THE MEASUREMENT OF BODY RESISTANCE BY BRIDGE METHODS.

By W. Grey Walter, M.A.Camb.
(Burden Neurological Institute).

[Received 5 February, 1942.]

The measurements described in Dr. Hemphill's paper are nominally of resistance to a direct current, but in view of the well-known variations in resistance according to the frequency used, it seems most probable that the actual phenomena reported are due not only to changes in resistance proper, but also to fluctuations in the E.M.F. generated by the superficial tissues, as a result of the small steady polarizing current used in the Wheatstone bridge circuit.

In these experiments the polarizing voltage for the bridge was 2 volts, and for resistances up to 10,000 ohms the ratio arms were both at 1,000 ohms. The current through the patient was therefore of the order of one milliamp. When resistances greater than 10,000 ohms were encountered, the resistance of the appropriate ratio arm was changed to 100 and the variable arm readings were then, of course, one-tenth of the patient's resistance at balance. This procedure is conventional and entirely trustworthy with inert resistances, but when polarization occurs in the resistance to be measured the conditions are not so simple. It has been known for a long time that when direct current is passed through the body a voltage is developed in the tissues which tends to oppose the current from the external source. The tissues behave like a small and inefficient battery. This voltage is called a " back E.M.F.," and within a certain range of values is roughly proportional to the current from the external source. The effect of this is to make the resistance of the body seem very much higher than it really is. For example, when the resistance is measured with a small steady current, as with a Wheatstone Bridge, the resistance may seem to be, say, 2,000 ohms, but if the measurement is made with an alternating current, which changes its direction so quickly that the back E.M.F. has no time to build up, the reading will only be about 800 ohms. It is found that this effect is reached at about 1,000 cycles per second (see his Fig. 2). Above this the apparent resistance decreases slightly for other reasons. Now this fact, that measurements made with direct current include this back E.M.F. in the apparent resistance reading, considerably complicates the results of the use of the Wheatstone bridge, particularly when high " resistances " are encountered, since it is most probable that high " resistances " are actually large back E.M.Fs. Moreover, when the resistances in the ratio arms are changed to extend the range of the bridge to over 10,000 ohms, the current through one side of the bridge will be increased and the polarizing effect of the bridge current will be enhanced. Apparent resistance values above 10,000 ohms are therefore even more likely to be subject to error than lower values, and this must be borne in mind in considering the results here presented.

It should therefore be clearly realized that, although the results are plotted as variations of resistance against time, there is a strong probability that many of the variations plotted are really changes in E.M.F. as well as in resistance. This is particularly likely in the case of the very large fluctuations in apparent resistance, since it is unlikely that true resistances as high as 35,000 ohms would be encountered in the skin. If this is the case, the further analysis of these results becomes extremely complicated, because there is no reason why an increase or decrease of E.M.F. should not be accompanied by an increase or decrease of true resistance. Such changes might run parallel to each other, or they might show an inverse

https://doi.org/10.1192/bjp.88.371.306 Published online by Cambridge University Press

relationship, or there might be no relationship at all. It may be that the apparently specific character of the very large fluctuations in certain cases is actually an E.M.F. variation, while the more moderate changes in the other patients are variations of true resistance. These matters are under consideration at the moment, and a series of experiments is in progress, designed to divide the problem into its component parts. An unusual opportunity is offered in electric convulsive therapy of observing the effect upon the body resistance of relatively very strong currents. If, before a convulsive shock is given to the head, the resistance between the head electrodes is measured at different frequencies, it is found that resistance at low frequencies such as 10 cycles is much the same as the D.C. resistance as measured on the Wheatstone bridge. As the frequency of the polarizing current is increased, resistance falls rapidly until about 1,000 cycles per second is reached, and from this point it decreases more slowly. It can be shown that from zero to 1,000 cycles the drop in resistance is due to the progressive falling out of the polarizing elements, while from 1,000 cycles up to the higher order of frequencies, the resistance is of the nature of a mixed impedance containing capacitative elements. When a similar series of measurements is made after the passage of the convulsant current—which is of the order of one ampere at 50 cycles lasting for about one-fifth of a second, it is found that the resistance at the lowest frequencies approximates closely to that at the high frequencies, and the whole curve relating resistance—or rather impedance—to frequency shows that the polarizing elements have been completely elminated, and the truly resistive and reactive ones alone are present. It is therefore possible to abolish the polarizing elements with a strong current, and to show also that they require some hours to recover their properties. When measurements are made through the head, so that the bridge current does not pass through the area of skin subjected to the convulsant stimulus, no such changes are found, and the inference may be drawn that the polarizing elements are in fact in the superficial layers, and that they can be temporarily abolished without in any way affecting either the appearance of the skin or its simpler physiological functions.

It is hoped that further investigations will permit more precise location of the polarizing elements, together with an analysis of the nature of their properties, which, as will be seen, seem to be closely related to the mental and endocrine condition.

https://doi.org/10.1192/bjp.88.371.306 Published online by Cambridge University Press