# MYOSINGNALS FOR CONTROL OF TECHNICAL ORTHOPEDIC AIDS FOR THE UPPER EXTREMITIES

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Summary:

Experiments with myosignals for 3 different types of supply are under discussion.
At first, signal getting with the help of surface electrodes in the case of extremely short upper arm stumps and shoulder exarticualtion are discribed.
As the second special case of supply with myoelectically controlled hand fitting parts, signal winning and processing for a multi-channel control as physiolological as possible is dealt with.
Finally, first results of the myosignal investigations at the forearms of tetraplegics are presented.
The possibilities of controlling active protheses or orthoses of the upper extremities are evaluated.

## 1. Measuring means and methods

All investigations were carried out with the help of surface electrodes. The EMG intersifier has the following values:
$R_i$ = 400k Ohm (input resistance); In-phase rejection: 80 dB
frequence range: 150 to 1.400 Hz

Surface electrodes, intesifier and rectifier are fitted in a common shielded plastic box. This unit (AE= receiving unit) has the dimensions of 43 mm x 18mm x16mm.

In the three studies, the unidirected myosignals were evaluated in different ways. Measuring results from the upper and forearm

experiments were recorded on tape and then printed (fig. land 2). In the case of experiments on the multi-channel control, the manually evaluated results were verified by a computing centre.

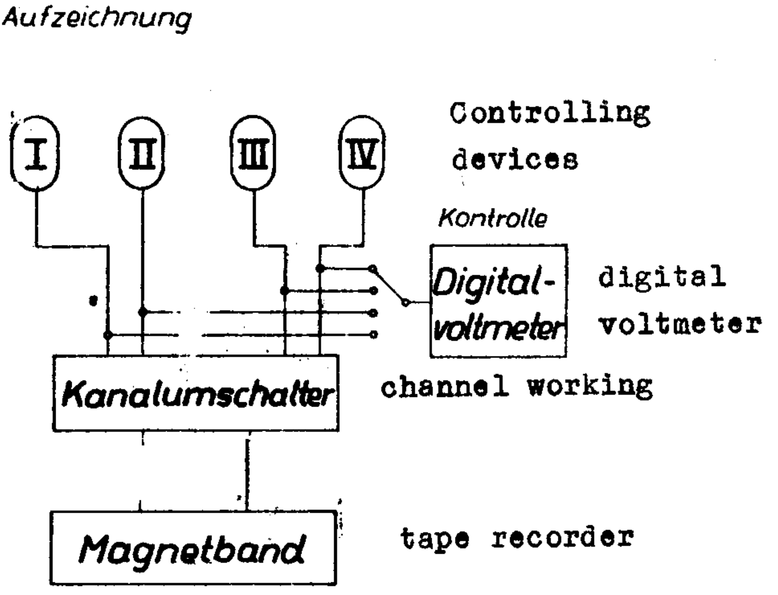
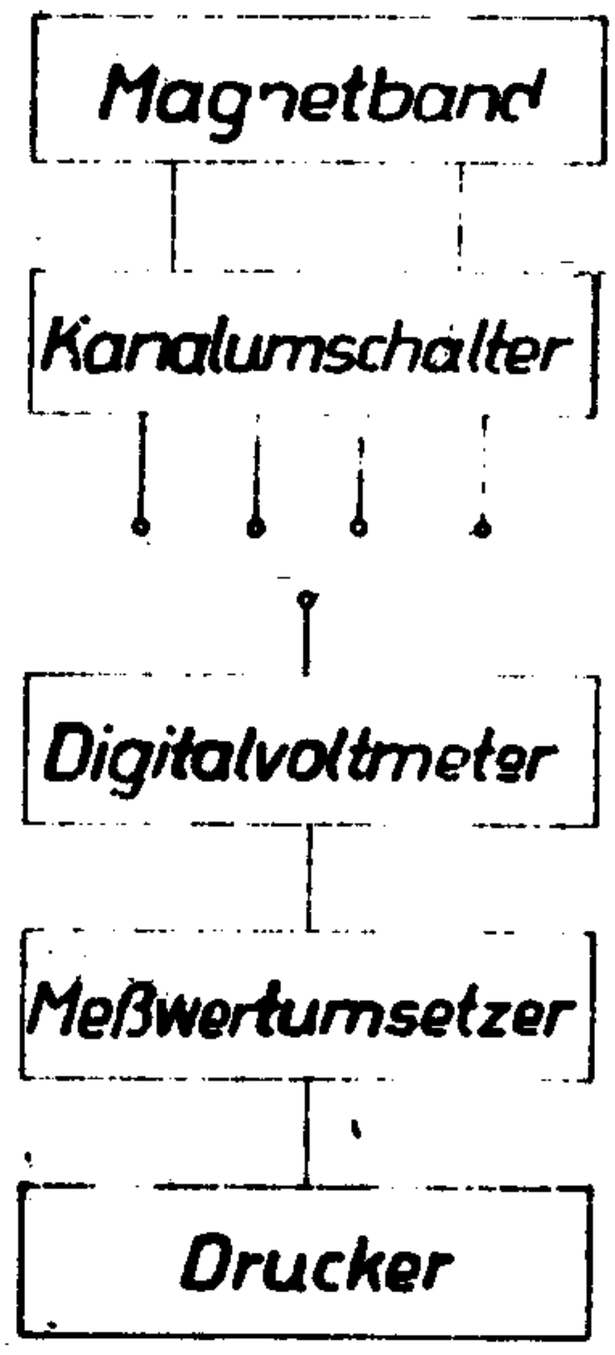



Fig. 1 Record

Fig.2 Reproduktion




tape recorder

channel working

digital voltmeter

measuring transformer

printer

As starting point for the measurements the groups of muscles mentioned in table 1 were selected.

| Study | Muscle groups | Driving signal for |
|---|---|---|
| short upper arm stump and shoulder exarticulation | M. deltoideus )<br>M. trapezius )<br>M. pectoralis | opening of the hand<br>closing of the hand of the protheses |
| Multi - channel control | M. extensor carpi radialis)<br>M. extensor digitorium) | Extension) |
| | M. extensor carpi ulnaris) | |
| | M. flexor carpi ulnaris) | |
| | M. flexor carpi radialis) | Flexion) of the wrist-joint |
| | M. palmaris longus | |

| Study | Group of muscles | Driving signals for |
|---|---|---|
| Multi-channel control | M. pronator teres<br>M. supinator | Pronation) of the<br>Supination)wrist joint |
| Lower arm with tetraplegics | M. extensor carpi<br>M. flexor carpi | Opening of hand<br>Closing of hand) of the orthoses |

Table 1: Muscle groups for control signal winning

Due to amputation or according to the degree of paralysis, there were different individual conditions with each patient. Therefore, in the couse of the study concerning the shoulder exarticualtion, myopotentials were taken also from the M. latissimus dorsi, and in the investigations concerning multi-channel control, often the desired coordination of function and muscle group could not clearly be shown.
Measuring was carried out while the patient made various movements with his artificial arm or his partially parlaized hand. On an average, the phase of tension took 1 to 3 seconds. The individual movements were repeated several times, interrupted by pauses.
In order to achieve a good reproducibleness of the results, for some patients, a test shaft with free places for the AEs was manufactured.

## 2. Measurement results:

### 2.1. Investigations with patients with short upper arm stump and with shoulder exarticulation

Out of a collective of 25 patients, 5 patients with typical individual conditions were selected:

(1) upper arm stump (8cm); good stump conditions
(2) upper arm stump (3cm); good stumo conditions
(3) shoulder exarticulation: good stum conditions
(4) shoulder exarticulation; several scars at the stump
(5) upper arm stump (5cm); synthetic stump conditions

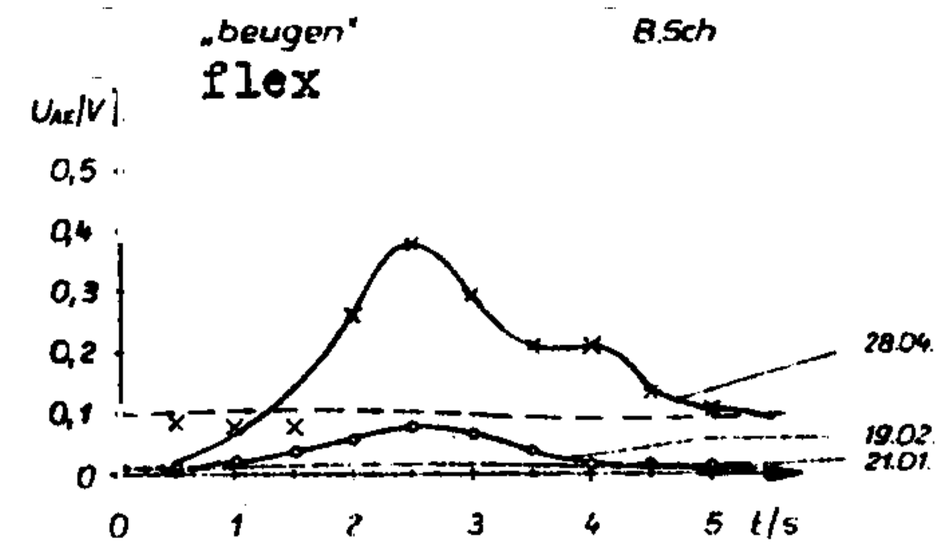
The average age of the selected patients was about 30 years.

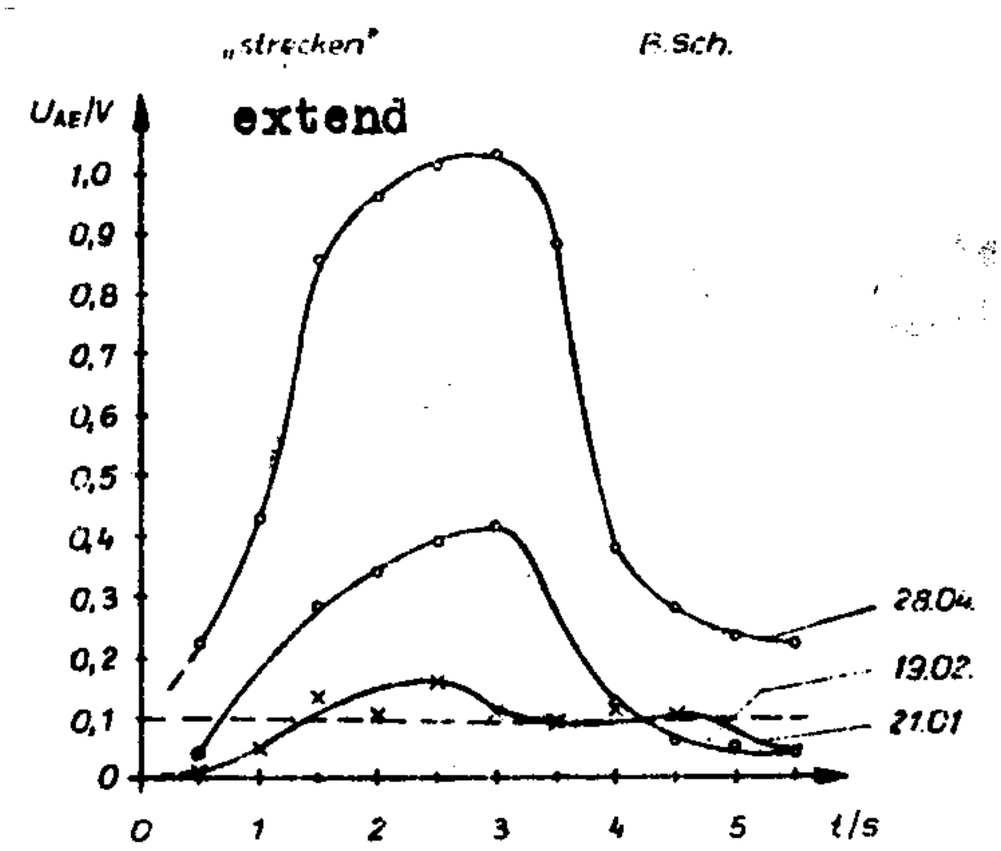
In four cases, the accidents were traffic or labour accidents. In one case, a tumour was the reason for the amputation. At the time of measurements, the amputation dated back 10 months on an average.

With each patient, myopotential measurements were taken at least 3 times in intervals of 4 to 8 weeks. Object of the study was to achieve 2 separate signals for controlling a myoelectrical hand fitting part, in all cases. This aim was reached by no patient after the first cyclus of measurements.

The threshold value of the AE-output voltage required for controlling (fig. 3) was slightly exceeded by only one patient for both the signals after the second cyclus of measurements.

Fig. 3 Myoelectrical potentials after three cyclus



After each measuring cyclus, patients were taught to carry out exercises for the strengthening of the required muscles.
In adition, special physio-therapeutical treatment was prescribed by specialist. Normally, successes are achieved with patients after 3 months. Three of the five patients examined were able to control the "opening" and "closing" of the myoelectrical hand fitting part.(example:fig.3).
With the patient H.T. (4) only one signal could be used, and with the patient K.H.Sch. (5) still no usable signals could be obtained.

With the patient H.T. (4) from 2 places, myopotentials could be received, separately and of sufficient activity, after 3.5 months of training, but after the tension phase was repeated 3 to 5 times, a sort of cramp occurred. Derivation of separate signals was no more possible. In this case, for the present, no myoelectrically controlled hand fitting part was supplied.
From patient K.H.Sch (5)measurements were taken for the first time 22 months after the amputation. He is adipose and his weight is 115 kg.! The course of the myopotentils taken from the epidermis indicates that in this case the signals are too much damped by the fatty tissues.

## 2.2. Information winning with forearm amputees for controlling multi-channel prothesis

It was the aim of the investigations to derive separable myosignal patterns for controlling a four-channel prothesis. 5 patients of an average age of 47 years were included in the study. With all patients, the amputation dated back more than 5 years, and since that time, they were using two-channel myoproteses. Stump length varied between 8 and 13 cm.

In the course of these investigations, too, patients were asked to come for measurements several times. This was particualrly necessary in order to find out the best possible receiving places on the surface of the skin. With respect to the artificial wrist-joint the patient carries out extension, flexion, pro and supinations during the measurements.

With the help of the digital voltmeter the myopotentials are examined at the exit of the individual receiving units. The best condition for the separation of the signal patterns is one AE delivering one great signal only in the course of one movement.

After the stump laces are fixed taking this principle into consideration, measuring begins. In order to increase the reproducibleness, in two cases test shafts with the recessed stump places were manufactured.

Figures 4 and 5 show the myosignal patterns of two patients. For each AE the maximum range of variations of the unidirected myosignal is plotted.

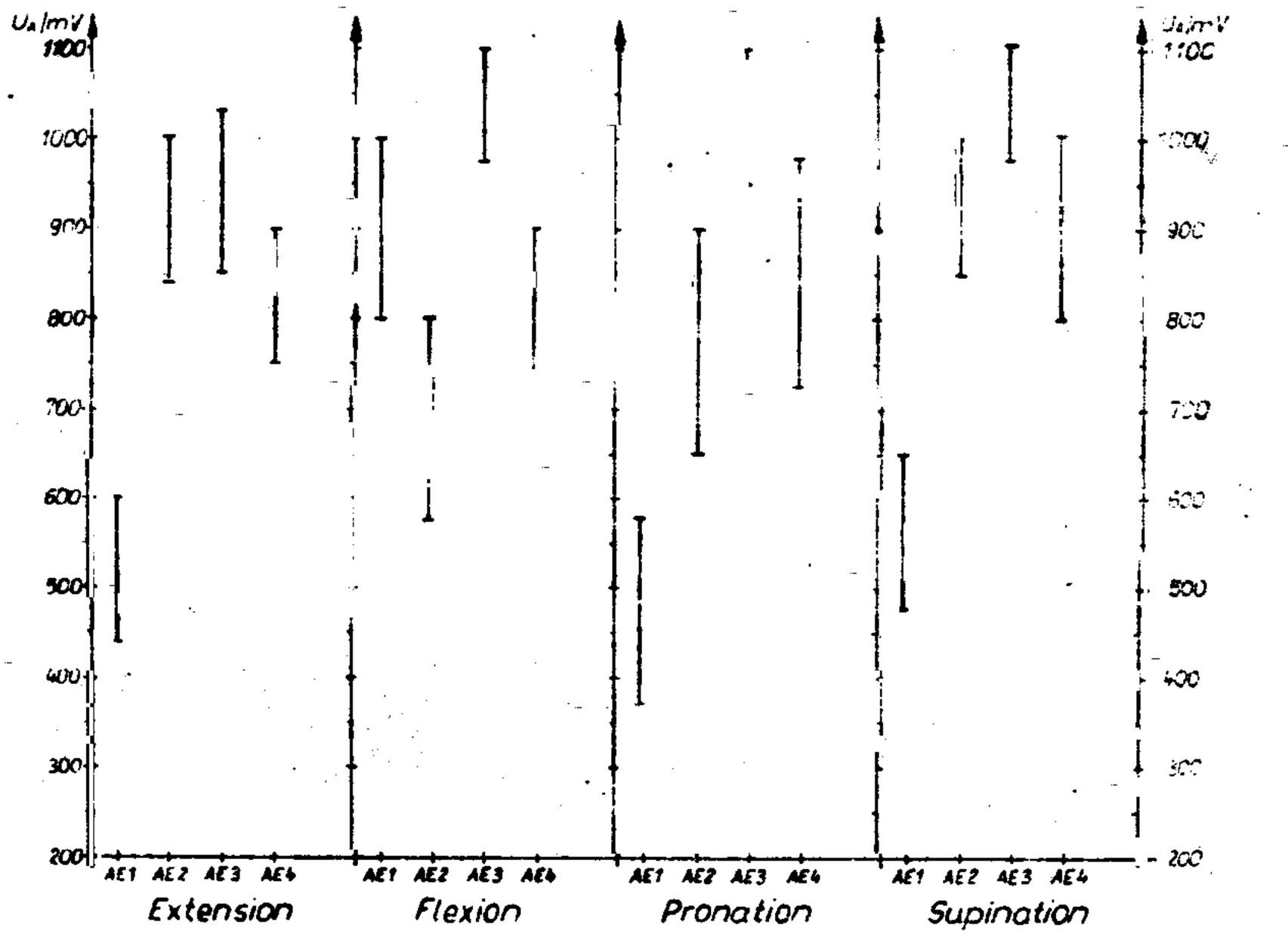



Fig. 4 Myoelectrical patterns , nonseparable

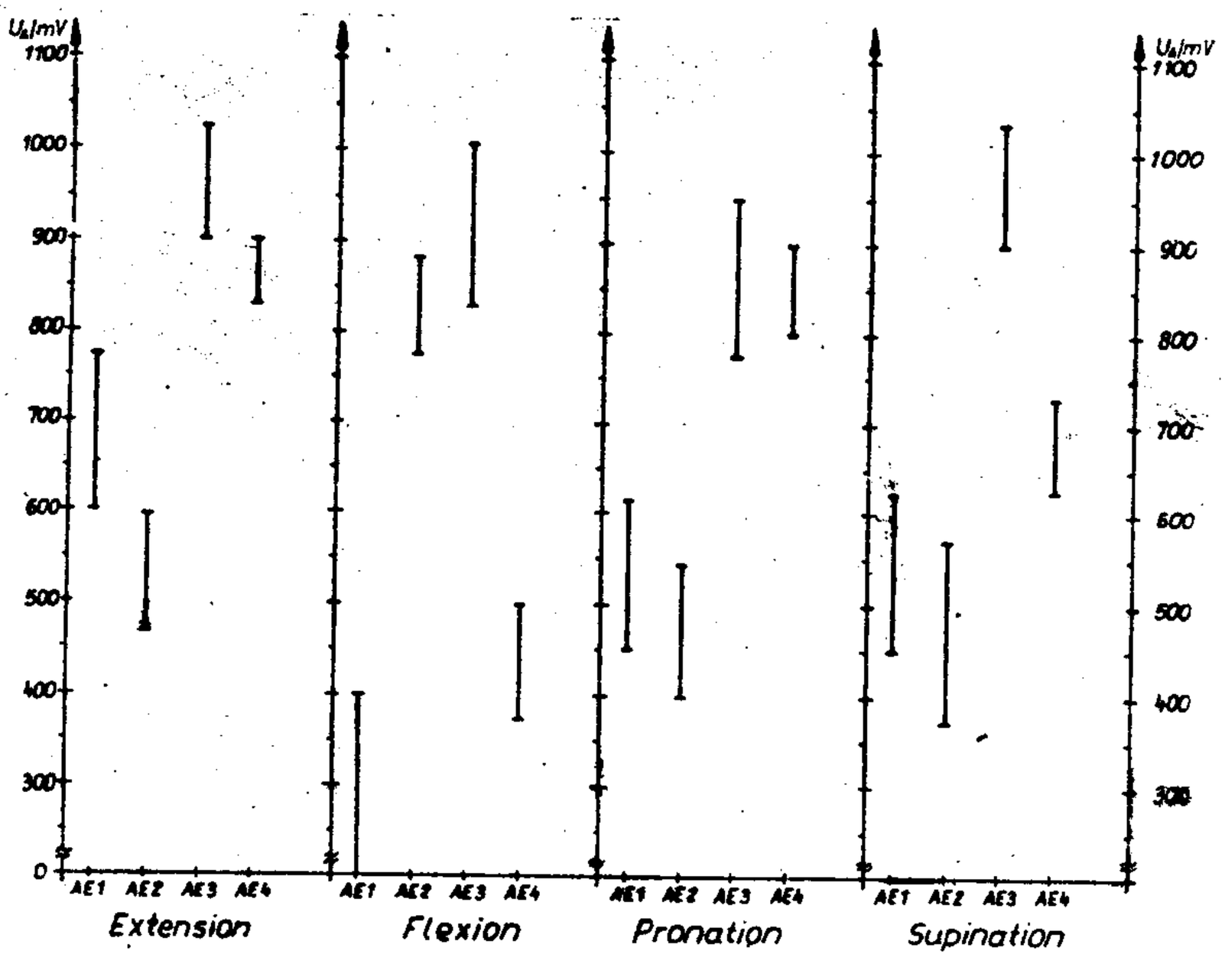



Fig. 5 Myoelectrical patterns , separable

A comparison of the values shows at first sight whether the patterns celarly differ. And if so, they will be separated. In the diagram of fig. 3 it is obvious that the signals are not separable, because-for instance- the patterns of pro and supination cannot be distinguished.

In the second case it is to be seen that the patterns differ at least in respect to one element. The myosignal patterns which by comparison were found to be separable were used as input parameter for a computing method that carries out the dimensioning of a four-channel drive on the basis of summator amplifiers. With the help of these four-channel drive, the myosignal patterns could be examined again in respect to their usability for controlling four functions.

After evaluating the measurement results, we found that only from one patient-even after a long trainig period- no separable signal patterns could be taken.
However, this is to be explained by the condition of the stump. Due to the kind of accident, the remaining muscles were badly deformed and showed extensive formation of scars. Partially, the arm stump was covered with skin plantations. Nevertheless, improvements were achieved during the time of taining.
The rest of the patients had to go through different training periods until their signal patterns were weparable.

## 2.3. Studies with patients suffering from lesions in the area of the cervical vertebra

The studies were carried out with patients suffring mainly from damages in the area of C 6. It was the aim of these measurements to find out if two independent muscle action potentials of different strength were to be found in the forearm area of these patients and if these potentials were suffciently strong.
Patients of an average age of 30 years were examined (Table2).

The majority of the examined patients had good action potentials in the area of M extensor carpi, but in the area of M. flexor carpi results were different.

Sometimes, there were no measurable or palpable muscle activities at all (serious atrophia). Control of short fast contractions was possible in all cases without training.

Control of contractions different in strength and thus generation of different EMG´swas also possible (but one case); yet, it created greater concentration problems: Most patients got tired, but not so much that an orthopeadic supply would become impossible.

In most of the examined cases, the existing action potentials would not give rise to any difficulties concerning an orthopeadic supply. The amplitudes of the EMG´sare sufficient, and there are also possibilities of dosing and control of so-colled trich switching. Now the experiment must show if an orthesis according to the threshold level principle or according to that of pulse switching (trick) would be more effective and safe or better to control.

## 3. Conclusions:

At present, supply of myoelectrically controlled protheses in the case of upper arm stumps and shoulder exarticulation is technicallv possible if independent action potentials can be derived from the muscle groups: M.deltoideus; M. trapezius; M pectoralis major without creating dusturbances of the artificial grip-function in carrying out the shoulder pull. This pull is necessary for raising the forearm of the prothesis.

In many cases, the required conditions can be fulfilled by therapeutical measures and exercises carried out by the patients independently. Such supply with prothesis,in our opinion, is a considerable contribution to the comprehensive rehabilitation of the mentioned circles of patients.

Every physiological multi-channel control ends, on principle, where the muscle groups necessary for the movements of the hand

a) are no more existing or
b) are no more able to function due to a certain kind of damage and the respective surgical measures.

If the muscles required for the multi-channel control had not been used for years, whinning of separable signals will only be enabled by intensive muscle training by the patients.

Naturally, most of the patients are very much interested in a multi-functional arm prothesis but would,on the other hand, not accept possible shortcomings of a complicated prothesis. In the future development and application of multi-functional arm prothesis . this aspect must be taken into consideration by all means.

If patients suffering from damages of the cervical vertebra are to be supplied with an orthesis, the question of the use of such supply must be individually decided in each case.

String drive and guide tiles represemt a general handicap, which must be balanced by a considerably improved grip function. The problem of chafing and squeezing of the skin must also be considered. Even if the signals for controlling and orthesis and produced in sufficient quality, the above mentioned aspects will decide whether an orthesis is successfully used or not.

Expression of thanks:

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