AN INSTRUMENT FOR QUANTITATIVE ANALYSIS OF TOTAL PULSED ACTIVITY

O. N. Serova and K. V. Golubtsov

UDC 612.822.3-087.5

The scheme and principle of operation are given of an instrument which analyzes the total electrical activity of nerves and which works on the frequency meter principle; the instrument incorporates integral elements, its circuit is simple, and its characteristics linear.

KEY WORDS: *frequency meter, pulsed activity.*

For certain electrophysiological purposes it is essential to be able to analyze the total electrical activity of nerves consisting of many fibers innervating a particular sensory organ. During adequate stimulation of various sensory organs visual quantitative analysis of this activity may be very difficult, mainly because of the relatively high frequency of discharge (200 impulses/sec or more). Furthermore, during the study of total nervous activity difficulties of detection of the impulses may arise because the amplitude of the recorded signal may be only a little greater than the noise level of an amplifier of the UBP type that is used (about 10 μV with a load of 100 kΩ). Under these circumstances, partial short-circuiting of the nerve trunk by drops of tissue fluid or incomplete removal of the membrane of the nerve trunk in a mammal (which is sometimes difficult to verify because of the nature of the operation), and also aging of the preparation may reduce the amplitude of the spikes and so reduce the signal to noise ratio even more.

To solve this problem it is possible to use pulse converters, whereby the parameters of total pulsed activity can be investigated. These converters include integrating systems, nowadays widely used both outside and inside the USSR, in particular for the analysis of total activity of taste receptors, recorded from chemosensory nerves of vertebrates [1, 2].

The instrument suggested works by the frequency meter principle and enables pulsed activity with an amplitude of 3-5 μV above the noise level to be integrated by frequency and its quantitative characteristics to be supplied in the form of an integrative curve or specially shaped pulses. The use of this principle avoids distortions which arise when instruments integrating impulses by frequency and amplitude simultaneously are used, with the possible introduction of uncontrollable changes in the amplitude of the pulses recorded in the course of the experiments. The useful signal is cut off by means of a Schmidt trigger. The increase in frequency in response to stimulation of receptors is converted into a vertical deflection of the oscilloscope beam. A record of this process on film taken by the photographic recorder and consisting of an integrative curve is shown in Fig. 1A, which also shows a record of the original spike activity. The afferent activity of the chorda tympani of a cat in response to irrigation of the tongue with an acid solution is shown in the same figure. A definite advantage of this type of analysis is that changes in the amplitude of the response in time can be examined, i.e., parameters such as the latent period, the rate of rise of the response, the time taken to reach a maximum, and the transition from the maximum to the "plateau" and to adaptation can be investigated. One property of this instrument is its reactivity, whereby rapidly developing processes such as the response of tactile phase receptors can be investigated (Fig. 1C).

The instrument is also equipped with a calculator with coefficients of between 2 and 64, by means of which the absolute frequency of the discharge can be determined at any moment of time. Responses of taste and phasic tactile receptors of the frog tongue, obtained by the use of a scaler, are shown in Fig. 1B and C (right).

P. K. Anokhin Institute of Normal Physiology, Academy of Medical Sciences of the USSR. Institute for Problems in Information Transmission, Academy of Sciences of the USSR, Moscow. (Presented by Academician of the Academy of Medical Sciences of the USSR V. V. Zakusov.)
Translated from Byulleten' Eksperimental'noi Biologii i Meditsiny, Vol. 85, No. 5, pp. 631-632, May, 1978. Original article submitted July 22, 1977.

 0007-4888/78/8505-0694$07.50

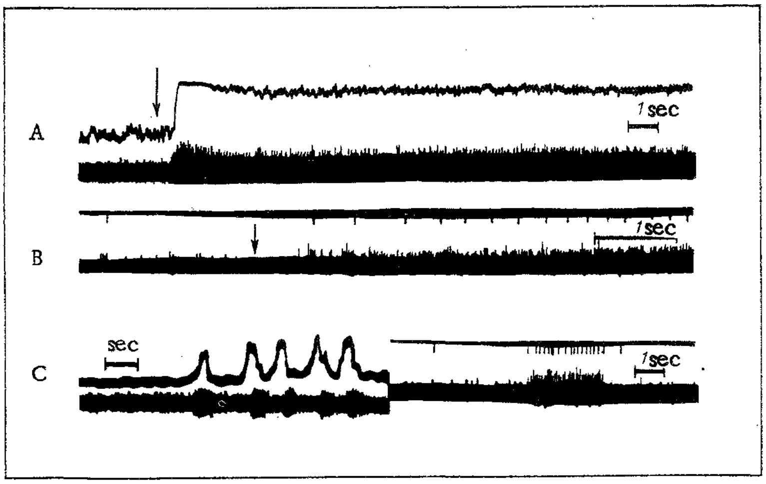

Fig. 1. Response of taste and tactile receptors of tongue to adequate stimulation. A) Record of afferent activity of chorda tympani of cat in response to irrigation of tongue with 3% solution of critric acid; B) the same as in A, recording from glossopharyngeal nerve of frog in response to irrigation with 5% NaCl solution; C) records of responses of phasic mechanoreceptors of frog tongue to stimulation with a glass rod. In all records: top beam) pulsed activity integrated by frequency, bottom beam) action potentials; integrative curve used in A and C (left), calculator in B and C (right).

In the experiments to be described a two-channel Medikor myograph was used as the recorder and the instrument was made as an interchangeable unit to replace the second amplifier unit of the myograph. The suggested instrument can also be used with cathode-ray oscilloscopes of the SI-19 and SI-17 types.

The instrument works as follows (Fig. 2). The signal from the first channel of the Medikor amplifier is led to the input of the operational amplifier (1), from which it passes to the Schmidt trigger (3). The pulse of positive polarity shaped by the trigger is led to the phase-inverter (4), and the phase-inverted pulse of negative polarity triggers the triggered multivibrator (5). The multivibrator shapes pulses with a duration of 100 μsec and pulses of positive polarity are led to integrator incorporating an operational amplifier (6), whereas pulses of negative polarity are led to a scaler circuit incorporating K1LB553 microcircuits and K1TK552 D-triggers (7-11). The coefficient of conversion is selected by means of the Key 2. The signal from the scaler is led to the phase inverter (12), from which it proceeds to the driven multivibrator (13), which gives out pulses with an amplitude of 3 V and a duration of 2 msec. Cutting off is carried out by the resistor R_1 by means of a smooth change in the amplification factor of the operational amplifier, and also by the resistor R_4

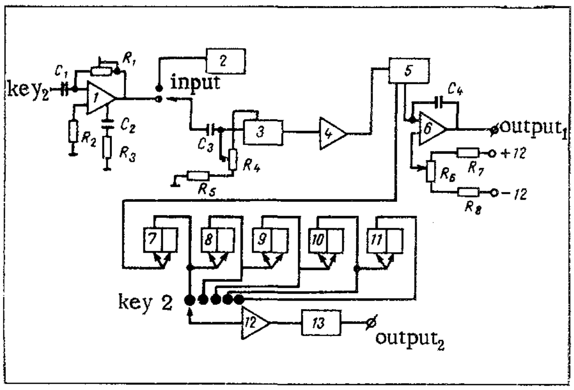

Fig. 2. Block diagram of instrument. 1) Operational amplifier U1401B; 2) self-oscillating multivibrator 2GF181; 3) Schmidt trigger KTSh221G; 4, 12) positive impulse inverter 2LN181; 5, 13) driven multivibrator 2GF182; 6) operational amplifier K1UT-401B; 7, 11) scaling triggers (see text); 12) positive impulse inverter 2LN181.

of the input circuit of the trigger. To check the work, a pulsed generator (2) is provided in the circuit. Linearity of the integrating amplifier is ensured by the resistor R_6 and the circuit is linear to 500 pulses/sec. The time constant is chosen by selecting the capacitor C_4.

An advantage of the instrument is the simplicity of its circuit and the possibility of studying the dynamics of processes under investigation on an oscilloscope screen without the use of expensive computers.

LITERATURE CITED

1. M. V. Kozlova, Fiziol. Zh. SSSR, No. 1, 76 (1975).
2. L. Beidler, J. Neurophysiol., 16, 595 (1953).

AN ELECTRONIC DEVICE FOR DETERMINING MOTOR ACTIVITY

Yu. N. Liseichikov and A. S. Zakharevskii

UDC 612.76-087.5:621.3.038

A brief account and the theoretical circuit are given of an electronic device for determining the motor activity of laboratory animals. The device is based on the principle of recording changes in capacitance arising in animals during motion.

Several devices exist for recording the motor activity of laboratory animals: mechanical, electromechanical, photoelectric, telemetric, etc. However, most of them have disadvantages and they are not produced on a large scale in the USSR, although there is a need for instruments of this type.

An actograph, based on the principle of recording changes in capacitance arising in animals during motion, has been designed, built, and tested for a long period successfully for determination of the motor activity of small laboratory animals in the Central Research Laboratory of Minsk Medical Institute. The theoretical circuit of one of the possible alternative forms of the instrument is shown in Fig. 1.

The actograph consists of capacitance grid transducer (Fig. 2), connected to a device converting changes in capacitance into electric pulses, consisting of a two-stroke balanced generator with load resistance at the tube anodes of the order of 20-100 kΩ. The output of the converter is led through a differential circuit with a filter and through a microcurrent amplifier, the load resistance at the anode of which is 15 MΩ, connected with a cathode follower. A voltage divider, connected to the cathode follower, has at its midpoint an output for connection to the recorder, such as the SB1M electromechanical counter. It is also possible to record a certain total number of pulses (1000-10,000) on continuously moving squared paper followed by simple determination of the total motor activity of the animal over any given period of time.

During the experiment the animals are kept in a special transparent plastic cage, differing little in shape and size from the cages in which they are normally kept. The cage is placed on the capacitance grid transducer.

Trials showed that the motor activity of albino mice (individual animals) during the day time in an air temperature of 20-22°C was equivalent to 70-80 pulses of the electromagnetic counter over a period of 1 min and 600-700 pulses over a period of 10 min. Repeated measurements over a long period of time confirmed the precision and stability of operation of the instrument.

The suggested actograph is thus sufficiently sensitive to record movements of small laboratory animals, but at the same time it is resistant to high-frequency interference and to

Central Research Laboratory, Minsk Medical Institute. (Presented by Academician of the Academy of Medical Sciences of the USSR V. V. Zakusov.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 85, No. 5, pp. 633-634, May, 1978. Original article submitted September 9, 1977.

0007-4888/78/8505-0696$07.50