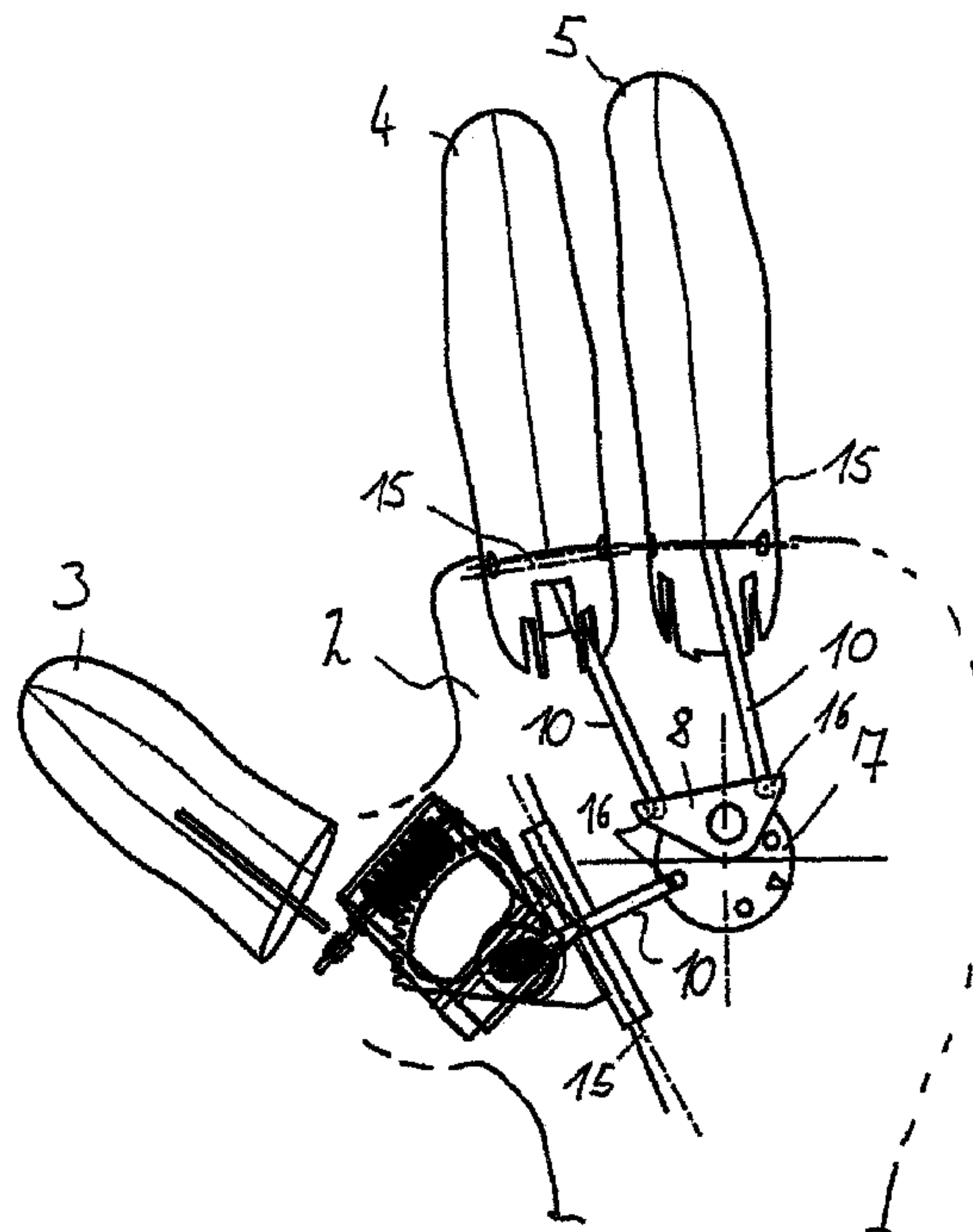




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(54) **Titre : PROTHESE DE MAIN ET DISPOSITIF DE TRANSFERT DE FORCE**
(54) **Title: HAND PROSTHESIS AND FORCE TRANSMISSION UNIT**



(57) **Abrégé/Abstract:**

The invention relates to a hand prosthesis (1) comprising a chassis (2) to which at least one finger prosthesis (3, 4, 5) is articulated, said finger prosthesis being swivelable about at least one swiveling axis (15) by means of a drive (6) that is connected to the finger prosthesis (3, 4, 5) via a force transmission device (10). Said force transmission device (10) is configured in such a way as to not yield to tension and to be pressure-elastic, especially flexible, between the drive and the finger prosthesis (3, 4, 5).

ABSTRACT

The invention relates to a hand prosthesis (1) comprising a chassis (2) to which at least one finger prosthesis (3, 4, 5) is articulated, said finger prosthesis being swivelable about at least one swiveling axis (15) by means of a drive (6) that is connected to the finger prosthesis (3, 4, 5) via a force transmission device (10). Said force transmission device (10) is configured in such a way as to not yield to tension and to be pressure-elastic, especially flexible, between the drive and the finger prosthesis (3, 4, 5).

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HAND PROSTHESIS AND FORCE TRANSMISSION UNIT

The invention relates to a hand prosthesis comprising a chassis, to which at least one finger prosthesis is articulated, said finger prosthesis being movable about at least one swiveling axis by means of a drive which is connected to the finger prosthesis by means of a force transmission unit, and relates to a force transmission unit as such.

10

If a hand has to be amputated or has been irreversibly severed from an arm by an accident, the appearance and some of the function of the hand can be replaced by a hand prosthesis. 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.

15

Apart from a two-finger gripper, as is known from US 2004/0015240 A1, hand prostheses which have a drive that is rigidly connected to a hand chassis by means of a bevel gear mechanism are proposed. Depending on the direction of rotation of the drive, the finger prostheses are thereby moved toward or away from one another. This drive may be activated by means of myoelectrical signals. Such a hand prosthesis is described in US 2005/0021154 A1. The appearance of such a hand prosthesis looks less natural.

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The object of the present invention is to provide a hand prosthesis and a force transmission unit, with which a design and function made to resemble the natural appearance of a hand can be provided.

5

Certain exemplary embodiments can provide a hand prosthesis comprising a chassis, to which at least one finger prosthesis is articulated, the finger prosthesis being movable about at least one swivelling axis by means of a drive that is
10 connected to the finger prosthesis by a plurality of force transmission units, the plurality of force transmission units including at least one of a cable, a fiber and a stranded wire, each of the plurality of force transmission units being formed between the drive and the finger prosthesis to be
15 rigid under tension and yielding under pressure or elastic under bending; the plurality of force transmission units being mountable at a common bearing point, the common bearing point being displaceable in relation to the at least one swivelling axes of the finger prosthesis, wherein two of the
20 plurality of force transmission units are connected to each other by means of at least one of a common cable, a common fiber and a common stranded wire; wherein the common cable, the common fiber or the common stranded wire is mounted at the common bearing point and on different finger prosthesis.

The hand prosthesis according to the invention comprising a chassis to which at least one finger prosthesis is articulated, said finger prosthesis being
5 movable about at least one swiveling axis by means of a drive which is connected to the finger prosthesis by means of a force transmission unit, provides that the force transmission unit between the drive and the finger prosthesis is formed so as to be yielding under
10 pressure or elastic under bending and rigid under tension. While the conventional hand prostheses provide a rigid coupling between the drive and the finger prosthesis, the pressure-yielding or flexurally elastic coupling of the drive to the finger prosthesis ensures
15 that, under pressure loading of the force transmission unit, that is to say under the effect of a force that brings about closing of the hand or reduction of the angle between the finger prosthesis and the hand chassis, the finger prosthesis gives way and, apart
20 from a natural looking appearance, also has the effect of minimizing the stress on the mechanical components. The stress on the components is minimized because the sometimes considerable forces that occur if the finger prostheses happen to knock against an object is not
25 transmitted directly via the force transmission unit to the drive. Rather, the flexurally elastic, preferably resilient, configuration of the force transmission unit allows displacement and conversion of the forces acting on the finger prosthesis into a movement. This movement
30 may take place up to the maximum bending angle of the finger prosthesis.

In order on the other hand to ensure an unhindered and reliable, as well as precise, closing movement of the
35 finger prosthesis, starting from an open basic position, the force transmission unit is formed so as to be rigid under tension, that is to say that tensile forces are transmitted as far as possible without the force transmission unit undergoing any elongation. For

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this purpose, it is provided that the force transmission unit has with preference a component comprising a cable, stranded wire or fiber, via which the tensile forces are transmitted. This cable, 5 stranded-wire or fiber component may be produced from a wire cable or high-strength fibers such as carbon fibers, aramid or glass fibers. Apart from them, other synthetic or natural fibers may be used. In order that high tensile forces can be transmitted from the drive 10 to the finger prosthesis, the cable, stranded-wire or fiber component is formed as a closed loop. Alternatively, the formation of an open loop or a twisted loop is envisaged. The connection of the two open ends of the cable or stranded wire or the 15 fastening in the remaining material or to the drive or the finger prosthesis may take place by twisting, splicing or adhesive bonding. Whenever a cable component is mentioned hereafter, fiber or stranded-wire components are also included.

20

A development of the invention provides that the force transmission unit has an elastomer component, by which it is possible to set the flexure or elasticity of the force transmission unit over a wide range. By suitable 25 choice of an elastomer material, which with preference at least partially encloses or completely takes up the cable component, it is possible to produce a body that is dimensionally stable in the position of rest, on the one hand has very high tensile forces on account of the 30 incorporated cable component and on the other hand has desired elastic characteristics under bending and pressure.

Alternatively, the force transmission unit may be 35 configured as a spring-damper unit, in particular as a pneumatic unit, in which the volume of air is compressed under pressure loading, expands once the force of the pressure is no longer applied and brings about a return displacement of a pneumatic piston, and

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consequently of the finger prosthesis. Alternatively, the force transmission unit may be formed as a spring, which is possibly prestressed.

- 5 For coupling the force transmission unit to the drive and the finger prosthesis, bearing bushes are provided, embedded in the force transmission unit. With preference, these bearing bushes are enclosed by the elastomer element or the elastomer component and are
10 located within the cable or fiber component, with preference within the cable or fiber loop.

- To be able to realize a return movement of a finger prosthesis bent in the direction of the inner surface
15 of the hand chassis, the force transmission unit is formed in a resiliently elastic manner, so that, without being subjected to a tensile force, the finger prosthesis is moved back into a starting position by the drive or by a transmission element coupled to the
20 drive. This starting position corresponds with preference to a slightly opened hand. The force transmission unit is consequently capable of transmitting a limited compressive force. A corresponding articulation or formation of the force
25 transmission unit allows slight overextension of the finger prostheses, starting from the basic position. The spring rate of the force transmission unit is in this case set such that, when the force transmission unit is subjected to the force of a pressure, that is
30 to say when the finger prosthesis swivels in the direction of the inner surface of the hand chassis, a return of the finger prosthesis into the starting position is brought about. The returning force must therefore be so great that the retaining and frictional
35 forces within the hand prosthesis are overcome.

A development of the invention provides that a number of force transmission units are mounted at a common bearing point and the bearing point is displaceable in

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relation to the swiveling axes of the finger prostheses in order to bring about bending of the finger prostheses. The common bearing point may be arranged directly on the drive or on a driven element of a gear mechanism. The common mounting allows synchronicity of the bending movements to be facilitated.

Likewise, two force transmission units may be connected to each other by means of a common cable, fiber or stranded-wire component, the common cable, fiber or stranded-wire component being mounted with preference at the common bearing point and on different finger prostheses. The cable, fiber or stranded-wire component then transmits the tensile force that is produced by the drive via the common bearing point on account of the displacement in relation to the swiveling axes of the finger prostheses to the finger prostheses and brings about bending of the finger prostheses. In this case, the cable, fiber or stranded-wire component can slide along on the bearing point and in this way ensure uniform bending of the finger prostheses that are connected to one another.

The force transmission units may be fastened to a rocker, which is mounted at the common bearing point. The force transmission units may be fastened to the rocker at different distances from the common bearing point, to allow the respective finger prostheses to be adapted to the geometrical conditions within the hand prosthesis or to the conditions of use.

The force transmission unit may be formed so as to be flexurally elastic in a number of orientations, so that under compressive loading in the direction of the longitudinal axis the bearing points are displaceable in relation to one another. The omnidirectionally flexural force transmission unit then acts like a ball joint and compensates for deviations from the ideal

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axial position. It may be possible to dispense with rotatable mounting about axes.

5 The force transmission unit for the transmission of forces from a drive of a hand prosthesis to finger prostheses articulated to a hand chassis is formed as described above and allows easy and inexpensive coupling of the drive and the finger prosthesis as well as effective transmission of tensile forces. In
10 addition, mounting that yields to unwanted loading and easy return are achieved with the force transmission unit.

15 An exemplary embodiment of the invention is explained in more detail below on the basis of the accompanying figures. The same designations denote the same elements in the different figures, in which:

20 Figure 1 shows a schematic representation of a hand prosthesis;

Figure 2 shows a schematic partial representation of the functional setup of a hand prosthesis;

25 Figures 3a-3d show a force transmission unit in different views;

30 Figure 4 shows a detailed representation of a rocker;

Figure 5 shows a detailed representation from Figure 2; and

35 Figure 6 is a variant of Figure 5.

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

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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 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 likewise 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, 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 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.

Figure 3 shows a force transmission unit 10 in a sectional representation. This unit comprises a cable or fiber component 11, which in the present case is formed as a loop. The cable component 11 may comprise a number of standard wires or individual loops, take the form of a steel cable or plastic cable or consists of some other high-strength fiber material. The cable component 11 is embedded in an elastomer element 12, whereby the force transmission unit 10 is given a dimensionally stable, but flexurally elastic form. The elastomer component 12 may consist of a silicone, a rubber or some other elastic material. In spite of the dimensional stability, a deformation, in particular bending, caused by compressive forces acting on the force transmission unit 10 is possible as result of the flexibility of the cable or fiber component 11 and the elastic characteristics under pressure or bending of the elastomer component 12. This allows the finger

prostheses 3, 4, 5 that are coupled to the drive 6 or the rotary disk 7 via the force transmission unit 10 to be displaced in the direction of the inner surface of the hand chassis, a return displacement taking place
5 when the corresponding counteracting force is no longer applied, as a result of the resiliently elastic characteristics of the force transmission units 10.

Located within the cable or fiber component 11, formed
10 as a loop, are two bearing bushes 13, 14, which are likewise embedded in the elastomer component 12, for example a silicone material. The bearing bushes 13, 14 are mounted on corresponding spindles on the finger prostheses 3, 4, 5 and on spindles 16 on the rotary
15 disk 7 or the bridge 8. The bearing bushes 13, 14 consist for example of bronze, in order to form a sliding mounting with the corresponding spindles 16. For reasons of overall clarity, the coupling spindles on the finger prostheses 3, 4, 5 are not represented.
20 These coupling spindles lie at a distance from the axes of rotation 15, so that a torque is produced about the axes of rotation 15 by applying tensile forces via the force transmission units 10, which leads to a corresponding displacement of the finger prostheses 3,
25 4, 5.

In Figures 3b and 3c it can be seen that the axes of rotation of the bearing bushes 13, 14 are perpendicular in relation to each other, the reason for which lies in
30 the actual arrangement of the rotary disk 7 and the spindles 16 arranged on it or assigned to it. The axes of rotation of the bearing bushes 13, 14 may also be aligned parallel or at some other angle in relation to each other.

35

It can likewise be seen in Figures 3a to 3c that the cable or fiber component 11 is completely embedded in the elastomer 12, whereby on the one hand the cable or fiber component 11 is protected from external

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influences and on the other hand the dimensional stability of the force transmission unit 10 is increased. Figure 3d shows a deformed shape of the force transmission unit 10, which has been subjected to compressive loading in the longitudinal direction and buckled. The bearing bush 14 is no longer at right angles to the bearing bush 13, as represented in Figures 3a to 3c, but instead the deformation brings about a skewed position of the bearing bushes 13, 14 in relation to each other, and consequently of the axes of rotation 15, 16. On account of the elastic deformability, the force transmission unit 10 acts in a number of orientations as a ball joint and can also compensate for skewed axial positions, caused for example by production tolerances.

As an alternative to the embodiment represented, the force transmission unit 10 may also be produced from some other element that yields under pressure, for example a resiliently elastic and tensionally rigid element, for example a resilient buckling or deflecting rod or a correspondingly designed wire loop.

The compressively elastic mounting has the effect that impact forces are not directly transmitted via the finger prostheses 3, 4, 5 to the drive 6 or the rotary disk 7. Rather, unintentional knocking movements are absorbed and damped. Apart from enhancing a natural looking appearance of the hand prosthesis 1, this also increases the service life of the mountings and drive components, for example in the event of a fall.

As an alternative to the embodiment represented, the force transmission unit may, as a spring-damper unit, also be equipped with a corresponding control, for example by means of a pneumatic or hydraulic cylinder with corresponding valve control, which can effectively transmit tensile forces but provides the ability to yield elastically under compressive forces. A pneumatic

configuration has the effect of bringing about a return displacement of the inwardly bent finger prostheses.

Given an adequately flexurally elastic configuration of the cable component, the elastomer component may be omitted; given adequate tensile strength of the elastomer component, it may be formed as the only force transmission unit.

Figure 4 shows the rocker 8 in an enlarged representation on its own. The rocker 8 has a common bearing point 18 in the form of a bush, which can be fitted onto a corresponding spindle on the rotary disk 7 (not represented). The rocker 8 may be mounted on this spindle rotatably about the common bearing point 18, and has at the rotating spindles 16 fastening points for force transmission units 10 (not represented). The distances a, b of the rotating spindles 16 or fastening points from the center of rotation of the common bearing point 18 may be made to differ, to make it possible to allow for the geometrical or mechanical conditions within the hand prosthesis.

Figure 5 shows a detail from Figure 2 on an enlarged scale. The same designations denote the same components. Figure 5 reveals that two force transmission units 10, which are separately formed, are mounted at the common bearing point 18 by means of the rocker 8. As an alternative to the configuration according to Figure 5, the force transmission units 10 may also be mounted on the rotary disk 7 without rocker 8, at a common bearing point or a common axis. The bearing bushes 14 assigned to the finger prostheses 4, 5 are substantially at right angles to the rotating spindles 16 on the rocker 8, but may also be skewed thereto, as indicated by the index finger 4.

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Figure 6 shows a variant of the configuration of Figure 5, in which the cable component 11 is formed as an open loop which is fastened to the bearing bushes 14, for example by welding or adhesive attachment. The cable component 11 connects the two bearing bushes 14 of the index-finger and middle-finger prostheses 4, 5, it being partially embedded in the elastomer component of the force transmission units 10. In the region of the rocker 8, the cable component 11 is led behind the common bearing point 18 or around the axis of rotation on the rotary disk 7 and absorbs the tensile forces caused by the displacement of the common bearing point 18 in relation to the axes of rotation 15. These tensile forces are transmitted to the bearing bushes 14 through the cable component 11 and, on account of the bearing bushes 14 being mounted at a distance from the axes of rotation 15, bring about a torque about the axes of rotation 15, whereby the finger prostheses 4, 5 are bent.

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Claims

1. A hand prosthesis comprising a chassis, to which at least one finger prosthesis is articulated, the finger
5 prosthesis being movable about at least one swivelling axis by means of a drive that is connected to the finger prosthesis by a plurality of force transmission units, the plurality of force transmission units including at least one of a cable, a fiber and a stranded wire, each of the
10 plurality of force transmission units being formed between the drive and the finger prosthesis to be rigid under tension and yielding under pressure or elastic under bending; the plurality of force transmission units being mountable at a common bearing point, the common bearing
15 point being displaceable in relation to the at least one swivelling axes of the finger prosthesis, wherein two of the plurality of force transmission units are connected to each other by means of at least one of a common cable, a common fiber and a common stranded wire; wherein the
20 common cable, the common fiber or the common stranded wire is mounted at the common bearing point and on different finger prosthesis.
2. The hand prosthesis as claimed in claim 1, wherein the
25 cable, the fiber or the stranded wire is formed as a closed, open or twisted loop.
3. The hand prosthesis of claim 1 or 2, wherein the force transmission units include an elastomer component.

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4. The hand prosthesis of claim 3, wherein the elastomer component at least partially encloses the cable, the fiber or the stranded wire.

5

5. The hand prosthesis as claimed in any one of claims 1 to 4, wherein the force transmission units are formed in a resiliently elastic manner.

10

6. The hand prosthesis of claim 5, wherein spring rates of the force transmission units are set such that, when the force transmission units are subjected to the force of a pressure, a return of the finger prosthesis into the starting position occurs.

15

7. The hand prosthesis of claim 1, wherein the force transmission units are formed as a spring-damper unit, include at least one of a pneumatic unit, a hydraulic unit, and a spring.

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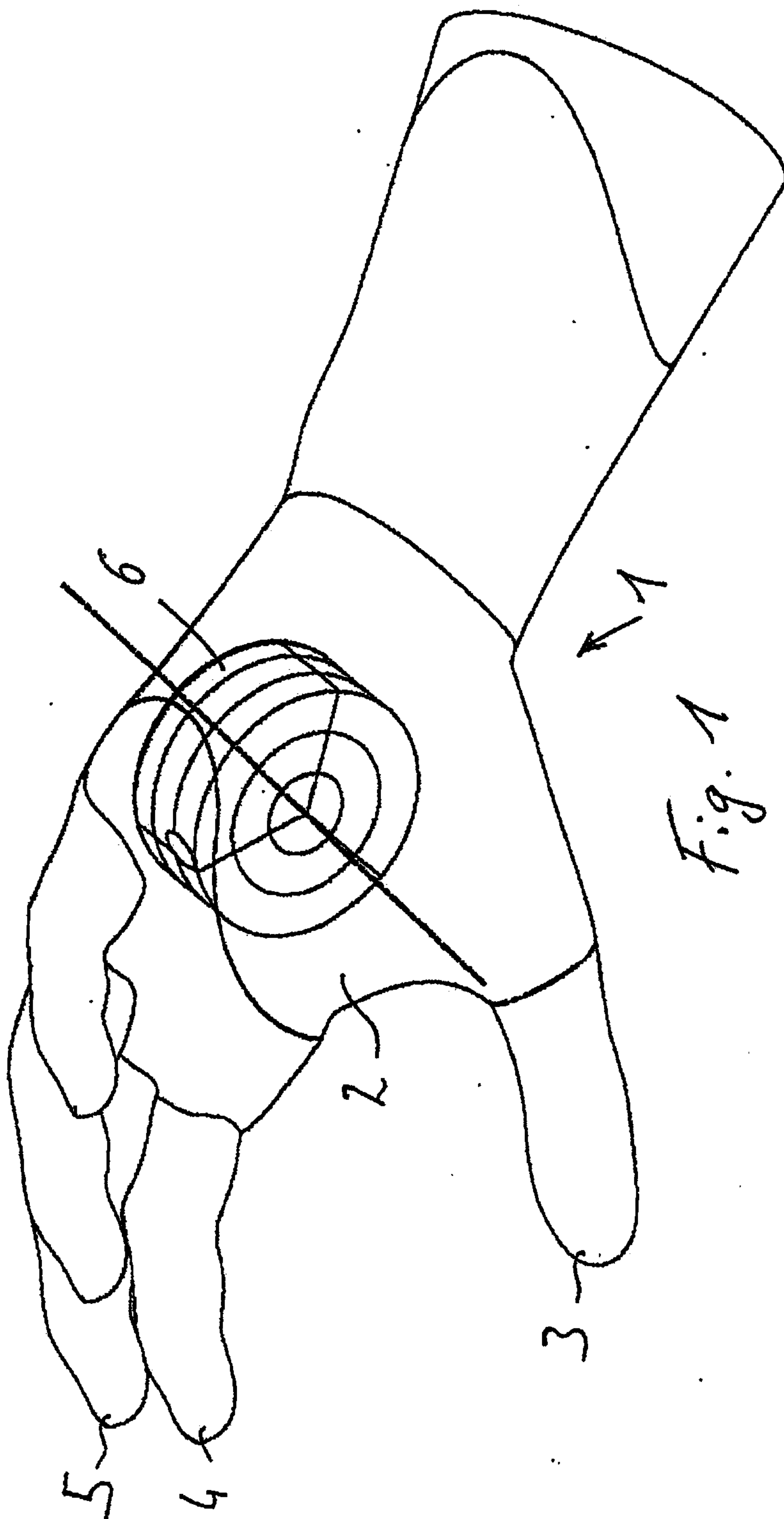
8. The hand prosthesis of any one of claims 1 to 7, wherein the force transmission units include bearing bushes for receiving spindles, which are assigned to the chassis and the finger prosthesis.

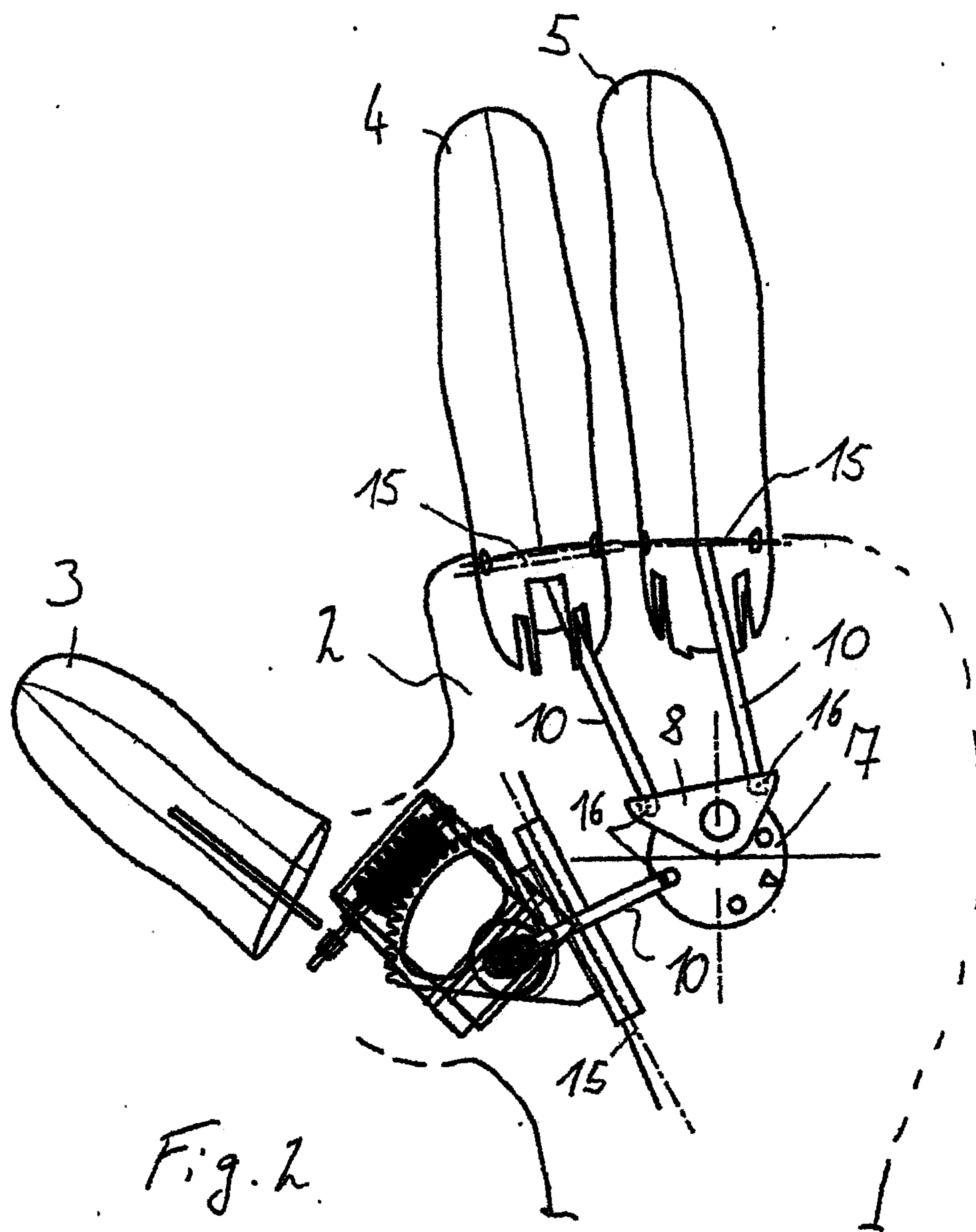
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9. The hand prosthesis of any one of claims 1 to 8, wherein the force transmission units are fastened to a rocker, which is mounted at the common bearing point.

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10. The hand prosthesis of claim 9, wherein the force transmission units are fastened to the rocker at different distances from the common bearing point.
- 5 11. The hand prosthesis of any one of claims 1 to 10, wherein the force transmission units are formed as flexurally elastic in a number of orientations.





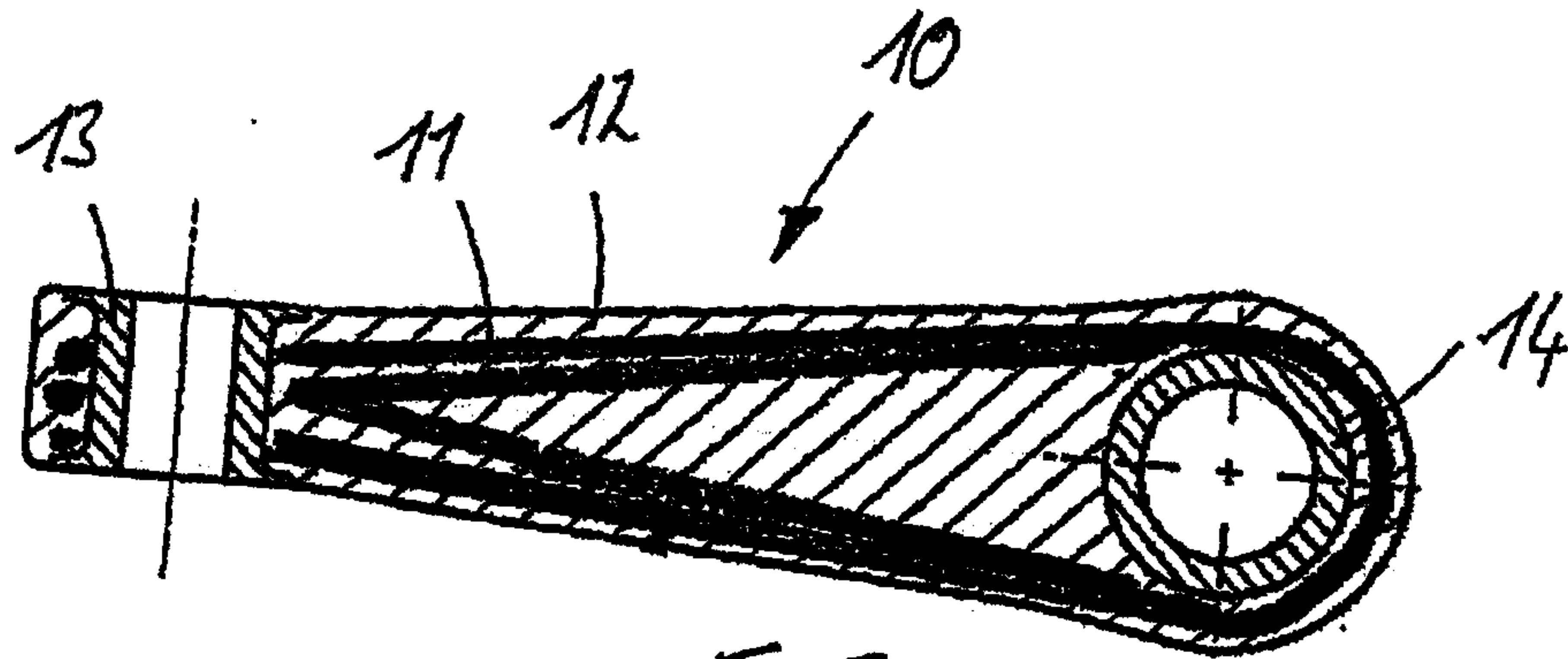


Fig. 3a

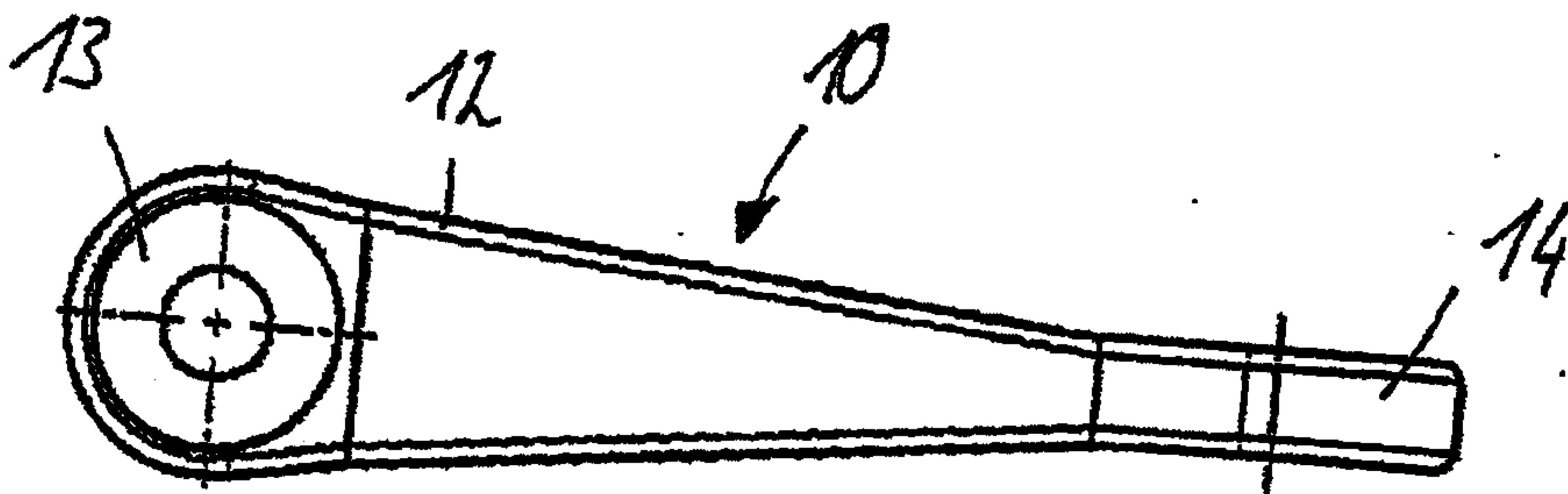


Fig. 3b

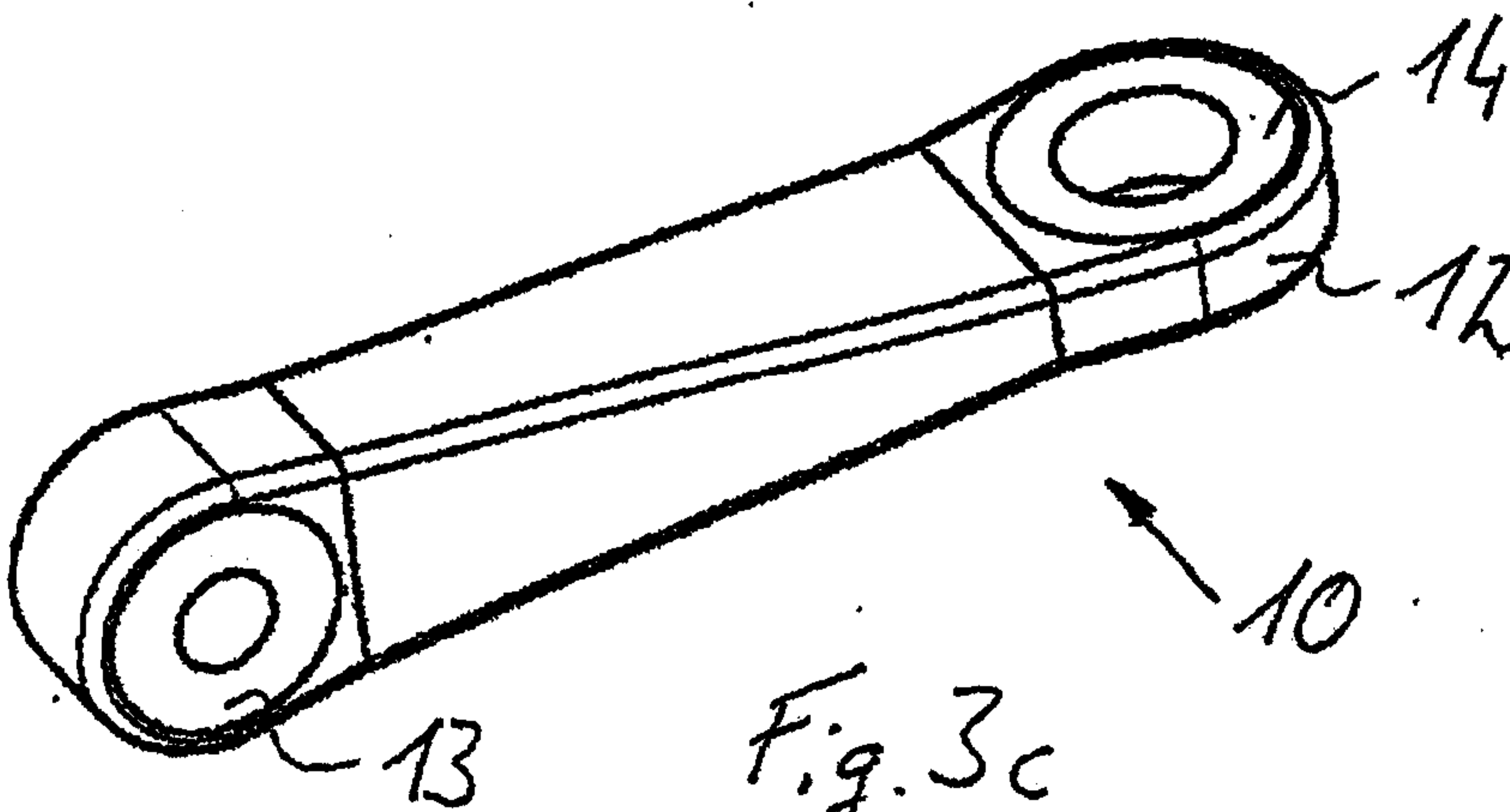


Fig. 3c

