

SELF-TUNED BIOLOGICALLY CONTROLLED TRAINING DEVICE

MAKSIMENKO, L.A.
Institute of Physical Culture
Krasnodar
USSR

Training devices with automatic dosage of physical load are commonly used in sports. They employ as a signal source biological activity of athlete's organs that control the value of the load, the activity being detected by electrodes. Bicycle trainers with load regime dosage that account for the activity of the cardiovascular system are used in particular to select the optimum mode of heart operation. Deviations in intervals between pulses from the specified values automatically change the load value. This allows for a long-term optimum operation of the cardiovascular system.

The athlete's nervous centers are also highly sensitive towards developing fatigue. The onset of the fatigue can be detected by a decrease in the pulse activity that influences the skeletal muscles. The process of becoming tired is accompanied by a decrease in the bioelectrical activity of both the brain and the spinal cord. An excessive fall in motor command levels due to the increase in nervous center fatigue can be prevented by means of reducing the training load. In other words, in order to automatically change the physical load during training one should take into account the degree of fatigue from the athlete's brain neuron structure.

This paper examines a set of electromagnetic devices designed for training at a specified level of the fatigue of the nervous system. The depression of the spinal cord nervous centers is determined by a degree of reduction in the reflexory T-potentials amplitude. The device used for this purpose sends a control signal from its output to the braking system electromagnetic unit. In the state of tiredness, as reflected by the T-potentials amplitude, the magnetic field strength is reduced, the braking device falls respectively and so does the load acting on the connecting rod.

The reflexory T-potentials are formed due to tendon stretching at the moment of short-term action of the striking mechanism (Fig.1). Action potentials via the brain stem come to the spinal cord where they are transformed by the presynaptic and postsynaptic inhibition mechanisms and directed towards the skeletal muscles as motive commands. Training on a bicycle ergometer causes fatigue followed by a reduction in the motive signals due to high sensitivity of the spinal cord nervous centers.

When the bicycle ergometer redals are rotated a permanent magnet comes close to an electromagnetic transducer forming a triggering pulse at its output. Programme assignment unit forms a pulse sequence that corresponds to the assigned rpm of the connecting rod (e.g., 1, 51, 101, 151, etc). This is the sequence of a striking action aimed at athlete's tendon (Fig.1). The pedalling range for delivering a short-term low intensity striking action is given by the delay value. Adjustment of the delay time of the delay unit makes it possible to deliver the blow at the beginning of pedals movement up from the lower dead center. At this moment pure T-potential can be recorded, unmasked by the calf muscle action currents.

The athlete rotates pedals with a regular assigned speed controlled by a speedometer placed on the bicycle ergometer handle-bars. A signal comes from the pulse stretcher output through the switching relay to a high speed recorder that is put on before a blow is delivered on the tendon. The delay occurs in the electronic delay line unit. The recorder chart gains the required speed due to the prior switching on of the recorder. At the moment of recording the action potential is recorded on an enlarged scale due to the increased recorder chart speed. Pulse switching mode saves the recorder chart by stopping the recorder when there are no pulses.

When a slight short-term blow is delivered on the achilles tendon a reflexory T-potential appears on the A, B and C pickup electrodes which is subsequently amplified and fed to the recorder (Fig.1).

The physical load dosage based on the brain bioelectrical activity is done against the changing Ω - potential values. A slowly changing potential is recorded by the recorder's second channel simultaneously with the spinal cord action potentials. The bioelectrical activities of the brain and the spinal cord are analog and discrete respectively. The T-potential is an induced reflexory potential while the Ω - potential is a background one and reflects the integral activity of the cortex.

The best way of fixing the pickup electrode is to connect it vertically to the temple area of the athlete working on the ergometer. The detection of the analog signal dictates the need of using a nonpolarizing electrode made of chlorine and silver. Its glass body is filled with saturated potassium chloride solution. The electrode touches the lobe of the ear where many biologically active points are located. The contact is made more reliable by use of special electrode paste. The indifferent electrode is fixed to a bracket of the

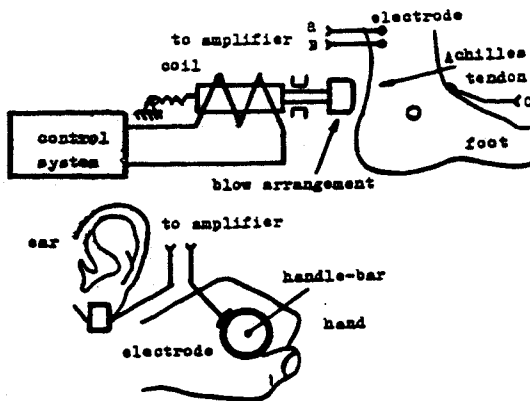


Figure 1: The register scheme of the potential reflex of the spinal cord (high) and a potential of the brain.

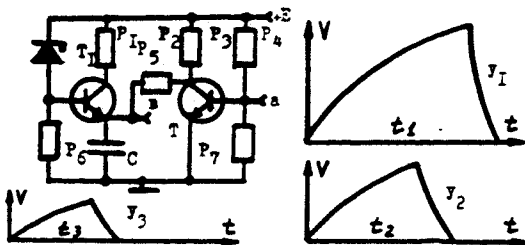


Figure 2: The discharge scheme of the capacity C from pulse electromagnetic transducer and influence illustration of between-impulses periodogram.

handle-bars. The contact of the glass indifferent chloride and silver electrode with the back of athlete's pala is also enhanced by the electrode paste. A cloth pad is interposed between the tip of the electrode and athlete's pala. Glass electrodes may be replaced by dry ones, however these must be chlorinated regularly (Fig.1).

The trainer has three operating modes. In the fatigue detection mode no electronic load control is used. In this mode the amplitude of the T- and Ω - potentials is recorded on a high speed large-format recorder. This is done according to a program assigned by the program assignment unit. Usually the action potential amplitude is recorded and the fatigue ratio K is determined after every 50 revolutions of the connecting rod. For this purpose the device gain factor is adjusted so that the recorder pen is set to "100" on the recorder chart. As the fatigue grows the action potential amplitude is reduced. The fatigue ratio is determined by dividing 100 by the value of pen deflection after a certain number of revolutions. For example, if at the moment of measurements the deflection was 85 divisions of the recorder chart the fatigue ratio is

$$K_f = \frac{100}{85} \approx 1.17$$

Similarly the endurance of other athletes can be determined. If, for instance, another athlete shows the nervous centers fatigue ratio of $K_f = 1.28$ one can conclude that his endurance is 9% less than that of the first one.

Now consider the operation of the training device in the training mode. To control the training process both signals are applied to a summator. The T-potential is integrated first. From the summator output the control signal in the analog form is applied to the ergometer load control unit. If its voltage falls as the fatigue grows the load at the connecting rod falls respectively. Load reduction makes it possible to maintain the athlete's nervous centers at a definite functional level and thus extend the training effect. Thus, the ergometer load is reduced depending on the functional state of athlete's nervous centers.

One of the goals of the biologically controlled training machine is to extend the training process and conduct it in the optimum mode, thereby preventing the nervous centers from becoming too tired due to overloading. Moreover by reducing the load we can prevent the exhaustion of athlete's nervous centers keeping them off excessive loads. Training is done in such a way as to keep the athlete in good physical form for a long period of time.

The third mode of the training device is the analyser accuracy control mode. The athlete is given a task to pedal with a constant speed. The speedometer is cut off in this mode and the output of the electromagnetic transducer is connected to an interval graphic device which performs the function of the "RPM - pulse voltage" inverted converter (Fig.2). A pulse comes from the transducer to the interval graphic device during pedalling resulting in an output signal with an amplitude conversely proportional to the pedalling frequency. A transistor T is connected to a charge capacitor C (Fig. 2). If a pulse comes from the electromagnetic transducer to the transistor base T within a time t_1 , then the voltage of the condenser C will fall from the value of V_1 to zero (Fig.2a). If the pulse comes to the system input a bit earlier (t_2) then the condenser C voltage will increase to the value of V_2 (Fig.2b) while if the triggering pulse comes still earlier (t_3), voltage in the condenser C will only increase slightly up to the value of V_3 (Fig.2c). The voltage E of the condenser C is consequently dependent on the intervals between the triggering pulses and this interval is determined by the pedalling frequency.

After gaining the required speed and making 100 revolutions a regular sequence of pulses is formed at the interval graphic device output, a periodogram consisting of 100 pulses (Fig.3a). The load value is pre-assigned on the basis of athlete's individual performance. The lower non-informative part of the periodogram is removed by an adjustable threshold device while the informative part is amplified and displayed on a high speed large-scale recorder (Fig.3b). A decade counter and a commutator count the connecting rod revolutions and switch on a signalling device after the 100-th revolution. At this moment the athlete stops pedalling and the obtained intervalogram is analyzed.



Figure 3: The illustration is the limitation noninformation part of the periodogram and amplify of the information part.

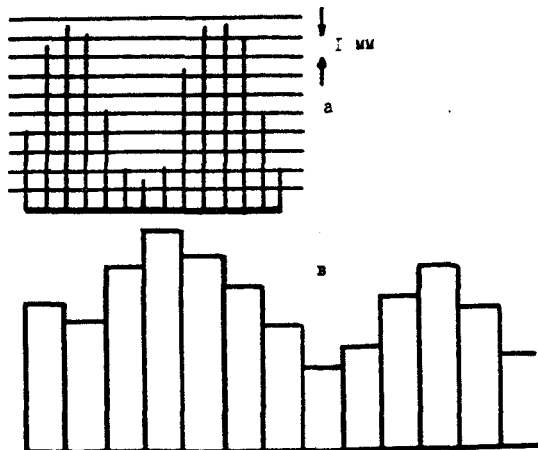


Figure 4: The division of the information part of periodogram on zone (A) and histogram is built on the number of the peaks in zone (B).

The uniformity of pedalling is determined from the informative part of the intervalogram. For this end a histogram is constructed from the intervalogram divided by 1-mm thick horizontal lines (Fig.4). Then a number of pulse peaks are counted within each zone. The height of the histogram rectangular is taken to be equal to the number of peaks. So the form of the histogram is used to evaluate the uniformity of pedalling and determine the degree of the athlete's analyser accuracy.

The recorder's enlarged scale raises counting accuracy by providing a possibility of drawing more horizontal lines as compared to a summed up undivided intervalogram. This leads to a considerable increase in the number of zones and since each zone corresponds to a definite value of interval between the revolutions of the connecting rod, even the slightest changes in these intervals during non-uniform pedalling can be evaluated.

The device described in this paper is designed for use in sports that require high accuracy of the analyser, such as cycling, skiing, rowing, athletics, touring, etc. The above sports are mostly based on the economy of athlete's energy resources, especially when competing on long distances. In this case it is desirable to cover the entire distance at a regular speed avoiding both acceleration and slowing down that require additional energy. Therefore, athlete's speed should be uniform over the entire distance and his analysers should be accurate.

Thus the training device can accurately evaluate the quality of athlete's analysts due to the extended intervalogram range and the use of a large-scale recorder.

So the device suggested in this paper can be used in three operating modes: (A) determining athlete's endurance, (B) determining analyser accuracy and (C) conducting training process.