USE OF ELECTRONIC AUTOMATIC POTENTIOMETERS FOR ELECTROPHYSICAL MEASUREMENTS

(UDC 612.014.421:621.317.727.1)

V. S. Korytnyi

(Presented by Active Member AMN SSSR A. V. Lebedinskii) (Deceased)
Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 60, No. 11, pp. 124-125, November, 1965
Original article submitted July 23, 1964

The measurement and recording of slow bioelectrical processes are connected with certain difficulties. The appreciable zero drift and instability of the amplification factor of direct-current amplifiers substantially limits the scope of their use in electrophysiological experiments, especially where it is necessary to record the observed activity for a long time.

To measure, record, and control technological parameters, our industry is producing automatic recording potentiometers which employ alternating-current amplifiers with preliminary conversion of the slowly changing voltages to pulsed voltages. These instruments after uncomplicated modifications in their circuit can be used in a number of electrophysiological experiments.

Underlying the operation of the automatically balancing bridges is the zero method of measurement: the measuring device is a balance bridge circuit having four arms. One of them has a slide wire. Into one of the bridge diagonals is connected the source of the measured emf in series with the zero indicator, and into the other is connected the balancing voltage. If the bridge is unbalanced a voltage drop arises in the input circuit of the indicator, the polarity of the voltage drop depending on the direction of unbalance. This direct-current voltage is converted to pulsed voltage with a frequency of 50 cps, which is then amplified by an a-c amplifier. The amplified pulsed voltage of the unbalanced bridge controls a RD-0.9 reversing motor which guides the contact of the slide wire to the position of balance. Simultaneously a kinematic connection with the indicator is made, as well as with a tubular pen or printing carriage. It is understandable that the resistance of the input of such devices is determined by the resistance of the arms of the measuring bridge. The input resistance of the plant potentiometers ÉPP and ÉPD amounts to about 100 ohms, which is completely unacceptable for physiologists. Attempts to increase

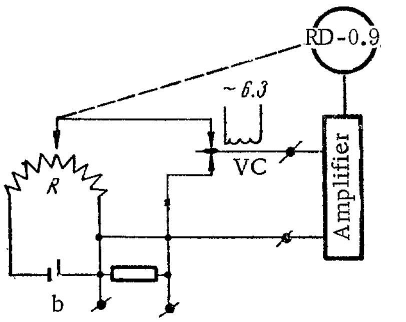

Fig. 1. Simplified comparison circuit. Explanation in text.

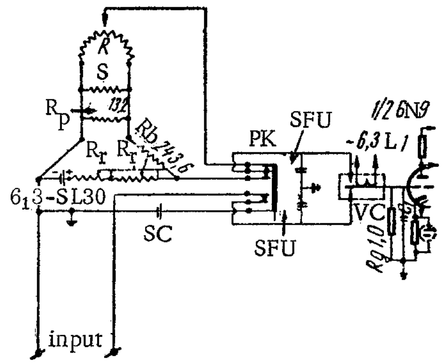

Fig.2. Basic diagram of measuring unit of potentiometer operating by the comparison method.

the input resistance of these instruments by using cathode followers are useless since such a small load (100 ohms) of the cathode follower will hardly permit obtaining an acceptable transmission coefficient, whereas the zero stability of the device markedly drops [1-3].

The most acceptable scheme is that of an automatic comparison of the measured emf with a standard. In this case, the input resistance is determined mainly by the resistance of the amplifier input.

The operation of the scheme reduces to the following. To the input of the amplifier (Fig. 1) controlling the direction of motion of the reversing motor is alternately fed by vibrating-reed converter, first the measured emf then the voltage from the slide wire R, which here acts as a divider of the voltage taken off the source of the standard emf. Depending on the predominance of one of the emf the motor drags the contact of the slide wire to a position corresponding to a balance between the compared voltages.

Figure 2 shows a part of the circuit of the modified plant potentiometer (the designations are the same as in the technical descriptions of the ÉPP and ÉPD potentiometers). Variable resistors R_r and R_r', which previously served to establish the working current, are now used to establish the total voltage drop at the slide wire with shunts and resistor R_b, which is equal to the voltage of the standard cell ÉN, which occurs when switching the movable group of contacts of the mechanical relay PK to the lower position in the circuit. The measurement limit of the instrument depends on the reduced resistance of the slide wire R with shunts R_s and R_p, and can be calculated from the simple relationship

$$\frac{R_b + R_{re}}{R_{re}} = \frac{V_{sc}}{V},$$

where R_{re} is the reduced resistance of the slide wire; V_{sc} is the emf of the standard cell (in mV); V is the maximal measureable voltage (in mV).

A measurement range from 0 to 40 mV is selected for the circuit.

By means of the described device built on the basis of the ÉPP-0.9-M1, we recorded the metabolic potentials of plants, the injury potentials of frog skeletal muscles, electrotonic potentials, and other slow processes. In all measurements the error in recording on the diagram tape did not exceed ±1% of the instrument measurement range. The input resistance was 1 mΩ, which is close to the value of R_d. The remaining technical data did not differ from the characteristics of the ÉPP-0.9-M1.

In multi-point potentiometers the number of simultaneously recorded magnitudes can reach 24 with a recording time up to 3 weeks. The connection of an electrometric cascade at the input of the comparison circuit permits using the instrument with microelectrodes. The easy changes in the circuit enable one to use Soviet electronic automatic potentiometers in various electrophysiological experiments where long recording of slowly changing processes is needed. The use of multi-point potentiometers provides simultaneous recording of several values.

LITERATURE CITED

1. I. Breido, Radio, 1 (1959), p. 21.
2. I. Breido, Radio, 2 (1959), p. 48.
3. Yu. I. Gribanov, Change of Voltage in High Resistance Circuits [in Russian], Moscow-Leningrad (1961).