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ON SOME SYSTEMS OF STIMULATION CONTROL

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The main purpose of this studies on stimulation was to obtain an effective grasping motion in paralyzed human upper limb. At the first stage studies were carried concerning several subjects such as implanted stimulator and transmitting unit design, problems relevant to the choice of electrodes and coating and advancement in surgical techniques. At the second stage we tried to obtain an effective motion of the controlled limb. In order to attain that the rehabilitation period was divided into two periods:

- the hospital period /on the inpatient basis/,
- "home" period /on the outpatient basis/.

After the implantation procedure, the grasping motion was forced and then this motion was to become an effective one. In order to attain that a special device was designed that provided optimum stimulation parametres, appropriately to the given case of paralysis and individual characteristic of the patient.

Rehabilitation training

It was noticed that force increment in stimulated limb depends on providing proprly "portioned" stimulating voltage for the patient. This refers to people in good health as well and may find applications particularly in sport; the point is to shorten the period of natural training by means of appropriately designed and programmed stimulation training. Studies concerning the choice of suitable stimulation programmes are in progress and the results will be published after completion of the experiments.

It results from the above that main purpose was to design a stimulating device that could secure individualization of the stimulation parametres.

A digitimer

A digitimer controlling the implanted stimulators is a device designed for the initial training during the patient's rehabilitation period.

The instrument consists of two parts:

- 1st part - a digitimer designed for programmed controlling of a certain process /e.g. rehabilitation process/,
- 2nd part - a three-output sequential stimulation transmitter designed for transmitting stimulating voltage to the implanted stimulators.

Within the process of control, the switching-on programme can be realized including adjustment of different times of operation. Adjustment of single stimulating pulse duration time andfrequency of these pulses is provided independently, as well as measurements of stimulating voltages. The instrument is designed for work in systems of either single stimulation or a sequential one. The instrument works with one, two or three transmiting coils. Voltage of continuously variable amplitude is supplied to transmitting coils, to each coil separately.

Continuously variable control of single stimulating pulse duration is providede in the range of 1 to 5 ms. Stimulating pulses repetition rate is also continuously variable in the range of 20 to 120 Hz /Fig. 1/.

After suitable setting of frequency /e.g. 40 Hz/ and duration of the stimulating pulse /e.g. 2 ms/ the training parametres should be adjusted. The stimulation process repetition time can be continuously varied in range of 30 to 60 minutes. The duration of the process itself can also be continuously adjusted in range of 3 to 10 minutes and duration of interval between two following stimulations - in range of 30 to 50 seconds. The stimulation duration can be continuously varied in the range of 3 to 10 ceconds.

Pushbuttons are placed over the stimulation parametres adjustment controls. The procedure is as follows. A person f from the staff, a doctor for example, keeps one of the pushbuttons pressed in and selects optimum stimulation parametres /i.e. frequency, duration and amplitude of the stimulating pulses/, while observing the stimulated limb. After completion of the procedure, the "Start" pushbutton should be pressed in, what causes beginning of counting of the stimulation process repetition time starting from the moment of pressing the pushbutton in, after adjusted time /e.g. after 30 to 60 minutes/.

If the stimulation process runs accordingly to adjusted parametres, in order to check e.g. the force in the stimulated limb after some time, the supervising person should press another pushbutton in. That causes immediate switching the stimulating voltage on /the time of which is previously set by adjusting a control/ without necessity of waiting for repetition. It means that if this pushbutton was not provided, the observation wouldn't be possible before elapsing of time between 0 and 30 to 60 minutes /i.e. before the next stimulating voltage appears/.

Example

In a certain rehabilitation process following parametres were set /Fig.2/:
a. stimulation duration is 6 s,
b. duration of interval between 6-second stimulation processes is 45 s,
c. the cycle from points a. and b. lasts 7 minutes,
d. after a 7 minutes stimulation cycle comes a repose period of 43 minutes duration,
e. the frequenyc of stimulation pulses is 40 Hz /25 ms/,
f. duration of the pulse: 4 ms.

An individual controling device

Since the rehabilitation process cannot end during the period of patient's stay in the hospital, a controlling device was designed and built that enabled extending the training period, so that the patient could perform the training himself at home. The instrument allows also functional control of an injured limb.

The controlling device belongs to individual equipment of the patient that has implanted stimulators. The instrument operates in common with a stimulation transmitter; amplitude is set by the patient himself, he also controls and switches the stimulation on anf off, thus forcing the grasping motion in stimulated limb.

The principle of an individual device operation is based on utilizing 4 head movements of the patient: to the right, to the left, onward and backward /Fig.2/. On spectacle rims worn by the patient 4 position sensing elements are placed. Such location of sensing elements enables individual choice of their optimum position. These sensing elements /platinum - mercury/ respond to three - dimensional head inclinations in the cone with an apex angle of 35^{0} - 40^{0} /if counted from vertical position/.

Principle of operation

4 basic operations can be distinguished:
A. I Operation - head inclination to the right - switches the system on.
B. II Operation - head downward inclination - engine drives onward the potentiometer slider.
C. III Operation - backward head inclination - engine drives backward the potentiometer slider.
D. IV Operation - head inclination to the left - switches the system off.

Operation B

The engine strts to wokr driving the potentiometer slider /joint to the engine by means of a 1 : 150 gear/. If head re-

mained inclined the stimulating voltage amplitude would continuously increase up to maximum value /stoppage of the engine and potentiometer by a limit-switch/. Reversion to normal head position, during this operation, causes stoppage of the engine and setting the potentiometer slider at adjusted amplitude value.

Operation C

Polarity of the engine is changed and it starts to revolve in reverse direction thus causing the potentiometer slider to recede up to the point of switching off /minimum amplitude value/. Reversion to normal head position, during this operation, causes stoppage of the engine and setting the potentiometer slider at a given amplitude value.

Block diagram of the controlling device is shown on Fig.3. The system consists of:

1. Spectacle rims,
2. Platimum-mercury sensing elements,
3. Relay system,
4. Micro-engine,
5. Synchronous gear,
6. Coupling,
7. Potentiometer,
8. Stimulation transmitter,
9. Epidermal coil,
10. Skin,
11. Implanted stimulator,
12. Nerve.

Conclusions

- Constructing of a digitimer programming the stimulation training of patient's paralyzed limb on inpatient basis /hospital period/ was the reason to initiate studies concerning finding the optimum stimulation parametres /referring to various sport lines as well/. Precipitation of the rehabilitation process /force increase/ was noticed.
- Application of suitably chosen stimulation parametres is useful in other spinal cord diseases.
- Application of autorehabilitation by means of providing the patient with a controlling device enables realization of a fundamental effective movement /grasping motion/.
- In case of spinal cord injuries /particularly the serious ones/ organs enabling autocontrol of the patient are very difficult to find.

References

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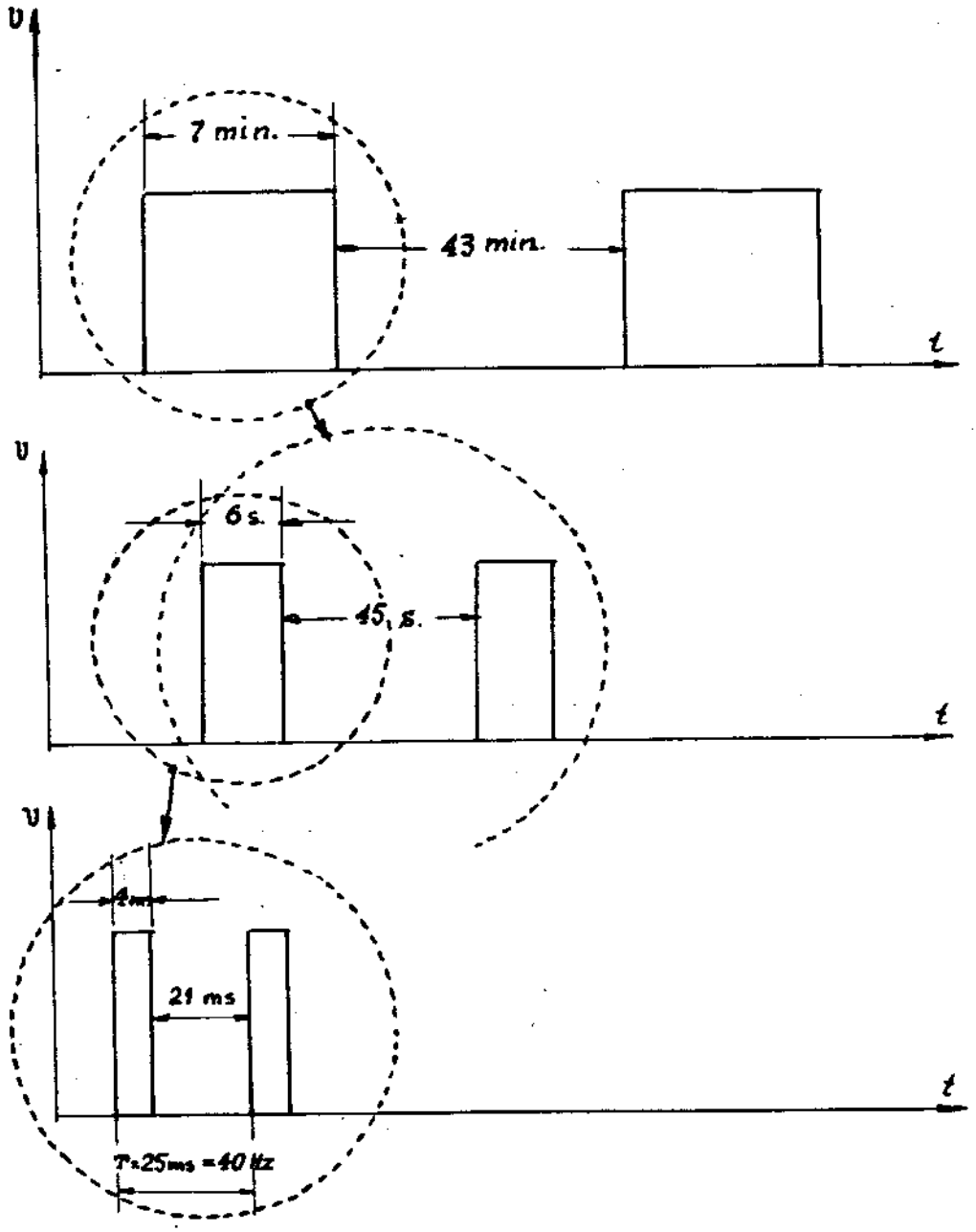


Fig. 1. Example of stimulation process

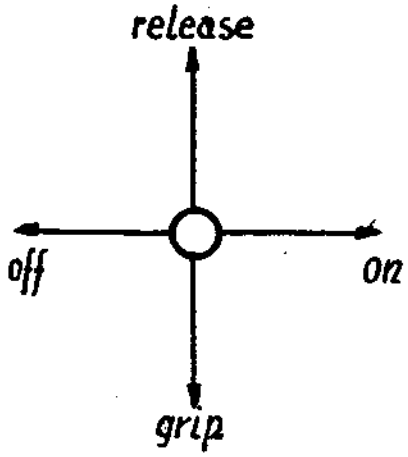


Fig. 2. Head movements of the patient

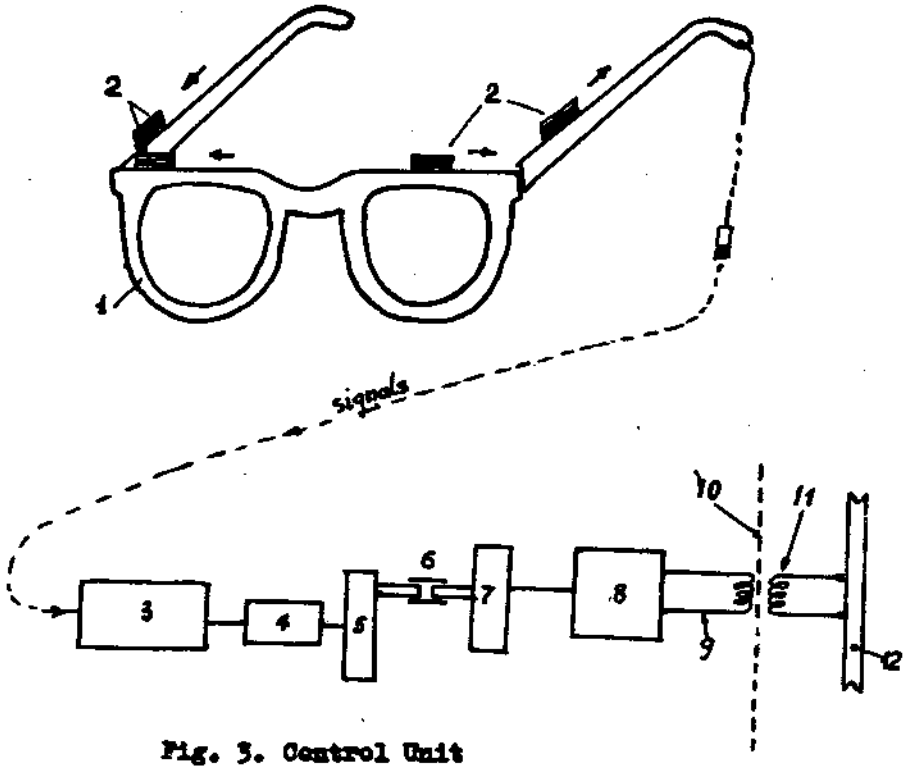
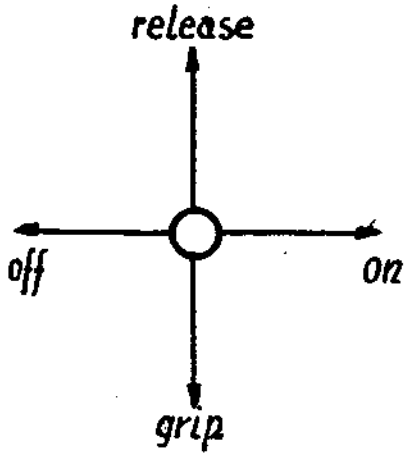


Fig. 3. Control Unit



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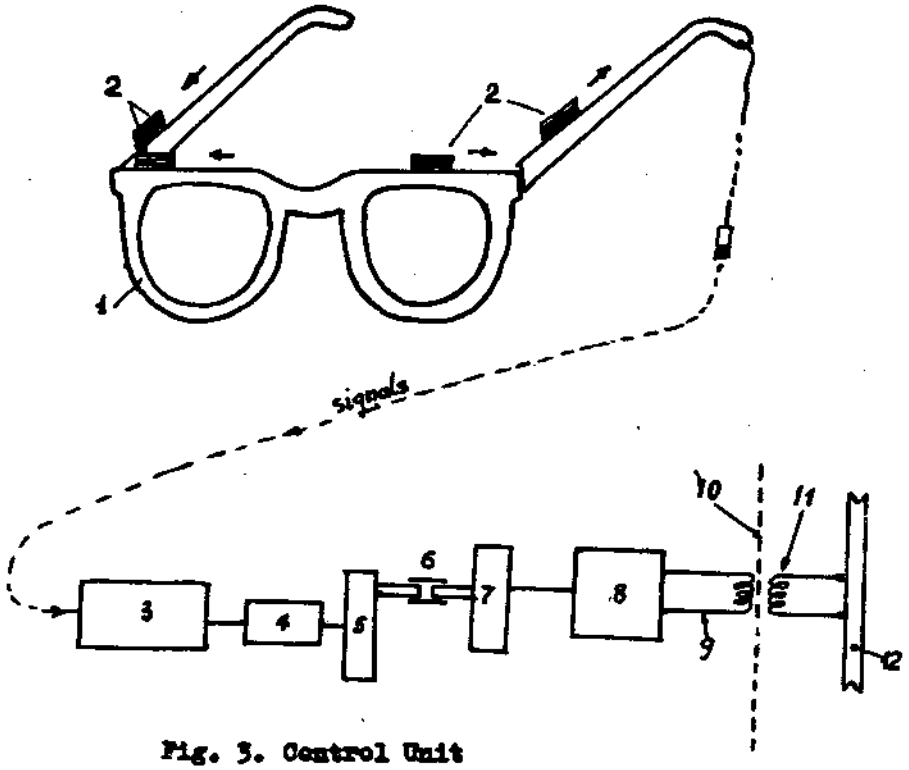

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