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CA 2631982 A1 2007/07/12

(21) 2 631 982

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(86) Date de dépôt PCT/PCT Filing Date: 2006/12/07
(87) Date publication PCT/PCT Publication Date: 2007/07/12
(85) Entrée phase nationale/National Entry: 2008/05/29
(86) N° demande PCT/PCT Application No.: DE 2006/002177
(87) N° publication PCT/PCT Publication No.: 2007/076765
(30) Priorité/Priority: 2005/12/20 (DE10 2005 061 313.6)

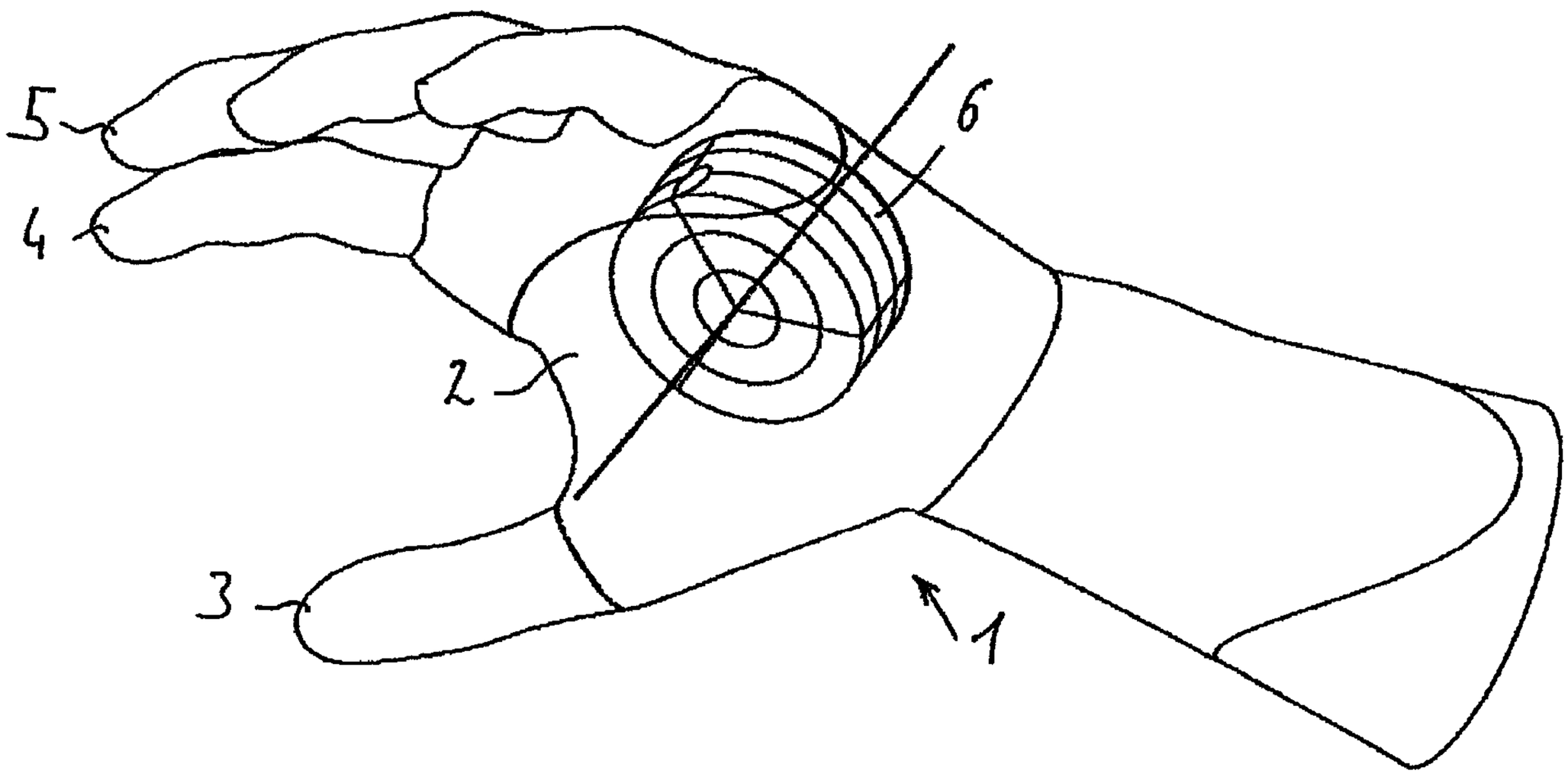
(51) Cl.Int./Int.Cl. *A61F 2/68* (2006.01),
A61F 2/58 (2006.01)

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(54) Title: HAND PROSTHESIS WITH FINGERS THAT CAN BE ALIGNED IN AN ARTICULATED MANNER



(57) Abrégé/Abstract:
The invention relates to a hand prosthesis comprising a chassis to which a plurality of finger prostheses are articulated, said finger prostheses being movable about at least one swiveling axis relative to the chassis and towards each other by means of a drive. The aim of the invention is to provide a hand prosthesis which has a simple control mechanism, works reliably and can be produced at low cost. For this purpose, the force transmission devices (10) on a common drive (6) are coupled to the finger prostheses (3, 4, 5) in such a manner that starting from a rest position and depending on the direction of rotation of the drive (6) at least two finger prostheses (3, 4, 5) go through different angles of adjustment relative to the chassis (2).

ABSTRACT

The invention relates to a hand prosthesis comprising a chassis to which a plurality of finger prostheses are articulated, said finger prostheses being movable about at least one swiveling axis relative to the chassis and towards each other by means of a drive. The aim of the invention is to provide a hand prosthesis which has a simple control mechanism, works reliably and can be produced at low cost. For this purpose, the force transmission devices (10) on a common drive (6) are coupled to the finger prostheses (3, 4, 5) in such a manner that starting from a rest position and depending on the direction of rotation of the drive (6) at least two finger prostheses (3, 4, 5) go through different angles of adjustment relative to the chassis (2).

WO 2007/076765 **PCT/DE2006/002177**

Hand prosthesis

The invention relates to a hand prosthesis comprising a chassis, to which a number of finger prostheses are articulated, said finger prostheses being movable relative to the chassis and toward one another about at least one swiveling axis by means of a drive.

The object of a hand prosthesis is to reproduce as fatihfully as possible the appearance and the function of a hand that has had to be replaced. For this purpose, the hand prosthesis must be capable of displacing gripping devices, which may be formed as replicas of fingers, in relation to one another, in order to allow gripping of an object.

US 2004/00195638 A1 discloses a two-finger gripper in which two gripping devices can be displaced from an open position into a closed position, in which the gripping devices lie directly opposite each other. In this way, an object located between the gripping devices can be held. To release the grip, a reversal of the direction of rotation of the drive can be initiated.

WO 03/017880 A1 discloses a prosthetic hand in which a separate drive is arranged in each individual finger prosthesis, which is mounted on a chassis. With such a prosthetic hand, it is possible to realize different gripping situations, for example fingertip gripping or lateral gripping. Disadvantages are the high degree of control required for each individual finger, the complex technology, with drives integrated in the finger, and increased susceptibility to faults on account of the complex type of construction.

Against the background of this prior art, the invention is based on providing a hand prosthesis which has

simple control, operates reliably and can be produced at low cost.

This object is achieved according to the invention by a hand prosthesis with the features of claim 1. Advantageous configurations and developments of the invention are presented in the subclaims.

The hand prosthesis according to the invention, comprising a chassis, to which a number of finger prostheses are articulated, said finger prostheses being movable relative to the chassis about at least one swiveling axis by means of a drive, provides that the force transmission units on a common drive are coupled to the finger prostheses in such a way that, starting from a rest position of the finger prostheses, at least two finger prostheses go through different adjusting angles relative to the chassis in dependence on the direction of rotation of the drive. If the drive is activated in one direction of rotation, for example, first the index finger and middle finger move from a rest position in the direction of the inner surface of the hand, while the thumb is activated later or more slowly. Then, so-called "lateral gripping" can be realized with these three fingers. In the case of the other direction of rotation, starting from the rest position, in which the hand prosthesis is held open, first the thumb is activated or moved more quickly in the direction of the inner surface of the hand, so that the tips of the finger prostheses are brought together, in order to realize "fingertip gripping". Therefore, a different time sequence of the movement takes place, in dependence on the direction of rotation of the drive, the finger prostheses being mechanically coupled to the drive, so that it is possible with a low degree of control, to be specific by a simple reversal of the direction of rotation, to set two different gripping states, with which the most frequent gripping tasks can be performed.

Apart from the different adjusting angles, which realize either fingertip gripping or lateral gripping, different fingertip gripping positions can also be realized by making the mechanism appropriately match requirements. The mechanical coupling can be produced at very low cost. In addition, only a single, common drive is required, accommodated with preference in the chassis of the prosthetic hand, which can be made much more efficient in its design on account of the generous space provided in comparison with the finger prostheses.

A development of the invention provides that the force transmission units are rotatably mounted on a swiveling coupling element, for example a rotary disk, in order to be able to transmit the desired forces with minimal incidental forces that result from instances of material bending in the case of rigid mounting. The coupling element may itself be formed in a rotatable or swiveling manner, a particularly simple configuration comprising that a rotary disk is arranged within the chassis in such a way that the axis of rotation of the coupling element runs substantially orthogonal to the palmar surface of the chassis. A gear mechanism may be arranged between the drive and the coupling element, in order to provide the possibly required speed reduction. With preference, the output axis of the drive likewise lies orthogonal to the palmar surface of the chassis, so that the possibly required gear stages can always operate with parallel axes of rotation. Should a change in the direction of rotation or orientation of the axis of rotation be necessary on account of the geometry of the drive or the chassis, this can be realized for example by means of an angular gear mechanism.

Particularly simple realization of the different adjusting angles is achieved by the force transmission

units being coupled to the coupling element in such a way that their mountings on the drive side have different dead center positions. With a force transmission unit mounted on a rotary disk, displacements are realized in a movement component in the course of the rotational movement of the rotary disk in the form of a sine curve. In dependence on the angle of rotation covered, different displacements are brought about in a directional component. The rotatable mounting of the force transmission unit on the coupling element means that only the displacement in a directional component is effective. If then the bearing points of the force transmission units on the coupling element or the rotary disk are chosen such that, when activation takes place in the first direction of rotation, first the thumb goes through a dead center position, then first the other prosthetic fingers, for example the index finger and the middle finger, are displaced, whereas in the case of the opposite direction of rotation, the adjusting path for the index finger and middle finger is smaller than that for the thumb. Alternatively, different adjusting angles may be realized by a force transmission unit rolling on a cam disk, the radius of which is different for each direction of rotation. If, starting from a rest position, the cam disk is moved in the first direction of rotation, the force transmission units, for example in the form of tension belts, are rolled onto a cam disk with a greater radius than the force transmission unit for the thumb. As a result, first the index finger and middle finger are displaced in the palmar direction, while the thumb follows. In the opposite direction of rotation, this takes place correspondingly in the reverse sense. A return movement can be performed by means of spring biasing of the finger prostheses. The cam disks also allow different movement sequences of the individual finger prostheses to be set, for example first a high swiveling speed that decreases with an increasing

swiveling angle of the finger prostheses, or vice versa.

To be able to transmit high forces, the drive is formed with preference as a pancake motor, which can be easily accommodated in the chassis, which may be formed in the form of the metacarpus. The pancake motor, formed with preference as a slow-running motor, can produce high torques with a relatively compact construction and low rotational speeds. The rotational speeds may be reduced further to the desired speed by means of a cycloidal gear mechanism or a harmonic-drive gear mechanism.

A development of the invention provides that the force transmission units are formed so as to be rigid under tension and yielding under pressure or elastic under bending, so that a limited elasticity is possible with palmar force transmission to the finger prostheses, while conversely opening of the prosthetic hand is not possible without unlocking the drive or reversing the direction of rotation. As a result, secure gripping is ensured. The force transmission units may to a certain extent be stable under pressure, to be able to provide compressive forces if need be to assist an opening movement.

For the stable transmission of tensile forces, it is provided that the force transmission component has a cable, stranded-wire or fiber component; for reasons of simplicity, from now on reference is only made to cable components. The other components are correspondingly included by this term.

The cable component may be formed as an open, closed or twisted loop and have an elastomer component, to make displacement on all sides possible, for example in the case of incorrect axial positions. Furthermore, the elastomer component protects the cable component from

external influences if it at least partially encloses the cable component.

Bearing bushes for receiving axial spindles that are assigned to the chassis or drive and the finger prostheses may be located in the force transmission unit. With a resiliently elastic configuration of the force transmission units, spring rates are set with preference such that, when the force transmission unit is subjected to the force of a pressure, a return of the finger prosthesis into a starting position is brought about.

An exemplary embodiment of the invention is explained in more detail below on the basis of the accompanying figures, in which:

Figure 1 shows a schematic representation of a hand prosthesis;

Figure 2 shows a schematic representation of the functional setup of a hand prosthesis in a palmar plan view;

Figure 3 shows a side view of Figure 2;

Figure 4 shows a closed hand in the act of lateral gripping;

Figure 5 shows a closed hand in the act of fingertip gripping; and

Figure 6 shows an individual representation of a thumb prosthesis.

Figure 1 shows a hand prosthesis 1, comprising a hand chassis 2 and at least three finger prostheses 3, 4, 5 articulated to the hand chassis 2. The finger prostheses 3, 4, 5 correspond to the thumb, index

finger and middle finger of a natural hand. Movable mounting of these three finger prostheses 3, 4, 5 that can be actuated by means of a common drive 6 is adequate to allow a plurality of gripping tasks of a hand to be performed. The two other fingers, the ring finger and the small finger, can be passively moved along with the other fingers and consist of an elastomer material, to achieve an appearance that looks as natural as possible. The drive 6 is mounted within the hand chassis 2 in the form of an electric motor with an associated gear mechanism. A power source for the drive 6 (not represented), may likewise be located within the hand chassis 2. The drive 6 is activated by means of a control device, which may be located in the hand chassis 2. The corresponding signals may be generated by means of a remote control or take the form of myoelectrical signals.

Figure 2 shows a schematic representation of the functional mode of the hand prosthesis 1. The three finger prostheses 3, 4, 5 are mounted on the hand chassis 2 such that they can swivel about articulating axes 15. The finger prostheses 3, 4, 5 are connected via force transmission units 10, the construction of which is described in detail further below, to a rotary disk 7, which is driven by the electric motor 6. The force transmission units 10 are mounted on the rotary disk 7 on spindles 16, either directly or by way of a rocker 8. The index finger 4 and the ring finger 5 are coupled to each other by way of the rocker 8, which is rotatably mounted on the rotary disk 7. The rotary disk 7 itself is mounted either directly on an output shaft of the drive 6 or a gear-mechanism output shaft. If the drive 6 is activated, the rotary disk 7 is moved by a corresponding rotational angle. As a result, the spindles 16 are displaced in relation to the swiveling axes 15 of the finger prostheses 3, 4, 5, which leads to a swiveling of the finger prostheses 3, 4, 5 on account of the tensionally rigid formation of the force

transmission units 10 and an articulation of the force transmission units 10 on the finger prostheses 3, 4, 5 that is at a distance from the axes of rotation 15. If the drive 6 is reversed and the rotary disk 7 moves into a position in which the spindles 16 are at a minimal distance from the swiveling axes 15 of the finger prostheses 3, 4, 5, the opened starting position or rest position is reached. The finger prostheses 3, 4, 5 then move into their opened starting position as a result of the resiliently elastic properties of the force transmission units 10. It is provided here that the force transmission units 10 can transmit much higher tensile forces than compressive forces. This corresponds to the physiological conditions of a natural hand, which can apply much greater forces when closing the hand than when opening it. For reasons of overall clarity, the ring finger and the small finger are not represented; they can be passively articulated to the middle finger 5 and thereby moved along with it. It is also possible for the ring finger and the small finger to be articulated on the widened rocker 8, to which further force transmission units 10, actively articulating further finger prostheses 3, 4, 5, are coupled.

Figure 3 shows in a side view of Figure 2 the hand prosthesis in a rest position, in which the thumb 3, the index finger 4 and the middle finger 5 are represented in a slightly opened position of rest, approximating the position in which the hand is naturally held. It can be seen from this figure that the force transmission units 10 are articulated to the finger prostheses 4, 5 at bearing points 16', which are at a distance from the axes of rotation 15 of the finger prostheses 4, 5. Bending of the finger prostheses 4, 5 is brought about by a displacement of the axis of rotation 16 on the coupling element 7, on account of the tensile forces transmitted. If then, starting from the rest position shown in Figures 2 and

3, the rotary disk 7 is turned in the clockwise sense, as shown in Figure 4a, first the index-finger and middle-finger prostheses 4, 5 move in the direction of the inner surface of the hand, while the thumb prosthesis 3 is only displaced thereafter in the direction of the inner surface of the hand, since the force transmission unit 10 that is assigned to the thumb prosthesis 3 first has to go through the dead center, that is to say the shortest distance between the axis of rotation 16 on the drive side and the swiveling axis 15. The special arrangement of the force transmission units 10 of the index-finger and middle-finger prostheses 4, 5 means that they are displaced in the palmar direction more quickly, or over a wider angular range, so that the thumb prosthesis 3 bears against the radial side of the index-finger prosthesis 4. As a result, the lateral gripping represented is made possible.

Figure 5 shows the position of the finger prostheses 3, 4, 5 in the case of a direction of rotation in the counterclockwise sense.

There, the thumb prosthesis 3 is first moved in the palmar and ulnar directions about the swiveling axis 15, while the finger prostheses 4, 5 first have to go through their dead center, or are articulated to the rotary disk 7 in such a way that only a small angular displacement is realized for a corresponding rotational angle. Therefore, the thumb prosthesis 3 is first guided inward and the tips of the finger prostheses 3, 4, 5 lie against one another in their end positions, so that so-called "fingertip gripping" is realized.

To be able to provide still further gripping possibilities, an additional drive may be provided in the thumb prosthesis 3, as shown in Figure 6. In Figure 6, it can also be seen that, apart from the first swiveling axis 15, the thumb prosthesis 3 has a

second swiveling axis 31, about which at least the distal end of the thumb prosthesis 3 is swivel-mounted. A second drive 30 and an inclined-screw gear mechanism 32 or a multiple-threaded worm gear mechanism are used to move an output worm 33, which meshes with a gearwheel segment 34 and so brings about a displacement of the finger prosthesis 3 about the swiveling axis 31 with the drive 30 and the gear mechanism 32. If both drives 6, 30 are activated at the same time, a combined movement of the thumb prosthesis 3 in the palmar and ulnar directions is performed in accordance with the displacement speeds, which corresponds to the natural mobility of a thumb.

This figure shows the function of the thumb prosthesis 3 in detail, comprising a molding 36, which replicates the contour of a natural thumb. Inside the molding 36, which is formed as a hollow body, there is a free space, in which the second drive 30 is located and fastened. The molding 36 is consequently coupled, for example adhesively attached, firmly clamped or positively connected, to the drive 30. The drive 30 is coupled to the gearwheel segment 34 by means of an angular gear mechanism in the form of an inclined-screw gear mechanism 32 and the worm 33 described in Figure 2.

On activation of the drive 30, the worm 33 is turned in one direction or the other. On account of the swivel-mounting about the axis of rotation 31 on the gearwheel segment 34, a movement about the swiveling axis 31 is possible in the direction of the double-headed arrow. A radial or ulnar movement may thereby be performed. The gearwheel segment 34 itself is swivel-mounted about the first swiveling axis 15 and can be swiveled in a palmar or dorsal direction by a turning of the rotary disk 7 and the displacement of the force transmission element 10 brought about as a result. This swiveling movement

is likewise indicated by the double-headed arrow around the swiveling axis 15.

The second drive 30 is likewise an electric motor and is located with preference in the longitudinal axis between the carpometacarpal joint and the interphalangeal joint. On account of the small type of construction and the possibly necessary high drive torque, the drive 30 is formed as a fast-running motor, it being possible for the speed-transforming gear mechanism 32 to be formed as an inclined-screw gear mechanism and with a deflection of the drive axis in relation to the longitudinal axis of the second drive 30 being produced in an angular range of 45° to 135°. On account of this angling away of the output spindle, it is possible for the worm 33, which meshes with the gearwheel segment 34, to bring about a corresponding movement of the thumb.

The first drive 6, arranged in the hand chassis 2, is with preference a slow-running pancake motor with a high torque, which is coupled to a highly speed-reducing gear mechanism, to allow a correspondingly slow and forceful gripping movement to be performed. The control signals may either be generated by a remote control or be myoelectrical signals and have a control device. By means of this first drive 6 and the rotary disk 7 it is possible to displace the gearwheel segment 34 together with the worm 33 as well as the gear mechanism 32 and the drive 30, covered by the molding 36.

Patent claims

1. A hand prosthesis comprising a chassis, to which a number of finger prostheses are articulated or elastically coupled, said finger prostheses being movable relative to the chassis and toward one another about at least one swiveling axis by means of a drive, characterized in that the force transmission units (10) on a common drive (6) are coupled to the finger prostheses (3, 4, 5) in such a way that, starting from a rest position, at least two finger prostheses (3, 4, 5) go through different adjusting angles relative to the chassis in dependence on the direction of rotation of the drive (6).

2. The hand prosthesis as claimed in claim 1, characterized in that the force transmission units (10) are rotatably mounted on a swiveling coupling element (7).

3. The hand prosthesis as claimed in claim 1 or 2, characterized in that the coupling element (7) is formed as a rotary disk.

4. The hand prosthesis as claimed in claim 2 or 3, characterized in that the axis of rotation of the coupling element (7) is aligned substantially orthogonal to the palmar surface of the chassis (2).

5. The hand prosthesis as claimed in one of the preceding claims, characterized in that the output axis of the drive (6) is aligned substantially orthogonal to the palmar surface of the chassis (2).

6. The hand prosthesis as claimed in one of claims 2 to 5, characterized in that the force transmission

units (10) are coupled to the coupling element (7) in such a way that their mountings on the drive side have different dead center positions.

7. The hand prosthesis as claimed in one of the preceding claims, characterized in that drive (6) is formed as a pancake motor.

8. The hand prosthesis as claimed in one of the preceding claims, characterized in that the drive (6) is coupled to a cycloidal gear mechanism or a harmonic-drive gear mechanism on which the coupling element (7) is located.

9. The hand prosthesis as claimed in one of the preceding claims, characterized in that the force transmission unit (10) is formed so as to be rigid under tension and yielding under pressure or elastic under bending.

10. The hand prosthesis as claimed in one of the preceding claims, characterized in that the force transmission unit (10) has a cable, stranded-wire or fiber component (11).

11. The hand prosthesis as claimed in claim 10, characterized in that the cable, stranded-wire or fiber component (11) is formed as a closed loop.

12. The hand prosthesis as claimed in one of the preceding claims, characterized in that the force transmission unit (10) has an elastomer component (12)

13. The hand prosthesis as claimed in claims 10 and 12, characterized in that the elastomer component (12) at least partially encloses the cable, stranded-wire or fiber component (11).

14. The hand prosthesis as claimed in one of the preceding claims, characterized in that the force transmission units (10) have bearing bushes (13, 14) for receiving axial spindles (15, 16) that are assigned to the chassis (2) and the finger prostheses (3, 4, 5).

15. The hand prosthesis as claimed in one of the preceding claims, characterized in that the force transmission unit (10) is formed in a resiliently elastic manner.

16. The hand prosthesis as claimed in claim 15, characterized in that the spring rate of the force transmission unit (10) is set such that, when the force transmission unit (10) is subjected to the force of a pressure, a return of the finger prosthesis (3, 4, 5) into a starting position is brought about.

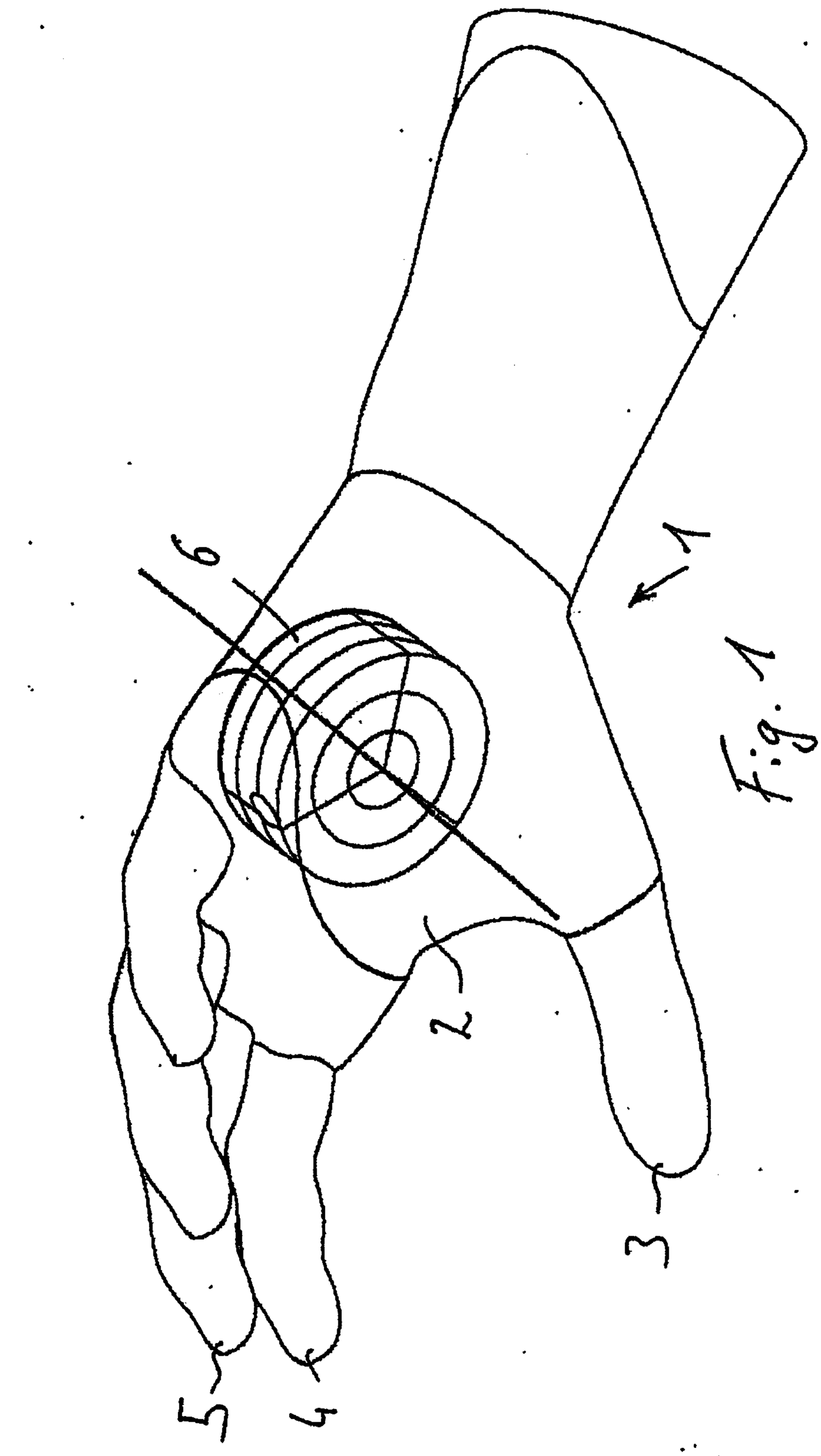


Fig. 1

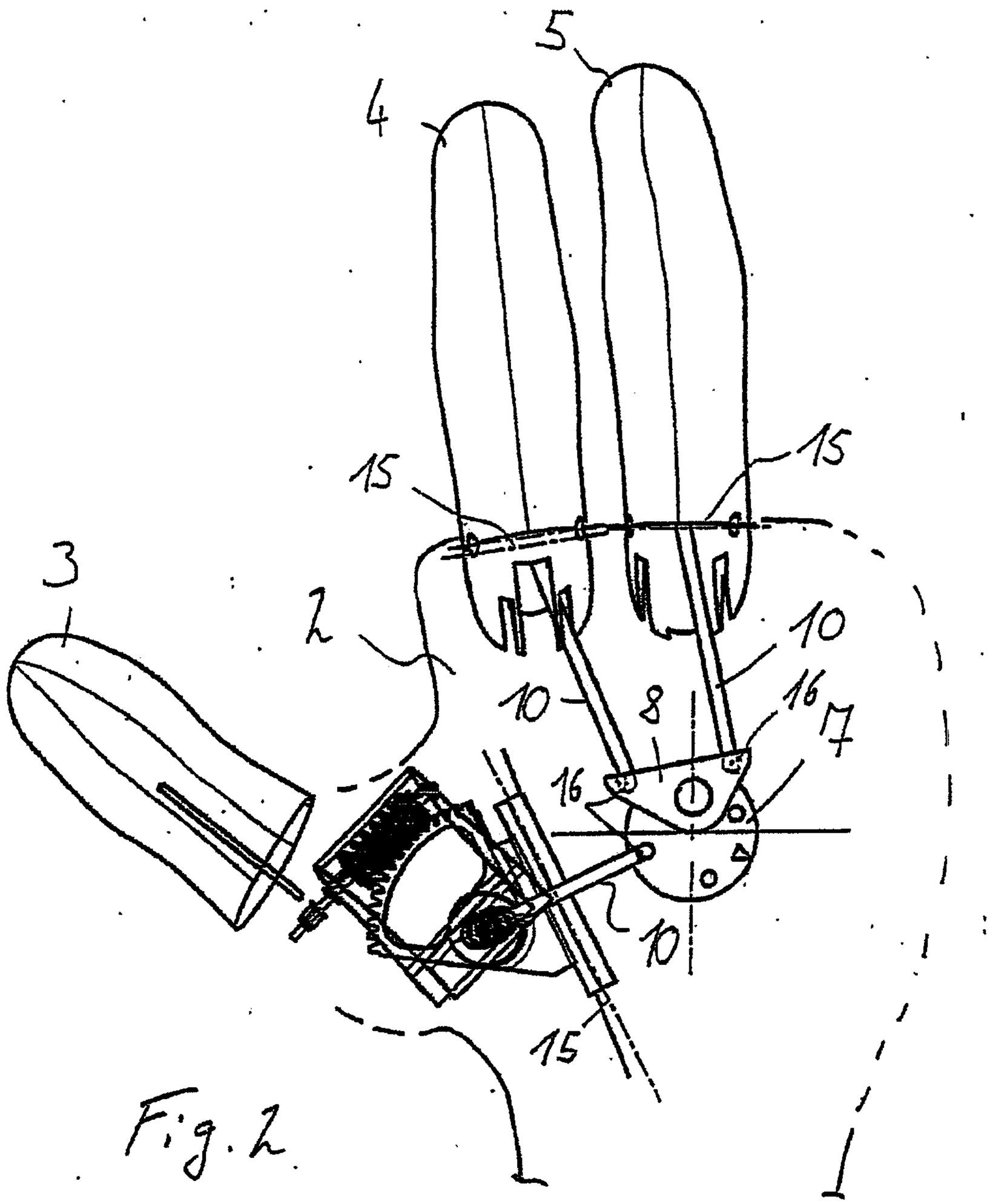


Fig. 2

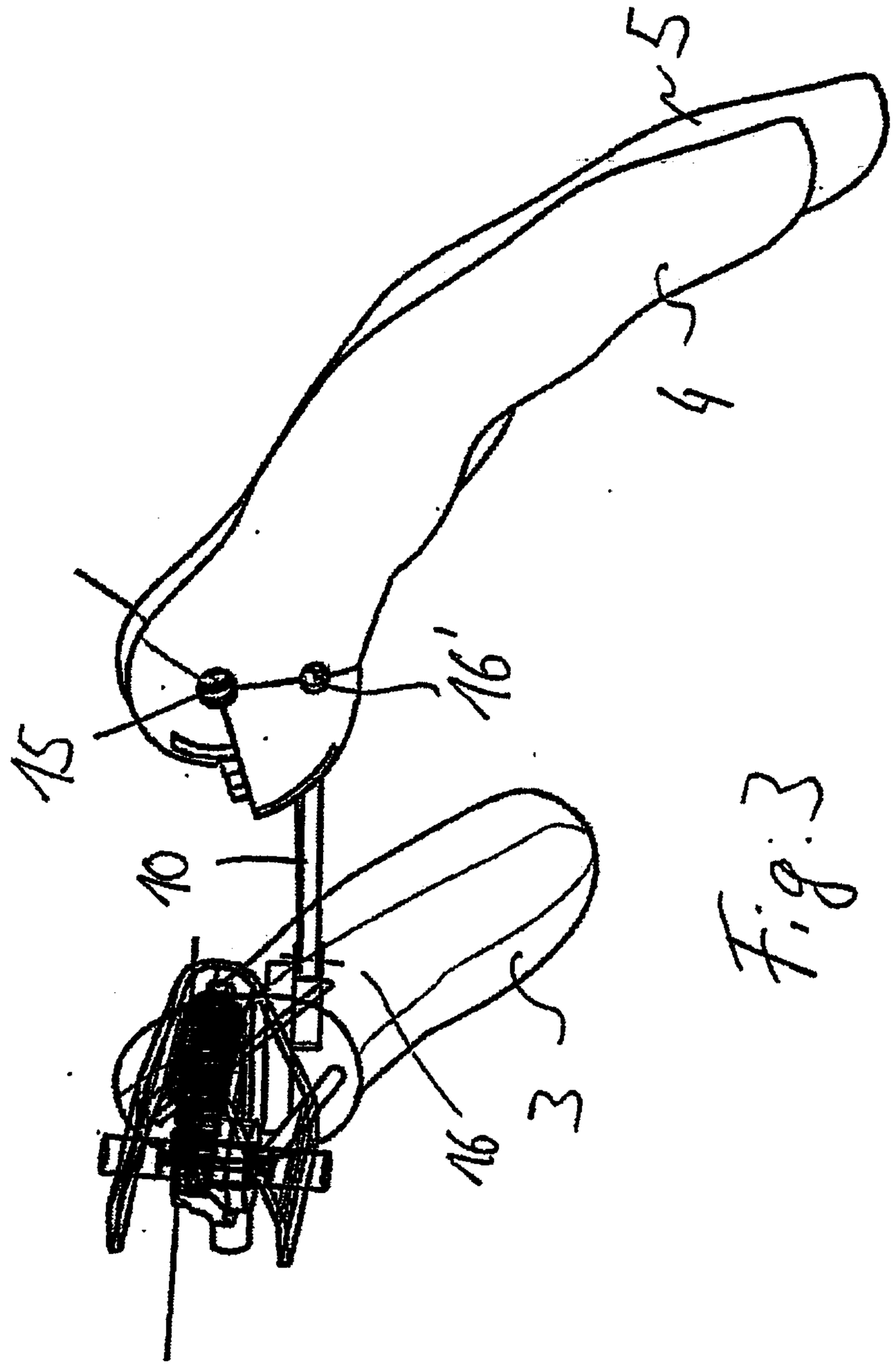


Fig. 1

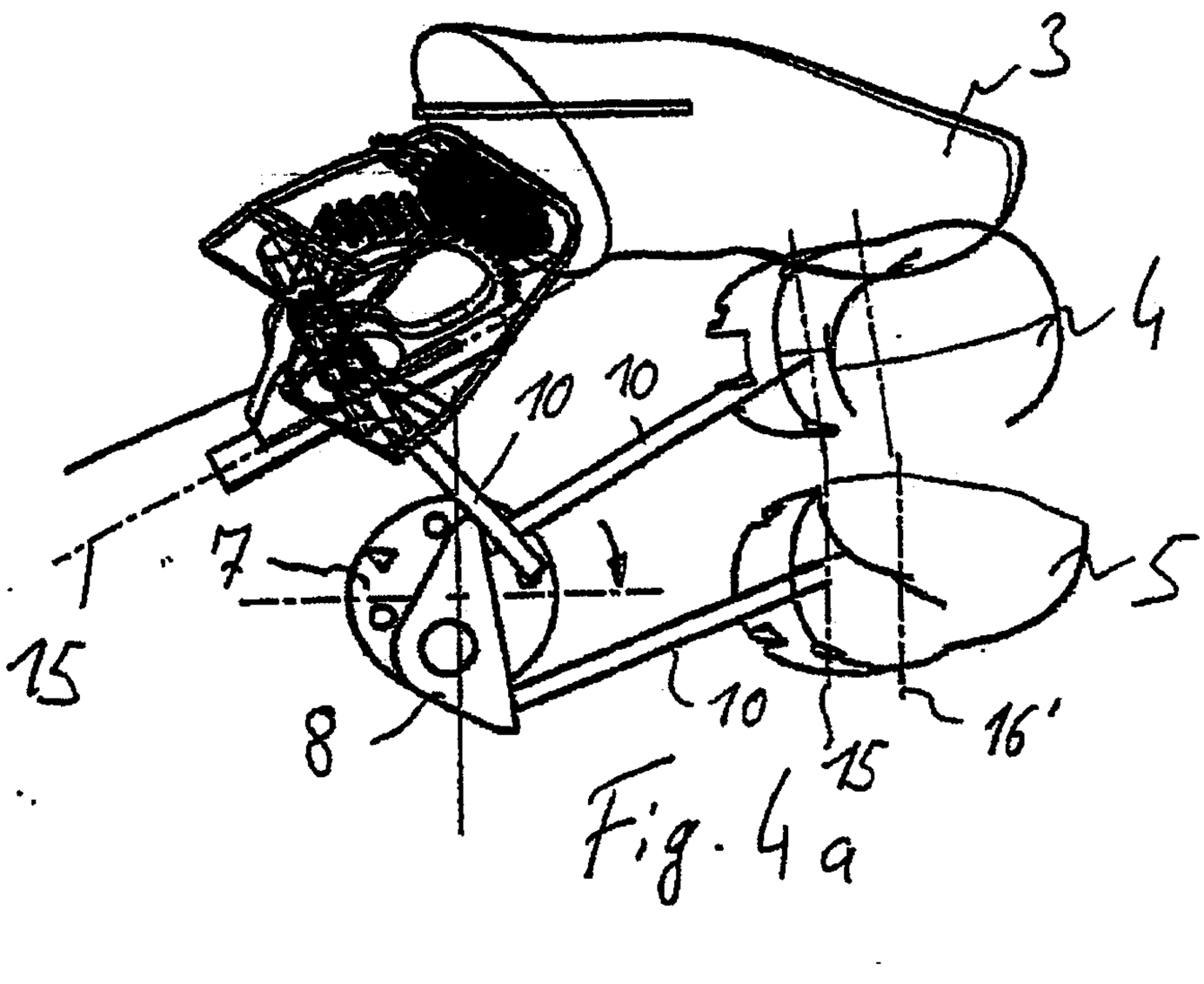


Fig. 4a

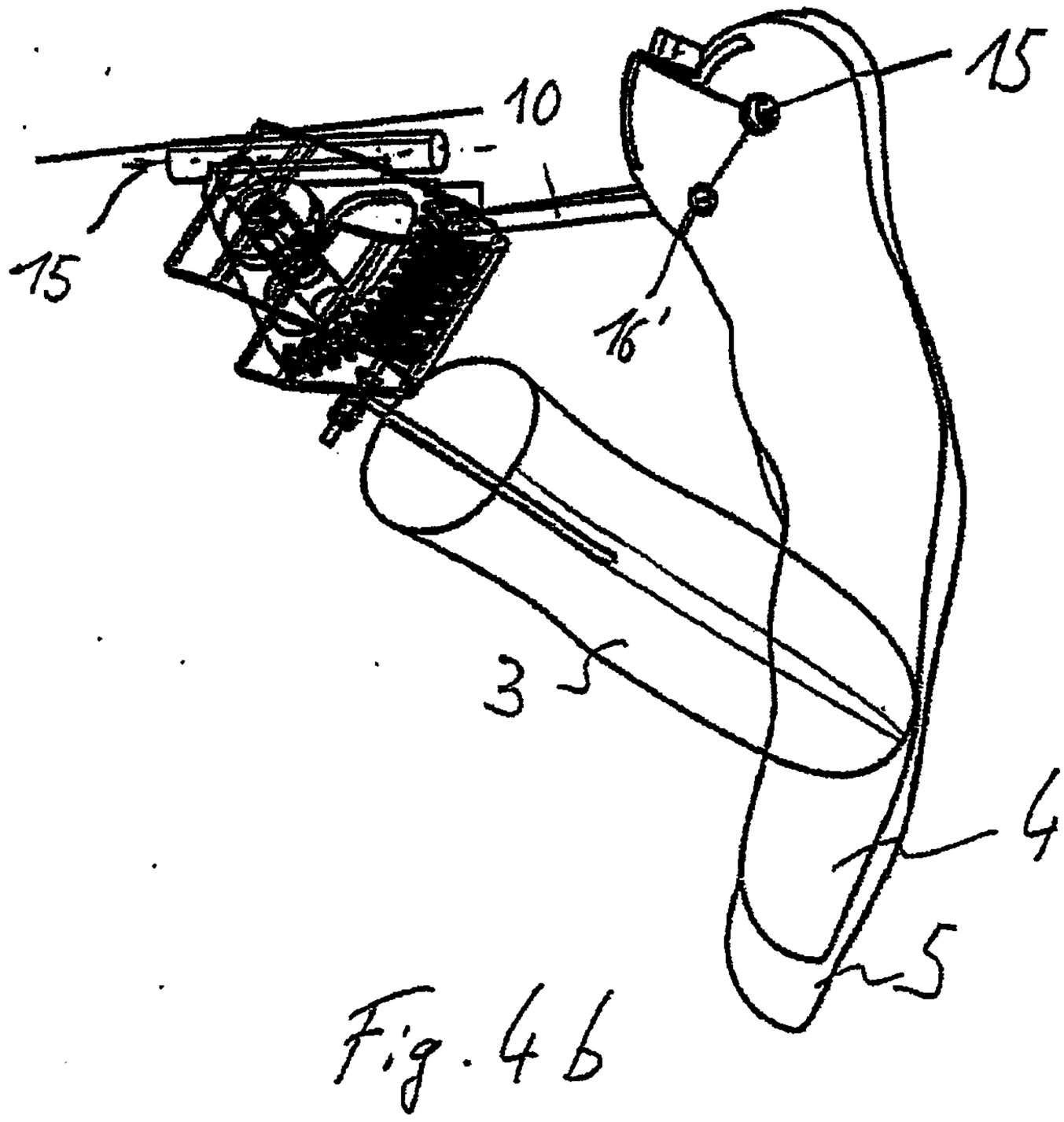


Fig. 4b

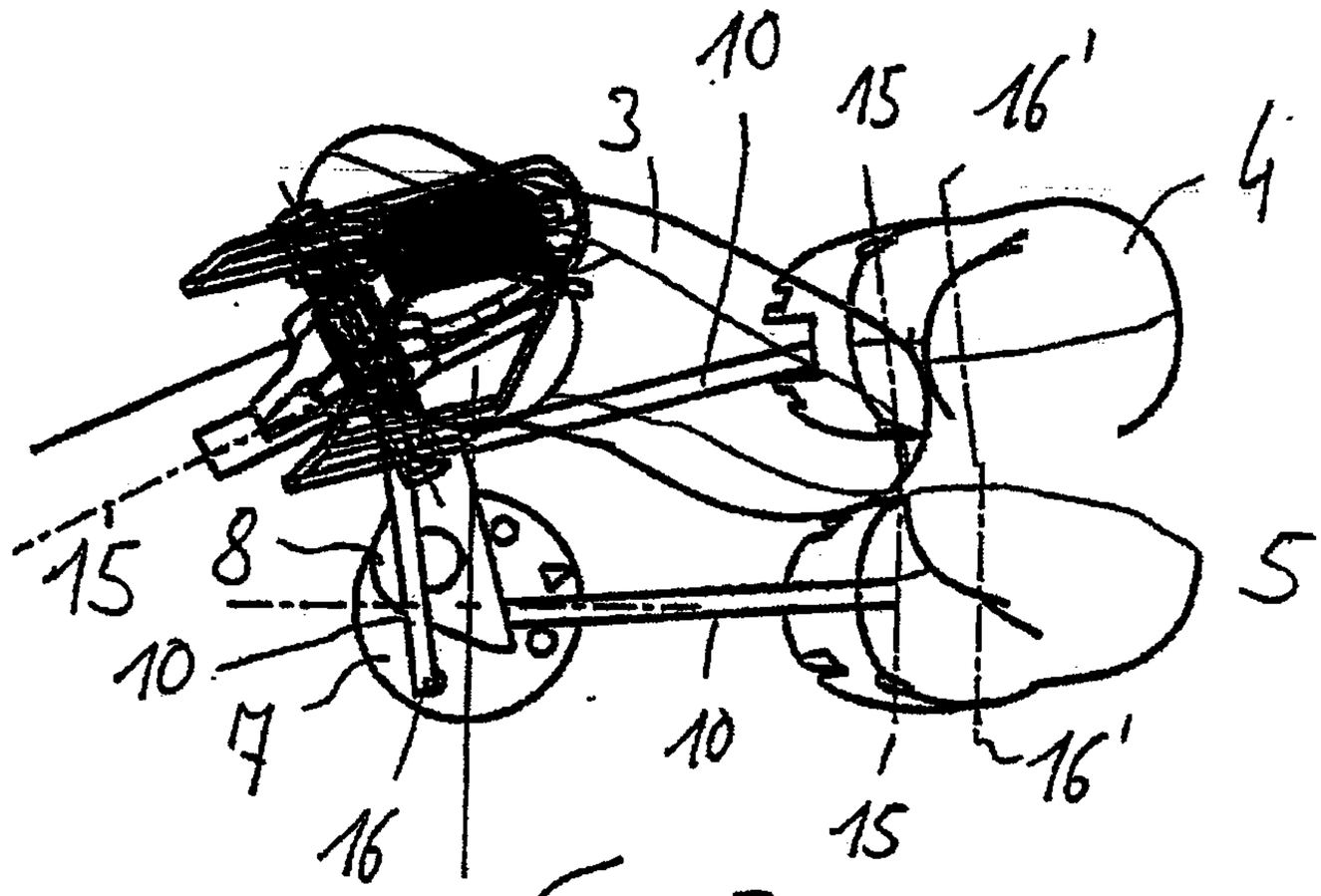


Fig. 5a

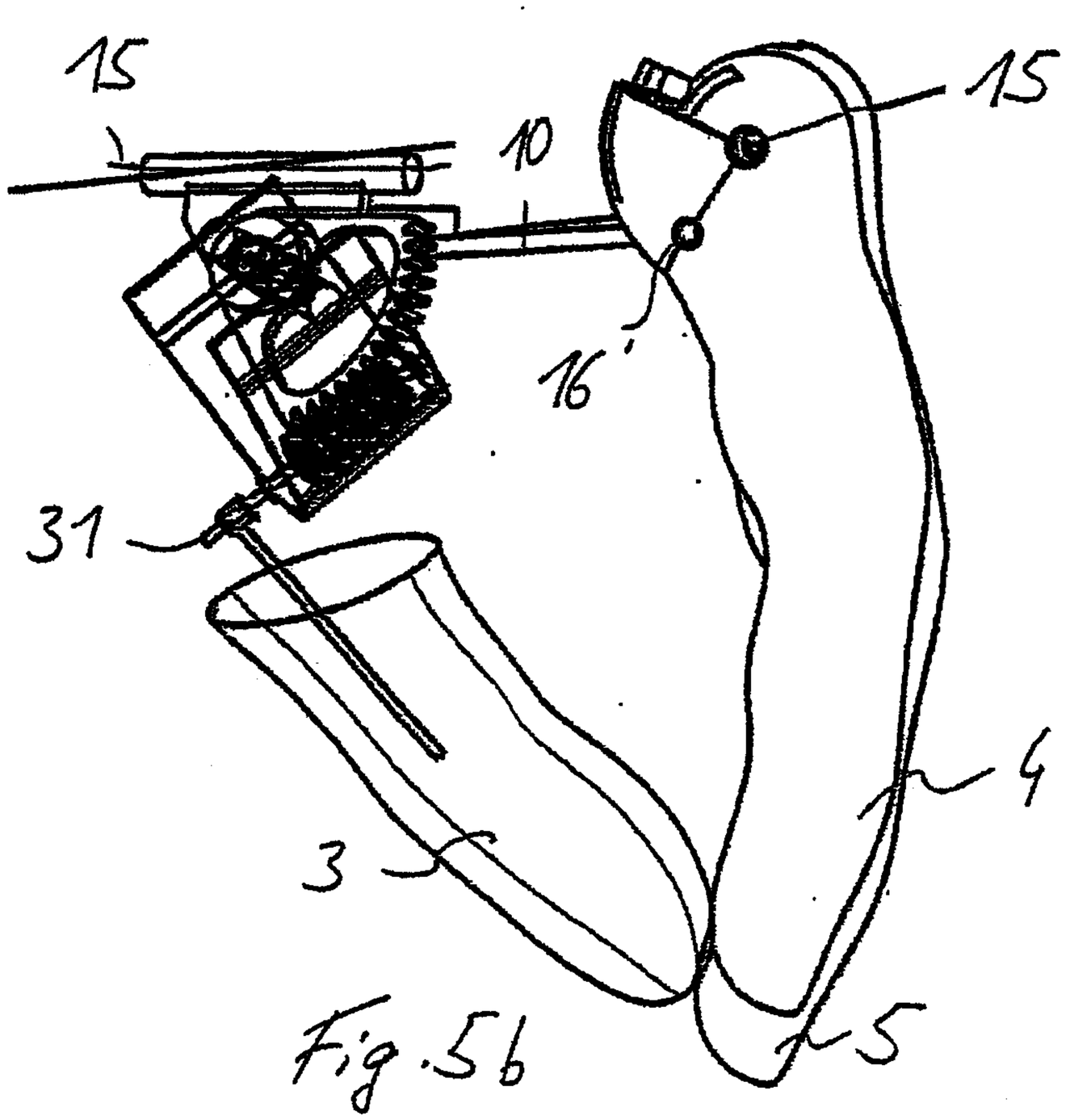


Fig. 5b

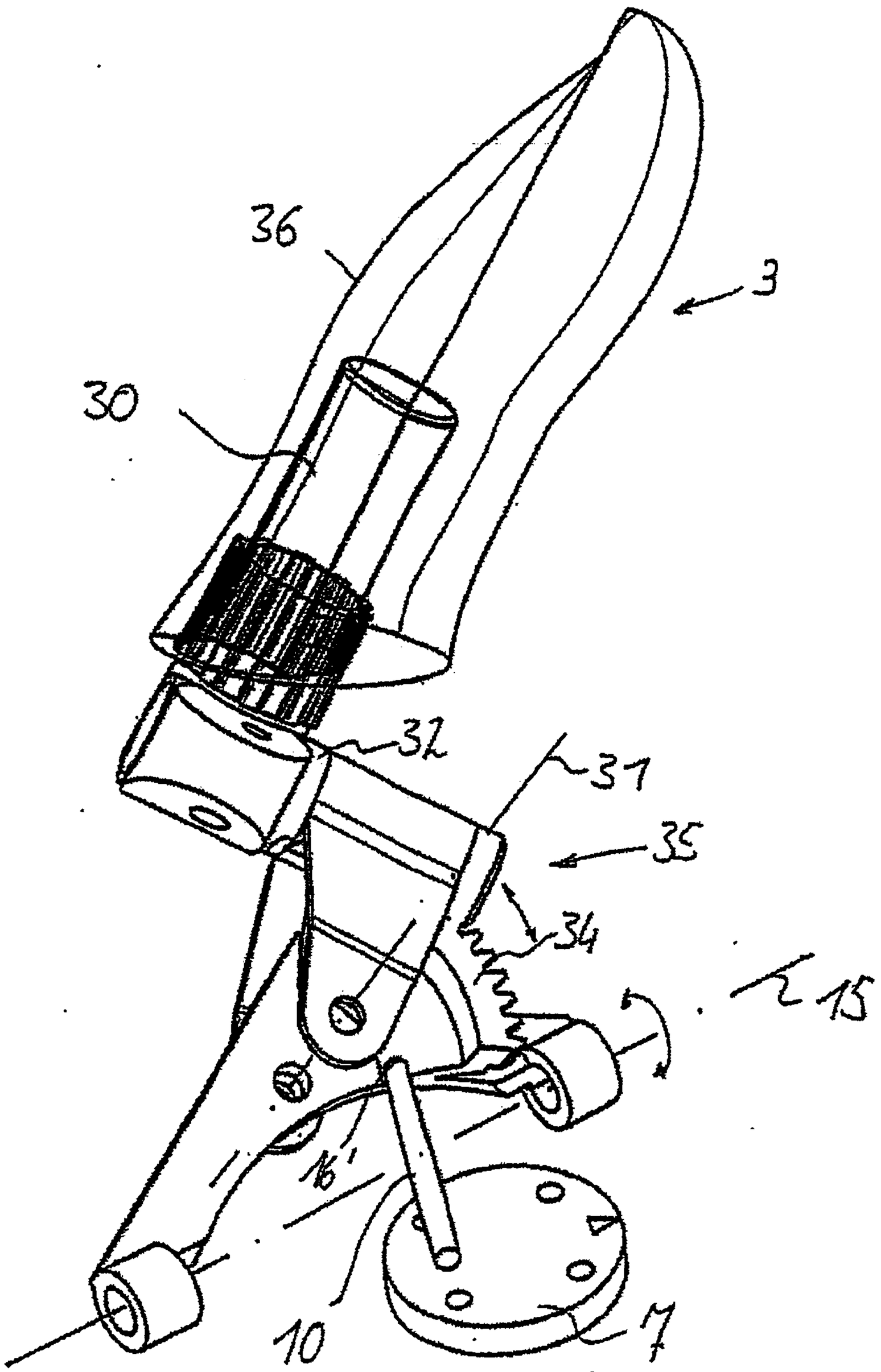
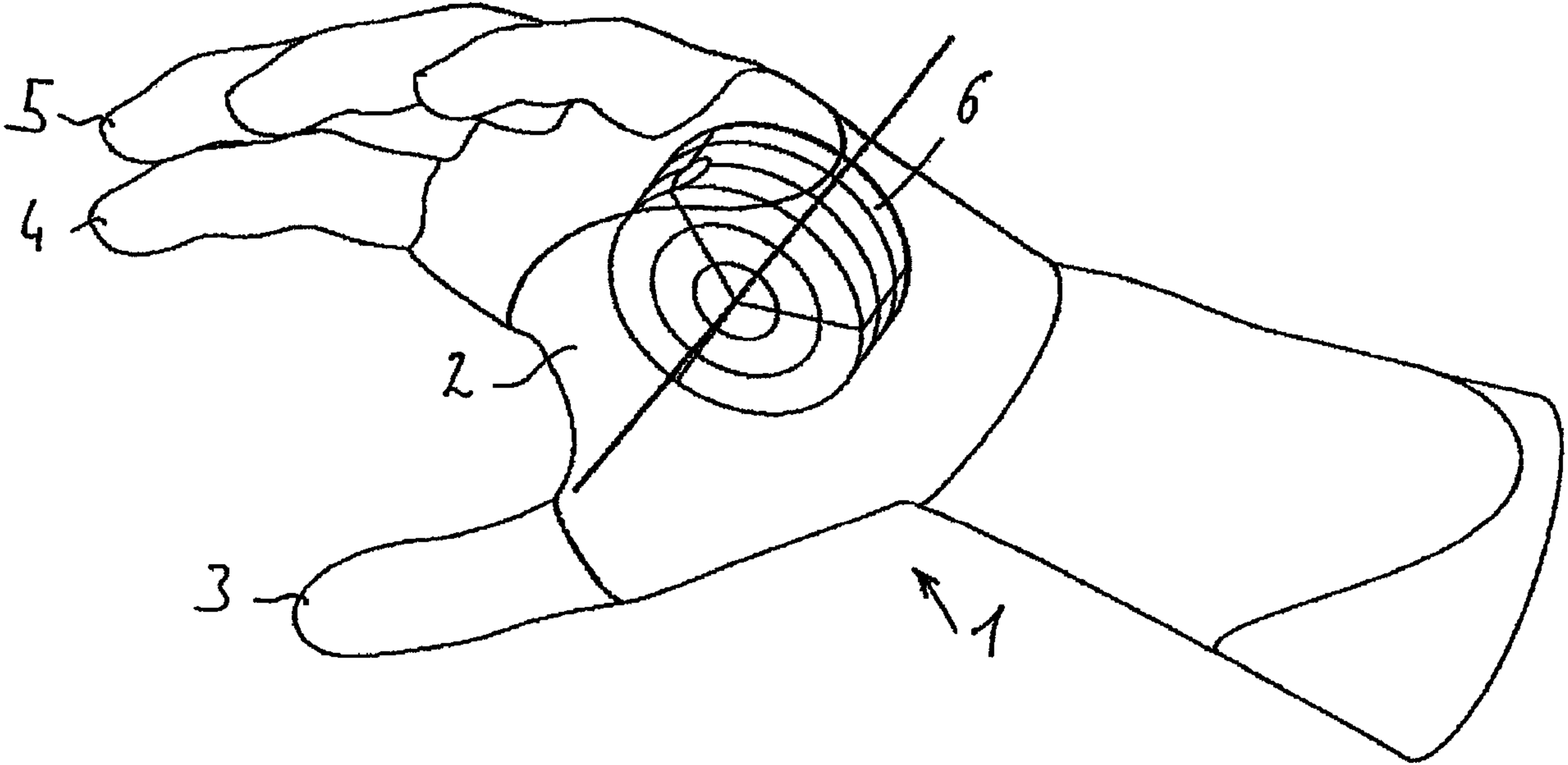


Fig. 6


5
6
4
2
3
1