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Technical note—auditory feedback of knee angle for amputees

J. A. GILBERT, G. M. MAXWELL, R. T. GEORGE JR,* and J. H. McELHANEY

*Department of Biomedical Engineering and * Department of Electrical Engineering, Duke University, North Carolina*

Abstract

A new gait training device has been developed to provide auditory feedback of knee angle information to above-knee and hip disarticulation amputees. Traditionally, new amputees have relied on visual feedback of knee position during gait training (van Griethuysen, 1979). This auditory feedback system eliminates the need for visual feedback by providing a frequency encoded tone corresponding to knee angle.

Operation

The system is designed to produce a tone which increases in frequency as the knee flexes. When the knee is fully extended there is an absence of sound. As the knee is slightly flexed (less than 2°) a tone of approximately 60 Hz is generated. This frequency increases linearly with knee flexion up to 600 Hz which corresponds to the knee being flexed to 70°. With flexion over 70° the tone is absent so as to allow the patient to sit without having to turn off the unit.

During the swing phase of gait there is constant auditory feedback which can be beneficial in establishing an even, repeatable cadence. In addition, the absence of sound at full extension indicates that it is safe for the amputee to place the heel down.

The electronic operation of the device is quite simple and is outlined in Figure 1. The voltage from the potentiometer is amplified and then inputted to a voltage comparator and also to a voltage controlled oscillator. If the voltage corresponds to an angle between 2° and 70° the voltage controlled oscillator is enabled and produces a tone.

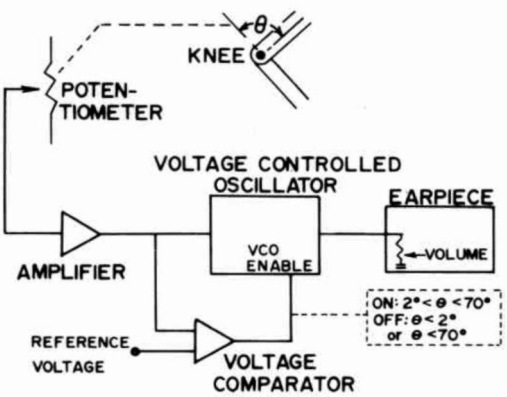

Fig. 1. The electronics of the angular feedback device.

Description

The knee angle feedback system consists of a single turn potentiometer with a miniature cable connecting it to a small belt box containing the electronics and a loudspeaker. As an alternative to the loudspeaker, a modified hearing aid earpiece can be used.

The potentiometer can be mounted either directly at the pivot point on a prosthesis (Fig. 2) or between two aluminium brackets which strap above and below the prosthetic knee (Fig. 3). The attachment method is used only on prostheses that have been fitted with cosmetic covers.

Discussion

This angular feedback system was originally designed to be used as a permanent system with a

All correspondence to be addressed to Mr. J. A. Gilbert, Department of Biomedical Engineering, Duke University, Durham, North Carolina, 27706, U.S.A.

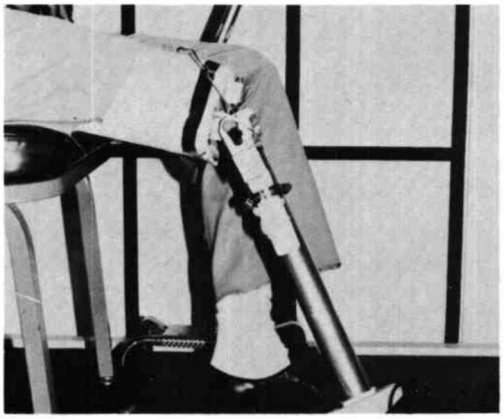

Fig. 2. Angular feedback device mounted on a temporary AK prosthesis.

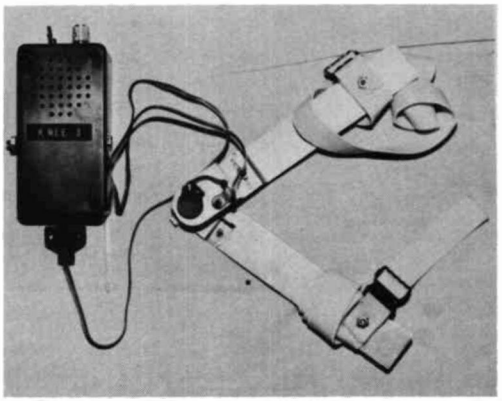

Fig. 3. Potentiometer mounted between two brackets for strapping to the prosthesis. Also shown is the belt box containing the electronics and loudspeaker.

small earpiece to deliver the auditory feedback to the patient's ear. The initial trial was on a 10 year old male. During the first week of gait training the patient elected to give up the device. The reasons for ending participation were that the patient did not like the additional attention brought to him by the device and the appearance of the earpiece was unacceptable. It was decided that these objections were not valid for a temporary training device. Also, experience with other auditory feedback systems for amputees indicates that they are most effective during the first weeks of training. Therefore, the system as described here for gait training evolved.

The research concerning the angular feedback system is still in the preliminary stages. Two additional patients have used the device after its conversion to the present training system. The first, a 31 year old AK amputee who used the system during a gait retraining period, indicated that it helped in knowing the period of swing of the prosthesis as related to the rhythm of her steps. The second patient was a 69 year old AK amputee who wore the device in his initial gait training. He reported that the device assisted him in knowing when his leg was straight. These favourable comments are supported by the positive reaction from the physical therapists involved in the gait training.

In conclusion, the angular feedback device provides a relatively inexpensive and simple means of assisting above-knee and hip disarticulation amputees in developing confidence in their gait during the training and retraining periods. From the patients' impressions it is concluded that this form of feedback can be readily learned and accepted. Expansion of the patient population and further evaluation of patient acceptability will be pursued.

Acknowledgement

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REFERENCE

VAN GRIETHUYSEN, C. (1979). Gait training for the below-knee amputee. *Pros. Orth. Int.* **3,** 163–165.