A DECATRON INDICATOR FOR A MICROMANIPULATOR POWERED BY A STEP MOTOR

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An account is given of a four-digit decimal reversive computer-indicator which can be used as a coordinate indicator for the insertion of electrodes into the brain tissue.

Step motors are nowadays widely used in physiological research. They can be used in the construction of micromanipulators [1] and follow-up systems for stabilizing the parameters of hydraulic devices. In the operation of these instruments it is frequently necessary to obtain information on the position of the operating part responsible for the to-and-fro motion. The most suitable way of directly monitoring the position of the operating part is by the use of mechanical indicators, but electronic indicators are better for remote control.

This paper describes a four-digit reversive decimal computer-indicator which has been used as a remote-control coordinate indicator for the insertion of electrodes into brain tissue by means of a micromanipulator powered by a step motor. No such instruments are yet manufactured in the Soviet Union, and types of reversive computers suggested by writers in other countries [2] require the use of special decatrons. In the circuit described below standard two-pulse decatrons are used.

To obtain a multidigit reversive computer-indicator the basic principles of work of a micromanipulator powered by a step motor were taken into account. The first of these is concerned with the instructions to change the direction of movement, which are given consecutively. In the case of manual and semiautomatic control the instruction to change direction usually occurs after a relatively long time interval (not less than one tenth of a second). The interval is measured in milliseconds only in automatic control systems (automatic "search" for neurons [3]). The possibility of a change in the transmission factor of rotary movement of the step motor in the to-and-fro movement of the microelectrode holder also was taken into consideration.

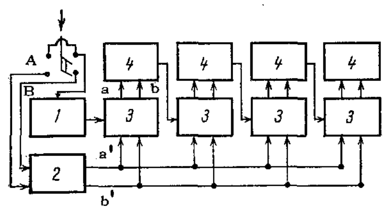

Fig. 1. Block diagram of four-digit reversive computer-indicator: 1) scale unit; 2) trigger; 3) control system; 4) decatrons: a and b) inputs of "Addition" and "Subtraction" decatrons; a' and b') bus bars of "Addition" and "Subtraction" trigger.

A block diagram of the digital coordinate indicator is shown in Fig. 1. It incorporates a digital indicator panel, control units for the decatrons, a scale unit, and a trigger for converting the system from forward to reverse counting and vice versa. A scale unit is required because the depth of insertion of the electrode during one step depends on the type of step motor used and on the transmission factor of the mechanical system.

The operation of the circuit is a combination of the following stages. The "forward motion" pulse from the step motor control generator reaches the input of the scale unit, which fills it with two, three, or four pulses depending on the tuning. Meanwhile the input signal

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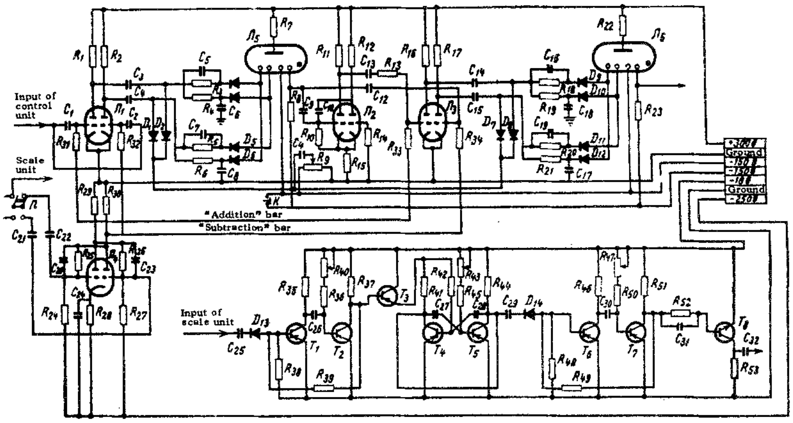

Fig. 2. Theoretical circuit of trigger, scale unit, and two cascades of the reversive computer. Tubes: L_1, L_3) 6N3P; L_2) 6N2P; L_4) 6N15P; L_5, L_6) OG-4. Crystal triodes: T_1-T_3, T_6, T_7) MP16B; T_4, T_5) P402; T_8) MP11A. Crystal diodes: D_1-D_{12}) D226B; D_{13}, D_{14}) D2E. Resistors: R_{15}) 200 Ω; R_{13}, R_{36}) 1 kΩ; R_{41}, R_{50}) 2 kΩ; R_{44}) 2.7 kΩ; R_{35}) 4.7 kΩ; R_{37}, R_{46}, R_{51}, R_{53}) 5.1 kΩ; R_{28}) 7.7 kΩ; R_{11}, R_{38}, R_{45}, R_{48}) 10 kΩ; R_{49}) 20 kΩ; R_{39}) 24 kΩ; R_1, R_2, R_{16}, R_{17}) 30 kΩ; R_{29}, R_{30}) 33 kΩ; R_3, R_6, R_{12}, R_{18}-R_{21}) 51 kΩ; R_8, R_{23}) 62 kΩ; R_{40}, R_{42}) 68 kΩ; R_{24}, R_{27}) 110 kΩ; R_9, R_{43}, R_{47}) 120 kΩ; R_{52}) 130 kΩ; R_{10}, R_{14}) 220 kΩ; R_{25}, R_{26}, R_{31}, R_{34}) 510 kΩ; R_7, R_{22}) 750 kΩ. Capacitors: C_{20}, C_{23}) 50 pF; C_6, C_8, C_{17}, C_{18}) 240 pF; C_{10}) 820 pF; C_1, C_2, C_5, C_7, C_9, C_{12}, C_{13}, C_{16}, C_{19}, C_{21}, C_{22}, C_{25}, C_{28}, C_{31}, C_{32}) 1000 pF; C_{27}, C_{29}) 0.01 μF; C_3, C_4, C_{14}, C_{15}, C_{26}, C_{30}) 0.025 μF; C_{24}) 0.1 μF; C_{11}) 1 μF. S) Change-over switch; K) resetting knob.

Some of the following Russian abbreviations may be found in the figure: Л = tube, Д = diode, Тр = transformer, Др or др = choke, Вк = switch, в = V, М = MΩ, к = kΩ, мк = μF or μH, н = pF or pH, and н = nF or nH.

reaches one of the inputs of the trigger and converts it into a state such that a voltage of −15 V is applied to the "Addition" bar and a voltage of −110 V to the "Subtraction" bar. The left half of the tube L_1 is opened and the right half is closed. Pulses from the output of the scale unit are led to the control unit, and then to the input of the "Addition" decatron. On the arrival of the "reverse motion" pulse at the input of the scale unit and, simultaneously, at one of the inputs of the trigger a voltage of −110 V is applied to the "Addition" bar and a voltage of −15 V to the "Subtraction" bar. In that case, the pulse from the control unit is led to the input of the "Subtraction" decatron.

The theoretical circuit of the trigger, scale unit, and two cascades of the reversive computer is shown in Fig. 2. The scale unit incorporates a driven multivibrator which forms a pulse of specified duration and converts the operation of the subsequent multivibrator into self-oscillating, stopping at the time when the pulse from the driven multivibrator ends. The input pulse is then filled with the specified number of pulses of shorter duration, which are led to the input of the second driven multivibrator, and from it through a phase-inversion cascade to the control system of the decatron. By means of the second driven multivibrator the duration of the leading edges of the pulses reaching the control unit can be calibrated and their steepness increased.

By contrast with existing decatron control systems [4], the control system used in the present instrument contains a driven multivibrator allowing a simple solution of the reversal problem. Under "forward motion" conditions, if the discharge is transferred from the indicator cathode 9 to cathode 0 the positive pulse is removed from the latter and is led directly to the input of the amplifier. Under reverse counting conditions the positive pulse must reach the input of the second amplifier during departure of the gas discharge from cathode 0. In that case, however, the negative pulse is taken from it. Inversion of this pulse is carried out by the driver multivibrator.

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