A METHOD OF CONTROL FOR BIOELECTRICAL UPPER-LIMB PROSTHESIS WITH SEVERAL GRADES OF MOBILITY

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When constructing and putting into practice of prosthetics multifunctional below-elbow and above-elbow prosthesis with bio-electrical control several scientific-technical principles have been taken into account:

- the whole program of constructing superfunctional prosthesis is devided in several stages with outcome int practice after completing each stage;
- prosthesis development is carried out on the basis of unification of the prostheses units and blocks involved (the modular principe of the prosthesis construction) to ensure the succession of the constructions made on the different stages;
- proceed from the functional asymmetry of the upper limbs specific tasks and prosthetics peculiarities are taken into account after unilateral and bilateral amputation of the upper extremities; in the latter case the principal prosthesis are indicated for the more functional stump to accomplish "grip-motor" finctions, for the second stump a supplement prostheses is prescribed for accomplishing the functions of gripping and keeping the object in certain position; after unilateral amputation both the supplement and the principal prosthesis may be indicated what is determined on the basis of considering complex of individual factors;
- prosthesis drive system is constructed using the independent individual drives for each joint, in which an active mobility is envisaged; this provides to the unification of the drives and separate prosthesis units, ensures manoeuvrebility and economy of the drive system, facilitates to use modular electronic units of the control system;
- as an important means of the economy of electric energy spent by an outer source serves the use of the gravity forces of the prosthesis´s links, mobility inertion of its components, friction forces and resiliency forces; this is provided by the rational mass distribution in the prostheses using the arm of a balancing mechanism for stabilazing the " forearm-hand" link relative to the resilient link, switching off of the elbow drive while walking to achieve free swing of the forearm relative to the shoulder, using of the friction mechanisms for fixation etc.;
- the use of the outer energy is combined with the use of the remained muscle resources (e.g. rudimental forearm or shoulder stump rataion), as well as compensating movements not worsening essentially aesthetics of the accomplishing motor functions;
- besides active movements by mobility separate grades passive movements by the rest grades of mobility are used (e.g. by means of a wrist joint mounted in the prosthesis with three grades of the passive mobility permitting to give the hand the most advantageous initial position depending on the solving motor task);
- to heighten the quality of the production orthopedical enterprises are provided with the ready-made components of the maximum readness, entirely complete, passed the finishing and control

test of the control system parameters, drives and ready-made components in general.

On the basis of the principles enlisted there has been developed and put into practice shoulder prosthesis with bioelectrical control of the finger movements and hand rotation as well as forearm prosthesis with bioelectrical control of the finger movements and hand rotation and flexion-extension in the elbow-joint. Elbow joints of the shoulder prosthesis allow to work in four regimes: active flexion; active extension; nonstaged fixation of the elbow joint; free swing of the "forearm-hand" link relative to axis of the elbow joint. Besides this the possibility of accomplishing passive movements in three-four grades of freedom is provided in the prosthesis. Active movements in two or three grades of freedom the disabled executes in sequence.

Heightening of the functionality of the bioelectrical prostheses with three-four active mobility grades demands to solve the highly complicated problem of the co-ordinated and proportional control of prostheses movements simultaneously in several mobility grades.

The complicacy of the indicated problem is connected with ergonometric requirements as to restrict the level of the psychophysiological stress of the amputee while using the prostheses; in order of safe "pick-off" of muscle biopotentials by means of the laid-on current readings it is now advisable to use only two sources of control commands. The above mentioned and a number of other restrictions accepted by us dont allow to realize the well-known ways of constructing bioelectrical systems of the simultaneous control of several prostheses movements.

As a hopefull solvation of indicated problem appears the development of multilevel control system, in which the number of voluntary controlled (by the disabled) parameters is diminished and the information processing simplified. Particularly when organizing the control it is expedient to combine the volitional bioelectrical control with the elements of the automatized one. To simplify the information processing in the system the results of the study of biomechanical peculiarities of purposeful arm movements must be used.

Biomechanical analysis of the most wide spread every day and occupational movements representing some difficult co-ordinated grip-motor hand functions has showed following pecularities:

a) when gripping the object, considerable angle displacement of the hand fingers take place, when large arm joints are of little mobility, and viceverse. This allows to divide the motor task into two time phases: grip of the object and its diplacement in the space;

b) depending on the motor task, both simultaneous and separate movements in the corresponding joints are observed in each phase;

c) each of the two phases is characterized either by stereotypicalness of the accomplishing the motor task in general, or by a composition of the stereotype elements;

d) stereotypes possess the stable coordination kinematic parameters and they are differing from each other by the character of function of the interrelation of interlink angles changing in the corresponding joints.

Considering all above-mentioned following organisation of the control system, in which the disabled is accomplishing a purposed movement by the help of the program complex realizing the stereotypes and the following regulation of its execution speed. At this stage the simultaneous work of the drives takes place; the disabled, however, is effecting indirectly only one drive (the leading one). Simultaneous work of the drives is expedient to accomplish both in the phase of manipulating with the object or preliminary hand orientation and in phase of gripping the object (if multifunctional hand is used with two drives). The considered system allows also the successive control of the drives.

Control task in the system is solved in the real scale of the time as program device synthesis is conducted on the basis of analogue functional converters, which connect the movement of the drives led (in accordance with the stereotype) with that of the leading drive. Proportional control is accomplishing by the amputee by means of dozing of electric activity in each time moment of a single muscle, what ensures low level of the psychophysiological stress. On the stages of gripping the object and manipulating with the object hold, control organization in the system may remain the unchanged, what simplifies technical realization of the control system at the cost of combining the functional blocks.