MONITORING THE TEMPERATURE DIFFERENCE BETWEEN THERMOCOUPLES IN THERMOELECTRIC TRANSDUCERS WITH HEATING ELEMENTS

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In order to express the temperature difference between the junctions (Δt) in thermoelectric transducers with heating elements, many investigators use the current (I) in the heating system. The authors consider that readings of I cannot be used for this purpose and they suggest an apparatus by which any temperature difference between the thermocouples can be determined and monitored.

Because of its simplicity and the fact that it can be used in long-term experiments, the thermoelectric method of investigation of the regional circulation has become widely used.

The principle governing the recording of changes in the volume velocity of the blood flow by thermoelectrodes is as follows: side by side with one of the thermocouples is placed a heating element, and when this is switched on an emf is generated between the junctions. The flowing blood cools the heated thermocouple; if the blood flow velocity is increased or decreased the temperature difference between the junctions will fall or rise, respectively, and this will be reflected by the recording instrument.

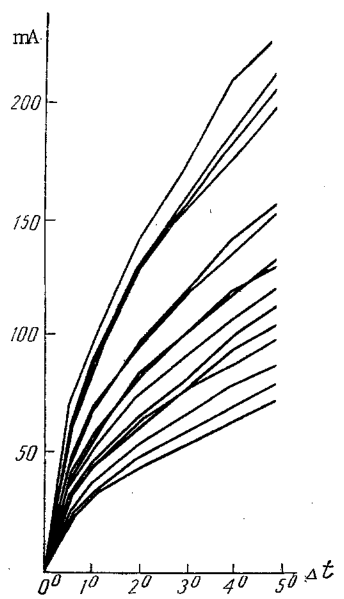

Fig. 1. Graph of Δt as a function of heating current I.

Many workers are at present attempting to improve the thermoelectric method so that it can be used to measure the blood flow quantitatively [1, 3, 4, 6]. One way of increasing the accuracy of the thermoelectric method is suggested below.

The temperature difference between the thermocouples (Δt), which some workers consider must be between 1 and 4°C, is set by changing the heating current (I), but authors differ in the values of I which they consider necessary to obtain this difference, within the range from 70 to 600 mA [1, 2, 5]. The contradictory nature of these figures may depend, first, on the fact that the finished electrodes differ in their sensitivity (different magnitude of response to equal changes in blood flow); this is due mainly to the position of the heating element relative to the working thermocouple. For instance, Lugovoi [2] states that the sensitivity of thermoelectrodes varies within ±15% of the mean level. Second, differences in the resistance of the heating element of each electrode, but with the same current, give rise to different heating values, so that different indices of the change in blood flow will be obtained from two transducers.

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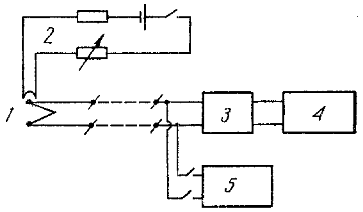

Fig. 2. Scheme used to activate the F = 116/1 measuring amplifier to monitor Δt while recording changes in blood flow by the thermoelectric method: 1) thermoelectrode; 2) system for heating working thermocouple; 3) dc amplifier; 4) recording instrument; 5) F = 116/1 measuring amplifier for determining and setting an assigned value of Δt.

Unreliability of using values of ΔI to determine the temperature difference between two junctions, on account of the wide range of variations in the value of Δt with an instrument of fixed size, is demonstrated in Fig. 1. As proof of this statement, with 16 arbitrarily chosen thermoelectrodes Δt was recorded with a type F = 116 /1 photocompensation amplifier, and with Δt set at 1-5°C the current required to obtain this temperature difference was measured by means of a type M-104 ammeter (accuracy class 0.5). For instance, when a temperature difference of 1°C was produced between the junctions of the electrode, the value of I varied from 30 to 96 mA. As Fig. 1 shows, the value of I cannot therefore be used as an index of the temperature difference between the junctions of the thermoelectrode. Since the value of Δt is not monitored in each experiment, and since Δt varies with the resistance of the heating element, as mentioned above, the statements made by some workers that in their experiments there was a known temperature difference between the junctions, must be disputed.

The authors have developed and conducted experimental tests with an apparatus for monitoring Δt with the use of a type F-116/1 photocompensation amplifier, by means of which any temperature difference between the thermocouples can be determined and monitored (Fig. 2).

An assigned value of Δt is set as follows: with a change in the resistance of the rheostat in the heating system, the degree of heating of the working junction is increased or decreased, and the F = 116/1 measuring amplifier connected to the thermoelectrode records its thermal emf at the rate of 42 μV per °C temperature difference between the junctions (for copper-constantan thermocouples).

If a multichannel thermoelectric apparatus is used, the F = 116/1 amplifier can be connected to it and used to measure Δt for each thermoelectrode in turn. If the same value of Δt is maintained at all electrodes in successive experiments, their qualitative characteristics are equalized and the curves obtained in the same or in different experiments can be compared.

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