

5919

**General Hyperthermia with Heat Localization by Radiotherapy.**

WILLIAM BIERMAN AND MYRON SCHWARZSCHILD.

(Introduced by B. N. Berg.)

*From the Departments of Physics and Physical Therapy, Beth Israel Hospital, New York.*

When some heat producing procedure is applied to a localized region of the body, it is difficult to secure any substantial elevation of temperature in that region above that of the body temperature due to the efficient heat regulatory mechanism which the body possesses. The heat produced locally is rapidly dispersed, the other regions of the body actively entering into the process of heat dissipation.<sup>1</sup> In the live anesthetized dog placed in the field of a high frequency current, the different organs heat up at approximately the same rate, the blood serving as a very efficient distributing mechanism of the generated heat.<sup>2</sup> In the following communication it is shown that when the systemic temperature is elevated by radiotherapy an increased local temperature may be produced and maintained simultaneously in the vagina by applying additional electrical energy in that area. This mechanism has been employed therapeutically by us in the treatment of pelvic inflammations.

The technique for the systemic elevation of temperature in the human subject by means of the high frequency electric field in the radiotherm has been described by Carpenter and Page.<sup>3</sup> The method consists essentially in placing the subject between the plates of a large condenser which forms part of an oscillating circuit. The oscillations in this circuit are produced by the use of radio tubes of appropriate construction (500 watt screen grid in push pull) with the necessary associated equipment for the attainment of a high frequency electric field of high intensity. The frequency commonly used for this work is approximately 10 million cycles per second, corresponding to a wave length of 30 meters. The condenser plates between which the subject is placed are large enough (50x80 cm.) to produce a field over a reasonable part of the volume of the subject, and are separated from one another by a distance of approximately one meter. The subject rests upon a stretcher between these plates

<sup>1</sup> Binger, C. A. L., and Christie, R. V., *PROC. SOC. EXP. BIOL. AND MED.*, 1927, **24**, 677; *J. Exp. Med.*, 1927, **46**, 571.

<sup>2</sup> Mortimer, B., *Radiology*, 1931, **16**, 705.

<sup>3</sup> Carpenter, C. M., and Page, A. B., *Science*, 1930, **71**, 450.

but not in contact with them, and is kept covered during the treatment so as to prevent excessive loss of heat. With a total DC plate current of 0.5 amperes using two UV861 tubes it is possible to produce an elevation of body temperature of about 4°C. in the course of an hour and one-half.

In order to produce a simultaneous increase of body temperature with a still higher increase in the temperature of the vagina the following method was employed. With the subject in place between the condenser plates of the radiotherm, an electrode is placed in the vagina. This electrode is connected, through an ammeter, to a small auxiliary metal plate suspended near one of the large condenser plates of the radiotherm. Under these conditions the electrical field produced in the region between the electrode and the condenser plate opposite to the one near which the auxiliary plate is suspended, is considerably higher than it is at any other part of the body. When the region to be heated is located asymmetrically in the body of the patient, the pick-up plate is brought near the condenser plate opposite to the affected side. If the region is centrally located in the body the pick-up plate is shifted from one side to the other. With a pick-up plate of about 300 sq. cm. area, the distance between the pick-up and the condenser plate varies from 10 to 30 cm. The readings on the radio-frequency ammeter usually vary from about one to 2 amperes. The localization may also be accomplished in regions where there is no convenient cavity by the use of surface electrodes.

By these means the average result in 50 instances was an elevation of the temperature in the vagina to 42.5°C. during an average time period of 53 minutes. This temperature was determined by a mercury thermometer inserted in the vaginal electrode. Coincidentally, the average rectal temperature rose to 40.5°C., an increase of about 3.5°C., while the average temperature in the mouth rose to 39°C., a rise of about 2°C. The rectal and mouth temperatures were also taken by means of mercury thermometers. All temperature readings were made while the current flow was discontinued.

The operation of the electrical circuit may be explained as follows: The radio-frequency potential of the electrode is raised to a value between the ground and that of the condenser plate adjacent to which a pick-up plate is suspended. Normally, the center of the body is at ground potential, hence, in this case, there must be a larger potential gradient from the electrode to the other condenser plate than would normally obtain in this region. Because of the small change in capacity of the system, a change in wave length was an-

ticipated. Measurements of the wave length show that this change is of the order of one-half meter.

5920

### Heterochronism in the Single Fiber Nerve-Muscle Complex of the Retrolingual Membrane.

HARRY GRUNDFEST. (Introduced by D. W. Bronk.)

*From the Eldridge Reeves Johnson Foundation for Medical Physics, University of Pennsylvania.*

A series of measurements has been made on the excitability of the single muscle fiber preparation in the retrolingual membrane of the frog's tongue. The relation between liminal intensity and stimulus duration has been studied with the direct excitation of normal and curarized fibers and also with indirect stimulation through nerve fibers lying in the membrane. In many experiments it has been possible to carry out all 3 types of measurements while observing throughout the response of the same single muscle fiber.

The preparation is made according to the method described by Pratt,<sup>1</sup> which permits the use of transilluminated membranes with intact circulation. Stimulation has usually been by condenser discharges. The stimuli are applied through a localized cathode which is a capillary tube having an opening 20-80 $\mu$  in diameter and which is filled with Ringer's solution.

These experiments were carried out to test the validity of Lapicque's<sup>2</sup> "law of isochronism" that transmission of excitation from a nerve to its muscle is possible only when the "chronaxies" of the 2 tissues are equal or differ by no more than a ratio of 1:2. That a block in transmission produced by drugs is due to an overstepping of this ratio. In particular, a curari block is supposedly due to an increase in the chronaxie of the muscle.

In the present experiments it has been found that the nerve fiber always has chronaxies from 2-8 times smaller than does the muscle fiber. The chronaxie of the muscle fiber does not change upon curarization. The values of the chronaxies range from about 0.03 to 0.06 $\sigma$  for the nerve and from 0.1 to 0.3 $\sigma$  for the muscle fiber. Furthermore, it has been possible to obtain compound curves of the

<sup>1</sup> Pratt, F. H., *Am. J. Physiol.*, 1930, **93**, 9.

<sup>2</sup> Lapicque, L., *L'Excitabilité en fonction du temps.*, 1926.