NEW METHODS

INTEGRATION OF BRAIN AND MUSCLE BIOPOTENTIALS

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Biopotentials are considered in modern electrophysiological research to be among the basic indicators of the functional state of living tissues. These researches are conducted with the aid of various types of amplifiers and oscillographic apparatus. The oscillograms permit of the qualitative characterization of brain and muscle biopotentials.

The difficulties of interpretation of electromyograms and electroencephalograms are almost identical. These difficulties are a result of the action potentials not representing directly monophasic effects from the living tissue, but of them being the resultant of interference by relaxational discharges proceeding in individual cells.

A study of the early publications of N. E. Vvedenskii shows convincingly that modern electromyography has added little to the telephonic registration results of this great scientist. Not only did he assess the summary sonic effect due to muscle or nerve biopotentials, but he also differentiated these effects, which actually represented integrals of the energetic effects arising within the tissue as a result of stimulatory or inhibitory processes.

A. A. Ukhtomskii wrote, in his paper "On the Condition of Excitation in the Dominant" [1] that a measure of the reaction of living matter in electrophysiological research is afforded by the summation of the area of action potentials over a given time interval.

Electromyograms and electroencephalograms should in the first place be evaluated planimetrically; this is not done by biologists because this method is exceedingly laborious.

We have worked out a method for automatic integration of bioelectric potentials in time, in the form of the expression:

$$P = \Sigma \int_0^t U dt.$$

P represents the sum of the amplitudes of all biopotentials acting for very short periods over the time of observation [2].

Our equipment consists of a two-channel electronic amplifier with successive rectification and integration of the biopotentials in both channels. The amplifying sections along the first and the second channel are symmetrical amplifying paths, the separate stages of which are connected by a resistance-capacity method. Four stages are used for amplifying potentials. This preliminary amplification will ensure, at an input strength of signal to the amplifier of 5-10 μv, a powerful discharge from the 6P3 tubes.

The detector unit in each channel is a Graetz assembly, using kenotrons of type 6Kh6 (it might be more convenient in some cases to use kenotrons of small internal resistance, such as type 30Ts6-S). The electronic

circuits chosen assure satisfactory linearity over the whole installation, including the detector units.

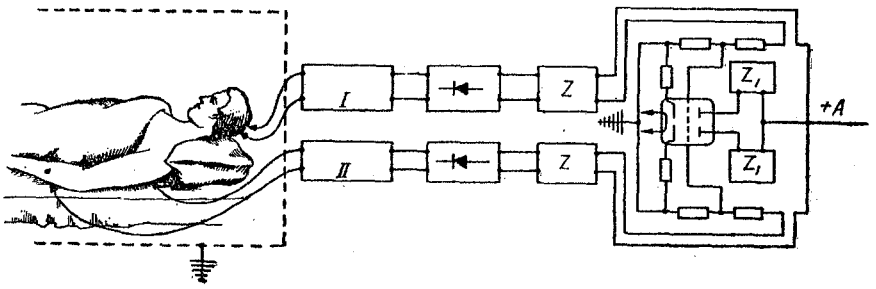

Fig. 1. Two-channel integrator (schematic representation). I) II) amplifiers.

After amplification and rectification, the biopotentials enter the armature coils of the magnetoelectric ampere-hour meters (Z). Since in practice the time of integration is from 5 to 60 minutes, the decimal counter mechanism is not discriminatory enough. This necessitated the reconstruction of the counting device, which registers the number of revolutions of the armature.

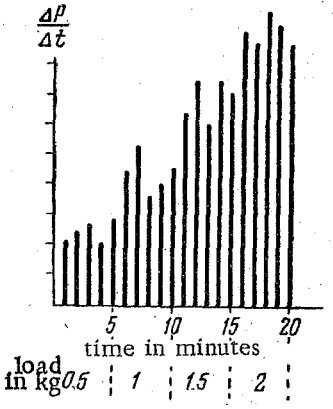

Fig. 2. Dynamics of the excitation process in muscle, in static work with a variable load. P) energy of the summated bioelectric effect during 5 minutes.

The modification in design of the counter consisted in attaching to the spindle a second "collector" device, which closes two auxiliary switches at each revolution. Each revolution of the armature would thus close the curcuit twice, by the agency of the attachment. This circuit controls the grid of a 6N8 tube emitting an anode current pulse. The anode current of the 6N8 tube activatesthe magnetoelectric decimal counter. Every revolution of the counters Z of the first and second channels gave two separate coordinated activations of the pulse counters Z_1. The whole circuit along the two channels is so adjusted that input to the amplifiers of a potential of sinusoidal form, of frequency 10 Hz and voltage 50μv , gave 50 pulses per minute. This setting is relative, and may differ for different equipments, inasmuch as quantitative relationships between bioelectric reactions may be expressed as percentages.

Brain and muscle biopotentials were measured in a screened chamber, using a two-channel integrator represented schematically in Fig. 1.

We used circular plate electrodes (diameter 10 cm) coated with silver chloride for the study of muscle biopotentials. The electrodes were wrapped in filter paper soaked in 5% sodium chloride, and were fixed to the arm by a rubber binder and connected to the amplifier.

Fig. 2 illustrates development of the process of stimulation of the arm muscles of a healthy man performing static work against variable loads.

In the study of the complex motor activity of muscle groups or of hyperkinesis we applied two strip electrodes to the arm and forearm, not fully encircling the limb. In both cases we measured the energetic effect, which is in the usual electromyogram expressed by the areas of all the consecutive bioelectric pulses over a given interval of time. The recordings of the integrator, expressed as arbitrary energetic units, are a measure of the intensity of processes of stimulation in the muscles, and of their variation in time.

In the study of hyperkinesis (when there was a whole complex of muscles between the electrodes) we measured the summated bioelectric effect, which is the resultant of the biopotentials of the individual muscle fibers and of groups of flexor and extensor muscles. The effect registered by the integrator over a given time interval is in this case a measure of the intensity of hyperkinesis. Since hyperkinesis depends on the state of the cortex, we thought it advisable to make use of reaction tests with closed eyes and with light stimulation.

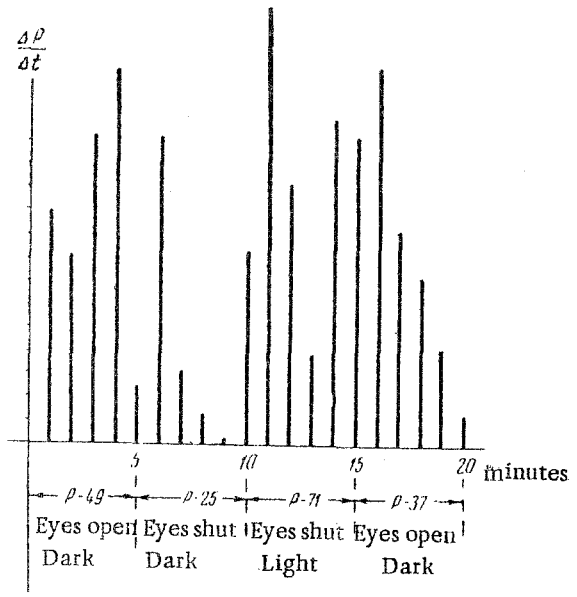

Fig. 3. Study of hyperkinesis (athetosis).

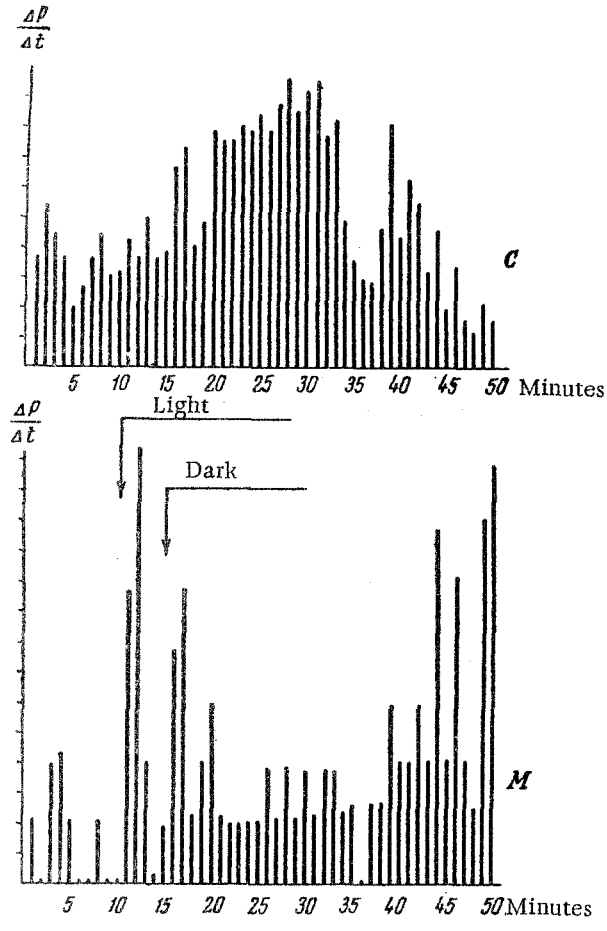

Fig. 4. Dynamics of cortical excitatory processes (C – occipital region) and of excitatory processes in the arm muscles (M), registered synchronously by the integrator.

We present the results of some investigations of hyperkinesis, performed jointly with N. G. Krol. Fig. 3 shows variants of bioelectric effects in the arm muscles of an athetotic patient according to whether the visual center is stimulated or inhibited.

Certain complications may arise in the use of the two-channel integrator (with which synchronous bioelectric activities of the brain and of muscles are contrasted), due to head movements of athetotic patients. Reliable results are obtainable when only the limbs are affected, leaving the head free of the condition. We were able to get quite satisfactory results, by appropriate selection of patients with only moderate athetosis.

For these experiments we placed two electrodes at the occipital protuberance area, and two strip electrodes on the arm affected by the condition. The patient was placed in a darkened screened chamber, so as to reduce the incidence of external stimuli to a minimum. Readings of the counters of both channels were made every minute over 30 minutes or more. These readings are represented as the ordinates $\Delta P/\Delta t$, representing the summated bioelectric effect for each minute.

Fig. 4 shows the results obtained from the study of an athetotic patient; it can be seen that as hyperkinesis diminishes, the bioelectric activity of the cortex (occipital lobes) increases. Switching the light on and off caused two "bursts" of hyperkinesis (M), which were barely reflected in the bioelectric activity of the cortex (C).

In other words, during excitation of the motor center (as indicated in our case by the bioelectric activity of the arm muscles-hyperkinesis) we find inhibition of the adjacent cortical area.

We determined the mean values of summated muscle bioelectric effects, in order to arrive at a comparative evaluation of the intensity of hyperkinesis in athetotic patients. The muscle groups affected were connected to our equipment for 20 minutes, and the recordings of the counters were divided by the number of minutes, to give the mean excitation characteristics.

Since attacks of hyperkinesis are aperiodic processes, it is possible at this stage of the disease to evaluate its intensity only in terms of mean values. This feature of hyperkinesis makes it pointless to apply the electromyographic method; the only acceptable and accurate method of following the development of the condition is the integrative method.

LITERATURE CITED

[1] A. A. Ukhtomskii, Collected Works, (1950) Vol. I.

[2] G. A. Shminke, Bull. Exptl. Biol. Med., 37, 6, 65-68, (1954); 38, 11, 71-73.