulley wheel were bolted to right angle braces, which were firmly screwed near the front of the plank mentioned above. Oil holes were drilled in the top of the stirrer shaft to reach the two bearings and the bushing. These holes were packed with felt in order to allow a slow, steady supply of lubricant. The 16 mm. (5/8 inch) main driving shaft and its bearings were mounted on a piece of 13 mm. (1/2 inch) thick, 52 mm. (2 inches) wide, and 2½ m. (98 inches) long, flat, cold-rolled steel which was screwed on the back half of the plank. A stock adjustable, floating type of bearing was found to be most satisfactory. Each had its own grease cup. Standard 52 mm. (2 inch) pulleys with 13 mm. (1/2 inch) grooves were placed in the proper place opposite each stirrer pulley. A one-third horse power type S.R., 1150 R.P.M., A.C. motor, protected by a thermal cut-out, was mounted at one end of the plank and joined by a flexible coupling to the main shaft. Endless leather belts 0.65 cm. (1/4 inch) in diameter were found to be most satisfactory for running the stirrers. The belts were kept pliable by the application of belt dressing. Two standard keyless, porcelain socket receptacles were mounted on the under side of the plank on the left of the stirrer in each bath for the carbon filament heater lamps. A 10 watt carbon filament lamp, used as a pilot heater, was placed in one socket, while the other socket contained a 60 or 120 watt carbon filament lamp, which is used as an intermittent heater and is controlled by the relay and thermoregulator of the individual bath. A bank of six telephone relays, modified to operate on 12 volts D.C. was mounted on the left end of the plank near the motor. A 12 volt battery energizing the relay circuits is kept on a floating charge. The connections are shown in the wiring diagram (Fig. 3).

The thermoregulators are hung in a wire basket attached to the plank at the right of the stirrers. They consist essentially of a glass capillary tube and bulb, a side arm with platinum wire fused in the wall to make contact with mercury in the capillary. Attached to the bulb is about 1 m. of 0.5 cm. glass tubing bent into a series of twelve compact loops which are filled with toluene. The bulb is filled with just enough clean mercury so that when the regulator is placed in a bath at the desired temperature the mercury ascends about half way up the capillary. The junction between the toluene and the mercury should occur in about the middle of the bulb so that a little tilting is possible during the mounting process without allowing the toluene to enter the capillary. The side arm is filled with mercury in which is immersed one of the connections to the relay, the circuit being completed through the mercury in the capillary and the tempera-

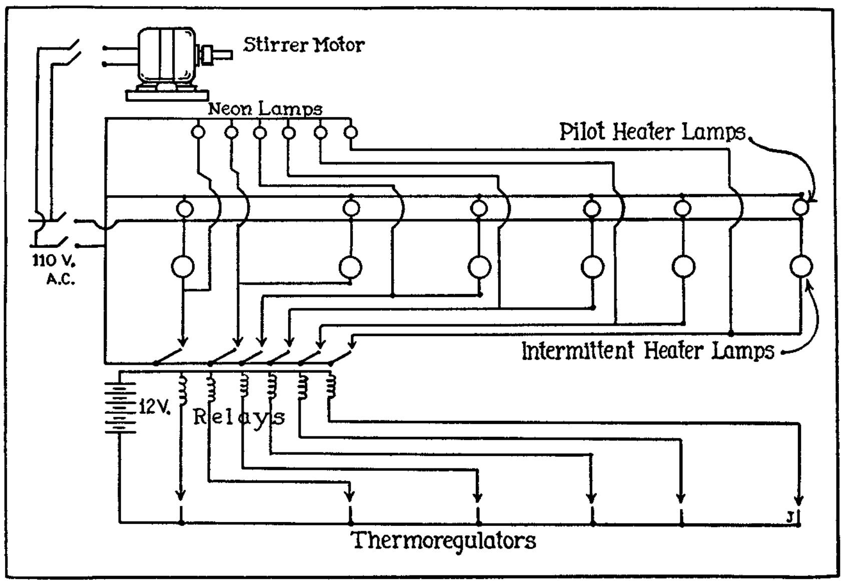

FIG. 3. Wiring diagram for constant temperature baths, with the recording thermometer circuits omitted.

ture-adjusting screw. The top of the regulator with its adjustable contact and side arm projects through a hole in the plank. The temperature is adjusted by means of the movements of a 6-32 screw 5 cm. long, to which is soldered a 6 to 8 cm. length of No. 28 (B. and S.) nichrome wire. This wire passes down into the 1 mm. capillary of the regulator to make contact with the head of the mercury column. The thermoregulators require about 17 turns of the screw to change the temperature of the bath 0.1°C. The glass blowing for the thermoregulators was done by Mr. W. Latchford of the Department of Physiology.

When the relay is activated so as to shut off the intermittent heater lamp, a small neon bulb is lighted (Fig. 3). Thus the rate at which the heater lamps flash on and off can be visualized and a check kept upon the operation of the baths.

The temperature of the baths with covers does not vary more than 0.002°C. as determined by a Beckman thermometer. Thermocouple measurements at various locations in the bath show that the temperature is uniform.

A resistance thermometer, encased in a brass tube, is placed beside the thermoregulator of each bath. Each one of the six resistance thermometers is connected successively every 2 minutes with a registering galvanometer by means of a rotating switch (Fig. 1) driven by a slow speed motor.

While this recorder cannot show extremely small fluctuations of temperature, it does permit the observation of variations of 0.1°C. or over, and allows a check on the constancy of the temperatures when the baths are allowed to run during the night without attendance.

There is an intercommunicating siphon of 1 cm. brass pipe between all baths, with an outside level maintained in a sink by a constant drip and overflow. By means of stop-cocks it is possible to fill or empty the baths, or maintain a constant water level, thus compensating for losses by evaporation.

SUMMARY

A series of six water baths in one unit, set at 37°, 39°, 40°, 41°, 41.5°, and 42°C., for the purpose of studying the thermal death time of bacteria and of body tissues has been described.

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