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TECHNIQUE OF ELECTRICAL STIMULATION OF THE VESTIBULAR  
ANALYZER UNDER CLINICAL CONDITIONS

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During the effect of a direct current on the labyrinth in man and animals vestibular reactions occur. Currently one can consider it to be proved that the direct current anode suppresses the spontaneous activity of the neurons in the vestibular ganglion, while the cathode intensifies it (Ledoux, 1949; S. N. Khechinashvili, 1958). The main method difficulty of electrical stimulation of the vestibular analyzer under clinical conditions consists of the need to transmit through the skin a direct current of fairly great strength (on the order of several milliamperes). In the majority of subjects strong pain sensations appear here in the region of electrode application, which prevents intensification of the current in the limits necessary to elicit sufficiently distinct vestibular reactions: vestibulo-oculomotor and vestibulospinal. /74\*\*

The effect of the irritating influence of the direct current on the extralabyrinth nerve formations can be reduced by two methods: 1) by using electrical stimuli with flat anterior and posterior fronts. The faster the current strength rises and drops, the stronger the irritating effect on the sensitive nerves of the skin; 2) with the help of preliminary anesthesia of the skin in the area of electrode application. Here it is most expedient to administer the anesthetic by electrophoresis.

Taking into account the interest that electrical stimulation of the vestibular analyzer has attracted in recent years (Gabersek and Dobert, 1965; Pfaltz,

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\*\*Numbers in margin indicate pagination in original foreign text.

1968; Breson et al., 1971; Swaar and Oosterveld, 1976), we developed a technique that permits a considerable reduction in the effect from the stimulating influence of the direct current on the extralabyrinth nerve formations.

### Technique of Study

We designed a generator of current pulses for electrical stimulation of the labyrinth that forms current pulses of trapezoid shape with smoothly changing fronts and duration (fig. 1). The instrument consists of a power block (storage battery, 36 V), block of automatics, time relay and current interrupter (fig. 2).

The instrument (see fig.1) operates in two patterns: in the first pattern the interelectrode resistance is calibrated by introducing additional resistance into the measuring circuit; the amount of current does not exceed 80  $\mu$ A. In the second pattern, a working current passes through the measuring circuit; its strength can be smoothly regulated from 0.1 to 10  $\mu$ A. The instrument is switched from one pattern to another with the help of lever 1 and tumbler switch 2 that switches the measuring instrument. The slide of the controllable potentiometer, depending on the assigned program, with the help of a clutch that can be triggered from the electromagnet, is connected to the motor through a reducer or branches off of it. Such design makes it possible to smoothly, linearly, and in broad limits change the fronts of the issued pulse. The use of the clutch that is triggered from the electromagnet reduces to nothing the time lag of the system. The pulse duration changes from 1 to 120 s with the help of the time relay that has a lever of rough (3) and precise (4) adjustment. The introduction of a current interrupter (5) was induced by the need for emergency stopping of the increase in current strength in the measuring circuit. Lever 6 regulates the number of motor turns, which makes it possible to smoothly change the pulse fronts. Tumbler switch 7 changes the polarity of the output voltage. Button 8 starts up the system. With the help of the interrupter, one can instantly stop the increase in current strength at any section of the front with simultaneous preservation of the assigned pulse duration (fig. 3). Force of the current is measured by microammeter (9).

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### Results of Observations and Their Discussion

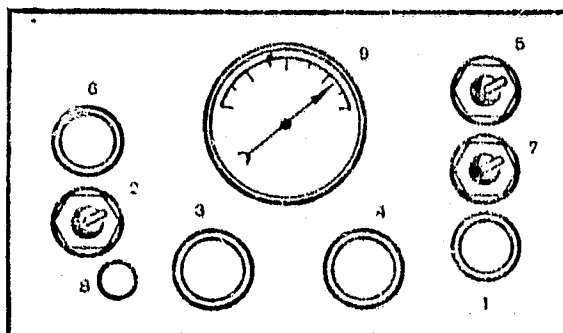


Figure 1. Overall View of Instrument

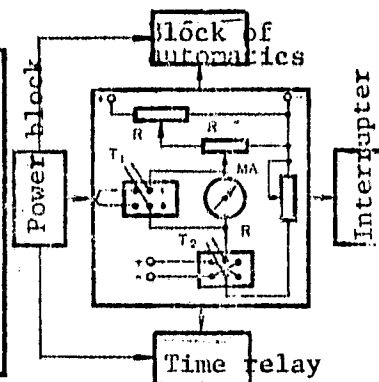


Figure 2. Block Diagram of Instrument

By using the instrument we designed, we expose the subject to the effect of a direct current of increasing strength. After the subject has reported that a painful sensation has developed in the region of electrode application, the increase in current strength is stopped and stimulation is conducted on the level of the pulse "plateau." If necessary, with the help of the same electrodes, in the region of electrode application a solution of novocaine is introduced into the skin by electrophoresis. Figure 4 presents a recording of the galvanic nystagmus.

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We will present an entry from the log.

Subject I., 32 years old, with normal hearing and vestibular function. The arrangement of electrodes was bipolar: the anode on the left ear, the cathode on the right. With an increase in current strength to 3.5 mA strong painful sensations developed without nystagmus. The study was stopped and electrophoresis of a 0.5% solution of novocaine was conducted (current strength 0.5 mA, exposure 3 minutes). With repeated electrical stimulation the pain threshold was increased to 6 mA. A clear recording of galvanic nystagmus was obtained with current strength of 3.5 mA. After a two-minute rest stimulation of the vestibular apparatus was started with a monopolar method: the anode on the left ear, the cathode on the chest. Galvanic nystagmus was obtained with current strength of 6 mA.

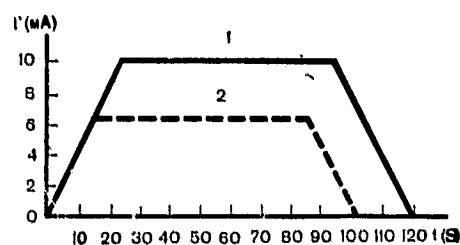


Figure 3. Scheme of Current Pulse of Trapezoid Shape  
 1--planned impulse pattern; 2--changed current pattern after engagement of interrupter.

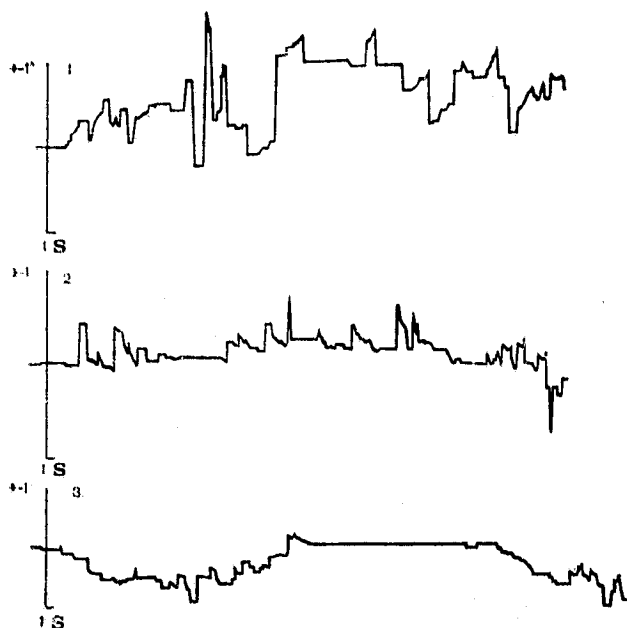


Figure 4. Recording of Galvanic Nystagmus  
 1--bipolar electrical stimulation (anode on right ear, cathode on left; current strength 3.5 mA); 2--bipolar electrical stimulation, (anode on left ear, cathode on right; current strength 3.5 mA); 3--monopolar electrical stimulation (anode on left ear, cathode on chest; current strength 6 mA).

The experimental use of the given technique under clinical conditions makes it possible to consider that it guarantees the optimal conditions for electrical stimulation of the vestibular apparatus. In this respect we consider it inexpedient to use short current pulses with steep anterior and posterior fronts (V. G. Bazarov et al., 1977) for electrical stimulation of the vestibular analyzer.

Like caloric stimulation of the labyrinth, electrical stimulation makes it possible to act on each labyrinth separately and to compare the emerging effects. Such a study is possible only under conditions of monopolar stimulation, i.e., with the arrangement of one electrode in the temporal region and the other on the torso or on one of the extremities. Here, a current strength is needed to induce vestibular reactions that is two times greater than during bipolar stimulation, i.e., with the arrangement of one electrode in the right temporal region, and the other in the left (S. N. Khechinashvili, 1958). The implementation of this condition considerably facilitates the use of the technique we have suggested for electrical stimulation of the vestibular analyzer.

The small dimensions of the instrument, and use of storage batteries as the power source make it possible to make a strictly linear change in the amount of the working current, as well as to make a study not only in the vestibulometric office, but also directly in the operating room.

#### Conclusions

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1. During electrical stimulation of the vestibular analyzer, of great importance are the front and the duration of the electrical stimulus. It is expedient to use electrical stimuli with flat anterior and posterior fronts, since the painful effect is the least here.
2. In order to obtain galvanic nystagmus during monopolar stimulation it is necessary to have great current strength; painful sensations are pronounced more strongly than in bipolar arrangement of the electrodes.
3. In order to reduce the effect of the irritating influence of the direct current on the extralabyrinth nerve formations, it is expedient to conduct preliminary electrophoresis of novocaine.

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