AN APPARATUS FOR MEASURING THE ELECTRICAL ACTIVITY OF MUSCLES

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The choice of a quantitative criterion for evaluation of electromyograms is a difficult problem. We consider that a promising method for this purpose is to use an index representing the sum of the amplitudes of all impulses during a given time interval. A value close to this is given by the length of the curve, obtained by measurement of the myograms with a curvimeter. This method, however, is little used because of its laboriousness and low accuracy.

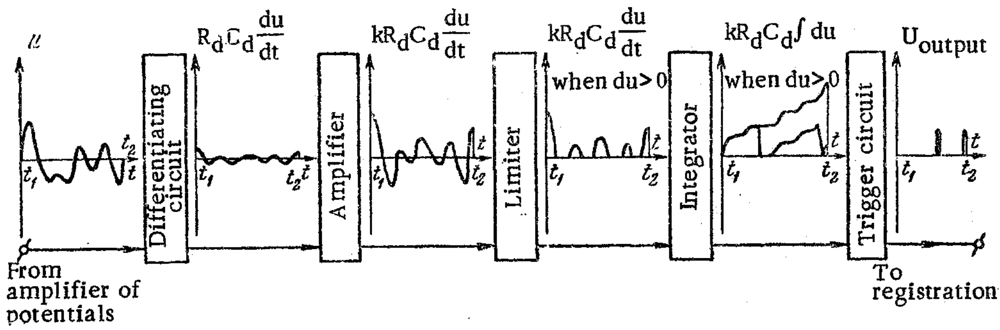

Fig. 1. Block diagram of the SA-1 apparatus and curves of the voltages on its elements.

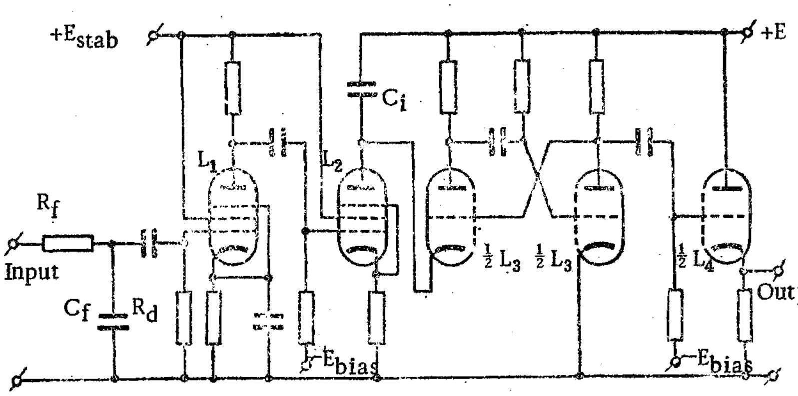

Fig. 2. Diagram showing the principle of the SA-1 apparatus.

In the method of measuring the electrical activity of muscles which we suggest, amplified potentials are fed into an apparatus for summing the amplitudes of all the impulses. The result for a given time of measurement is obtained in the form of a number of volts corresponding to the sum of the amplitudes of all the impulses occurring during this time, $-\sum_{t_1}^{t_2} U_{max}$. We shall consider that the appearance of the impulse coincides with the extreme point of the curve of the myogram, and that its amplitude U_{max} is the positive increment from the extreme point to zero or to the next extreme point.

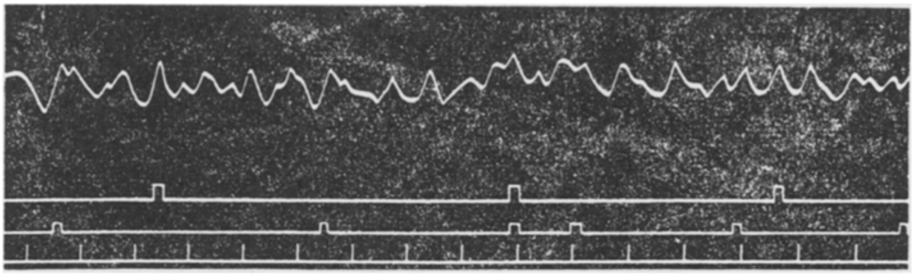

Fig. 3. Example of measurement of the electrical activity of muscles by means of the SA-1 apparatus. Significance of the curves (from above down): electromyogram of the right biceps brachii muscle when carrying a load of 5 kg with the upper limb flexed at the elbow to 90°; electrical activity of the same muscle recorded with the SA-1 apparatus (distance between impulses corresponds to the sum of the amplitudes of the impulses of the myogram reaching 20 V); electrical activity of the same muscle recorded by an integrator (distance between impulses corresponds to $15 \cdot 10^{-3}$ in 1 sec); time marker (20 msec).

The following mathematical operations are carried out in the apparatus: The initial function is differentiated and increased by a factor k. The resulting value $kR_gC_d(du/dt)$ is limited below; we assign a region of existence in this way to du. If this condition holds, the integration of du within the limits of the duration of each impulse gives the sum of the positive increments within the given limits, i.e., the amplitude of this impulse, and integration within the limits of the duration of a few impulses gives the sum of the amplitudes of these impulses (Fig. 1).

In our variant (Fig. 2), the apparatus consists of a differentiating circuit R_dC_dm, an amplifying cascade on L_1, an integrator L_2 with a reservoir capacitor C_i, an auxiliary trigger circuit on L_3, and an output cascade on $\frac{1}{2}L_4$. The differentiating circuit is preceded by a filter R_fC_f with a transmission band corresponding to the form of the potentials; limitation of kRC(du/dt) is created by the system L_2.

The voltage on the capacitance integrator will be determined by the following expression:

$$U_{C_i} = kR_d C_d \frac{S'}{Cu} \int_{t_1}^{t_2} dU \text{ when } dU > 0,$$

where k is the general coefficient of amplification of the cascades on L_2; R_dC_d is the time constant of the differentiating circuit; S' is the composite slope; C_i is the capacitance of the integrator; $(t_2 - t_1)$ are the time limits of the measurement.

This capacitance is discharged through $\frac{1}{2}L_3$ whenever the voltage on it is changed by the amount ΔU (when it operates the trigger system on L_3). The number of these operations is recorded by a counter or writing device. The sum of the amplitudes of the incoming impulses for one operation amounts to $C_i \frac{\Delta U}{kR_dC_dS'}$, and is the value of one division of the counter. The sum of the amplitudes during the time of measurement is given by the product of the value of a division and the reading on the counter.

The apparatus has been tested in the physiological laboratory of the Orthopedic Hospital (Fig. 3).

The readings of the apparatus when voltages from displacement detectors are fed into its input represent the path taken by the moving point, obeying any law in relation to one coordinate and returning to the original point, i.e., the apparatus may be used as an ergometer, to record the intensity of a tremor, etc.

SUMMARY

It is suggested that the sum of amplitudes for the given length of time may be used as a numerical characteristic of the myogram. An electronic instrument, summing up the amplitudes by the principle of integration of positive increments of the myogram curve, is described. An ink recorder or a counter is used for recording.

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