OPIC
Office de la propriété intellectuelle du Canada

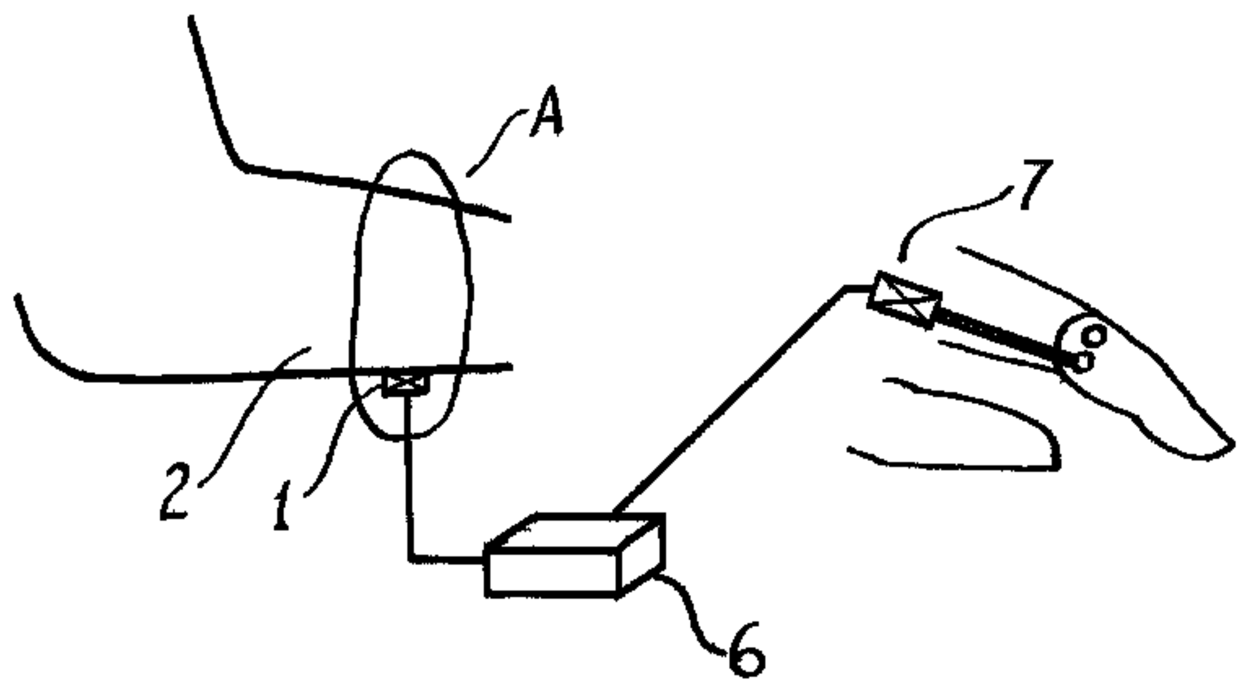
CIPO
Canadian Intellectual Property Office

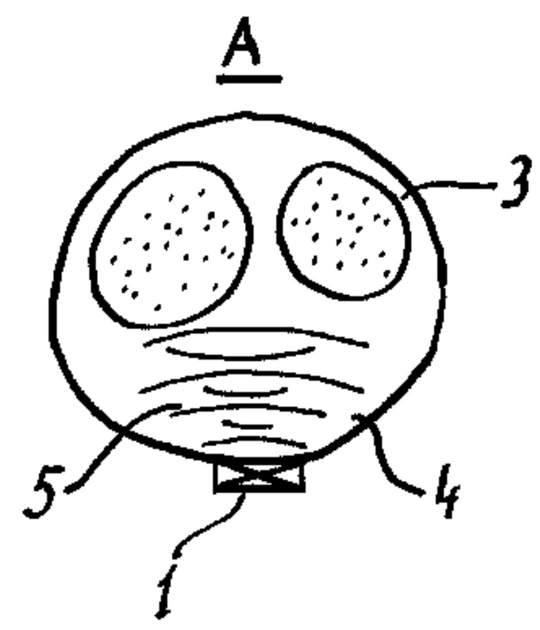
(12) (19) (CA) **Demande-Application**

(21) (A1) **2,332,747**

(22) 2001/01/31
(43) 2001/04/27

(72) VDOVENKOV, ILIA, CA
(71) VDOVENKOV, ILIA, CA
(51) Int.Cl.^{7} A61F 2/48
(54) **SYSTEME DE COMMANDE DE PROTHESE PAR ULTRASONS**
(54) **ULTRASONIC PROSTHESIS CONTROL SYSTEM**





(57) A control system for operating prosthetic devices is provided. It comprises an ultrasonic transducer attached to the amputee's body. This transducer irradiates ultrasonic wave into the particular zone of the amputee's body and receives returning waves that deliver information about amputee's tissue movements, strains and other changes, caused by vulnerable contractions and relaxations of muscles, effected by the amputee in order to operate prosthesis. The received signals are then processed by the processing means that associate the received signals with the preset ultrasonic patterns. Commands, associated with the matched pattern are then generated in order to operate prosthesis or similar device.

ABSTRACT

A control system for operating prosthetic devices is provided. It comprises an ultrasonic transducer attached to the amputee's body.

This transducer irradiates ultrasonic wave into the particular zone of the amputee's body and receives returning waves that deliver information about amputee's tissue movements, strains and other changes, caused by vulnerable contractions and relaxations of muscles, effected by the amputee in order to operate prosthesis.

The received signals are then processed by the processing means that associate the received signals with the preset ultrasonic patterns. Commands, associated with the matched pattern are then generated in order to operate prosthesis or similar device.

ULTRASONIC PROSTHESIS CONTROL SYSTEM

BACKGROUND OF THE INVENTION

The present invention relates to the field of control systems for use with prosthetic devices.

The craft of making artificial limbs has a long history. Starting from the primitive pieces used in the ancient times up to the sophisticated computerized devices of nowadays it pursues, as the main objective, providing help and relieving life of those who miss or have nonfunctioning limbs.

The earliest examples of the prosthesis making craft may be found in the culture of the ancient Egypt: scientists discovered a skillfully fabricated artificial leg's thumb that was used by a person living in 1065 BC – 740 BC ["Fancy footwork from ancient Egypt", BBC News, Dec. 22, 2000]. Devices of this kind were used rather for decorative purposes, but the functional constructions, intended to help person in the everyday life, are known for a long time as well. For example, this is a hook and cable systems used in order to partially restore functionality of missing arm. The first systems of this type were first implemented in the 17-th century and now are still in use in various modifications.

With time passing by, constructors were sophisticating the craft, making prosthesis more functional, less burdensome for the amputee.

Systems that use amputee own strength or body weight such as the "hook and cable", mentioned above, and other mechanic or hydraulic systems are still widely in use.

Alternatively, another trend becomes more and more widespread. This is the area of powered systems that utilize various types of electronic controls that operate motors and other actuating devices that drive prosthesis.

These systems are much more convenient in use and enable to restore more functionality of a missing limb. One of the common problems in constructing of these systems is the way an amputee dispatches commands to the device.

Here are some currently implemented methods that solve this problem.

First, those are voice-controlled systems where amputee has to pronounce special commands in order to initiate particular movements of the prosthesis. These systems were advancing rapidly in the recent years and continue to evolve due to the fast development of digital voice recognition technologies. These systems virtually do not have limitations on number of available commands, but they have some disadvantages.

First off all, these systems require from the amputee to constantly pronounce commands. This may be inconvenient in certain circumstances. As well, system of this kind becomes un-functional in places with high level of noise.

Systems, operated by moving healthy body parts may implement variable resistors or variable capacitors in order to detect movement of shoulder, for example, or healthy arm, in order to generate commands to the prosthesis. More advanced electromagnetic, piezoelectric or fiber optic detectors may be used as well.

These systems are not influenced by noise, control circuits process signals faster than ones of the voice recognition systems. Unfortunately, these devices require from the amputee to make unnatural, unsightly movements and in most cases provide limited set of executable commands.

Systems that monitor electric fields of muscles in order to operate prosthesis may be divided into two types: systems with surface mounted electrodes and systems with implanted or invasive electrodes.

Systems that use implanted electrodes may possess virtually unlimited set of commands because properly located electrodes can deliver reliable output from as many closely located nerves as needed. These systems, as well, require neither pronouncing commands nor performing special movements.

The main disadvantage of these systems lies in need to penetrate skin in order to set electrodes in proper position. This restricts usage of this technique to a quite limited number of cases.

Systems with attachable electrodes, on the other hand, are free of this serious limitation. They are used without unpleasant and potentially dangerous implanting procedures. This simplifies tremendously service and operating of the prosthesis.

Unfortunately, this method has disadvantage of it's own. Electric fields, produced by nerves and myofibrils intensively dissipate in the body tissues and the electrode, applied to the skin, detects not only field of the nearest muscles but of the distant ones as well. In order to reliably read signals, electrodes have to be attached to the body far enough from each other. This limits number of commands available in the set.

Special types of electrodes help to solve this problem, but only to a certain extent. The problem remains when it is needed to read signals of muscles located deep under the skin.

As the result, the most preferable locations of the electrodes are on the places where muscle nerves are located close to the skin - on the forehead, for example, which may appear inconvenient and sets limitations on use of this technology.

The present invention uses principle of ultrasound body scanning in order to generate prosthesis operating commands. In this method ultrasonic transducer irradiates acoustic waves into a particular zone inside the amputee's body in order to collect information regarding muscle activity in the said region, i.e. straining and relaxing of muscles and tendons and consequent changes in other tissues and liquids: pressure and flow rate fluctuations, relative movements. All these changes may be reliably detected by this method.

DESCRIPTION OF PRIOR ART

1. US Patent 6,106,560 issued to Boender on August 22, 2000, is an example of the weight operated leg prosthesis that doesn't require electronic control system for it's operation.

2. US Patent 6,091,977 issued to Tarjan et Al. on July 18, 2000 describes the skin attachable electrode that reads electric potentials of muscles;

3. US Patent 5,480,454 granted to Bozeman, Jr. on January 2, 1996 describes a control system for prosthetic device that comprises a transducer for receiving of movements from a body part for generating a sensing signal. In order to use this device, the amputee has to move particular body part;

4. US Patent 4,521,924, issued to Jacobsen et Al. on June 11, 1985, is another example of the system, operating prosthesis by reading of muscles myopotentials.

5. Application for Patent of Canada 2,326,542 on December 4, 2000 demonstrates implementation of the ultrasonic scanning principle in the computer control device.

SUMMARY OF THE INVENTION

An object of this invention is to provide a prosthesis control system that uses ultrasonic body scanning in order to generate commands to the prosthesis.

Method of ultrasonic diagnostics in widely used in modern medicine: inner body parts, their movements and anomalies are easily viewable and measurable using it. This technique is based on the fact that body tissues in different conditions have different acoustic properties, i.e. reflect, dissipate and attenuate the wave in different manners. As the result these tissues modulate ultrasonic wave propagating inside the body. This wave is then received by the transducer, analyzed and presented in some convenient form - image, table of data or other.

Straining, relaxing and moving of muscles and consequent changes in the other tissues are measurable by means of ultrasonic diagnostics as well. In this invention this effect is used for generating commands to the prosthesis, basing on amputee's straining and relaxing particular groups of muscles in the zone, scanned by the ultrasonic waves.

The groups of scanned muscles and consequently, locations of the transducer on the skin may vary and should be chosen in each case separately. They may be located in various places - on wrist, forearm, shoulder, leg etc.

There may be one or more sources and one or more receivers of the ultrasonic waves. Sources and receivers may be represented by the same or separate elements.

The ultrasonic transducer radiates waves into the body. In most practical cases that will be impulses, although that may be continue waves as well. These waves pass through the body, interact with tissues and finally get detected by the transducer, delivering information regarding muscle activity of the scanned zone.

When the amputee decides to activate some mechanisms of the prosthesis, he or she strains or relaxes particular groups of muscles in a predetermined manner.

This causes changes in the detected signal that is then processed by the processing means. The said processing means filter out irrelevant information and compare the signal to the stored patterns.

In the case if the signal is similar to one of the patterns, the function, associated with this pattern is activated.

The present invention doesn't impose any restrictions upon type of the ultrasonic transducers, used with it. Those may be typical for the field of ultrasonic diagnosis: piezoelectric elements or arrays, magnetic elements or arrays, rotating or oscillating transducers etc.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 depicts ultrasonic transducer attached to the forearm of the amputee in order to operate prosthesis of the arm if the arm was amputated above the wrist.

The system consists of: the transducer (1) that is attached to the amputee's forearm (2) and radiates ultrasonic waves (5) into the tissue (4) and receives responses coming from the said tissue and bones (3);

And processing means (6) that sends control signals to the executive systems (7) of the prosthesis.

Fig. 2 shows two ultrasonic transducers attached to the leg of the amputee in order to operate prosthesis of an artificial knee joint.

The system includes the ultrasonic transducers (1) and (2) attached to the leg of the amputee (3). The said transducers radiate ultrasonic waves (5) into the tissue (6) and receive responses coming from the said tissue and the bone (8);

And processing means (7) that send control signal to the artificial knee joint actuator (4).

DESCRIPTION OF THE PREFERRED EMBODYMENT

Particular embodiments of this invention may vary strongly depending on the amputee's case. Quantity and locations of the ultrasonic transducers will change depending on which muscles will be chosen to provide the control signals.

Hereby are presented two possible embodiments, first adapted for operating the arm prosthesis in case when amputation was done below the elbow, close to the wrist, and the second - for prosthesis of the leg with amputation done above the knee.

In the first embodiment, a piezoelectric transducer 1 is attached to the amputee's forearm as shown on Fig. 1. It radiates ultrasonic waves 5 into the tissues 4 of the forearm and detects returning impulses, reflected from the said tissues and bones 3.

When the amputee strains muscles of the said forearm, the tissues' ultrasonic response, received by the transducer, changes.

The processing means 6 constantly analyze incoming signal. This includes its digitizing, filtering out noise and comparing the result with the set of patterns, stored in the memory. Every pattern has separate command, associated with it. When the signal matches one of the patterns, the associated command is sent to the executive systems of the prosthesis 7.

The above-mentioned patterns are created at the time of the system adjustment. First, the transducers are located on the skin in order to get optimal readings of the chosen muscles activity. Then the amputee strains and relaxes these muscles while the signals, coming to the transducers are processed and stored in the memory, forming the set of patterns. The amputee assigns desirable commands to these patterns at the same time.

In the other embodiment the transducers 1 and 2 are attached to the amputee's leg 3 as shown on Fig. 2. They radiate ultrasonic waves 5 into the two different zones of the body 6 in order to read signals from the two different muscles, responsible for operating a knee joint. The radiated signals deliver to the transducers information regarding the muscle activities in these zones.

When the amputee strains muscles of the said leg, the ultrasonic response changes.

The said signals are processed by the processing means 7 in the order, similar to one in the first embodiment, and generate commands, operating executive systems of the prosthesis 4.

CLAIMS

1. A prosthetic control system comprising:

(a) At least one ultrasonic transducer located on the user's body with ultrasound radiation directed into the said user's body in order to retrieve information regarding muscular activity in the zone of interest of the said user's body and changes in non-muscular tissues caused by the said activity;

(b) Means of processing of the information collected by the said transducer into the control signals operating prosthesis or similar device;

2. A prosthetic control system of claim 1 where a single transducer is used for the purpose of scanning of the said zone of interest;

3. A prosthetic control system of claim 1 where multiply transducers are used for the purpose of scanning of the said zone of interest;

4. A prosthetic control system of claim 3 where separate transducers are used as source and receiver of the said ultrasonic signal;

5. A prosthetic control system of claim 1 where there is more than one said zones of interest in the user's body;

6. A prosthetic control system of claim 1 where the said transducer is piezoelectric;

7. A prosthetic control system of claim 1 where the said transducer is a piezoelectric array;

8. A prosthetic control system of claim 1 where the said transducer is magneto-electric;

9. A prosthetic control system of claim 1 where the said transducer is a magneto-electric array;

10. A computer input device of claim 1 where the said transducer is of rotating type;

11. A computer input device of claim 1 where the said transducer is of oscillating type;

12. A computer input device of claim 1 where the said transducer is directly applied to the said operator's body;

13. A computer input device of claim 1 where the said transducer is applied to the said operator's body via liquid or gel;

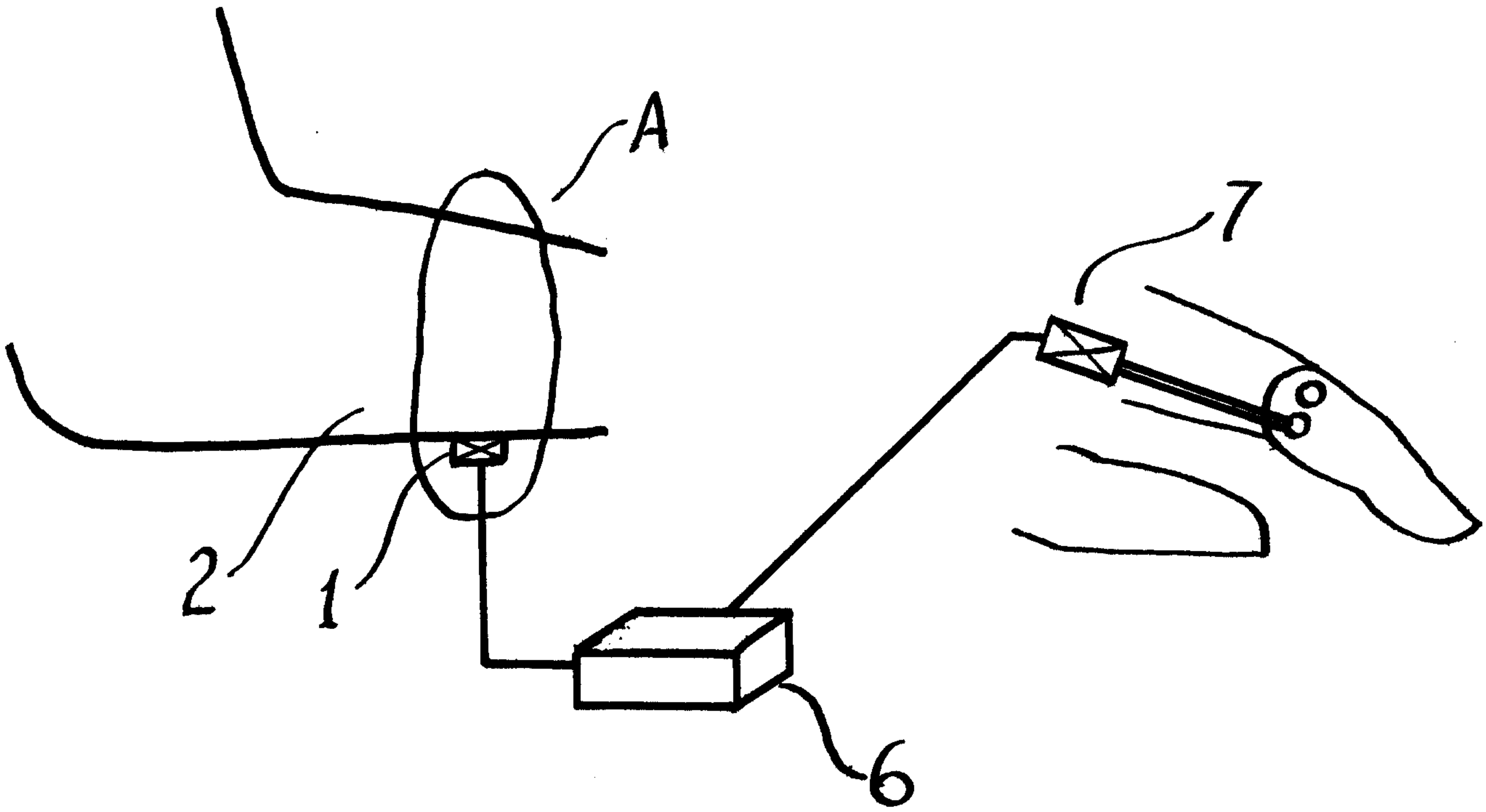
14. A method of operating a prosthetic device, comprising:

(A) Providing at least one ultrasonic transducer, located on the user's body and sensing muscular activity and resulting movements of the said user's body;

(B) The amputee straining and relaxing muscles with or without moving of the body parts;

(C) Processing signals received by the said transducer into the signals operating prosthesis or similar device.

FIG 1



A

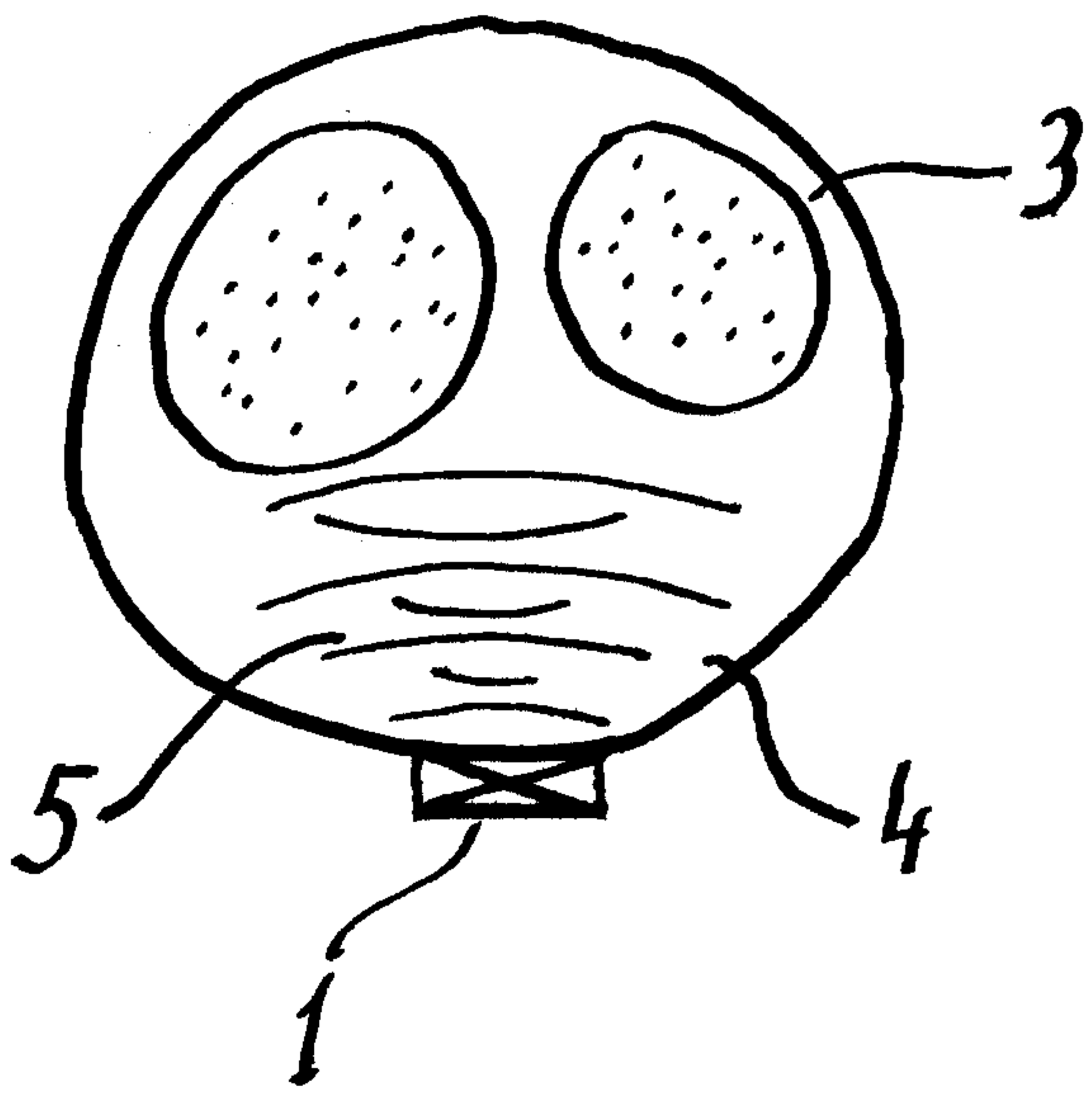
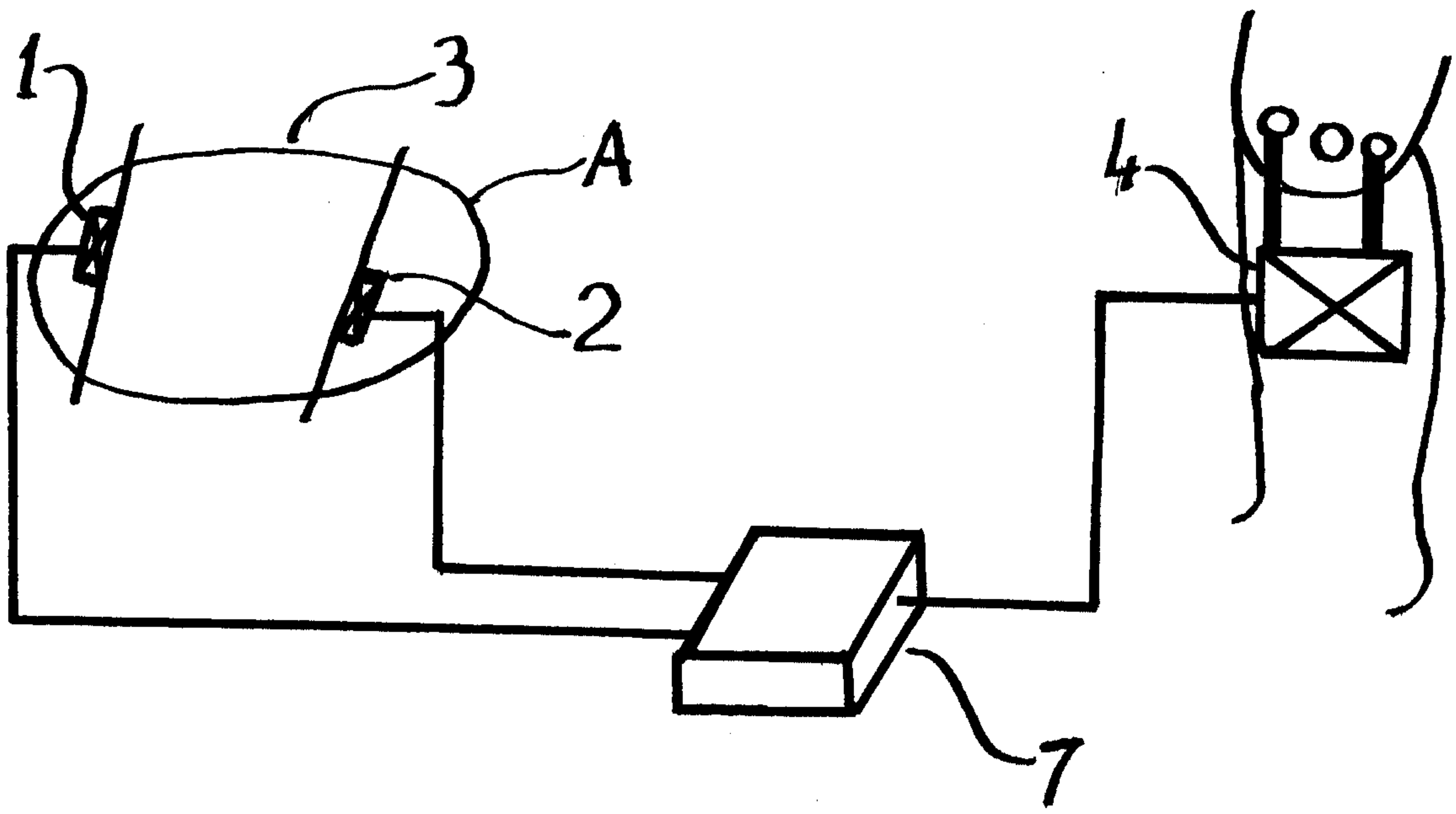
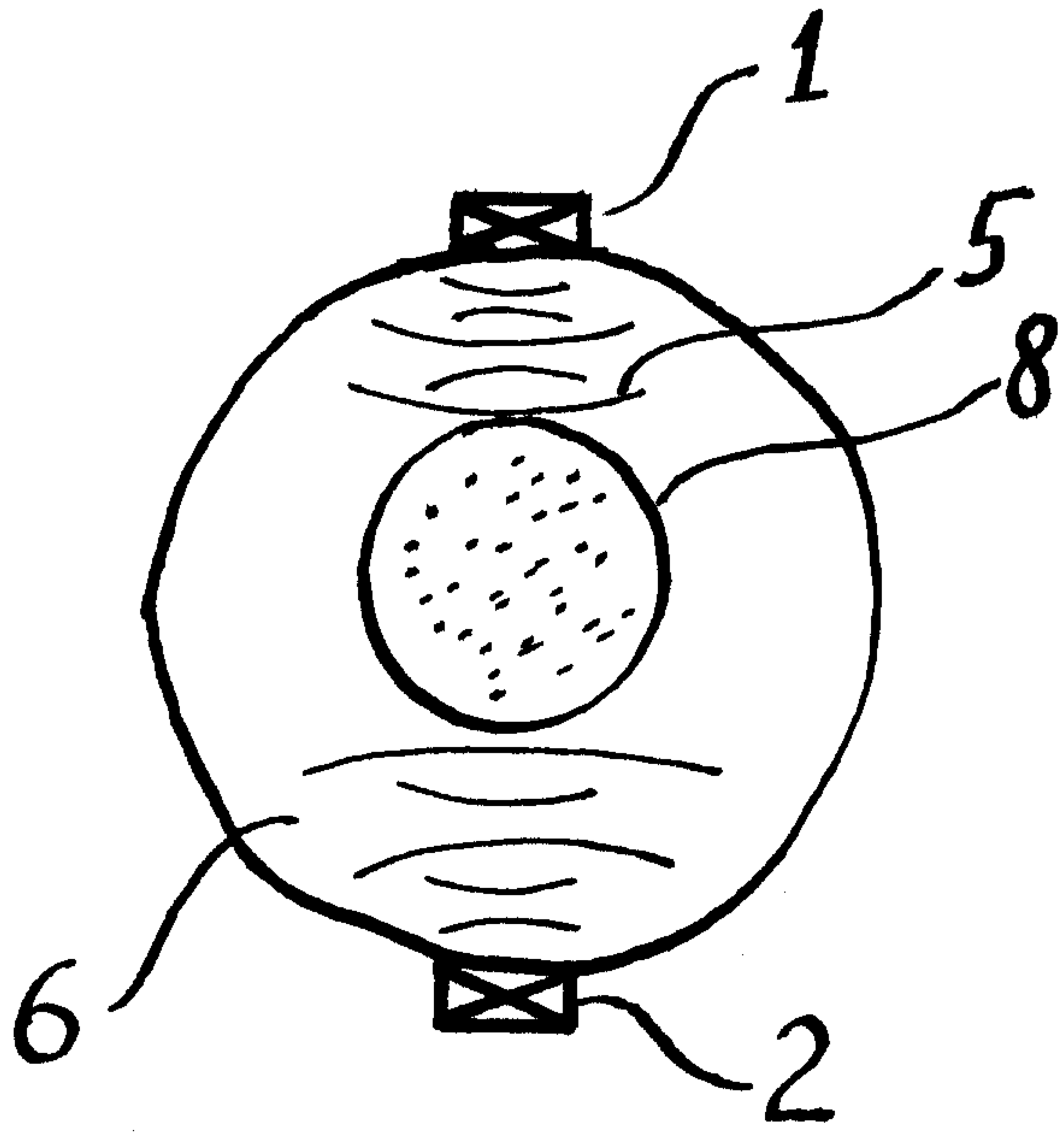
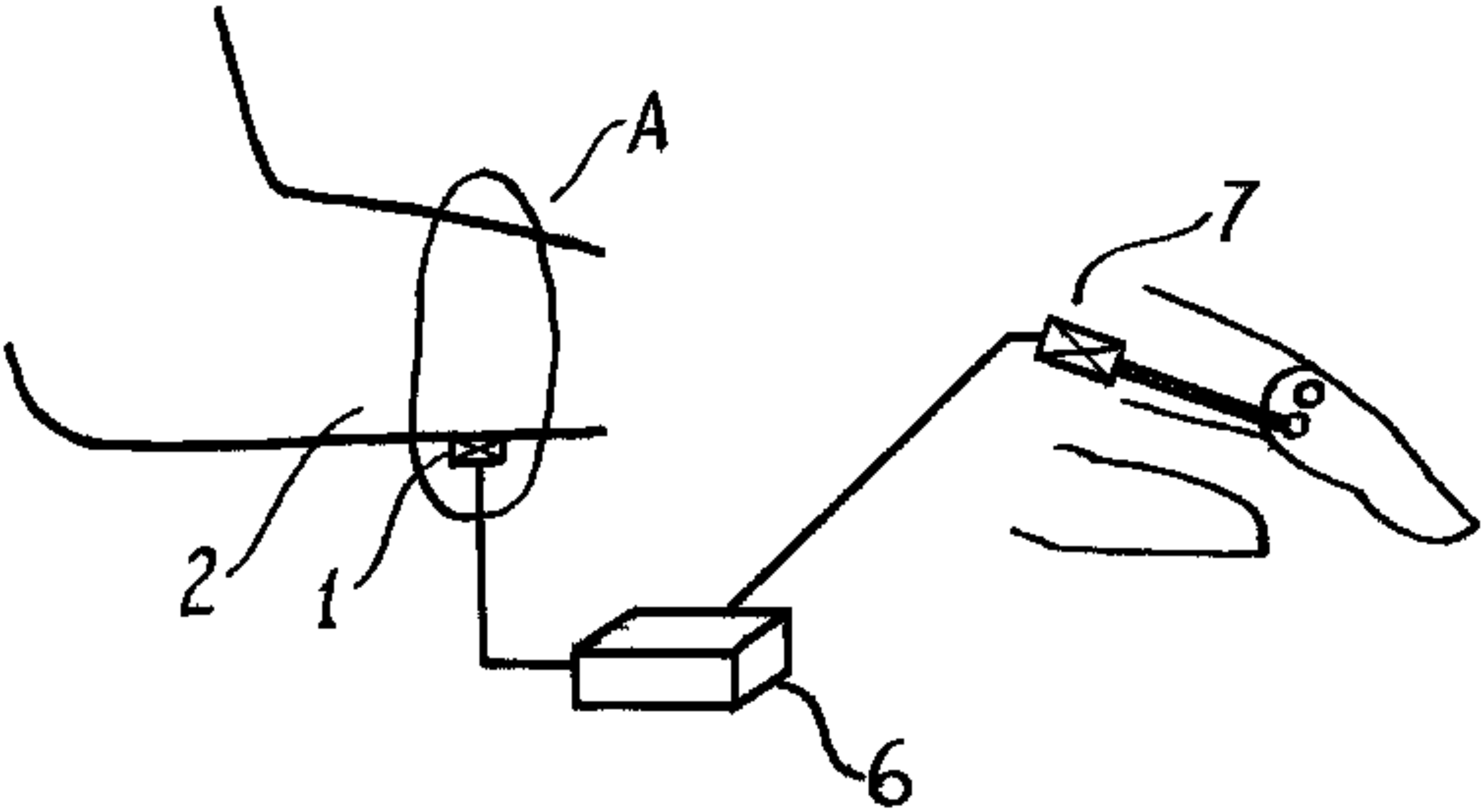


FIG. 2



A





A