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- (57) Sammendrag:
The present invention relates to a surgical instrument (1) comprising a handle (2), a hollow shaft (3), and an end effector (4) coupled to said hollow shaft (3), said end effector (4) being operatively connected to said handle (2) through operating means (5) extending within said hollow shaft (3). A multiaxial joint (6) couples said handle (2) to said hollow shaft (3), said multiaxial joint (6) allowing multiaxial rotation of said handle (2) in relation to said hollow shaft (3).

Fortsættes...

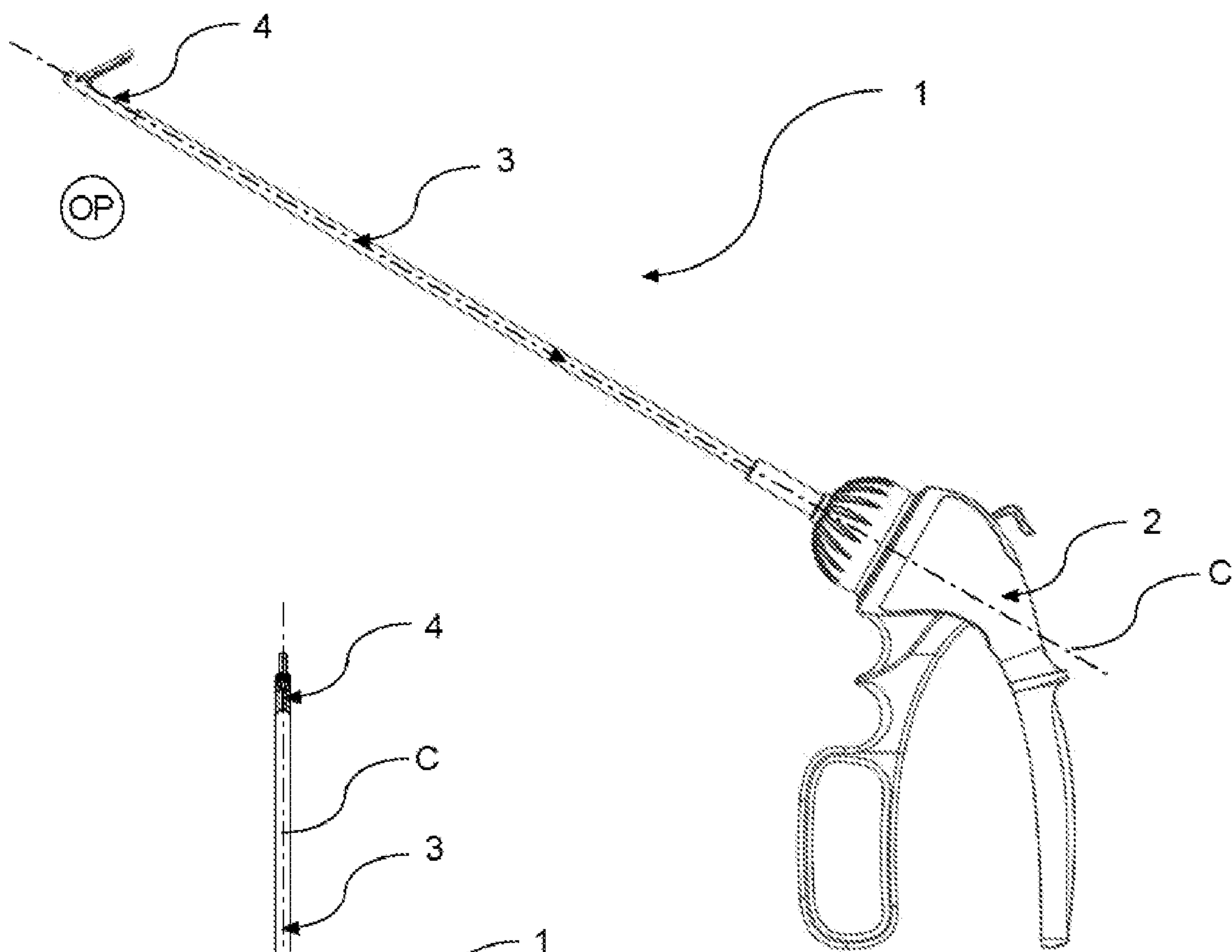


Fig. 1a

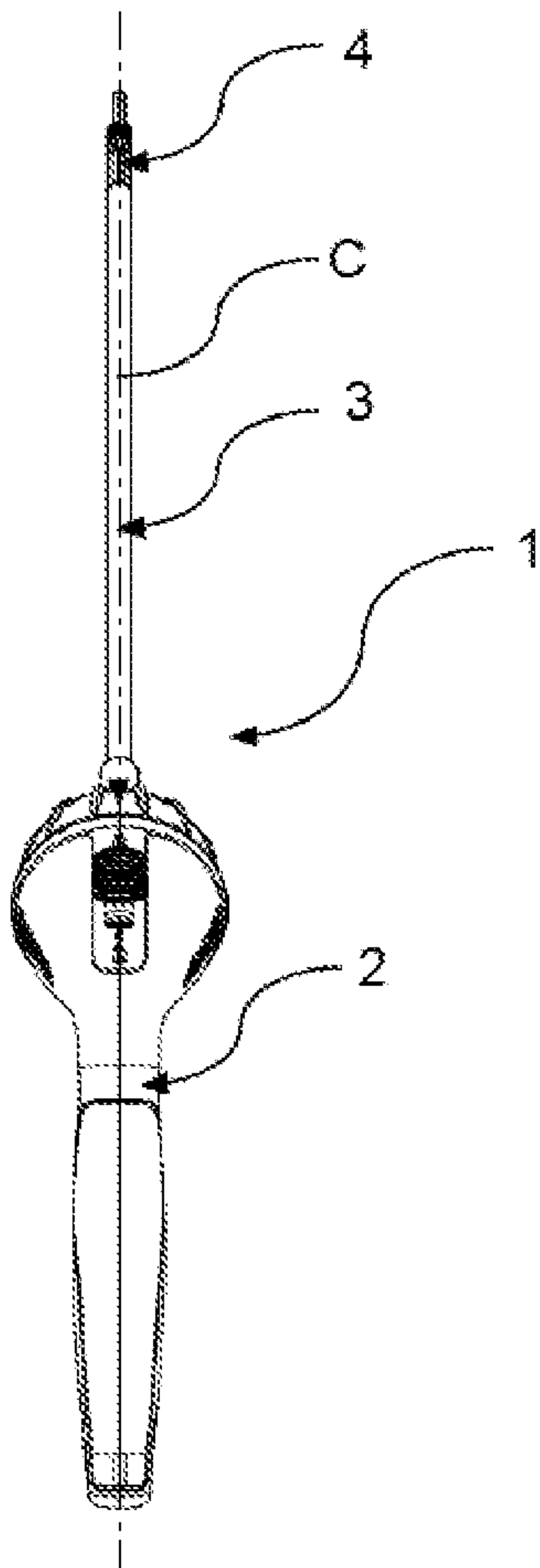


Fig. 1b

ERGONOMIC SURGICAL INSTRUMENT FOR MINIMALLY INVASIVE SURGERYTECHNICAL FIELD

The disclosure relates to a surgical instrument for
5 minimally invasive surgery, said surgical instrument
comprising a handle, an end effector which is operatively
connected to the handle, and a hollow shaft connecting the
handle to the end effector.

BACKGROUND

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Minimally invasive surgery requires surgical instruments
which engage tissue through small incisions or natural
orifices in the body of a patient, and often reduces the
recovery time and amount of complications in comparison with
15 traditional open surgery.

Minimally invasive surgery requires some versatility to be
inbuilt in the instrument, such that the user has the best
possible conditions for engaging tissue. These conditions
20 include allowing the user to be able to hold the handle of
the surgical instrument ergonomically, e.g. allowing the
user to maintain his/her wrist straight.

EP1836986 discloses a surgical instrument comprising a ball-
25 and-socket joint connecting the handle to the shaft,
allowing the handle to be somewhat pivoted in two planes of
motion relative the shaft. The end effector is connected to
the handle by means of four wires extending equidistantly
along the outside of the shaft. As the handle is pivoted,

one opposite pair of wires interact to cause the end effector to mimic and move simultaneously with the handle. Hence, the end effector mimics the movement of the handle, which mimicking movement includes corresponding movement, 5 whereby the end effector moves in the same direction and orientation as the handle, and mirrored movement, whereby the end effector moves in an opposite direction and orientation as the handle. The control over the end effector is improved, however the ergonomic situation for the user is not significantly improved. Hence, there is a need for 10 providing an improved surgical instrument which allows the user to operate the instrument without bending or otherwise straining the wrist.

15 US 2010/0030018 shows a similar instrument also comprising four wires extending equidistantly along the outside of the shaft and connecting the end effector to the handle.

US 2012/0209254 shows a further surgical instrument wherein 20 the handle is adjustable relative to the end effector. The handle can be moved to a different position and/or orientation relative to the end effector by pivoting relative to the end effector around one or more joints. The handle may pivot about an axis of a hinge joint or a point 25 of a ball and socket joint.

SUMMARY

It is an object to provide an improved surgical instrument. The foregoing and other objects are achieved by the features 30 of the independent claims. Further implementation forms are

apparent from the dependent claims, the description, and the figures.

According to a first aspect, there is provided a surgical
5 instrument comprising a handle, a hollow shaft, an end
effector coupled to a distal end of the hollow shaft, the
end effector being operatively connected to the handle
through operating means extending within the hollow shaft, a
multiaxial joint coupling the handle to a proximal end of
10 the hollow shaft, the multiaxial joint allowing multiaxial
rotation of the handle in relation to the hollow shaft.

This surgical instrument allows the user to be able to hold
the handle of the surgical instrument ergonomically, e.g.
15 allowing the user to maintain his/her wrist straight,
relative the shaft and end effector, which is comfortable
for an extended period of time.

Such a solution allows the user to adjust the location of
20 the handle around multiple axes, thereby allowing the user
to place the handle in a comfortable position while
maintaining the shaft and the end effector in a correct
working position. Furthermore, the instrument becomes more
flexible which in turn improves the reach of the instrument
25 and, subsequently, the user.

In a possible implementation form of the first aspect, the
multiaxial rotation includes rotation around a center axis
of the hollow shaft, which allows the handle to be placed in
30 a position which is comfortable for the user.

In a further possible implementation form of the first aspect, the multiaxial rotation does not affect the position of the end effector, which allows the secure and stable placement of the end effector to be maintained regardless of possible movement of the handle.

In a further possible implementation form of the first aspect, the operating means comprises at least one of a wire, a hose, and a rod, the operating means extending through an interior of the multiaxial joint such that the operating means is completely protected from the exterior.

In a further possible implementation form of the first aspect, the handle is rotatable around the center axis, and the handle is rotatable in two planes in relation to the proximal end of the hollow shaft.

In a further possible implementation form of the first aspect, the two planes extend parallel with or perpendicular to the center axis and perpendicular to each other, allowing the handle to be placed in at least any desired two-dimensional position relative the shaft, within certain limitations.

In a further possible implementation form of the first aspect, the handle is rotatable in the three perpendicular planes simultaneously, allowing the handle to be placed in any desired three-dimensional position relative the shaft, within certain limitations.

In a further possible implementation form of the first aspect, the multiaxial joint is a spherical joint comprising first and second partially spherical shells, open ends of the first and second shells having mating surfaces such that there is a common overlap area between the first shell and the second shell, allowing the handle to be rotated in relation to shaft over essentially the full surface of one of the spherical shells.

10 In a further possible implementation form of the first aspect, the common overlap area changes size as the first and second shells are rotated in relation to each other, around at least one of the axes, allowing an as large rotation as possible between the two shells.

15 In a further possible implementation form of the first aspect, one of the first and second shells is rigidly connected to the hollow shaft and the other of the first and second shells is rigidly connected to the handle, facilitating secure and intentional multiaxial rotation.

20

In a further possible implementation form of the first aspect, at least one of the first and second shells is provided with a hollow guiding tube, protruding from at least one of an outer surface and an inner surface of the first and second shells, and accommodating at least one of the proximal end of the hollow shaft, the operating means, and a connection to the handle, the hollow guiding tube providing additional support and protection for the components accommodated within the hollow guiding tube as well as assisting in aligning e.g. the operating means with connection to the handle.

25

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In a further possible implementation form of the first aspect, at least one of the first and second shells is provided with slits extending from an open end of the first and/or second shells, allowing tongues to be formed in between the slits which tongues can flex radially outwards, allowing one shell to be pushed over the surface of the other shell.

10 In a further possible implementation form of the first aspect, at least one mating surface of the first and second shells is provided with a microstructure and/or a coating for increased friction in the common overlap area, further increasing the level of interlocking between the first and
15 second shells.

In a further possible implementation form of the first aspect, the multiaxial joint further comprises a third shell arranged around a periphery of the first and second mating
20 shells, in the common overlap area, a locking lever protruding from the third shell, the third shell being moveable between an unlocked position and a locked position by operating the locking lever, wherein, in the unlocked position, diameters of the first and second shells are
25 unaffected by the third shell and the first and second shells can be rotated in relation to each other, and wherein, in the locked position, the diameters of at least one of the first and second shells are reduced in at least the common overlap area such that the first and second
30 shells cannot be rotated in relation to each other. This allows the handle to be not only rotated, but also locked in

a rotated position, in relation to the shaft. Thus, this implementation allows the user to lock the handle in a comfortable position.

5 In a further possible implementation form of the first aspect, a radially outermost positioned shell of the first and second shells comprises a peripherally extending groove, the radial depth of the groove decreasing in a direction towards an open end of the first or second shell such that
10 the groove comprises a maximum bottom thickness section and a minimum bottom thickness section, the third shell being in the unlocked position when the third shell is at least partially arranged within the minimum bottom thickness section, and the third shell being in the locked position
15 when the third shell is at least partially arranged within the maximum bottom thickness section. Hence, a locking function which is comprises as few interacting parts as possible is provided.

20 In a further possible implementation form of the first aspect, the surgical instrument further comprises a joint housing, a proximal end of the joint housing being connected to the handle and a distal end of the joint housing being rigidly connected to the first or the second shell, the
25 joint housing covering the multiaxial joint and the proximal end of the hollow shaft, providing additional support and protection for the components accommodated within the joint housing.

30 In a further possible implementation form of the first aspect, the joint housing shares a center axis with the

hollow shaft, and the joint housing is partially rotatable around the center axis, providing a degree of flexibility to the joint housing such that the handle can be rotated essentially uninhibitedly.

5

In a further possible implementation form of the first aspect, the joint housing comprises an elastic part extending between at least first and second rigid parts, in the direction of the center axis, the first rigid part being connected to the first or second shell, the second rigid part being connected to the handle, facilitating secure connections between components while still allowing the handle to be rotated.

15 In a further possible implementation form of the first aspect, at least one of the first and second rigid parts comprises a plurality of grooves extending in the direction of the center axis, each groove comprising an end surface extending at an angle to the center axis, the end surface being arranged at a proximal end of the first rigid part, the end surface being arranged at a distal end of the second rigid part, the elastic part filling the grooves such that an elastic part surface corresponding to the end surface is formed in each groove. This allows for a tight and secure interface between the elastic part and the rigid parts.

In a further possible implementation form of the first aspect, the end surface comprises an opening through which the elastic part extends, the opening extending generally parallel with the center axis, providing a simple yet rigid connection between the elastic part and the rigid parts such

30

that the elastic part cannot easily be separated from the rigid parts.

5 In a further possible implementation form of the first aspect, a section of the elastic part extends on a radially outer side and/or a radially inner side of the first rigid part and a section of the elastic part extends on a radially inner side and/or a radially outer side of the second rigid part, facilitating a more stable joint housing.

10

In a further possible implementation form of the first aspect, at least one of the first and second rigid parts have a truncated cone shape, the first rigid part having an outer diameter and/or an inner diameter which is smaller
15 than the outer diameter and/or an inner diameter of the second rigid part, facilitating a joint housing having a shape which essentially corresponds to the shape of the multiaxial joint as far as allowing as small outer dimensions as possible.

20

In a further possible implementation form of the first aspect, a proximal end of the second rigid part comprises a peripheral flange adapted for interacting with a corresponding recess in the handle, such that a secure and
25 simple interconnection, which does not limit the rotation, is provided between the handle and the joint.

In a further possible implementation form of the first aspect, the handle and the operating means are configured to
30 actuate the end effector between an open position and a closed position, a proximal end of the end effector being

coupled to a distal end of the hollow shaft, the end effector comprising a first leg and a second leg, the second leg being pivotally connected to the first leg at a distal end of the end effector, the second leg extending at an acute angle to the first leg when the end effector is in the open position, and the second leg extending generally parallel with the first leg when the end effector is in the closed position. Such a solution facilitates an end effector which is safe to insert through an incision or an opening into a body, since the legs of the end effector, should they be in an open configuration, are automatically closed to a closed configuration such that they cannot get accidentally caught in tissue. Furthermore, the surgical instrument is actuated only by means of the handle, dispensing with the need for external instruments.

In a further possible implementation form of the first aspect, the end effector is adapted for one of severing, ligation clipping, injecting, burning, cutting, grasping, tearing, and stitching tissue, facilitating a surgical instrument having a wide range of applications.

According to a second aspect, there is provided a surgical instrument comprising a handle, a hollow shaft, an end effector operatively connected to the handle through operating means extending within the hollow shaft, the handle being coupled to a proximal end of the hollow shaft, a proximal end of the end effector being coupled to a distal end of the hollow shaft, the handle and the operating means being configured to actuate the end effector between an open position and a closed position, the end effector comprising

a first leg and a second leg, the second leg being pivotally connected to the first leg at a distal end of the end effector, the second leg extending at an acute angle to the first leg when the end effector is in the open position, and
5 the second leg extending generally parallel with the first leg when the end effector is in the closed position.

Such a solution facilitates an end effector which is safe to insert through an incision or an opening into a body, since
10 the legs of the end effector, should they be in an open configuration, are automatically closed to a closed configuration such that they cannot get accidentally caught in tissue. Furthermore, the surgical instrument is actuated only by means of the handle, dispensing with the need for
15 external instruments.

In a possible implementation form of the second aspect, a distal end of the second leg is pivotally connected to a distal end of the first leg such that the second leg is
20 superimposed over the first leg in the closed position, the pivotal connection being arranged at an end of the end effector being farthest away from the handle. This solution facilitates an end effector which is safe to insert through an incision or an opening into a body, while also allowing
25 an as large range of reach as possible for the user of the instrument.

In a further possible implementation form of the second aspect, a proximal end of the second leg is moved at least
30 partially towards the handle when the end effector is actuated from the open position to the closed position,

allowing the second leg to close completely or almost completely against the first leg.

In a further possible implementation form of the second aspect, the end effector is adapted for one of severing, ligation clipping, injecting, burning, cutting, grasping, tearing, and stitching tissue, facilitating a surgical instrument having a wide range of applications.

10 In a further possible implementation form of the second aspect, the second leg comprises cutting means and the first leg comprises a recess for accommodating the cutting means when the end effector is in the closed position, facilitating a safe cutting application having a
15 significantly reduced risk of accidental cutting of tissue.

In a further possible implementation form of the second aspect, the second leg comprises a staple magazine, facilitating a further application for the surgical
20 instrument.

In a further possible implementation form of the second aspect, the distal end of the end effector comprises protection lips extending between the first leg and the
25 second leg, the protection lips preventing tissue from getting stuck in the connection between the first leg and the second leg.

In a further possible implementation form of the second aspect, the surgical instrument further comprises at least
30 one support rod, a proximal end of the support rod being

pivotally connected to the proximal end of the end effector, the support rod extending at an acute angle to the first leg when the end effector is in the open position, the support rod extending in parallel with the first leg
5 when the end effector is in the closed position. The support rod assures that tissue clamped between the legs of the end effector cannot accidentally slide out from between the legs.

10 In a further possible implementation form of the second aspect, the operating means comprises an axially extending rod and a pivot link, the rod being partially enclosed by the first leg of the end effector, a distal end of the rod being coupled to a distal end of the second leg by means of
15 the pivot link, a proximal end of the rod being operably connected to the handle, the end effector being actuated from the open position to the closed position when the rod is moved in a direction away from the distal end of the end effector, the end effector being actuated from the closed
20 position to the open position when the rod is moved in a direction towards the distal end of the end effector. This facilitates reliable operating means which comprise as few parts as possible while still providing sufficient force to actuate the end effector between positions also when tissue
25 is arranged within the end effector.

In a further possible implementation form of the second aspect, the operating means further comprises a piston and a spring, the rod being partially enclosed by the piston and
30 the spring, the spring applying a force onto a proximal end of the piston in a direction towards the distal end of the

end effector, the rod and the piston being axially moveable in relation to at least one of each other and the end effector, facilitating operating means which can not only actuate the end effector but also move e.g. ligation clips
5 to a correct position.

In a further possible implementation form of the second aspect, the rod and the piston are releasably connected such that the rod and the piston are axially moveable as one
10 unit, in relation to the end effector, allowing the operating means to be multifunctional yet still reliable.

In a further possible implementation form of the second aspect, the rod and the piston are releasably connected by
15 means of a piston lock, the piston lock comprising a plurality of locking grooves arranged in the rod, and a corresponding locking protrusion arranged at a distal end of the piston, allowing the surgical instrument to be operated, allowing the components of the operating means to be
20 interlocked by means of a simple and reliable solution which is easy to implement.

According to a third aspect, there is provided a surgical system comprising the above described surgical instrument
25 and at least one ligation clip, the end effector of the surgical instrument being configured to enclose the ligation clip such that a distal end of the ligation clip is arranged adjacent the distal end of the end effector and a proximal end of the ligation clip is arranged adjacent the proximal
30 end of the end effector, the ligation clip comprising a first ligation clip leg and a second ligation clip leg, the

first ligation clip leg and the second ligation clip leg being pivotally connected at the distal end of the ligation clip, the first ligation clip leg and the second ligation clip leg comprising locking means for interlocking the first and second ligation clip legs at the proximal end of the ligation clip in a position where the first ligation clip leg and the second ligation clip leg are superimposed onto each other, wherein, when the end effector is in an initial open position, the ligation clip has an open configuration where the second ligation clip leg extends at an acute angle to the first ligation clip leg, when the end effector has been actuated to a closed position, the ligation clip has a closed configuration where the first and second ligation clip legs are superimposed onto each other, when the end effector is returned to an open position, the ligation clip remains in the closed configuration by means of the locking means.

Such a system facilitates a surgical instrument which is safe to insert through an incision or an opening into a body, since the legs of the end effector, should they be in an open configuration, are automatically closed to a closed configuration such that they cannot get accidentally caught in tissue. Furthermore, the system is actuated only by means of the handle, dispensing with the need for external instruments.

In a possible implementation form of the third aspect, comprising a plurality of ligation clips, in open configuration and arranged successively between the distal end of the end effector and the handle, all ligation clips

but a first ligation clip located adjacent the distal end of the end effector being enclosed by the first leg of the end effector and the rod, allowing the surgical instrument to be charged with several ligation clips and, hence, the surgical system to be used to ligate several locations in one session without having to recharge between separate ligation instances.

In a further possible implementation form of the third aspect, the ligation clips are arranged in abutment such that axial displacement of any ligation clip enclosed by the first leg and the rod induces a corresponding displacement of all ligation clips located between the ligation clip and the distal end of the end effector, providing a simple way of moving a sequence of ligation clips from a storage position to a position of use.

According to a fourth aspect, there is provided a method of operating the surgical system, wherein the operating means comprises at least an axially extending rod and wherein a first ligation clip is arranged within the end effector such that the first ligation clip is enclosed by the first leg of the end effector and the rod, the first ligation clip having an open configuration, the method comprising the steps of displacing the first ligation clip in a direction towards the distal end of the end effector, to a position where the first ligation clip is enclosed by the first and second legs of the end effector and the end effector is in an open position, by moving the rod in a direction towards the distal end of the end effector, closing the first ligation clip by actuating the end effector to a closed position by

moving the rod in a direction away from the distal end of the end effector, and moving the rod in a direction towards the distal end of the end effector, such that the end effector is returned to the open position, allowing the first ligation clip, having a closed configuration, to be released from the end effector.

By means of this method, there is provided an end effector which is safe to insert through an incision or an opening into a body, since the legs of the end effector, should they be in an open configuration, are automatically closed to a closed configuration such that they cannot get accidentally caught in tissue. Furthermore, the system is actuated only by means of the handle, dispensing with the need for external instruments for e.g. closing the end effector or removing a closed ligation clip.

In a further possible implementation form of the fourth aspect, the operating means further comprises a piston and a spring, a piston lock comprising rod locking grooves and a piston locking protrusion interlocking the rod and the piston in a first locking position when the end effector is returned to the open position, a second ligation clip being arranged within the end effector such that the second ligation clip is enclosed by the first leg of the end effector and the rod, the second ligation clip having an open configuration the method further comprising the steps of moving the rod in a direction away from the distal end of the end effector, whereby the piston lock is released from the first locking position and the piston is allowed to move in relation to the rod, simultaneously actuating the end

effector to the closed position, and the piston moving towards the end effector, by means of the spring applying force onto a proximal end of the piston until the piston lock engages a second locking position, a distal end of the piston being arranged closer to the distal end of the end effector when the piston lock is in the second locking position than in the first locking position, moving the rod in a direction towards the distal end of the end effector, the piston being moved along with the rod in the same direction, simultaneously actuating the end effector to the open position, moving the rod in a direction away from the distal end of the end effector, whereby the piston lock is released from the second locking position, the locking protrusion engaging a longitudinal groove arranged in the rod such that the piston is allowed to move in relation to the rod, simultaneously actuating the end effector to the closed position, the distal end of the piston engaging with the second ligation clip, pushing the second ligation clip in a direction towards the distal end of the end effector by means of the spring, until the second ligation clip, or a third ligation clip located between the second ligation clip and the distal end of the end effector, is enclosed by the first and second legs of the end effector, moving the rod in a direction towards the distal end of the end effector, simultaneously actuating the end effector to the open position. The method allows reliable operation of the surgical instrument, due to the provision of as few parts as possible which components still provide sufficient force to actuate the end effector between positions also when tissue is arranged within the end effector.

In a further possible implementation form of the fourth aspect, the method further comprises the steps of closing the second or third ligation clip, enclosed by the first and second legs of the end effector, by actuating the end effector to the closed position by moving the rod in a direction away from the distal end of the end effector, moving the rod in a direction towards the distal end of the end effector, such that the end effector is returned to the open position, allowing the second or third ligation clip, in the closed configuration, to be released from the end effector. The method allows actuation only by means of the handle of the surgical instrument, dispensing with the need for external instruments for e.g. closing the end effector or removing a closed ligation clip.

According to a fifth aspect, there is provided an end actuator for a surgical instrument for actuating an end effector between open and closed positions, the end actuator comprising an elongated base member and an actuation rod, the base member being configured to guide the actuation rod for translative movement of the actuation rod, an end effector leg pivotally suspended from the base member at a first position on the end effector leg, a pivot link operatively connecting the actuation rod with the end effector leg by a first end of the pivot link being pivotally connected to the actuation rod and a second end of the pivot link being pivotally connected to the end effector leg at a second position spaced from the first position.

In a possible implementation form of the fifth aspect, the pivot link comprises a plate extending between the first end and the second end.

- 5 In a further possible implementation form of the fifth aspect, the first end is connected to the actuation rod by a first hinge pin.

10 In a further possible implementation form of the fifth aspect, the second end is connected to the end effector leg by a second hinge pin.

In a further possible implementation form of the fifth aspect, the end effector leg is hinged to the elongated base member by a third hinge pin.

20 In a further possible implementation form of the fifth aspect, the end effector leg has a free end and a hinged end, and wherein the first position is at or adjacent the hinged end.

In a further possible implementation form of the fifth aspect, the second position is nearer to the hinged end than to the free end.

- 25 In a further possible implementation form of the fifth aspect, the third hinge pin is arranged in or adjacent the longitudinal axis of the base member.

30 In a further possible implementation form of the fifth aspect, the pivot link is operatively connected to the actuation rod at or near an extremity of the actuation rod.

In a further possible implementation form of the fifth aspect, the end effector leg is configured to fold towards the base member when the actuation rod is translated in a direction away from the third hinge pin and the end effector leg is configured to fold away from the base member when the actuation rod is translated in a direction towards the third hinge pin.

10 This and other aspects will be apparent from and the embodiment(s) described below.

BRIEF DESCRIPTION OF THE DRAWINGS

15 In the following detailed portion of the present disclosure, the aspects, embodiments, and implementations will be explained in more detail with reference to the example embodiments shown in the drawings, in which:

20 Figs. 1a and 1b show a side view and a top view of a surgical instrument in accordance with one embodiment of the present invention;

Figs. 2a and 2b show a cross-sectional side view and a perspective exploded view of components of the surgical instrument in accordance with one embodiment of the present invention;

Fig. 2c shows a perspective exploded view of components of the surgical instrument in accordance with a further embodiment of the present invention;

Figs. 3 shows a perspective exploded view of a multiaxial joint in accordance with one embodiment of the present invention;

5

Figs. 4a and 4b show a side view and a perspective exploded view of an assembled multiaxial joint, joint housing, and handle in accordance with an embodiment of the present invention;

10

Figs. 5a and 5b show a side view and a cross-sectional side view of an assembled multiaxial joint and joint housing in accordance with an embodiment of the present invention, the multiaxial joint being in an unlocked position;

15

Figs. 6a and 6b show a side view and a cross-sectional side view of the assembled multiaxial joint and joint housing shown in Figs. 5a and 5b, the multiaxial joint being in a locked position;

20

Figs. 7a and 7b show a perspective view and a cross-sectional side view of a multiaxial joint in accordance with an embodiment of the present invention;

25 Fig. 7c shows a side view of the multiaxial joint shown in Figs. 7a and 7b;

Figs. 8a and 8b show a perspective view and a cross-sectional side view of a joint housing in accordance with an
30 embodiment of the present invention;

Fig. 9a shows a side view of components of the joint housing shown in Figs. 8a and 8b.

5 Figs. 9b and 9c show perspective views of the components shown in Fig. 9a.

Figs. 10a and 10b show detailed views of the interlocking between an elastic part and the components shown in Figs. 9a-9c.

10

Figs. 11a and 11b show a side view and a cross-sectional side view of a shaft, operating means, and an end effector in accordance with an embodiment of the present invention, the end effector being in an open position;

15

Figs. 11c and 11d show a side view and a cross-sectional side view of the shaft, operating means, and end effector shown in Figs. 11a and 11b, the end effector being in a closed position;

20

Figs. 12a and 12b show perspective views of an end effector in accordance with an embodiment of the present invention, the end effector being in open position and closed position, respectively;

25

Figs. 13a and 13b show perspective views of an end effector in accordance with a further embodiment of the present invention, the end effector being in open position and closed position, respectively;

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Fig. 14 shows a side view of a ligation clip in accordance with an embodiment of the present invention;

5 Figs. 15a and 15b show a perspective view and a cross-sectional side view of a shaft, operating means, and an end effector in accordance with a further embodiment of the present invention;

10 Fig. 15c shows a perspective exploded view of the shaft, operating means, and end effector shown in Figs. 15a and 15b.

15 Figs. 16a to 16h show partial side views of a surgical system and the function of the surgical system in accordance with an embodiment of the present invention;

20 Figs. 17a and 17b show a side view and a cross-sectional side view of a shaft, operating means, and an end effector in accordance with a further embodiment of the present invention, the end effector being in an open position.

Figs. 17c and 17d show a side view and a partial side view of the end effector shown in Figs. 17a and 17b.

25 DETAILED DESCRIPTION

30 Figs. 1a and 1b show a surgical instrument 1 comprising a handle 2, a hollow shaft 3, and an end effector 4. The hollow shaft 3 is an elongated body of a suitable material, such as e.g. stainless steel or carbon fiber reinforced composite material. A multiaxial joint 6, shown in more

detail in Figs. 3 to 7, couples the handle 2 to the proximal end 3a of the hollow shaft 3. A multi-axial joint is a joint in which movement occurs around a plurality of axes and/or in a plurality of planes. The multiaxial joint 6 allows rotational movement in one plane that is not parallel with the hollow shaft 3. In another embodiment the multi-axial joint 6 also allows rotational movement in two planes that are parallel with the hollow shaft 3.

10 The handle 2 may be a squeeze handle or any other type of suitable handle, operated manually or by means of a robot.

By "surgical instrument" is meant a device by means of which tissue of a patient is engaged by a further individual such as a surgeon. Throughout this application, the term "surgical instrument" includes devices such as prostheses or implants.

"Proximal" refers to the end of a component which is closest to the handle, and hence the individual holding the handle of the surgical instrument. Correspondingly, "distal" refers to the end of a component which is farthest away from the handle and the individual holding the handle.

25 As shown in Figs. 1a-1b and Figs. 11a-11d, the proximal end 4a of the end effector 4 is coupled to the distal end 3b of the hollow shaft 3, and the end effector 4 is adapted for one of severing, ligation clipping, injecting, burning, cutting, grasping, tearing, and stitching tissue such as veins, arteries, intestines, or umbilical cords (nonexhaustive list).

The end effector 4 is operatively connected to the handle 2 through operating means 5 which extend within the hollow shaft 3, towards and past the proximal end 3a of the hollow shaft 3. The operating means 5 comprises at least one of a wire, a hose, and a rod. In one embodiment, the operating means 5 comprises a combination of a wire and a rod. The operating means 5 extend, from the end effector 4, through the hollow shaft 3, and through an interior of the multiaxial joint 6 to the handle 2.

The multiaxial joint 6 allows multiaxial rotation of the handle 2 in relation to the hollow shaft 3. The multiaxial rotation includes rotation around the center axis C of the hollow shaft 3. Furthermore, the multiaxial rotation does not affect the position of the end effector 4, such that the end effector 4 remains in the same position, in relation to the hollow shaft 3, when the handle 2 is pivoted. In other words, the end effector 4 remains stationary and neither rotates nor pivots as the handle 2 is moved. Movement relating to the end effector 4 is limited to actuating the end effector 4 between an open position OP and a closed position CP, which will be described in more detail farther below.

25

The handle 2 is rotatable around the center axis C of the hollow shaft 3. In an embodiment the handle 2 is also rotatable in three planes in relation to the proximal end 3a of the hollow shaft 3, such that free rotation is allowed in the three planes at the same time while preventing translation in any direction. In an embodiment each plane

30

extends parallel with or perpendicular to the center axis and perpendicular to each other. The handle 2 is rotatable around the center axis C and in the three planes simultaneously.

5

In one embodiment, the multiaxial joint 6 is a spherical joint comprising first 7 and second 8 partially spherical shells, each spherical shell comprising a spherical-shaped portion. In one embodiment, the first 7 or second 8 shell
10 comprises a spherical segment formed by a pair of parallel planes cutting a hypothetical sphere with the center of the hypothetical sphere being arranged between the parallel planes. In a further embodiment, one of the parallel planes coincides with the center of the hypothetical sphere. In
15 another further embodiment, both parallel planes extend on the same side of the center of the hypothetical sphere, i.e. one of the parallel planes is arranged between the center of the hypothetical sphere and the other parallel plane.

20 As shown in Fig. 3, the first shell 7 comprises an open end 7a, and the second shell 8 comprises an open end 8a. The first 7 and second 8 shells are arranged such that either the open end 7a of the first shell 7 overlaps the open end 8a of the second shell 8, or the open end 8a of the second
25 shell 8 overlaps the open end 7a of the first shell 7. The overlap is shown in more detail in Figs. 5a-5b, 6a-6b, and 7a-7c. The open end of one shell is pressed into the other shell, providing a so-called press fit between the two shells, but in a way which allows the one shell to rotate in
30 relation to the other shell. In other words, the open ends 7a and 8a have mating surfaces 7b, 8b such that there is a

common overlap area A between the first shell 7 and the second shell 8.

With regards solely to the movement of the first 7 and second 8 shells in relation to each other, the multiaxial joint 6 corresponds to a ball-and-socket joint, wherein a ball moves within a socket so as to allow rotary motion in every direction within certain limits.

10 As the first 7 and second 8 shells are rotated in relation to each other, in at least one of the planes, the common overlap area A changes its size. Furthermore, the overlap area A at least partially changes its location. The first 7 and second 8 shells may both share a center axis C with the
15 hollow shaft 3, i.e. as long as the handle 2 is not rotated in any of the three above-mentioned planes in relation to the proximal end 3a of the hollow shaft 3, and in which case the common overlap area A extends all around the periphery of both first 7 and second 8 shells. This position is shown
20 in Figs. 1a as well as 4a to 6a. When the first 7 and second 8 shells are rotated in relation to each other, as shown in Figs. 7a and 7b, the common overlap area A extends only along a part of the periphery of both first 7 and second 8 shells.

25

One of the first 7 and second 8 shells is rigidly connected to the hollow shaft 3 and the other of the first 7 and second 8 shells is rigidly connected to the handle 2. For the sake of ease of reading, the text below will describe an
30 embodiment wherein the first shell 7 is rigidly connected to the hollow shaft 3 and wherein the second shell 8 is rigidly

connected to the handle 2. Furthermore, the first shell 7 will be described as the inner shell and the second shell 8 will be described as the outer shell, of the two partially overlapping shells. However, embodiments comprising an outer
5 first shell and an inner second shell, as well as a first shell 7 rigidly connected to the handle 2 and a second shell 8 rigidly connected to the hollow shaft 3 are equally possible.

10 At least one of the first 7 and second 8 shells may be provided with a hollow guiding tube 9. The hollow guiding tube 9 protrudes from one or both of the outer surface and the inner surface of the first shell 7 and/or the second
15 shell 8 shell. The hollow guiding tube 9 accommodates at least one of the proximal end 3a of the hollow shaft 3, a section of the operating means 5, and a connection to the handle 2.

At least one of the first 7 and second 8 shells may be
20 provided with throughgoing slits 10 extending from the open end 7a, 8a of the shell, which allows the shells 7,8 to overlap. By providing the second shell 8 with slits, tongues formed in between the slits can flex radially outwards, allowing the second shell 8 to be pushed over the surface of
25 the first shell 7. Furthermore, the tongues can return to a radially more inward position as the second shell 8 is pushed farther across the first shell 7, in a direction from the open end 7a of the first shell, since the cross-
sectional outer diameter of the first shell 7 decreases in
30 the direction. This allows the first 7 and second 8 shells

to interlock, at least to some extent, by means of press fit.

At least one of the mating surfaces 7b, 8b of the first 7
5 and second 8 shells, which surfaces together constitute the
common overlap area A, may be provided with a
microstructure, a coating and/or a roughening for increased
friction, further increasing the level of interlocking
between the first 7 and second 8 shells.

10

In one embodiment, the multiaxial joint 6 further comprises
a third shell 11 arranged around the periphery of second
shell 8, in the common overlap area A. The third shell 11 is
preferably essentially ring-shaped but may also have any
15 other suitable configuration, such as e.g. a partially
spherical or elliptical shell. The third shell 11 has an
inner diameter which is somewhat smaller than the largest
outer diameter of the second shell 8, such that the third
shell 11 can press the tongues on the second shell 8
20 inwards, toward the first shell 7, and subsequently
interlock the first 7 and second 8 shells.

A locking lever 12 protrudes from the third shell 11, the
third shell 11 being moveable between an unlocked position
25 P1 and a locked position P2 by operating the locking lever
12, either manually or by means of a robot. The third shell
is pivoted, around the first 7 and second 8 shells, such
that one peripheral section of the third shell 11 is moved
in a direction towards the open end 8a of the second shell 8
30 and the opposite peripheral section is moved from the open
end 8a of the second shell 8. Depending on the actual

position of the third shell 11, the first 7 and second 8 shells can be either interlocked or not interlocked in relation to each other. By interlocking the first 7 and second 8 shells, the position of the handle 2 is locked in relation to the hollow shaft 3, allowing the person operating the surgical instrument to lock the instrument at any suitable angle.

The diameter of at least the outer second shell 8 remains unaffected by radial pressure from the third shell 11, such that the first 7 and second 8 shells can be rotated in relation to each other, when the third shell 11 is in the unlocked position P1.

The diameter of at least the outer second shell 8 is reduced by means of radial pressure applied by the third shell 11, at least in the common overlap area A, such that the outer second shell 8 presses against the inner first shell 7, preventing the first 7 and second 8 shells from rotating in relation to each other, when the third shell 11 is in the locked position P2.

The radially outermost positioned shell of the first 7 and second 8 shells, i.e. the second shell 8 for ease of reading, comprises at least one peripherally extending groove 13. As shown in Fig. 7c, the radial depth D of the groove 13 decreases in a direction towards the open end 8a of the second shell 8, such that the groove 13 comprises a maximum bottom thickness section T1 and a minimum bottom thickness section T2, the bottom thickness section being defined by the perpendicular distance between the outer

surface and the inner surface of the second shell 8, i.e. the thickness of the shell wall.

When the third shell 11 is in the unlocked position P1, the
5 third shell 11 is at least partially arranged within the
minimum bottom thickness section T2, as shown in Figs. 5a
and 5b. When the third shell 11 is in the locked position
P2, the third shell 11 is at least partially arranged within
the maximum bottom thickness section T1, as shown in Figs.
10 6a and 6b.

In one embodiment, the surgical instrument 1 further
comprises a joint housing 14. The proximal end 14a of the
joint housing 14 is connected to the handle 2 and the distal
15 end 14b of the joint housing 14 is rigidly connected to the
first 7 or the second 8 shell, preferably the inner first
shell 7. The joint housing 14 is arranged such that it
covers the multiaxial joint 6 and the proximal end 3a of the
hollow shaft 3, see Figs. 4a and 4b.

20

The joint housing 14 shares a center axis C with the hollow
shaft 3, and the joint housing 14 is at least partially
rotatable around the center axis C.

25 In one embodiment, shown in Figs. 8a-8b and 9a-9c, the joint
housing 14 comprises an elastic part 15 extending between at
least first 16 and second 17 rigid parts, in the direction
of the center axis C. The first rigid part 16 is connected
to the first 7 or second 8 shell, and the second rigid part
30 17 is connected to the handle 2. The rigid parts are
preferably made of a hard plastic such as e.g. ABS

(acrylonitrile butadiene styrene) plastic. Thus, "rigid" as used herein is not an absolute rigidity and indicates a relatively high stiffness of the material, that is significantly higher than the stiffness of parts that are
5 denoted as being "elastic".

As shown in Fig. 9a, the proximal end 17a of the second rigid part 17 may be connected to the handle 2 by means of a peripheral flange 20 which is adapted for interacting with a
10 corresponding recess 21 in the handle 2.

At least one of the first 16 and second 17 rigid parts comprises a plurality of grooves 18 extending in the direction of the center axis C, i.e. in a direction from the
15 first rigid part to the second rigid part 17. Each groove 18 comprises an end surface 18a extending at an angle to the center axis C, as shown in Figs. 10a and 10b. The end surface 18a is arranged at a proximal end 16a of the first rigid part 16, while being arranged at a distal end 17b of
20 the second rigid part 17. The elastic part 15 fills the grooves 18 such that an elastic part surface 15a corresponding to the end surface 18a is formed in each groove 18.

25 Each end surface 18a comprises an opening 19 through which the elastic part 15 extends, the opening 19 extending generally parallel with the center axis C.

A section 15 of the elastic part may extend on a radially
30 outer side and/or a radially inner side of the first rigid part 16, and a section of the elastic part 15 may

correspondingly extend on a radially inner side and/or a radially outer side of the second rigid part 17. In one embodiment, the section of the elastic part 15 extends on the radially outer side as well as the radially inner side of the first rigid part 16, such that the two sections of the elastic part 15 extend in parallel, separated by the wall of the first rigid part 16.

In one embodiment, at least one of the first 16 and second 17 rigid parts have a truncated cone shape, the first rigid part 16 having an outer diameter and/or an inner diameter which is smaller than the outer diameter and/or an inner diameter of the second rigid part 17.

The handle 2 and the operating means 5 are configured to actuate the end effector 4 between any possible open position OP and a closed position CP, i.e. from an open position to the closed position as well as from the closed position to an open position.

20

The end effector 4 comprises a first leg 22 and a second leg 23, the second leg 23 being pivotally connected to the first leg 22 at the distal end of the end effector 4b. As shown in Figs. 11a and 11b, the second leg 23 extends at an acute angle α to the first leg 22 when the end effector 4 is in the open position OP. As shown in Figs. 11c, 11d, and 12b, the second leg 23 extends generally parallel with the first leg 22 when the end effector 4 is in the closed position CP. In other words, the first leg 22 is stationary in relation to the hollow shaft 3, while the second leg 23 is pivotable in relation to the first leg 22.

As shown in Figs. 12a and 13a, the distal end 23b of the second leg 23 is pivotally connected to the distal end 22b of the first leg 22 such that the second leg 23 is
5 superimposed over the first leg 22 in the closed position CP. The pivotal connection is arranged at an end 4b of the end effector 4 which is farthest away from the handle 2, and hence the individual operating the handle 2. When the end effector 4 is actuated from the open position OP to the
10 closed position CP, the proximal end 23a of the second leg 23 is moved at least partially towards the handle 2.

In one embodiment, as shown in Fig. 12a, the second leg 23 comprises cutting means 24 for cutting tissue and the first
15 leg 22 comprises a recess 25 for accommodating the cutting means when the end effector 4 is in the closed position CP.

In a further embodiment, the second leg 23 comprises a
20 staple magazine.

As shown in Figs. 12a and 13a, the distal end 4b of the end effector 4 may comprise protection lips 26 extending between the first leg 22 and the second leg 23, the protection lips 26 preventing tissue from getting stuck in the pivot
25 connection connecting the first leg 22 and the second leg 23.

At least one support rod 27 may be connected to the end effector 4, as shown in Figs. 13a and 13b. The proximal end
30 27a of the support rod 27 is pivotally connected to the proximal end 4a of the end effector 4, such that the support

rod 27 extends at an acute angle β to the first leg 22 when the end effector 4 is in the open position OP, allowing the first leg 22, the second leg 23, and the support rod 27 to enclose a triangular space which may contain tissue. The
5 support rod 27 extends in parallel with the first leg 22 when the end effector 4 is in the closed position CP.

In one embodiment, the operating means 5 comprises an axially extending rod 28, extending in parallel with the
10 center axis C of the hollow shaft 3, and a pivot link 29. The rod 28 is partially enclosed by the first leg 22 of the end effector 4, preferably being arranged in a radially extending recess in the first leg 22, as shown in Figs. 15a-15c.

15

The distal end 28b of the rod 28 is coupled to the distal end 23b of the second leg 23 by means of the pivot link 29, the pivot link 29 extending at an angle to the axial extension of the rod and at an angle to the second leg 23.
20 The proximal end 28a of the rod 28 is operably connected to the handle 2. The end effector 4 is actuated from the open position OP to the closed position CP when the rod 28 is moved in a direction away from the distal end 4b of the end effector 4. Correspondingly, the end effector 4 is actuated
25 from the closed position CP to the open position OP when the rod 28 is moved in a direction towards the distal end 4b of the end effector 4.

The operating means 5 may further comprise a piston 30 and a
30 spring 31, the rod 28 being partially enclosed by the piston 30 and the spring 31. Preferably, a proximal section of the

rod 28 is enclosed by the first leg 22, and a distal section of the rod 28 is enclosed by the piston 30 and the spring 31. The spring 31 is arranged between the piston 30 and the handle 2 and/or the multiaxial joint 6. The spring 31
5 applies a force onto the proximal end 30a of the piston 30 in a direction towards the distal end 4b of the end effector 4.

The rod 28 and the piston 30 are axially moveable in
10 relation to at least one of each other and the end effector 4. Furthermore, the rod 28 and the piston 30 are releasably connected such that the rod 28 and the piston 30 are axially moveable as one unit, in relation to the end effector 4. The rod 28 and the piston 30 are releasably connected by means
15 of a piston lock, as shown in Figs. 15b, 16a and 16c, the piston lock comprising a plurality of locking grooves 32 arranged in pairs in the rod 28 and a corresponding locking protrusion 33 arranged at a distal end 30b of the piston 30.

20 The present disclosure further relates to a surgical system comprising the above discussed surgical instrument 1 and at least one ligation clip 34. A ligation clip, also known as a clamp, is e.g. used for ligating flow of bodily fluids within tissue, see Fig. 14.

25

The end effector 4 of the surgical instrument 1 is configured to enclose the ligation clip 34 such that the distal end 34b of the ligation clip 34 is arranged adjacent the distal end 4b of the end effector 4 and the proximal end
30 34a of the ligation clip 34 is arranged adjacent the proximal end 4a of the end effector 4, as shown in Fig. 16a.

The ligation clip 34 comprises a first ligation clip leg 35 and a second ligation clip leg 36, the first ligation clip leg 35 and the second ligation clip leg 36 being pivotally
5 connected at the distal end 34b of the ligation clip 34. The first ligation clip leg 35 and the second ligation clip leg 36 comprise locking means 37 for interlocking the first 35 and second 36 ligation clip legs at the proximal end 34a of the ligation clip 34 in a position where the first ligation
10 clip leg 35 and the second ligation clip leg 36 are superimposed onto each other.

When the end effector 4 is in an initial open position OP, and the ligation clip 34 is enclosed by the first leg 22 and
15 the second leg 23 of the end effector 4, the ligation clip 34 has an open configuration where the second ligation clip leg 36 extends at an acute angle γ to the first ligation clip leg 35. When the end effector 4 subsequently is actuated to a closed position CP, the configuration of the
20 ligation clip 34 changes to a closed configuration where the first 35 and second 36 ligation clip legs are superimposed onto each other. As the end effector 4 is returned to the open position OP, the ligation clip 34 remains in the closed configuration by means of the locking means 37.

25

The surgical system may comprise a plurality of individual ligation clips 34, all in open configuration and arranged successively between the distal end 4b of the end effector 4 and the handle 2 along the rod 28 and/or the first leg 22 of
30 the end effector 4. All ligation clips 34-X, except a first ligation clip 34-1 located adjacent the distal end 4b of the

end effector 4 and enclosed by the first leg 22 and the second leg 23 of the end effector 4, are enclosed by the first leg 22 of the end effector 4 and the rod 28.

5 The ligation clips 34 are arranged in abutment with each other such that axial displacement of any one of the ligation clips 34-X, enclosed by the first leg 22 of the end effector 4 and the rod 28, induces a corresponding displacement of all ligation clips 34 located between the
10 ligation clip 34-X and the distal end 4b of the end effector 4. In other words, all ligation clips 34 located closer to the distal end 4b of the end effector 4 than the ligation clip 34-X are pushed in a direction towards the distal end 4b by means of the ligation clip 34-X.

15

The present disclosure further relates to a method of operating the above described surgical system, shown in Figs. 16b to 16h, wherein a first ligation clip 34-1 is arranged within the end effector 4 such that the first
20 ligation clip 34-1 is enclosed by the first leg 22 of the end effector 4 and the rod 28, and the first ligation clip 34-1 has an open configuration.

The first ligation clip 34-1 is displaced in the direction
25 towards the distal end 4b of the end effector 4, to a position where the first ligation clip 34-1 is enclosed by the first 22 and second 23 legs of the end effector 4 and the end effector 4 is in an open position OP, by moving the rod 28 in a direction towards the distal end 4b of the end
30 effector 4, as shown in Fig. 16a.

The first ligation clip 34-1 is closed by actuating the end effector 4 to the closed position CP by moving the rod 28 in the direction away from the distal end 4b of the end effector 4.

5

Subsequently the rod 28 is moved in a direction towards the distal end 4b of the end effector 4, such that the end effector 4 is returned to the open position OP, which allows the first ligation clip 34-1, having a closed configuration, to be released from the end effector 4.

10

The surgical system may comprise a plurality of ligation clips 34. For ease of reading, the following description will be limited to a first, a second, and a third ligation clip 34, however additional ligation clips 34 are possible.

15

A second ligation clip 34-2 may be arranged within the end effector 4 such that the second ligation clip 34-2 is enclosed by the first leg 22 of the end effector 4 and the rod 28, the second ligation clip 34-2 having an open configuration. Furthermore, the piston lock 32, 33 interlocks the rod 28 and the piston 30 in the first locking position LP1 when the end effector 4 is returned to the open position OP, as mentioned above and shown in Fig. 16a.

20

25

The rod 28 is moved in the direction away from the distal end 4b of the end effector 4, as shown in Fig. 16b, whereby the piston lock 32, 33 is released from the first locking position LP1 and the piston 30 is allowed to move in relation to the rod 28. Simultaneously, the end effector 4 is actuated to the closed position CP, and the piston 30

30

moves towards the end effector 4, by means of the spring 31 applying force onto the proximal end 30a of the piston 30 until the piston lock 32, 33 engages the second locking position LP2, as shown in Fig. 16c. The distal end 30b of the piston 30 is arranged closer to the distal end 4b of the end effector 4 when the piston lock 32, 33 is in the second locking position LP2 than in the first locking position LP1.

The rod 28 is moved in the direction towards the distal end 4b of the end effector 4, and the piston 30 is moved along with the rod 28 in the same direction. Simultaneously, the end effector 4 is actuated to the open position OP, as shown in Fig. 16d.

The rod 28 is moved in the direction away from the distal end 4b of the end effector 4, whereby the piston lock 32, 33 is released from the second locking position LP2, as shown in Fig. 16e. The locking protrusion 33 engages a longitudinal groove 38 arranged in the rod 28 such that the piston 30 is allowed to move in relation to the rod 28, simultaneously actuating the end effector 4 to the closed position CP, as shown in Fig. 16f.

The rod 28 and piston 30 may comprise only one piston lock 32, 33 and one longitudinal groove 38. However, the rod 28 preferably comprises several longitudinal grooves 38 as well as several individual or pairs of locking grooves 32, each pair allowing the locking protrusion 33 of the piston 30 to assume a first locking position LP1 when engaging one locking groove of the pair, and assume a second locking position LP2 when engaging the other locking groove of the

pair. Each longitudinal groove 38 is associated with one individual or one pair of locking grooves 32.

5 The distal end 30b of the piston 30 engages with the second ligation clip 34-2, pushing the second ligation clip 34-2 in the direction towards the distal end 4b of the end effector 4 by means of the spring 31, until the second ligation clip 34-2, or a third ligation clip 34-3 located between the second ligation clip 34-2 and the distal end 4b of the end
10 effector 4, is enclosed by the first 22 and second 23 legs of the end effector 4, as shown in Fig. 16g. The ligation clips 34 slide over the longitudinal grooves 38 such that the longitudinal grooves 38 and the ligation clips 34 do not interact.

15

The rod 28 is moved in the direction towards the distal end 4b of the end effector 4, simultaneously actuating the end effector 4 to the open position OP, as shown in Fig. 16h.

20 The second 34-2 or third 34-3 ligation clip, enclosed by the first 22 and second 23 legs of the end effector 4, is closed by actuating the end effector 4 to the closed position CP by moving the rod 28 in the direction away from the distal end 4b of the end effector 4.

25

The rod 28 is moved in the direction towards the distal end 4b of the end effector 4, such that the end effector 4 is returned to the open position OP, which allows the second 34-2 or third 34-3 ligation clip, being in the closed
30 configuration, to be released from the end effector 4.

With reference to Figs. 11a-d and 17a-17b there is disclosed an embodiment of an end actuator for a surgical instrument 1 for actuating an end effector 4 between open and closed
5 positions. The end actuator comprises an elongated base member 3 and an actuation rod 28. The base member 3 is configured to guide the actuation rod 28 for translative movement of the actuation rod 28. An end effector leg 23 is pivotally suspended from the base member 3 at a first
10 position on the end effector leg 23. The end effector leg 23 has a free end and a hinged end, and the first position is at or adjacent the hinged end.

A pivot link 29 operatively connects the actuation rod 28 with the end effector leg 23 by a first end of the pivot
15 link 29 being pivotally connected to the actuation rod 28 and a second end of the pivot link 29 being pivotally connected to the end effector leg 23 at a second position spaced from the first position. In one embodiment, the pivot
20 link 29 comprises a plate extending between the first end and the second end.

The first end is connected to the actuation rod 28 by a first hinge pin. The pivot link 29 may be operatively
25 connected to the actuation rod 28 at or near an extremity of the actuation rod 28. Correspondingly, the second end may be connected to the end effector leg 23 by a second hinge pin. The second position is nearer to the hinged end than to the free end.

The end effector leg 23 is, in one embodiment, hinged to the elongated base member 3 by a third hinge pin. The third hinge pin is arranged in or adjacent the longitudinal axis of the base member 3.

5

The end effector leg 23 is configured to fold towards the base member 3 when the actuation rod 28 is translated in a direction away from the third hinge pin and the end effector leg 23 is configured to fold away from the base member 3
10 when the actuation rod 28 is translated in a direction towards the third hinge pin.

The various aspects and implementations have been described in conjunction with various embodiments herein. However,
15 other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed subject-matter, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other
20 elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measured cannot be used to advantage.

25

The reference signs used in the claims shall not be construed as limiting the scope.

PATENTKRAV

1. Kirurgisk instrument (1) omfattende
et greb (2),

5 et hult skaft (3),

en endeeffektor (4), der er koblet til en distal ende (3b) af
det hule skaft (3), hvilken endeeffektor (4) er operativt
forbundet med grebet (2) via betjeningsmidler (5), der
strækker sig inde i det hule skaft (3),

10 et fleraksialt led (6), der sammenkobler grebet (2) med en
proksimal ende (3a) af det hule skaft (3), hvilket fleraksialt
led (6) muliggør fleraksial rotation af grebet (2) i forhold
til det hule skaft (3),

k e n d e t e g n e t ved, at den fleraksiale rotation
15 indbefatter rotation omkring en midterakse (C) af det hule
skaft (3) og i mindst to plan i forhold til en proksimal ende
(3a) af det hule skaft (3).

2. Kirurgisk instrument (1) ifølge krav 1, hvor den
20 fleraksiale rotation ikke indvirker på endeeffektorens (4)
position.

3. Kirurgisk instrument (1) ifølge et hvilket som helst af de
foregående krav, hvor betjeningsmidlerne (5) omfatter mindst
25 én af en wire, en slange og en stav, hvor betjeningsmidlet
(5) strækker sig gennem et indre af det fleraksiale led (6).

4. Kirurgisk instrument (1) ifølge et hvilket som helst af de
foregående krav, hvor grebet (2) kan rotere omkring
30 midteraksen (C), og grebet (2) kan rotere i mindst to plan i
forhold til den proksimale ende (3a) af det hule skaft (3),

hvilke plan fortrinsvis strækker sig parallelt med eller vinkelret på midteraksen og vinkelret på hinanden.

5. Kirurgisk instrument (1) ifølge krav 4, hvor grebet (2)
5 kan rotere omkring midteraksen og i tre plan samtidigt.

6. Kirurgisk instrument (1) ifølge et hvilket som helst af de foregående krav, hvor det fleraksiale led (6) er et sfærisk led omfattende første (7) og anden (8) mindst delvist sfæriske
10 skaller, hvor åbne ender (7a, 8a) af den første (7) og den anden (8) skal har sammenkoblingsoverflader (7b, 8b), således at der er et fælles overlappingsområde (A) mellem den første skal (7) og den anden skal (8), når en åben ende af én af den første skal (7) og den anden skal (8) presses ind i den anden
15 af den første skal (7) og den anden skal (8).

7. Kirurgisk instrument (1) ifølge krav 6, hvor mindst én sammenkoblingsoverflade af den første (7) og den anden (8) skal er forsynet med mindst én af en mikrostruktur, en coating
20 og en opruning for øget friktion i det fælles overlappingsområde.

8. Kirurgisk instrument (1) ifølge krav 7, hvor mindst én af den første (7) og den anden (8) skal er forsynet med et hult
25 føringsrør (9), der rager frem fra mindst én af en udvendig overflade og en indvendig overflade af den første (7) og den anden (8) skal, og rummer mindst én af den proksimale ende (3a) af det hule skaft (3), betjeningsmidlet (5) og en forbindelse til grebet.

9. Kirurgisk instrument (1) ifølge krav 7 eller 8, hvor mindst én af den første (7) og den anden (8) skal er forsynet med spalter (10), der strækker sig fra en åben ende (7a, 8a) af den første (7) og/eller den anden (8) skal.

5

10. Kirurgisk instrument (1) ifølge et hvilket som helst af kravene 7 til 9, hvor det fleraksiale led (6) endvidere omfatter en tredje skal (11) anbragt omkring en periferi af den første (7) og den anden (8) sammenkoblingsskal, i det fælles overlappingsområde (A),

10

en låsestang (12), der rager frem fra den tredje skal (11), hvor den tredje skal (11) kan bevæges mellem en ulåst position (P1) og en låst position (P2) ved anvendelse af låsestangen (12),

15

hvor, i den ulåste position (P1), diametrene på den første (7) og den anden (8) skal ikke påvirkes af den tredje skal (11) og den første (7) og den anden (8) skal kan rotere i forhold til hinanden,

20

og hvor, i den låste position (P2), diametrene på mindst én af den første (7) og den anden (8) skal er reduceret i mindst det fælles overlappingsområde (A), således at den første (7) og den anden (8) skal ikke kan rotere i forhold til hinanden.

25

11. Kirurgisk instrument (1) ifølge krav 10, hvor en radiale yderst placeret skal af den første (7) og den anden (8) skal omfatter en rille (13), der strækker sig periferisk, hvor den radiale dybde (D) af rillen (13) aftager i en retning mod en åben ende (7a, 8a) af den første (7) eller den anden (8) skal, således at rillen (13) omfatter en maksimal bundtykkelsessektion (T1) og en minimal bundtykkelsessektion (T2),

30

hvor den tredje skal (11) er i den ulåste position (P1), når den tredje skal (11) er mindst delvist anbragt inde i den minimale bundtykkelsessektion (T2), og

hvor den tredje skal (11) i den låste position (P2), når den
5 tredje skal (11) er mindst delvist anbragt inde i den maksimale bundtykkelsessektion (T1).

12. Kirurgisk instrument (1) ifølge et hvilket som helst af de foregående krav, hvor grebet (2) og betjeningsmidlet (5)
10 er konfigureret til at aktivere endeeffektoren (4) mellem en åben position (OP) og en lukket position (CP),

hvor en proksimal ende (4a) af endeeffektoren (4) er koblet til en distal ende (3b) af det hule skaft (3),

hvor endeeffektoren (4) omfatter et første ben (22) og et
15 andet ben (23), hvor det andet ben (23) er drejbart forbundet med det første ben (22) ved en distal ende af endeeffektoren (4b),

hvor det andet ben (23) strækker sig i en spids vinkel (α) til det første ben (22), når endeeffektoren (4) er i den åbne
20 position (OP), og

hvor det andet ben (23) strækker sig generelt parallelt med det første ben (22), når endeeffektoren (4) er i den lukkede position (CP).

25 13. Kirurgisk instrument (1) ifølge et hvilket som helst af de foregående krav, hvor endeeffektoren (4) er tilpasset til én af adskillelse, ligering, klipning, injektion, brænding, skæring, gribning, rivning og syning af væv.

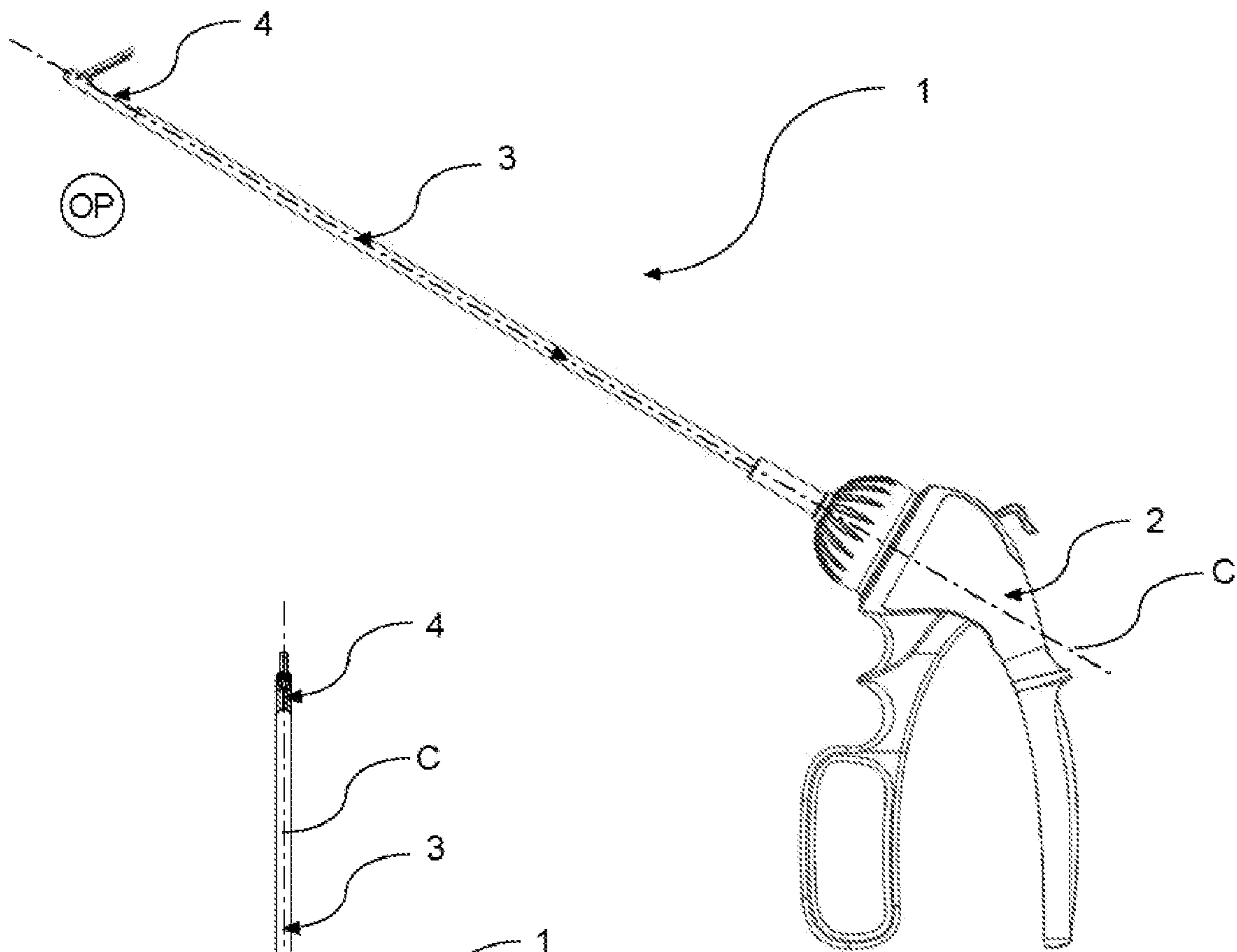


Fig. 1a

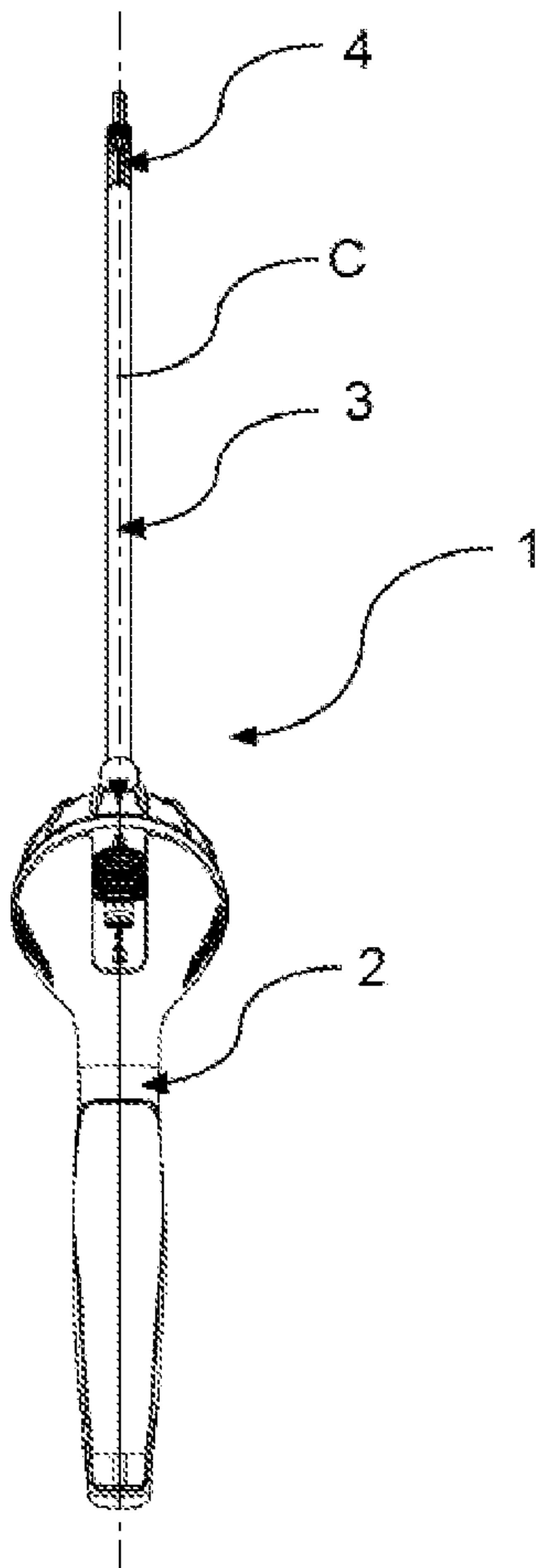
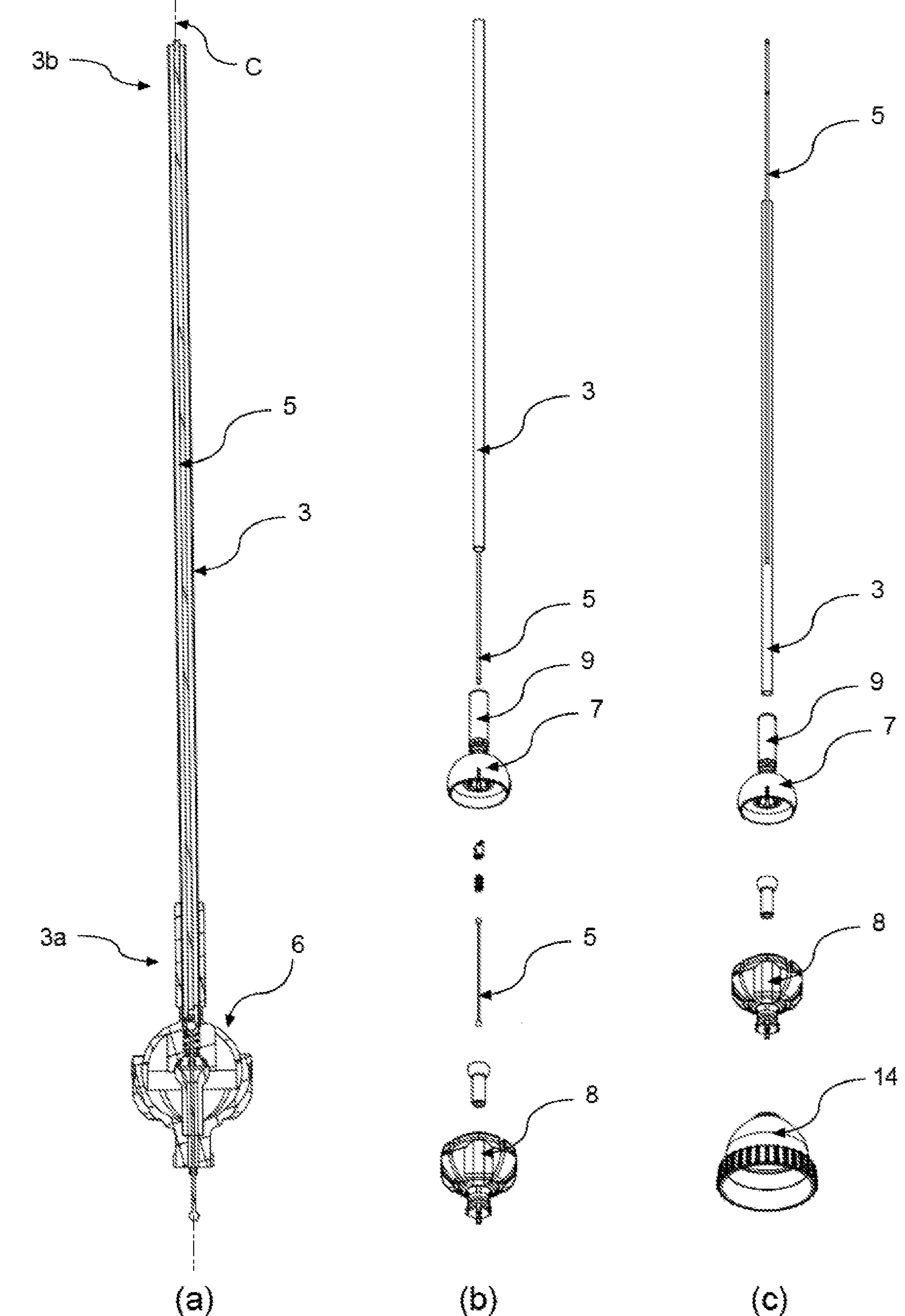
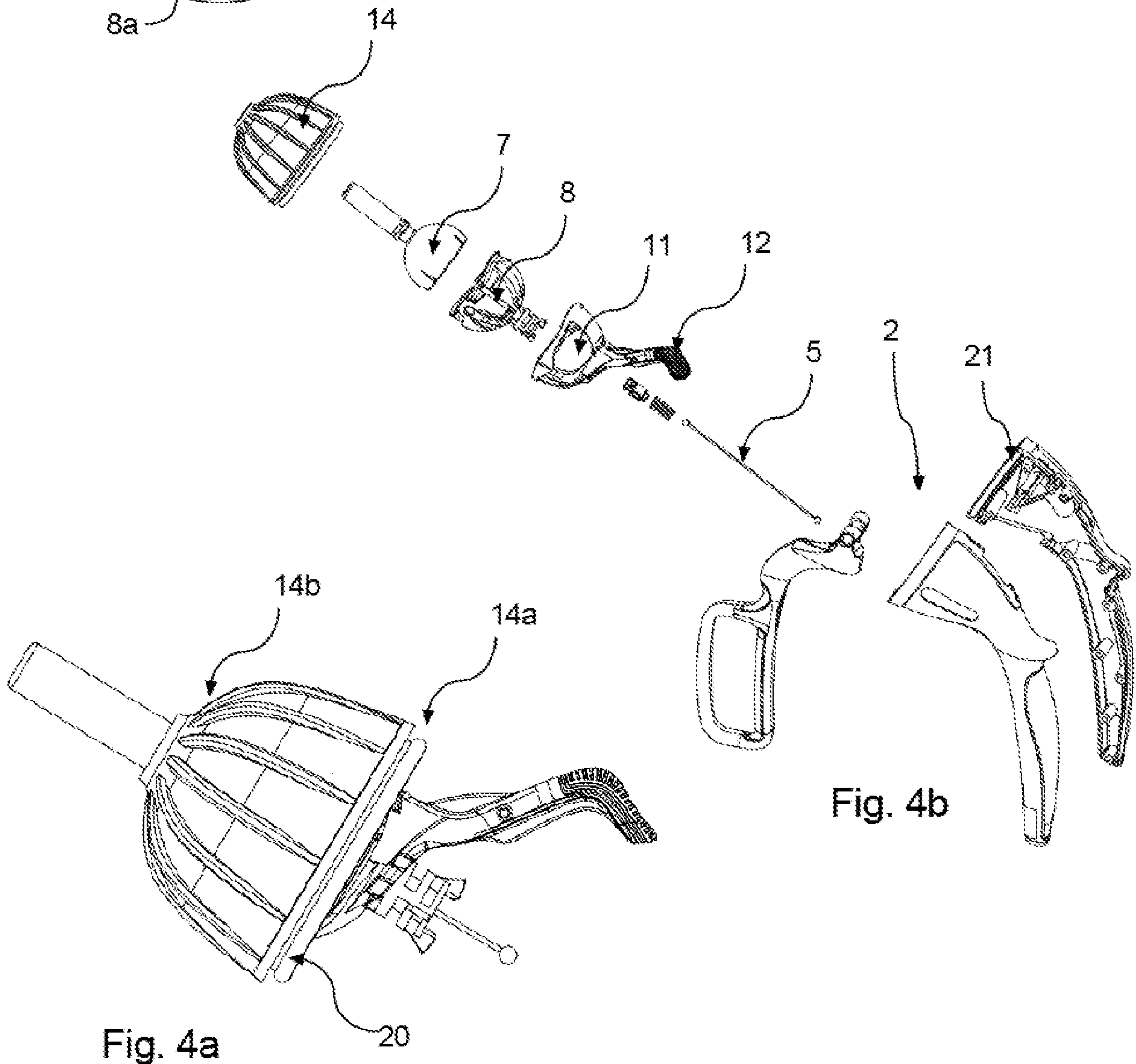
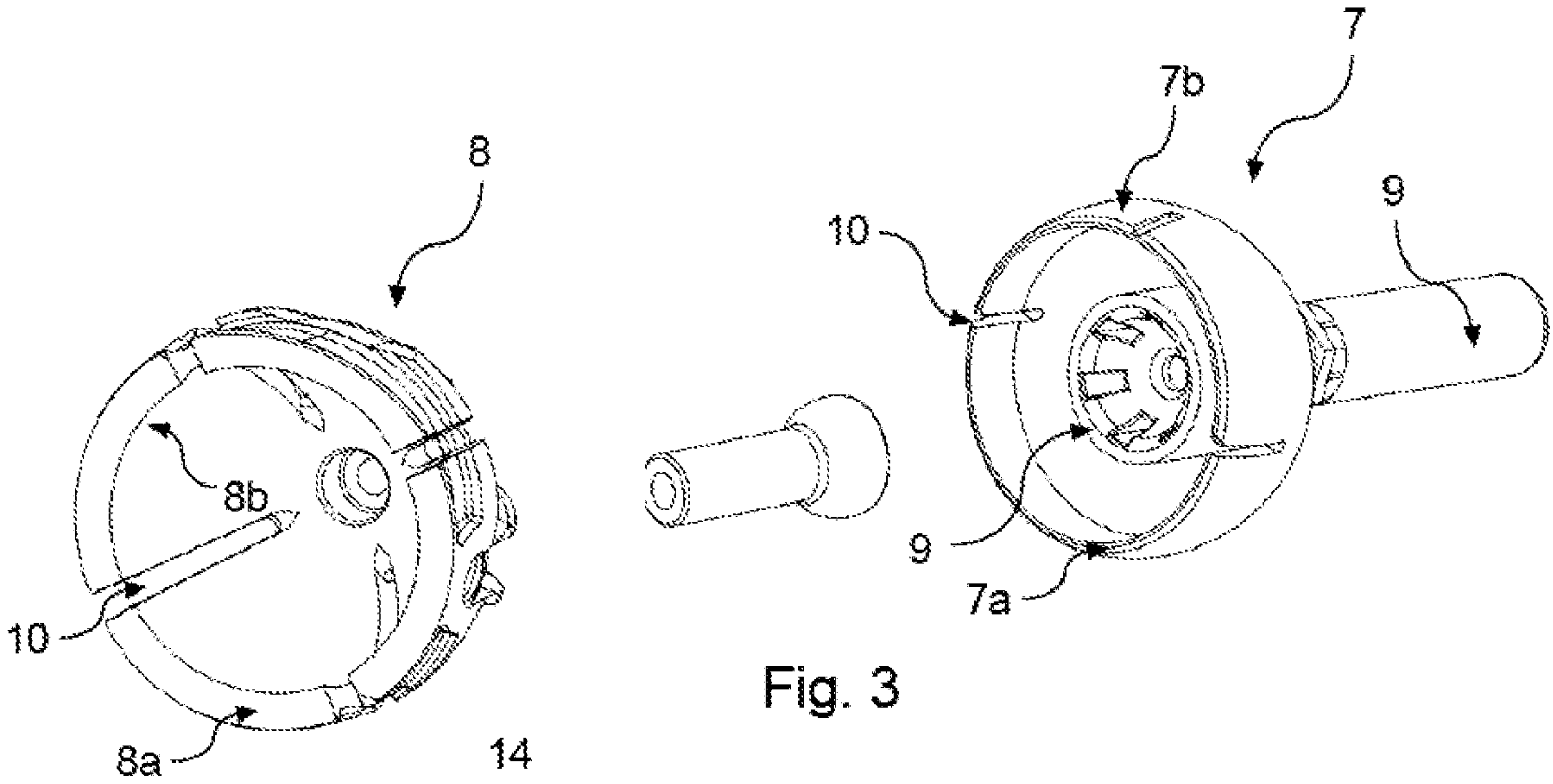


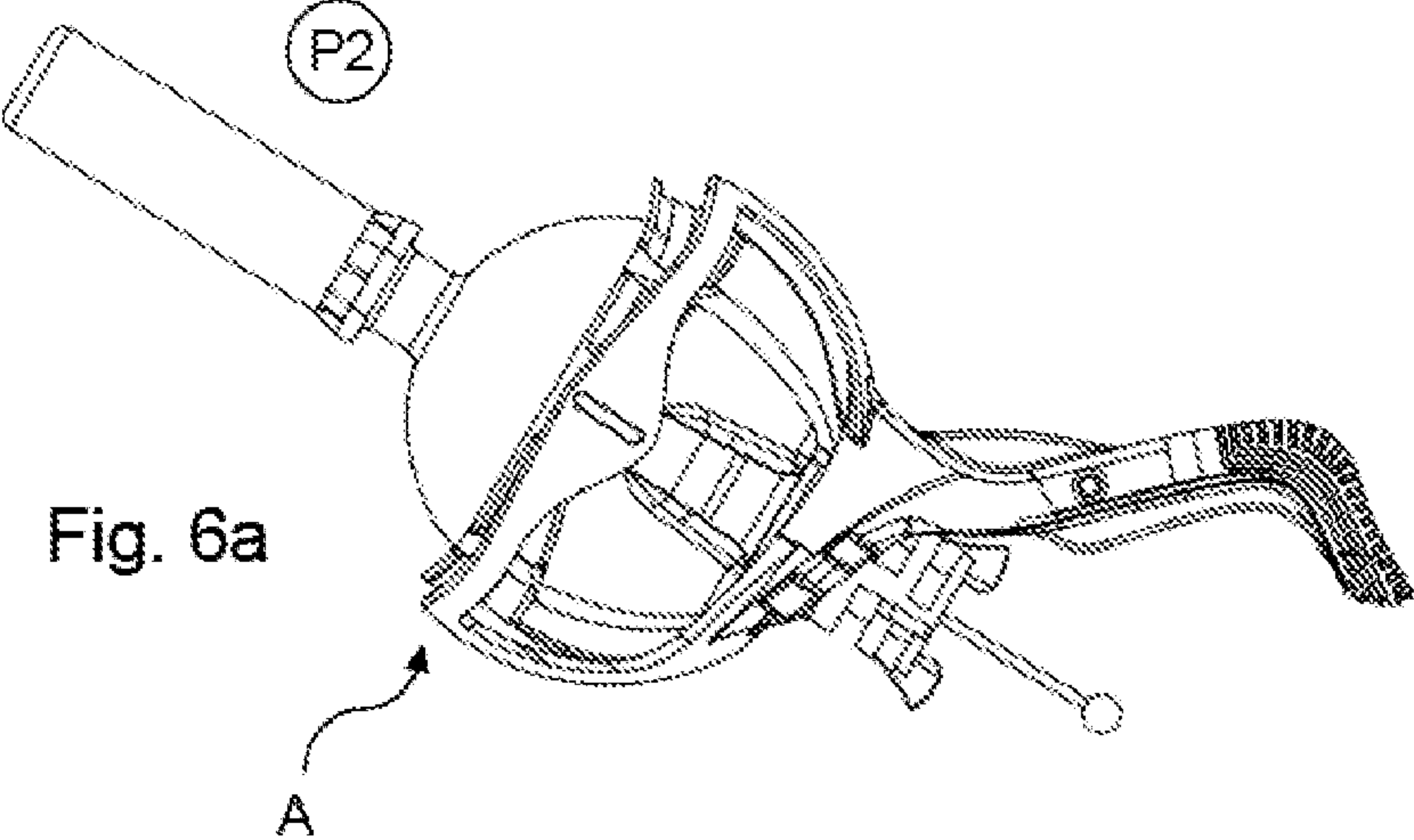
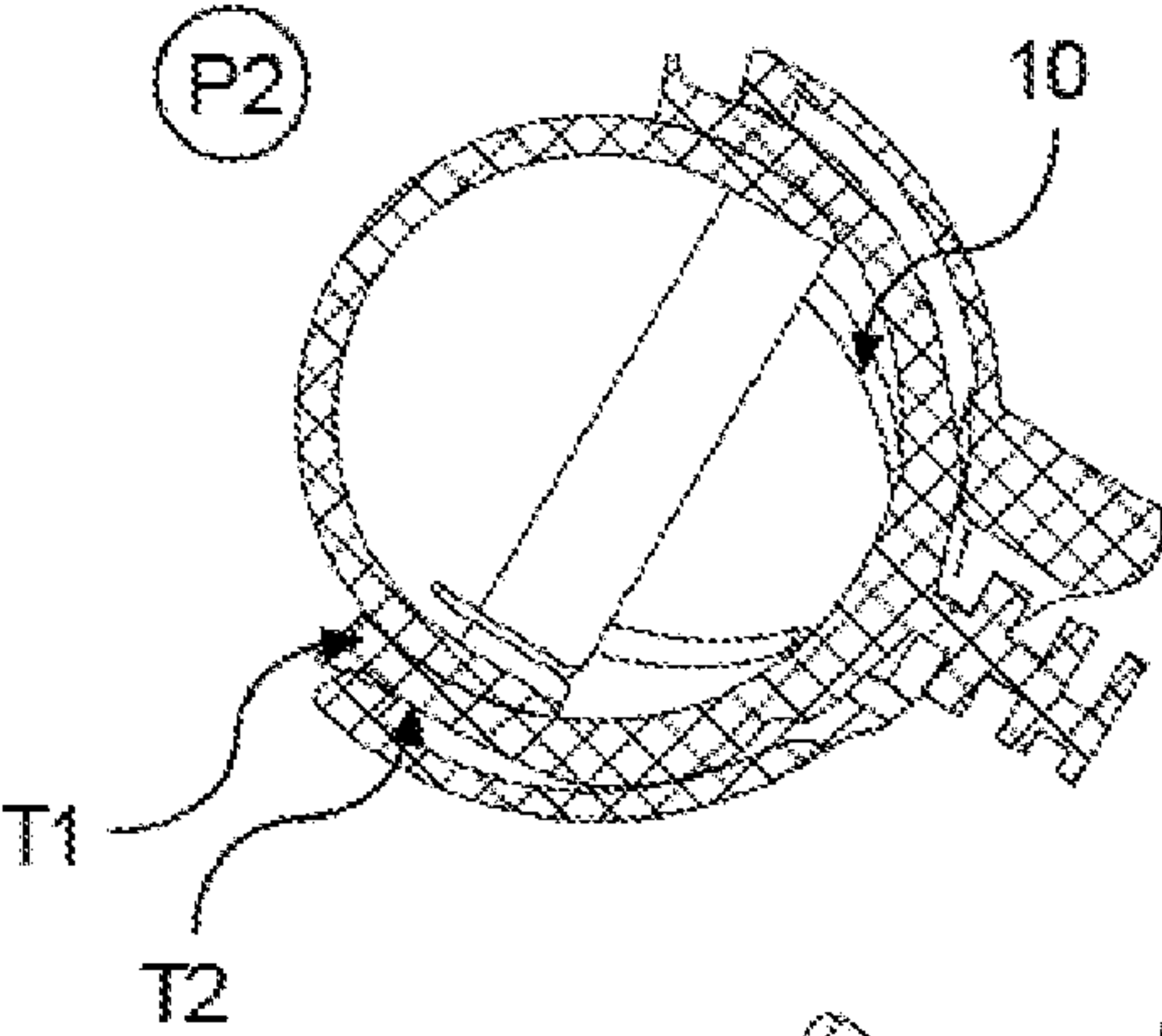
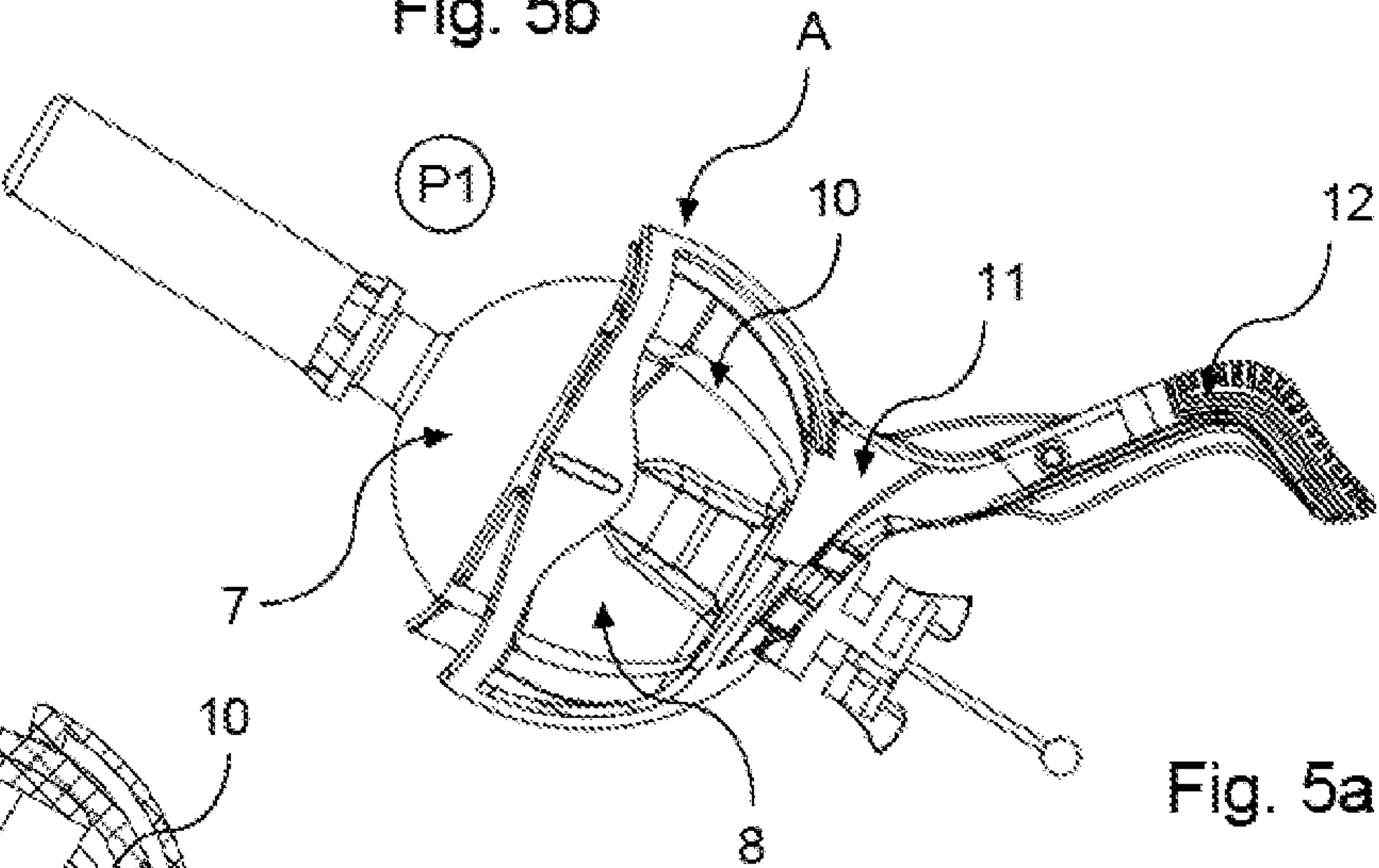
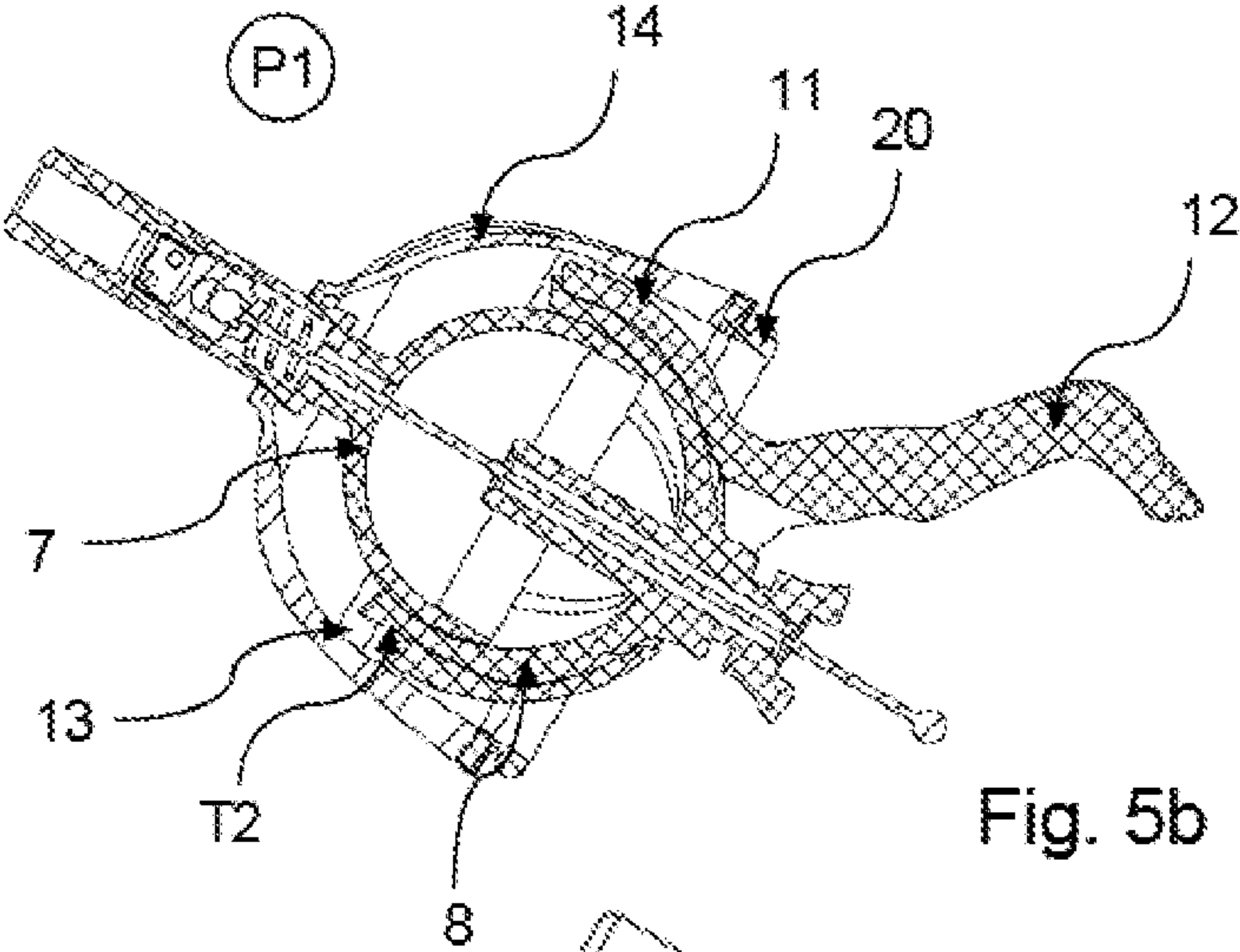
Fig. 1b

Fig. 2

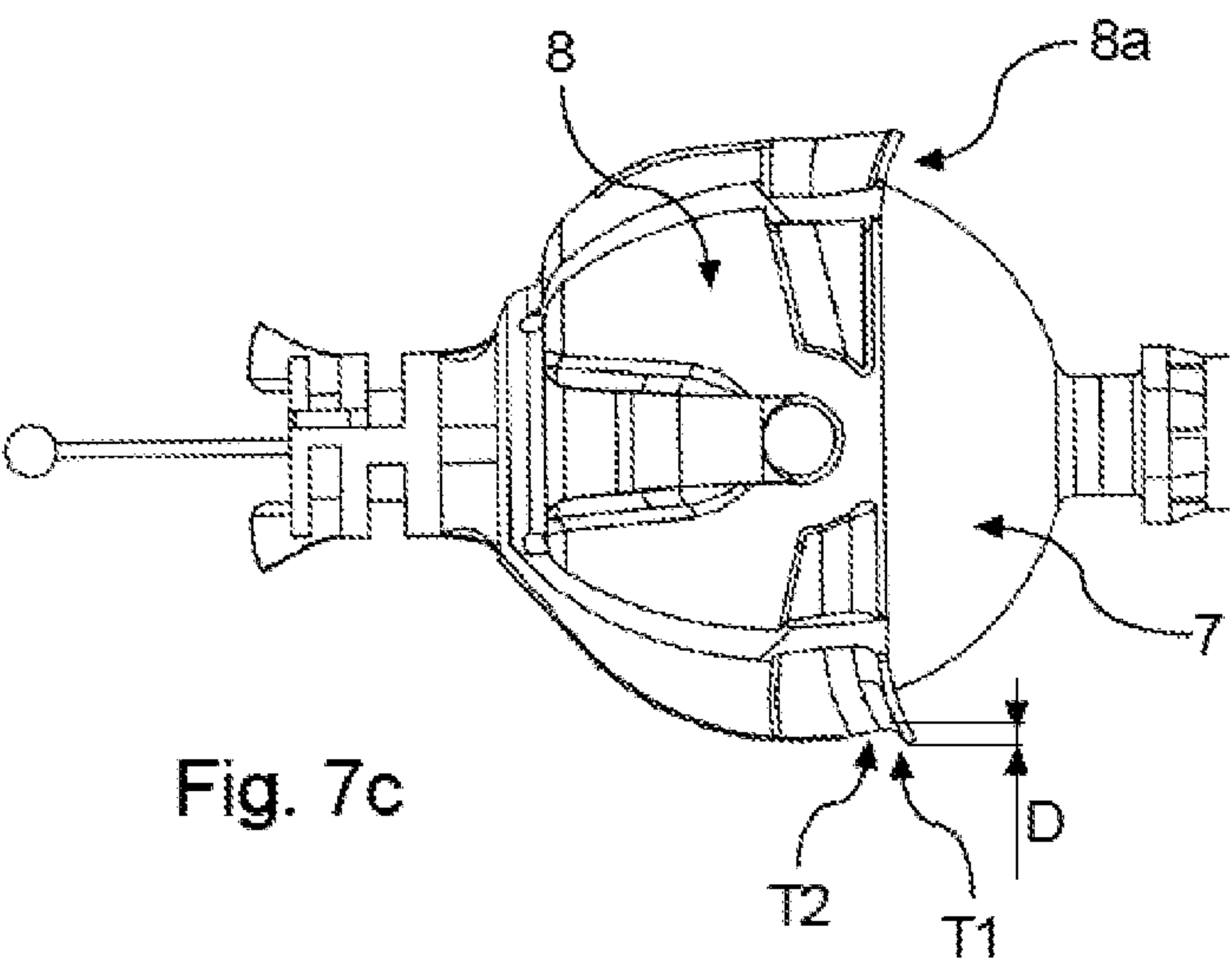
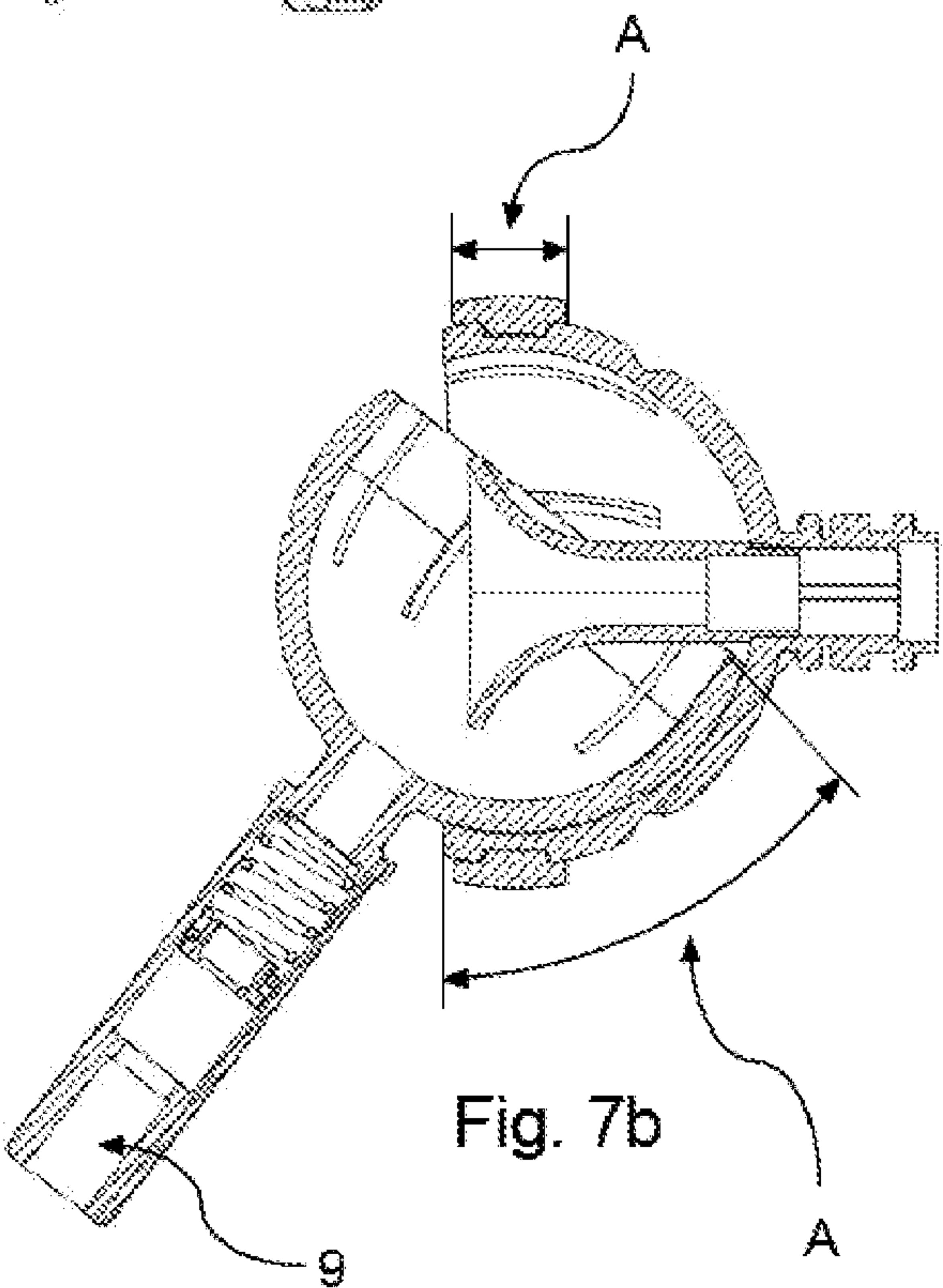
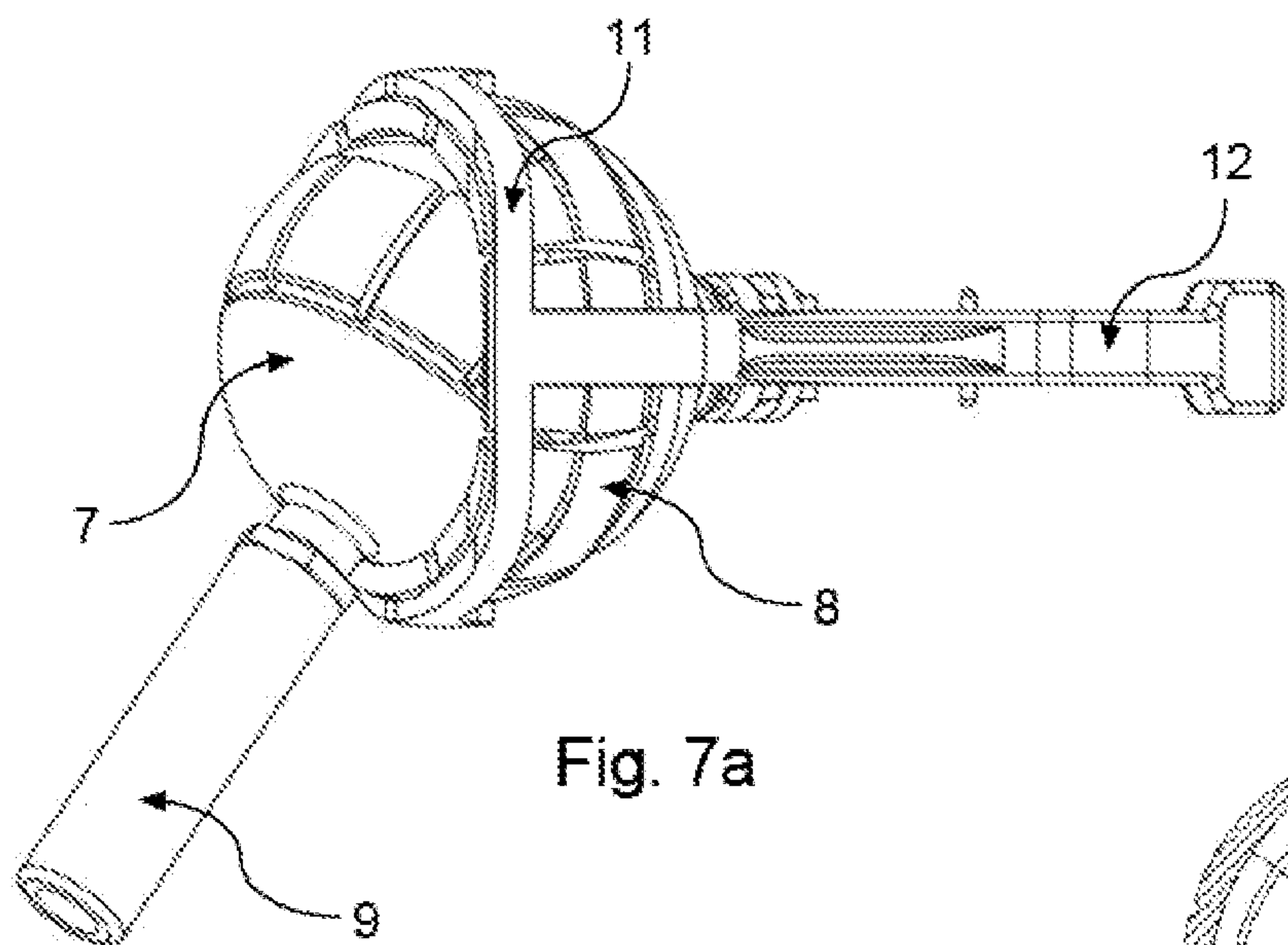




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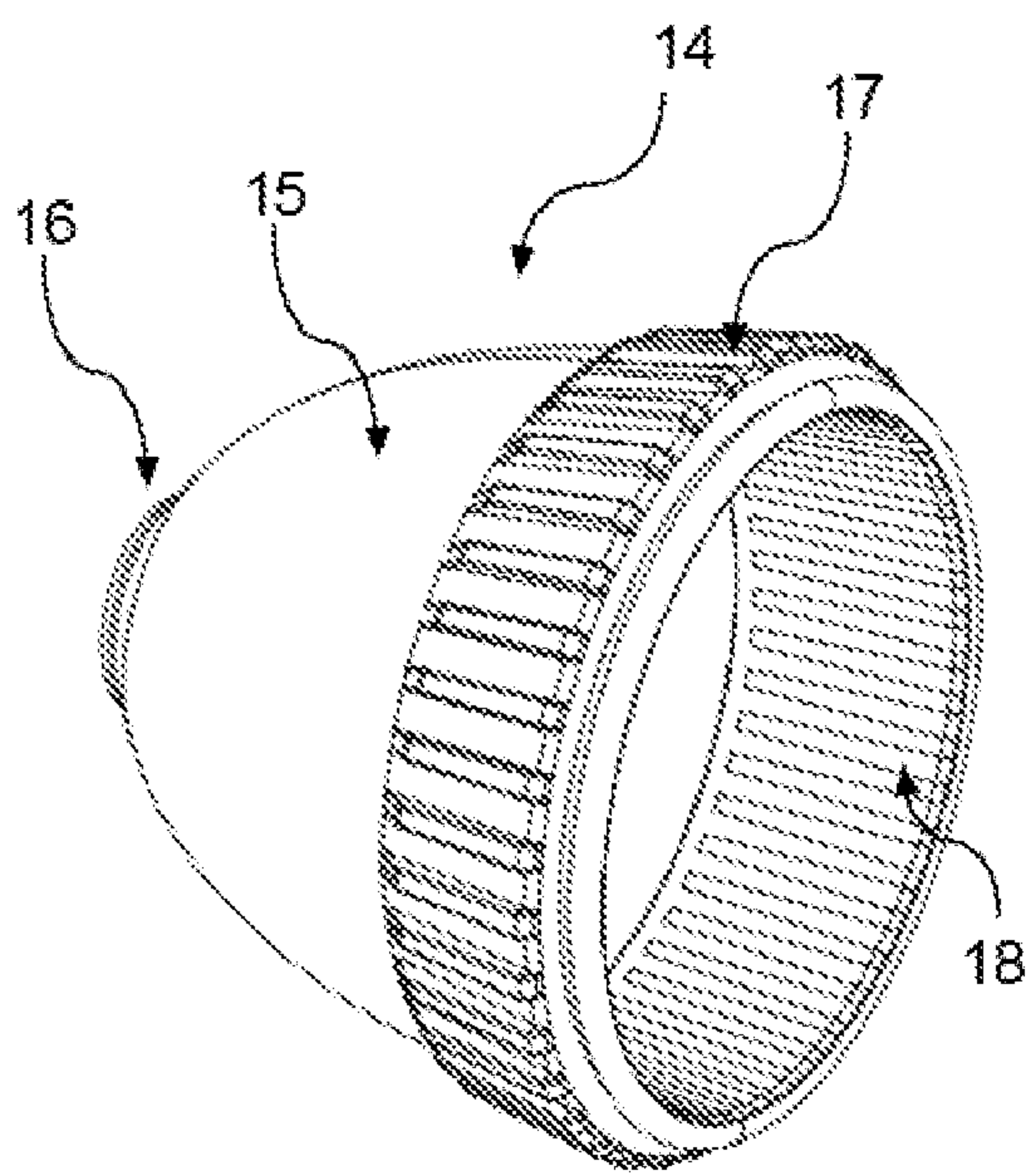


Fig. 8a

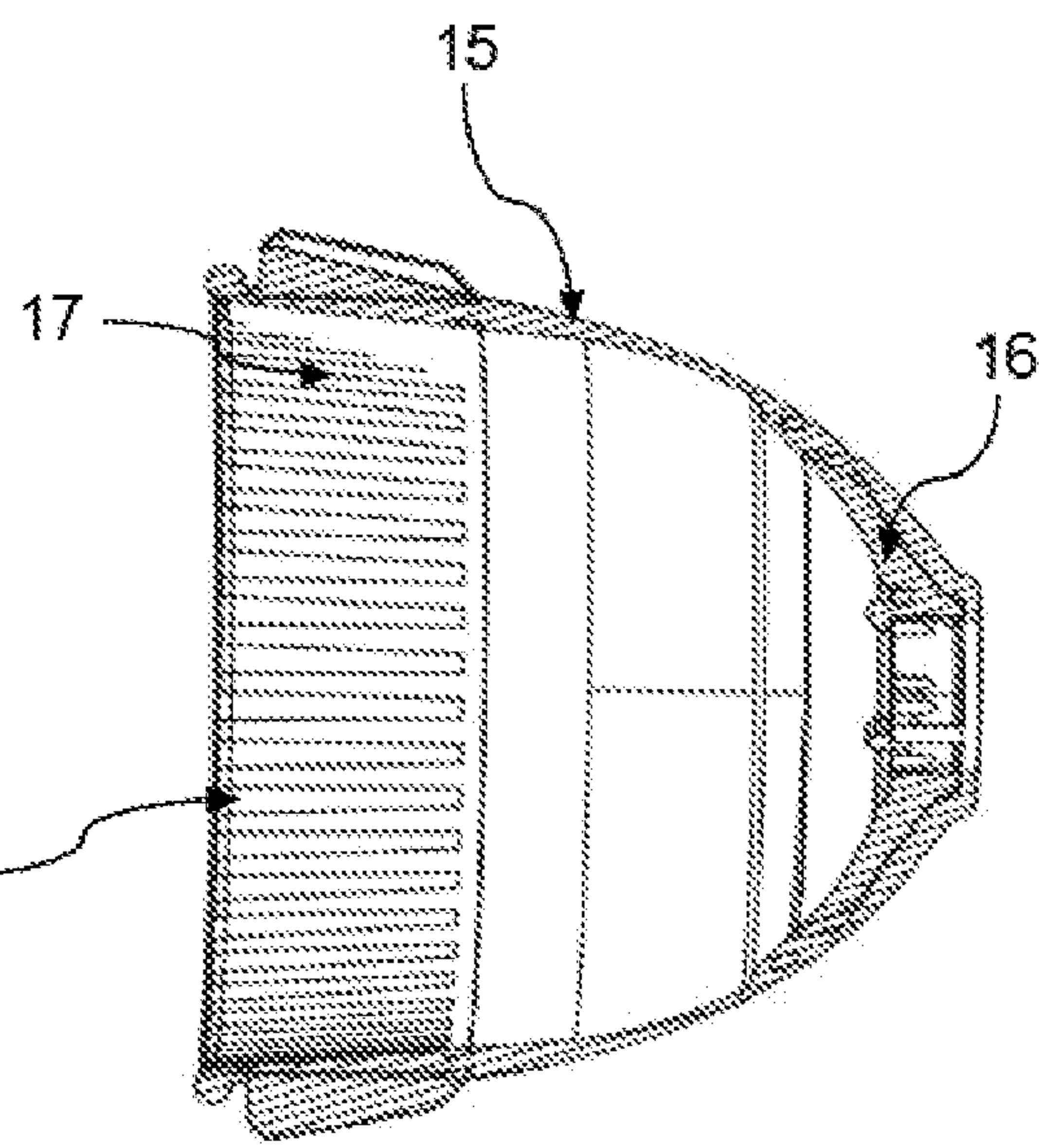


Fig. 8b

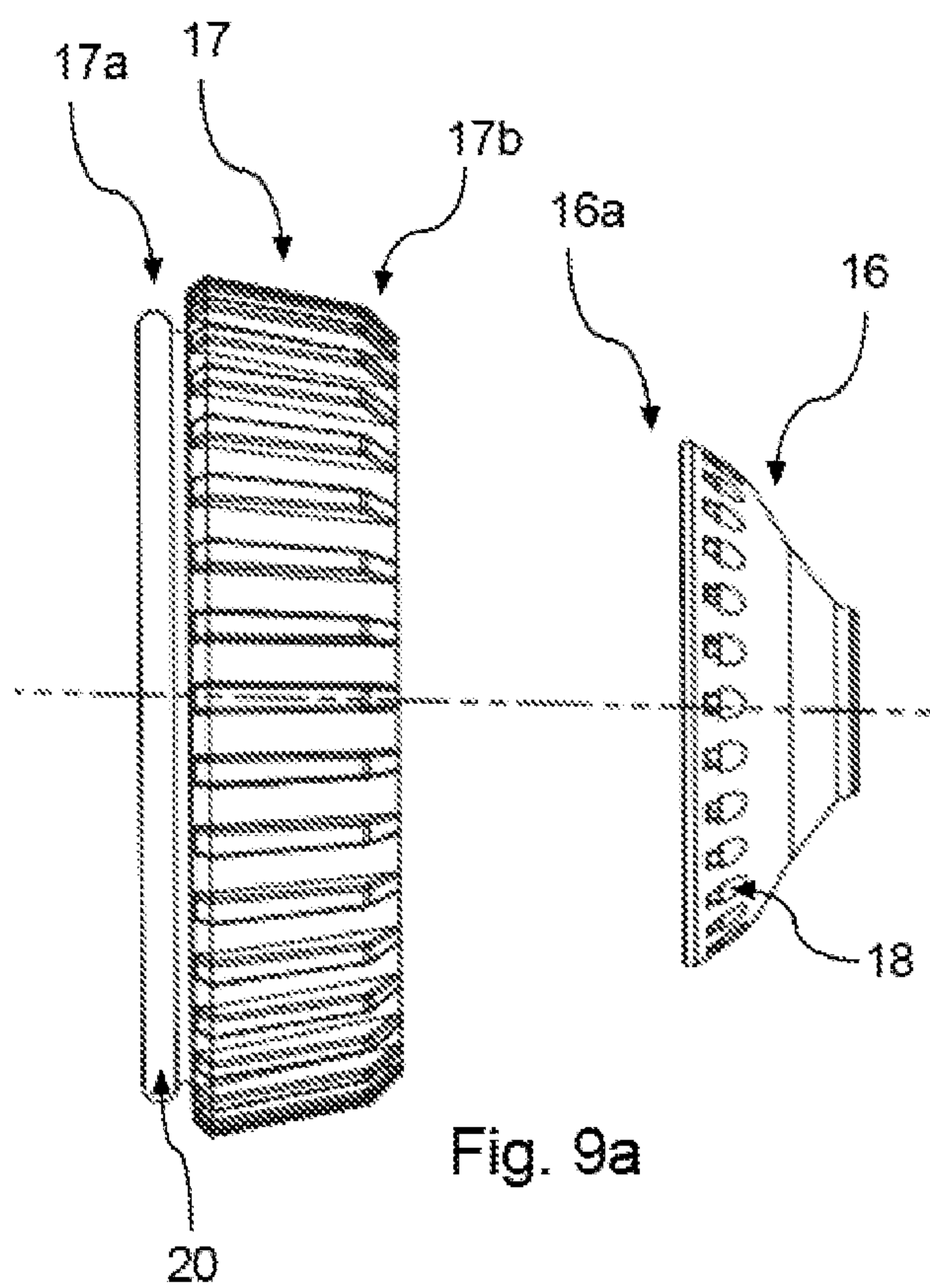


Fig. 9a

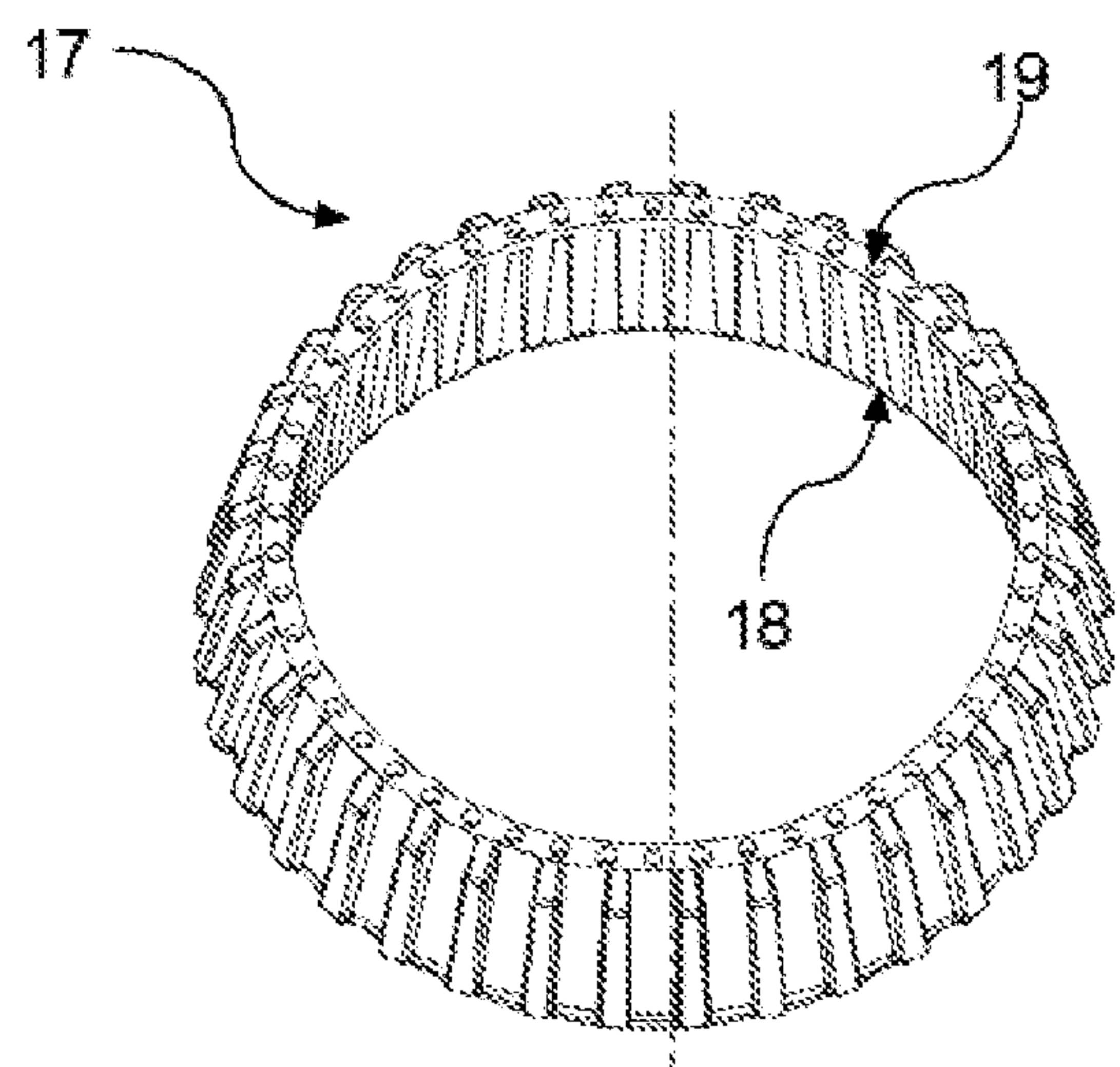


Fig. 9b

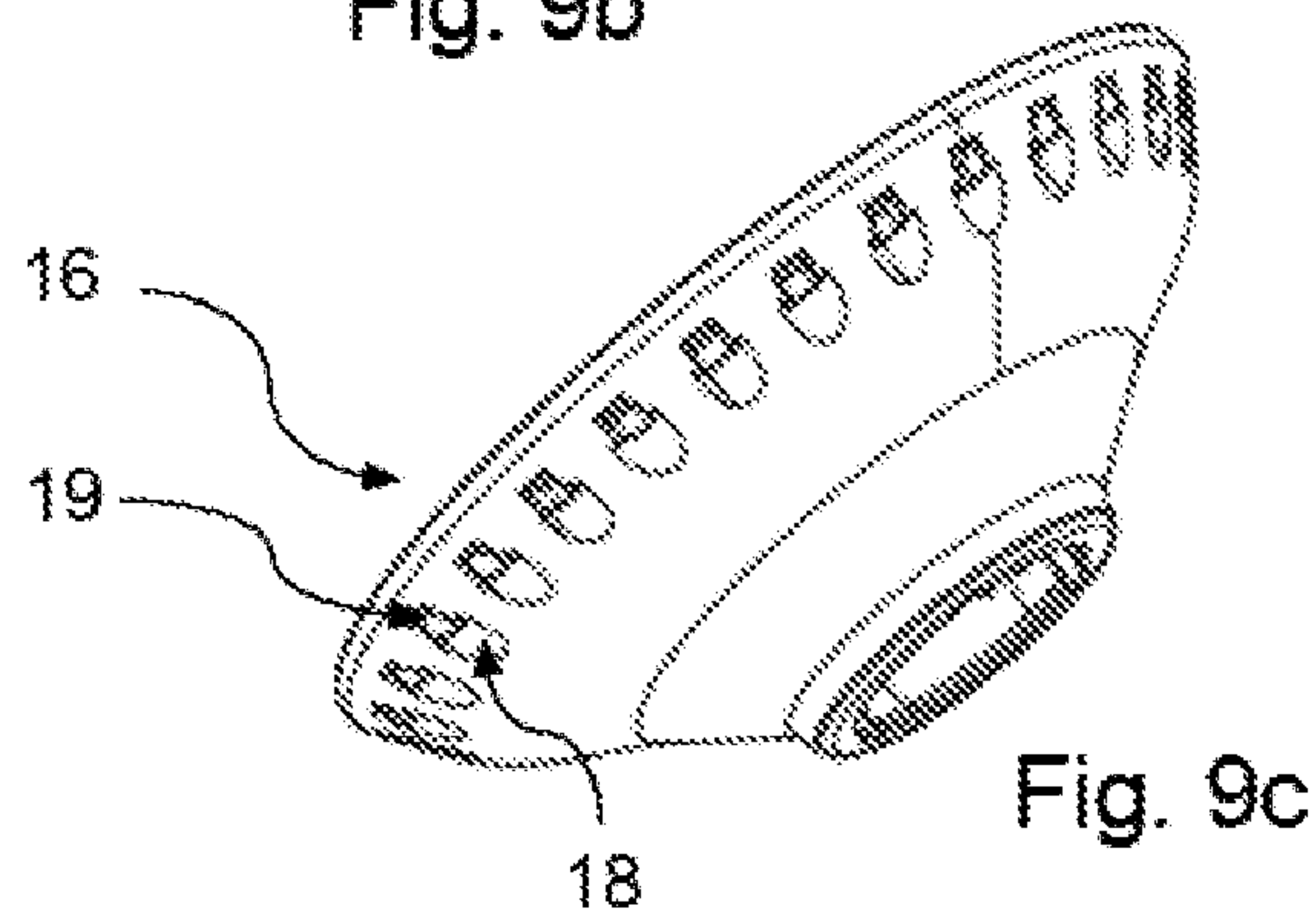


Fig. 9c

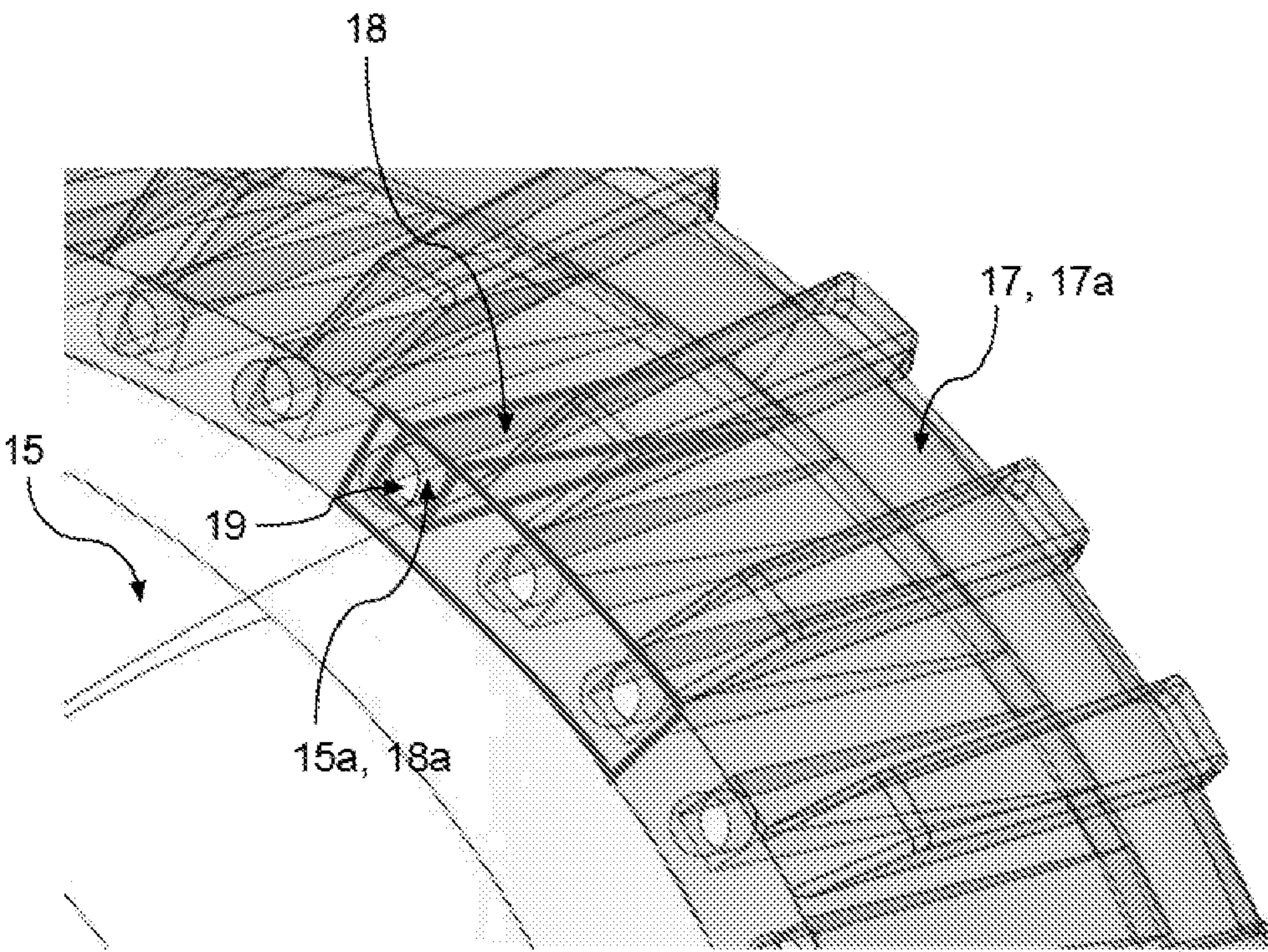


Fig. 10a

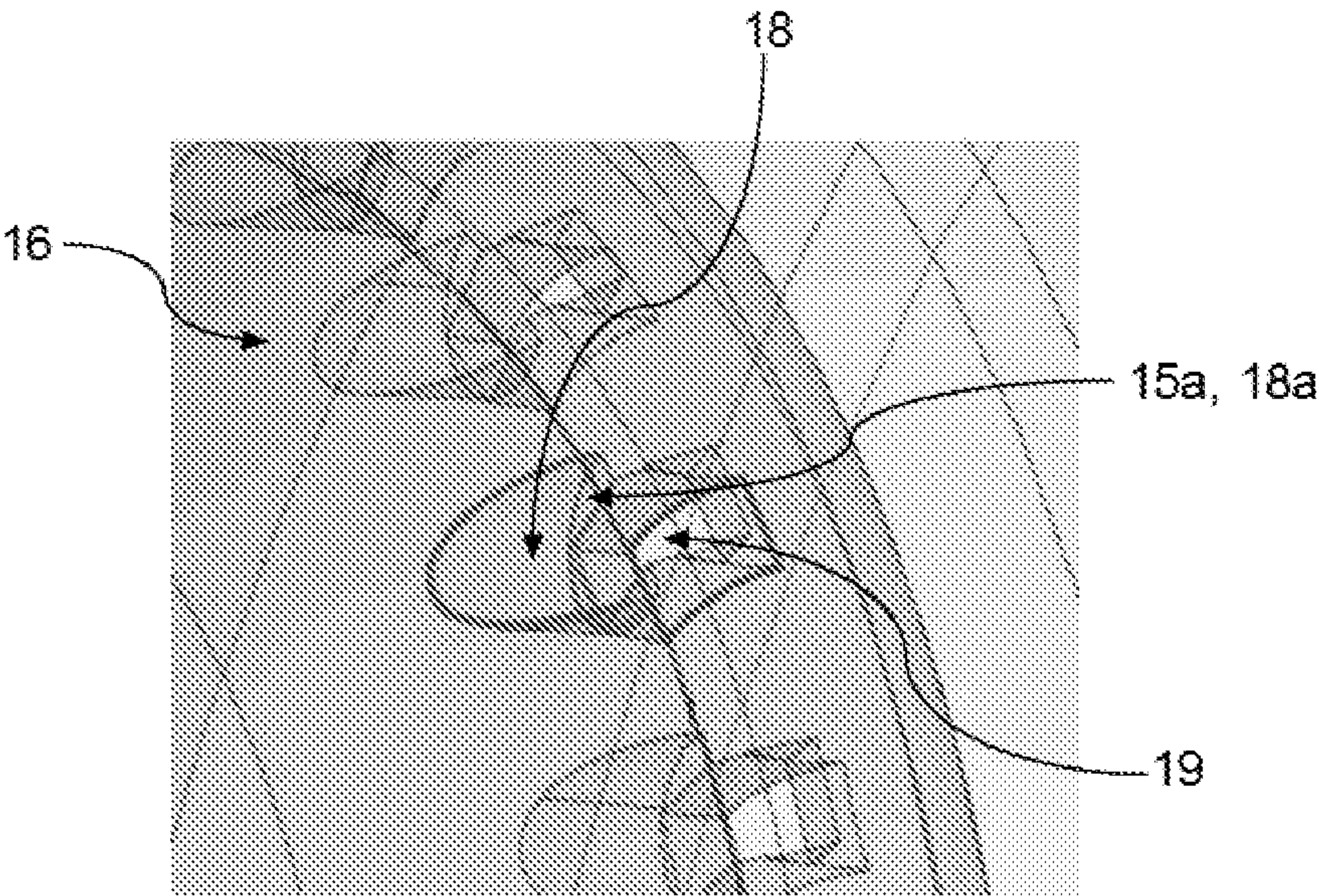
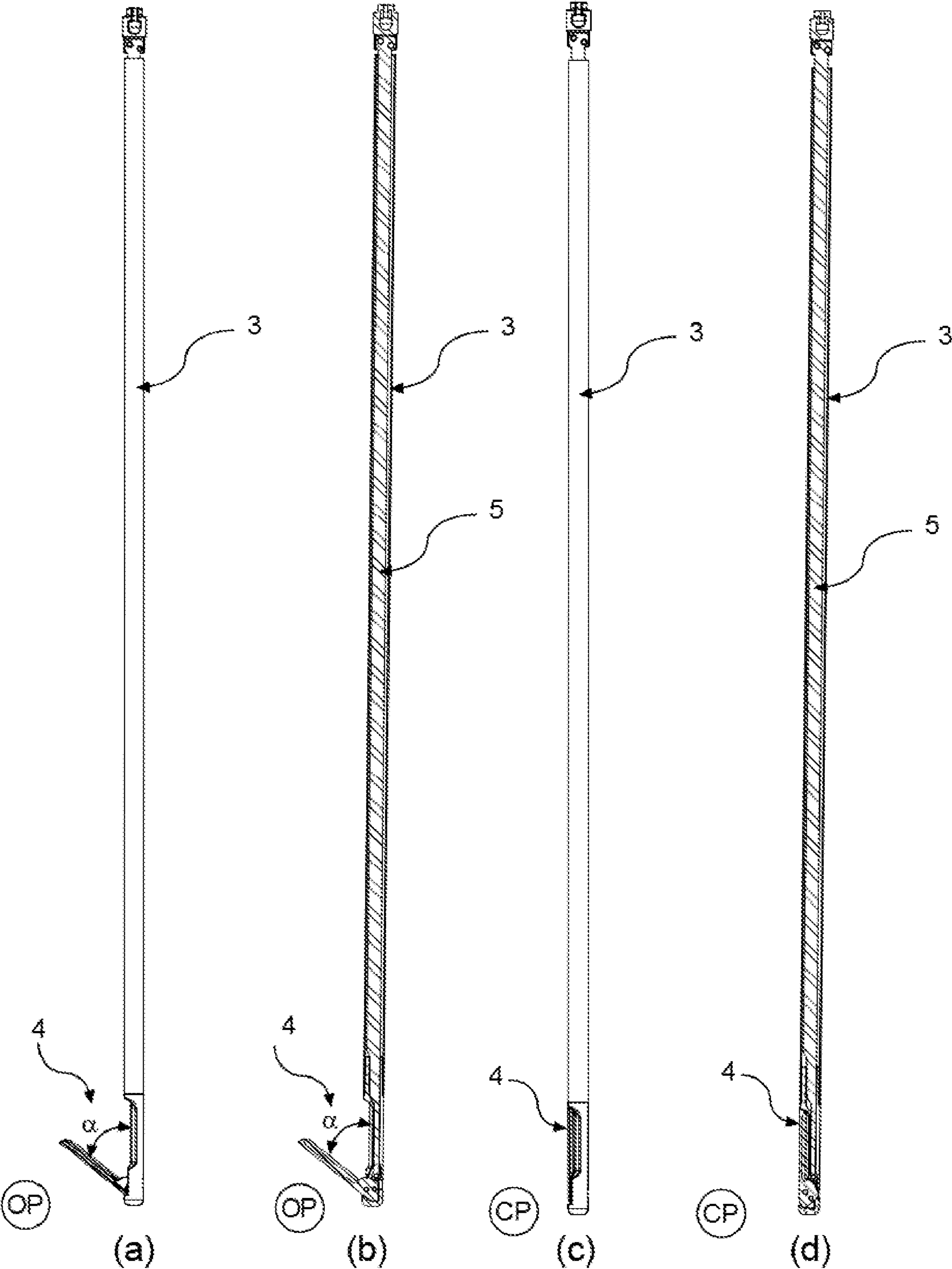


Fig. 10b

Fig. 11



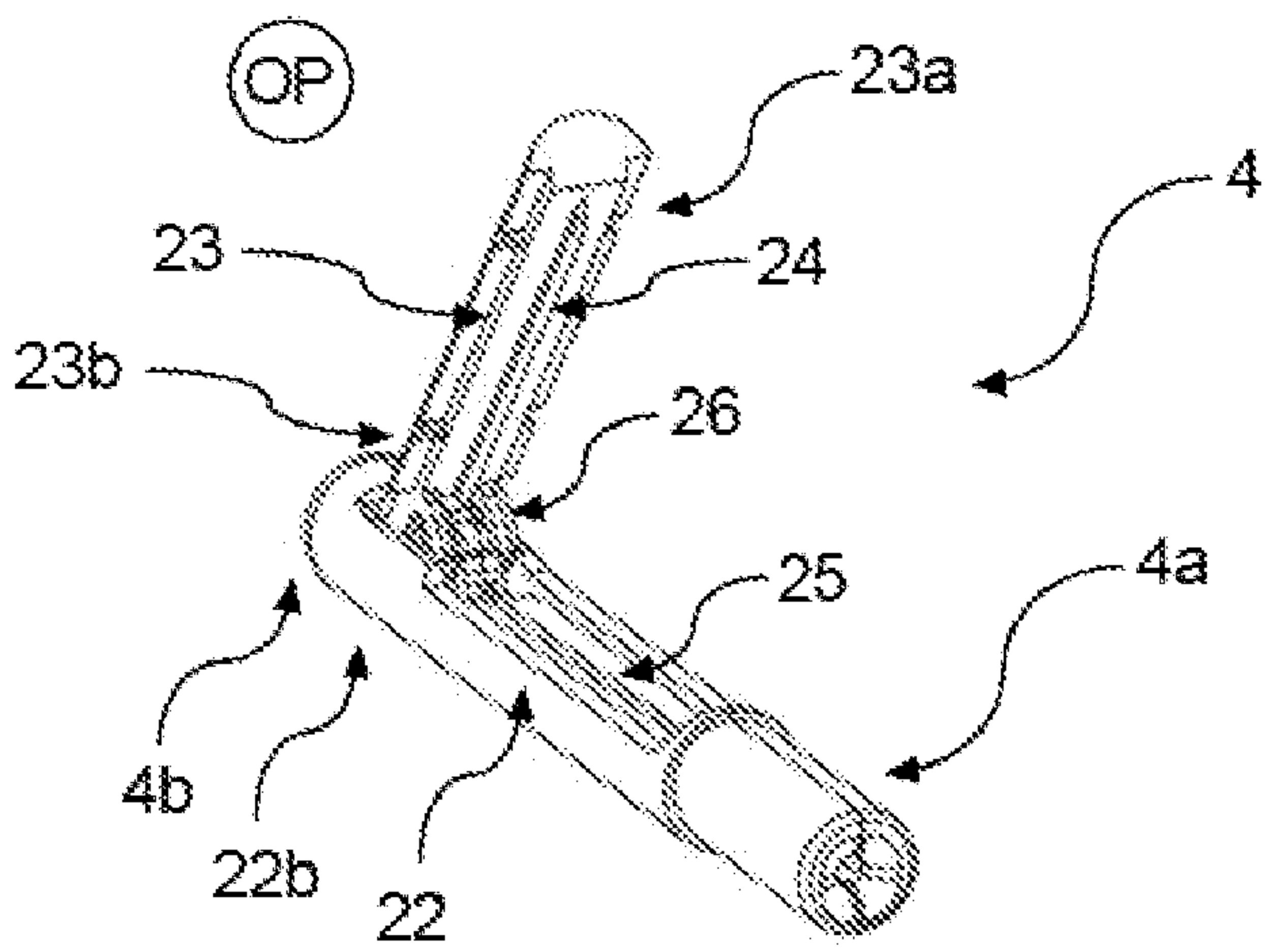


Fig. 12a

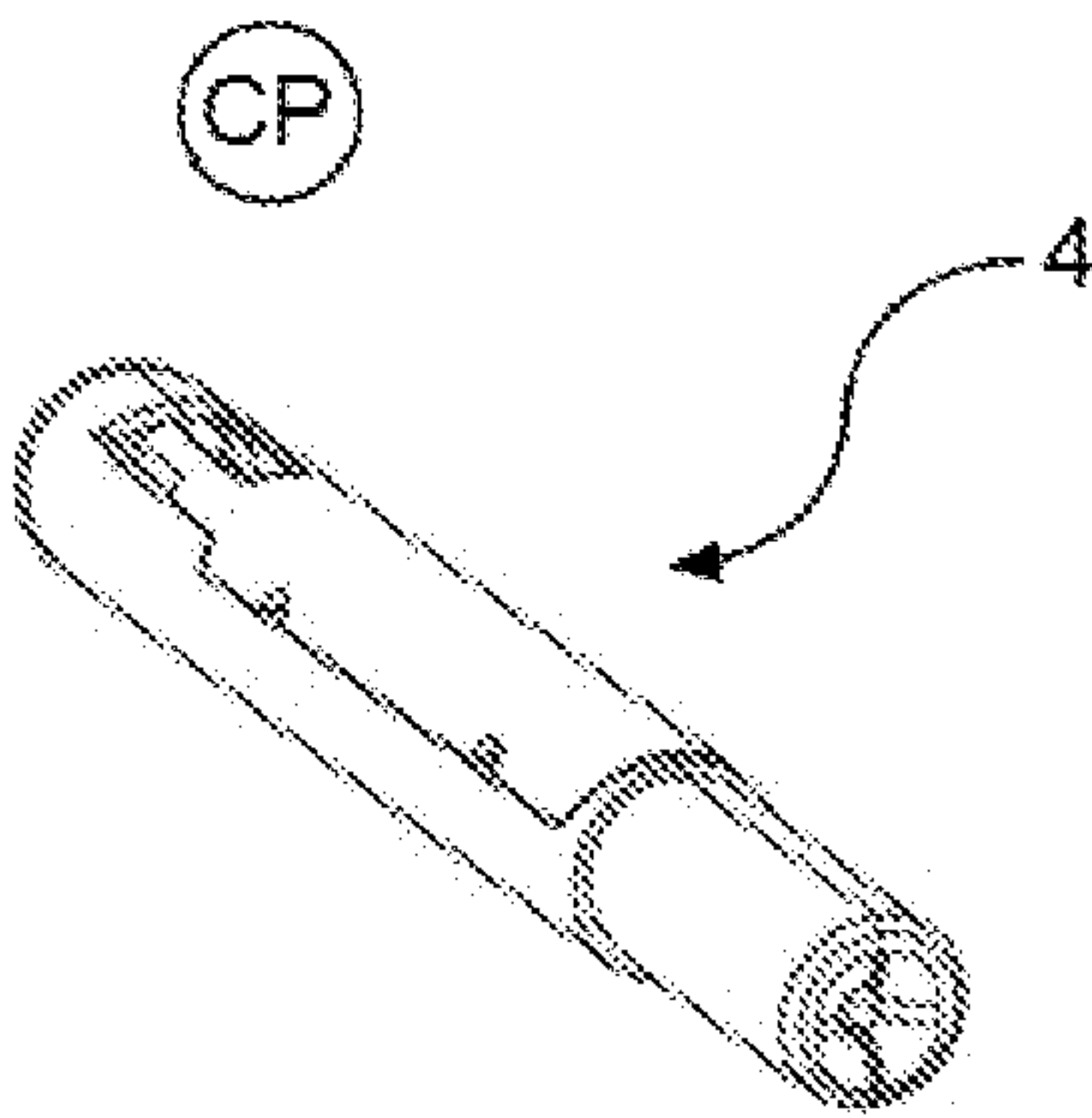


Fig. 12b

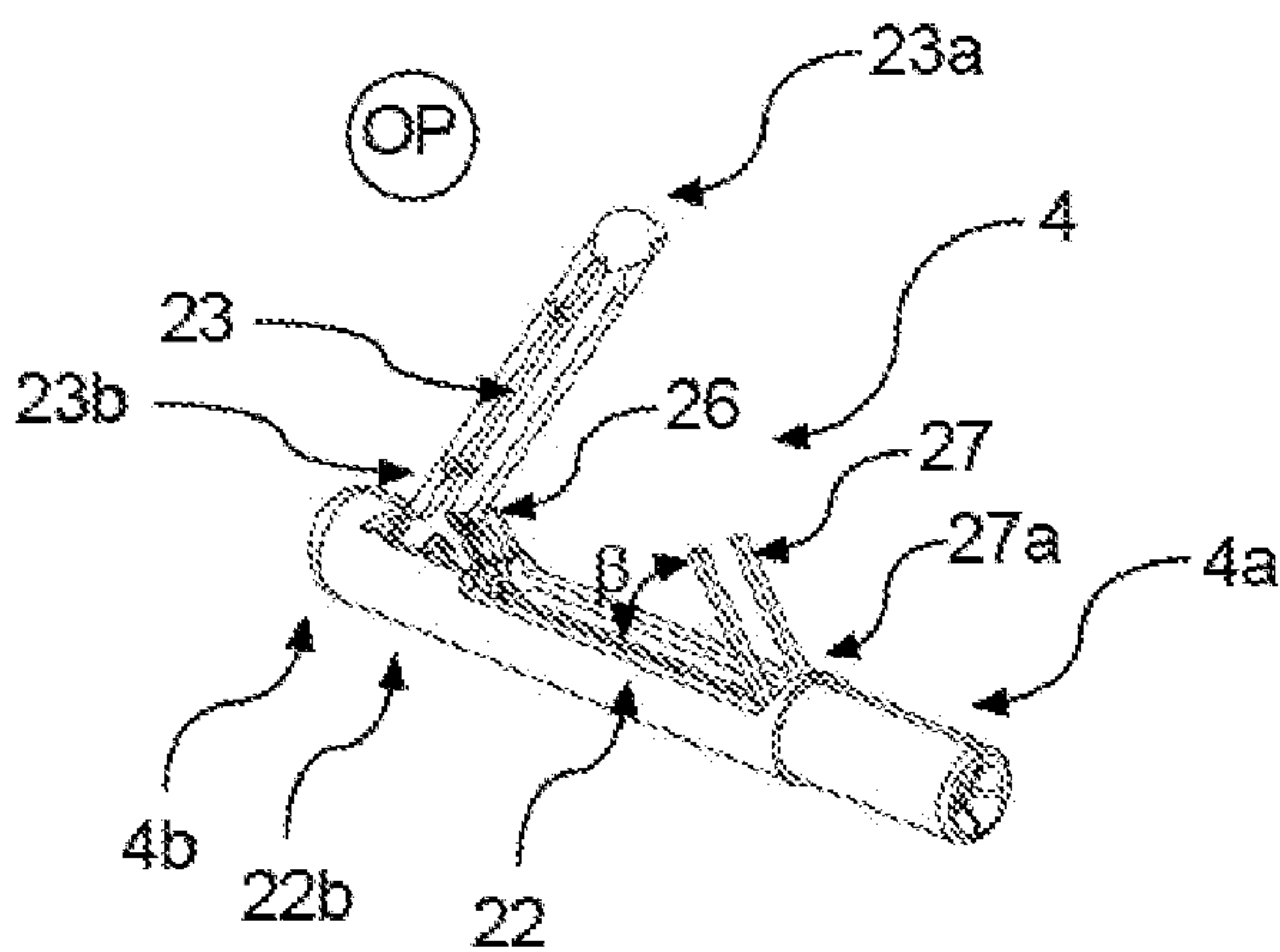


Fig. 13a

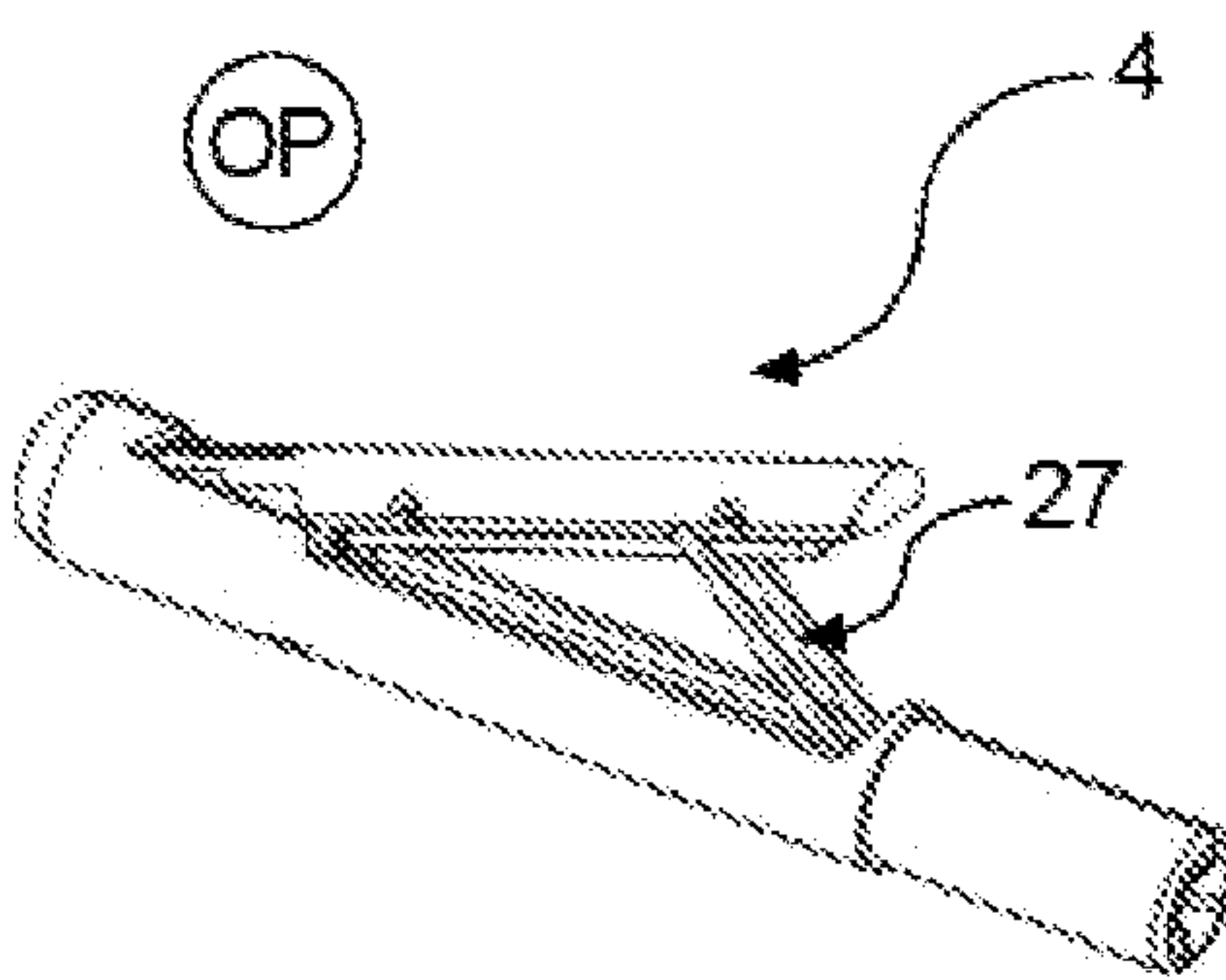


Fig. 13b

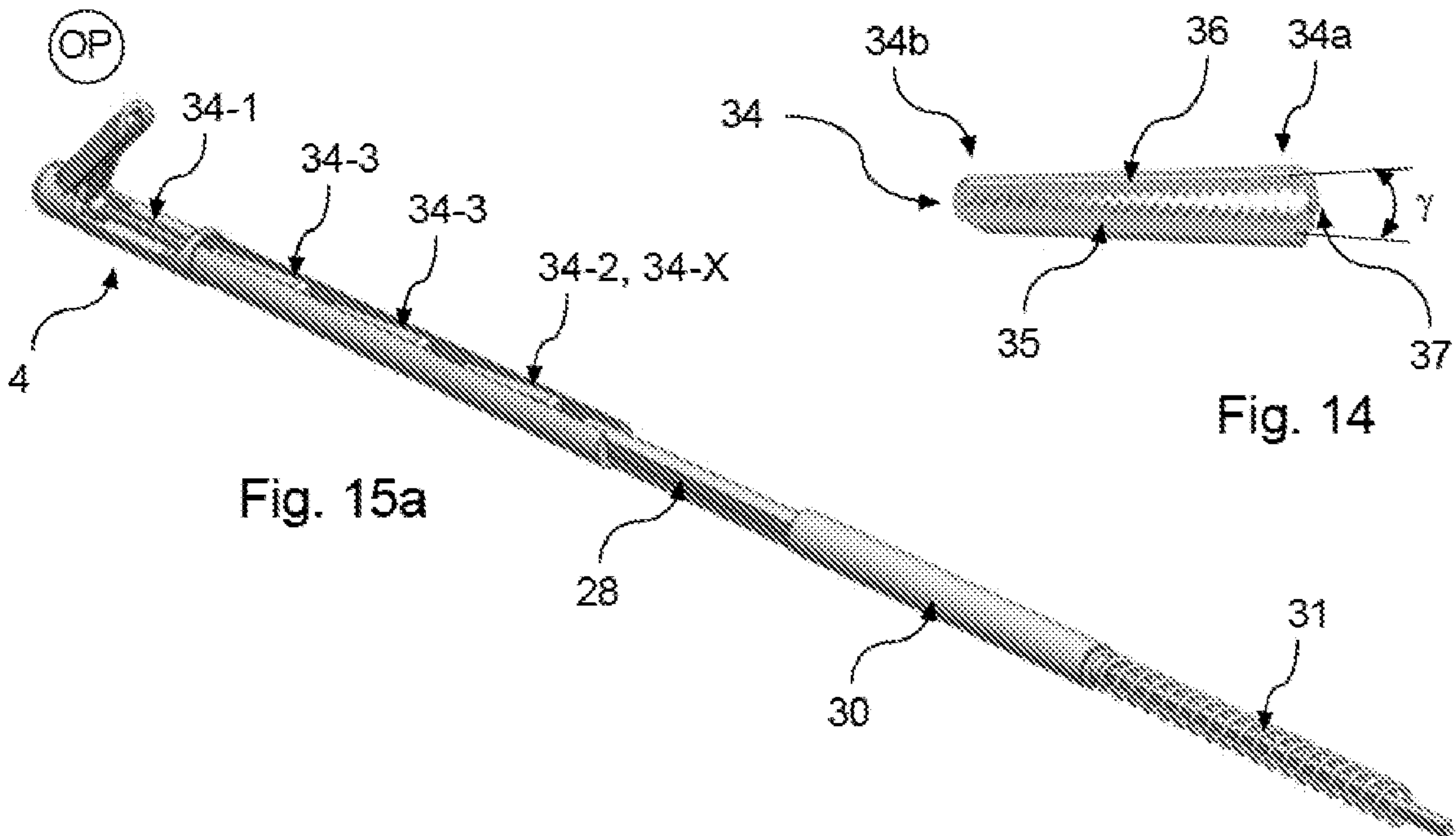


Fig. 15a

Fig. 14

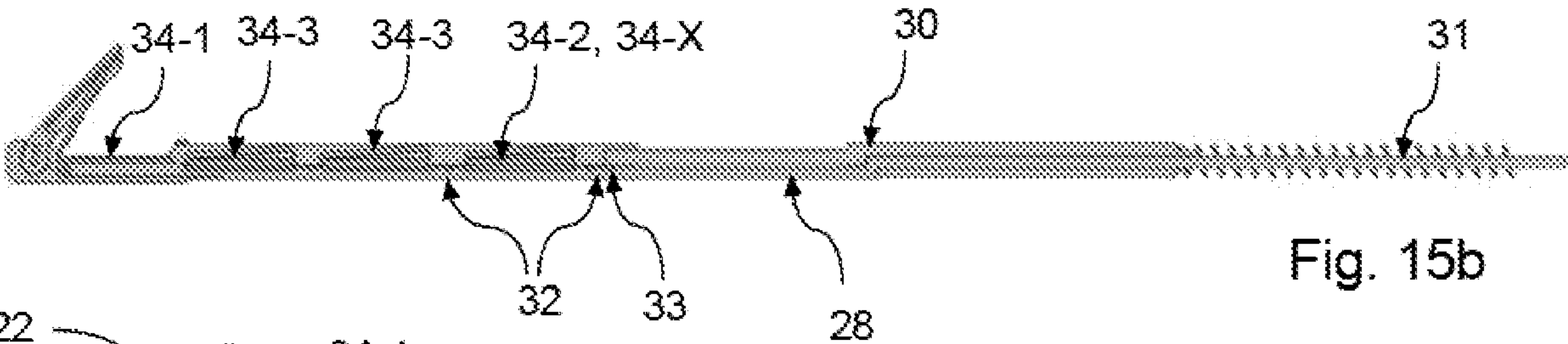


Fig. 15b

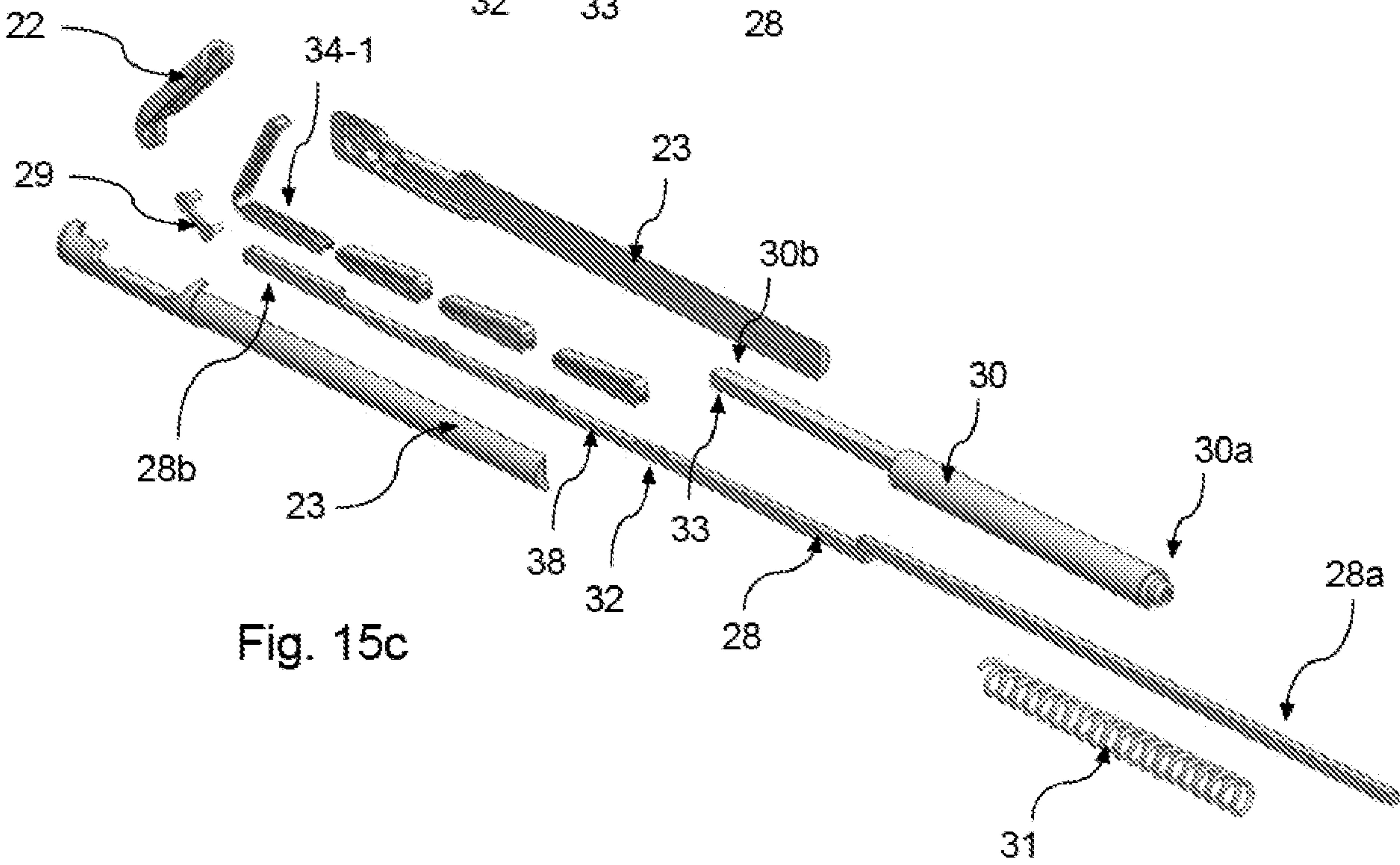
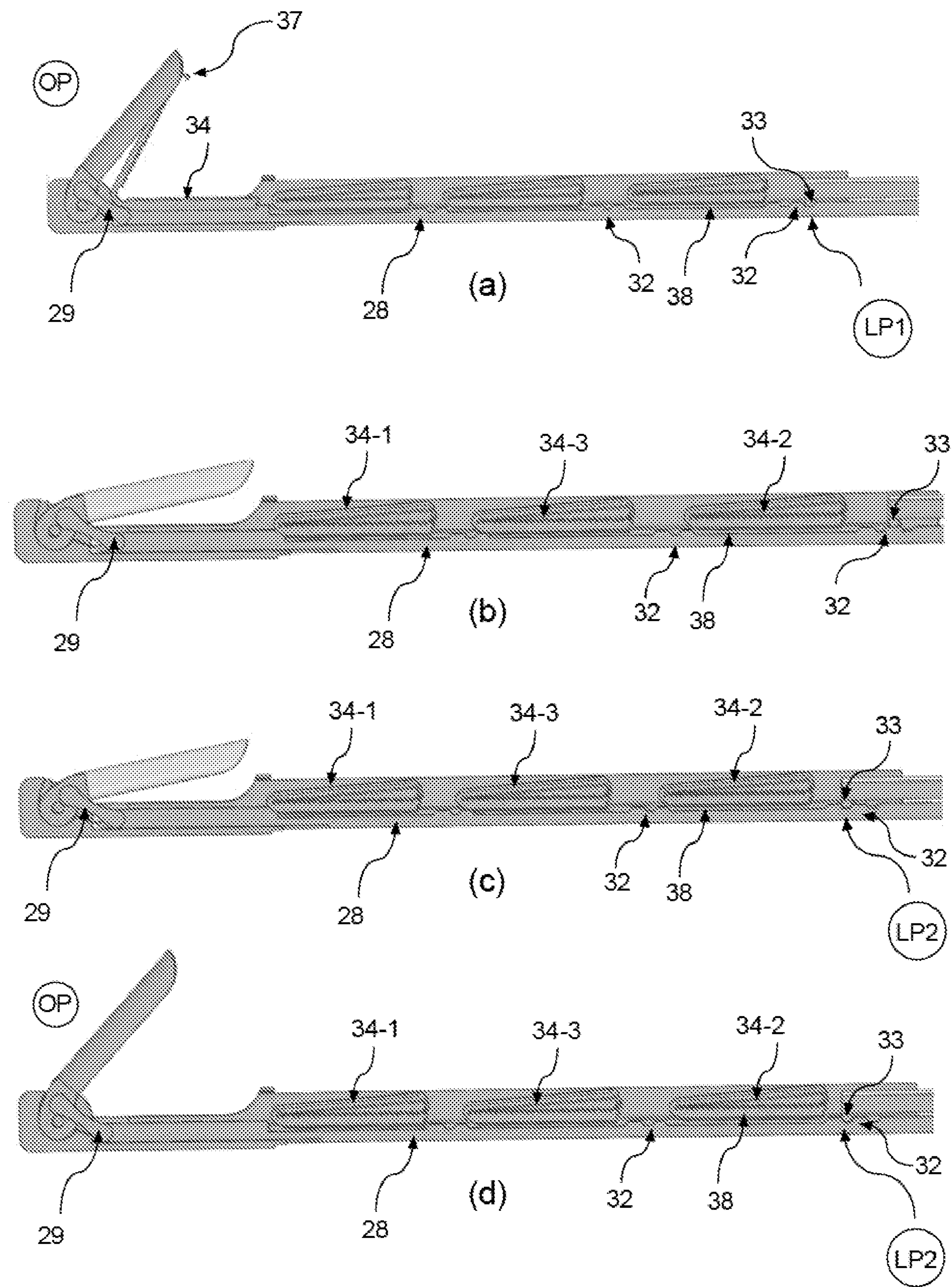
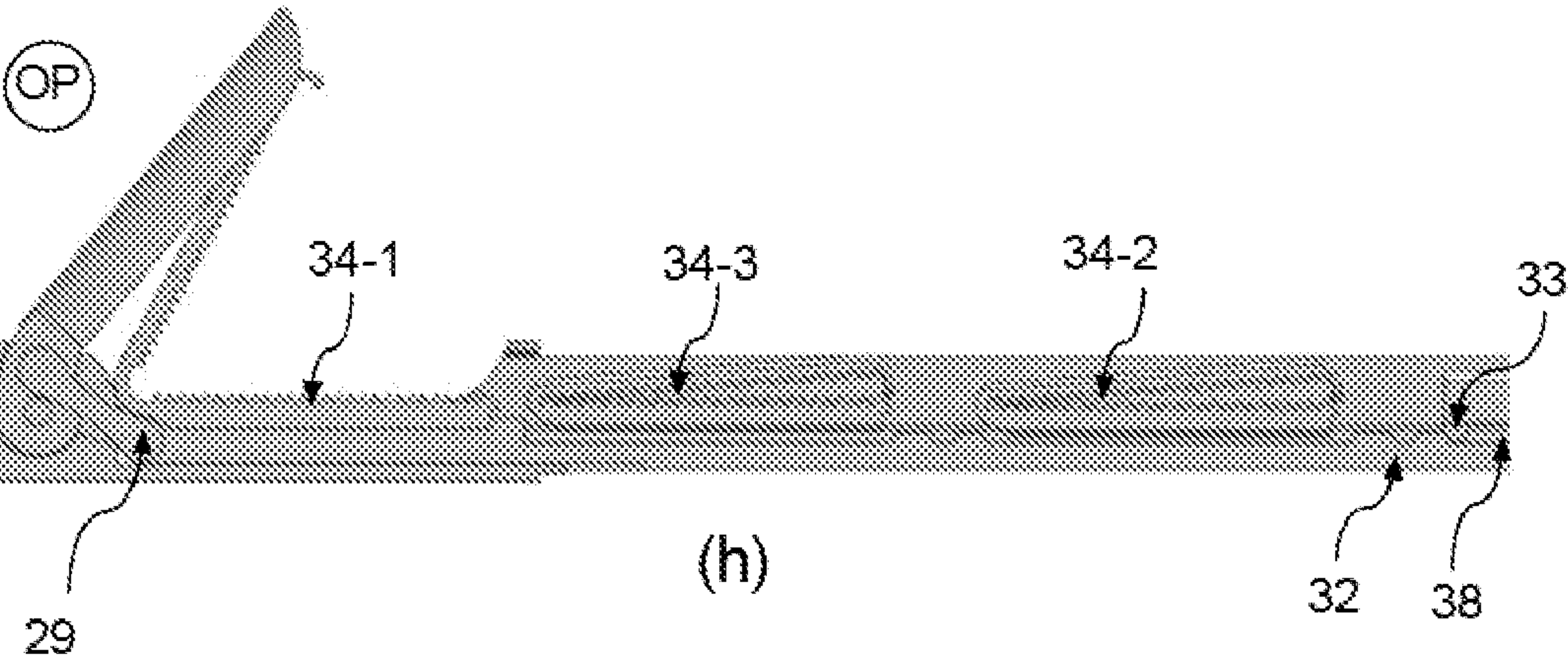
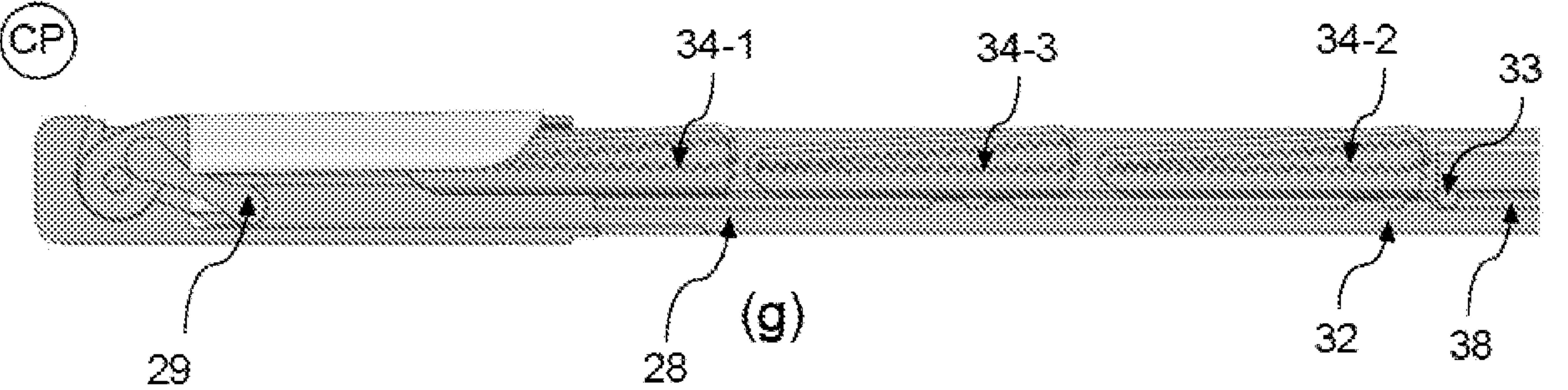
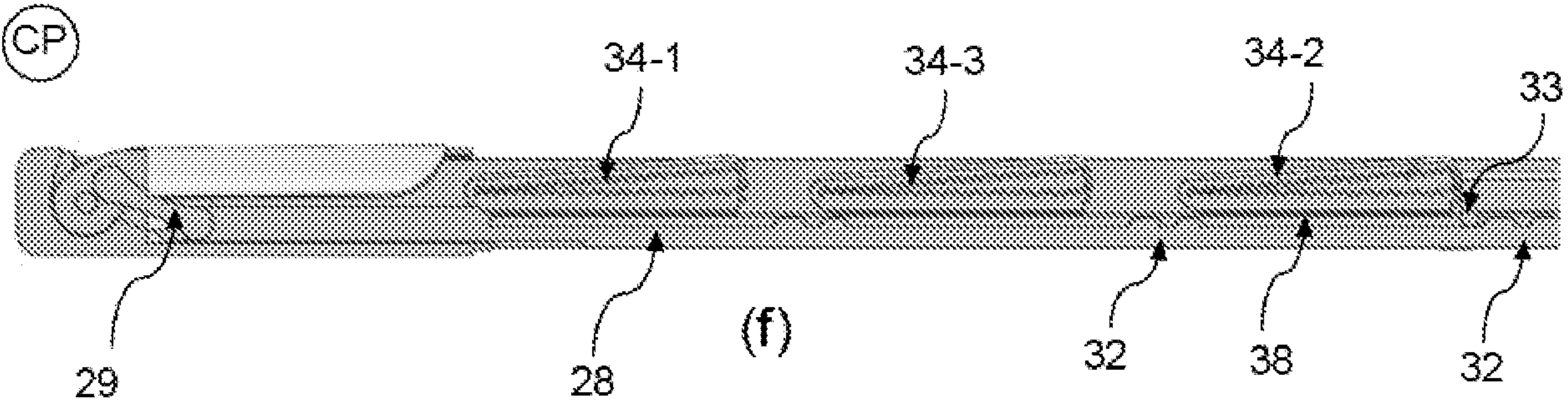
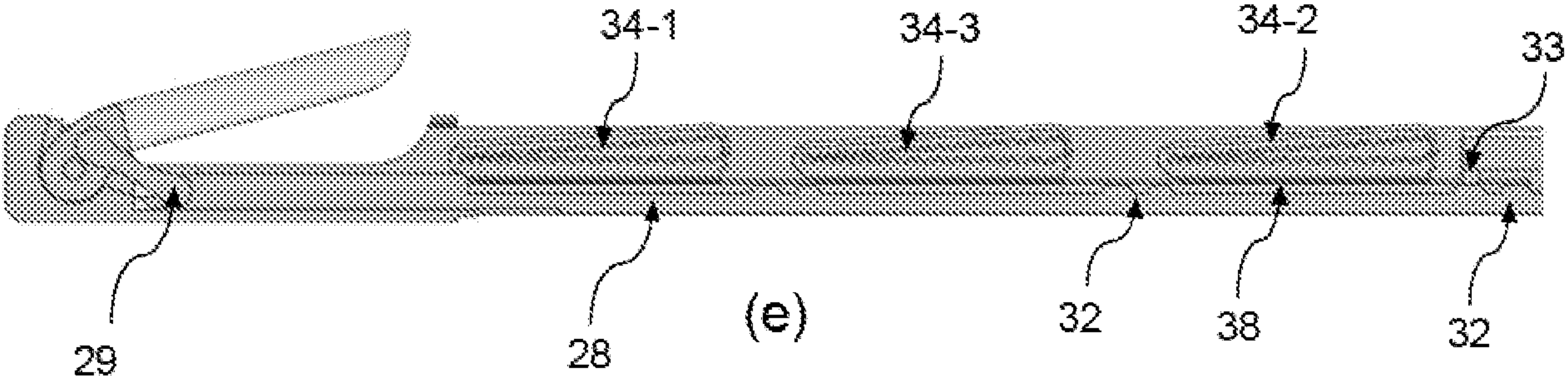


Fig. 15c

Fig. 16



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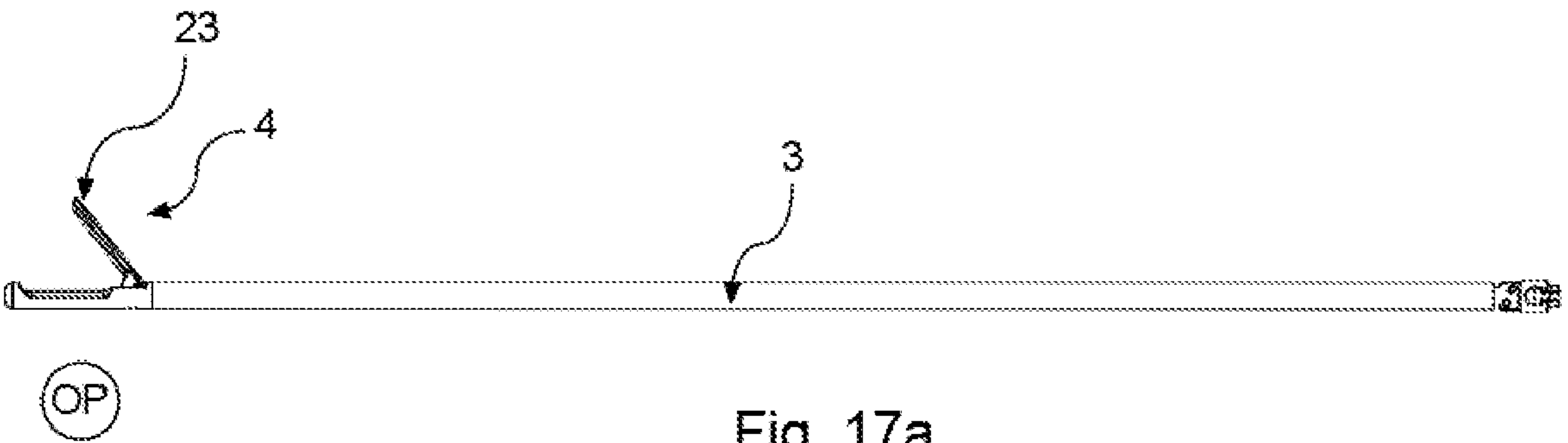


Fig. 17a

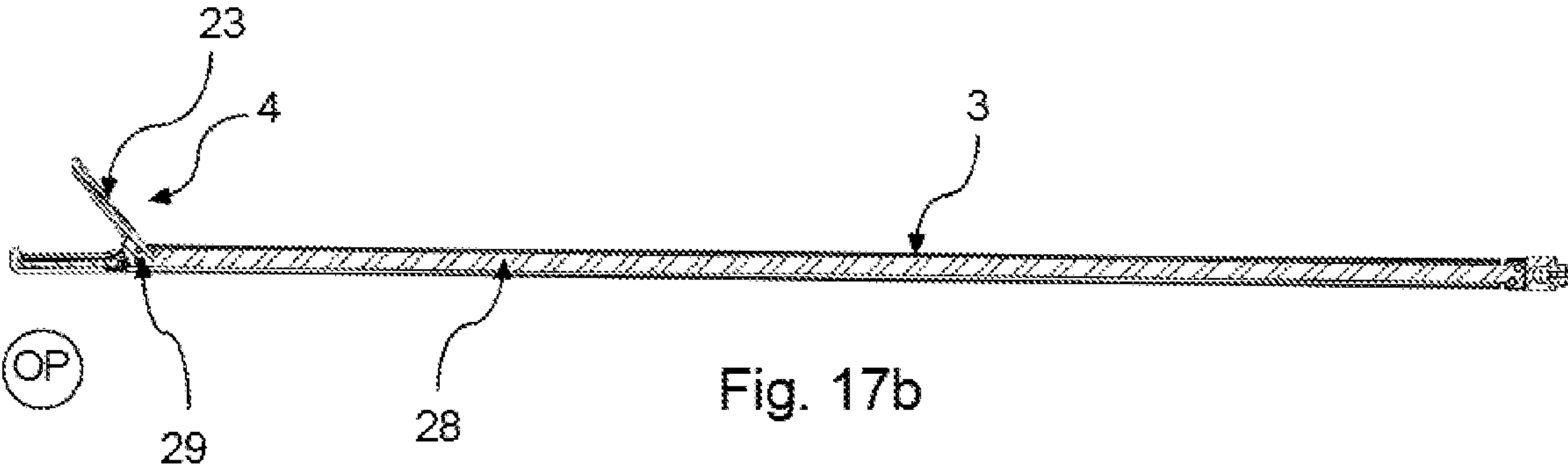


Fig. 17b

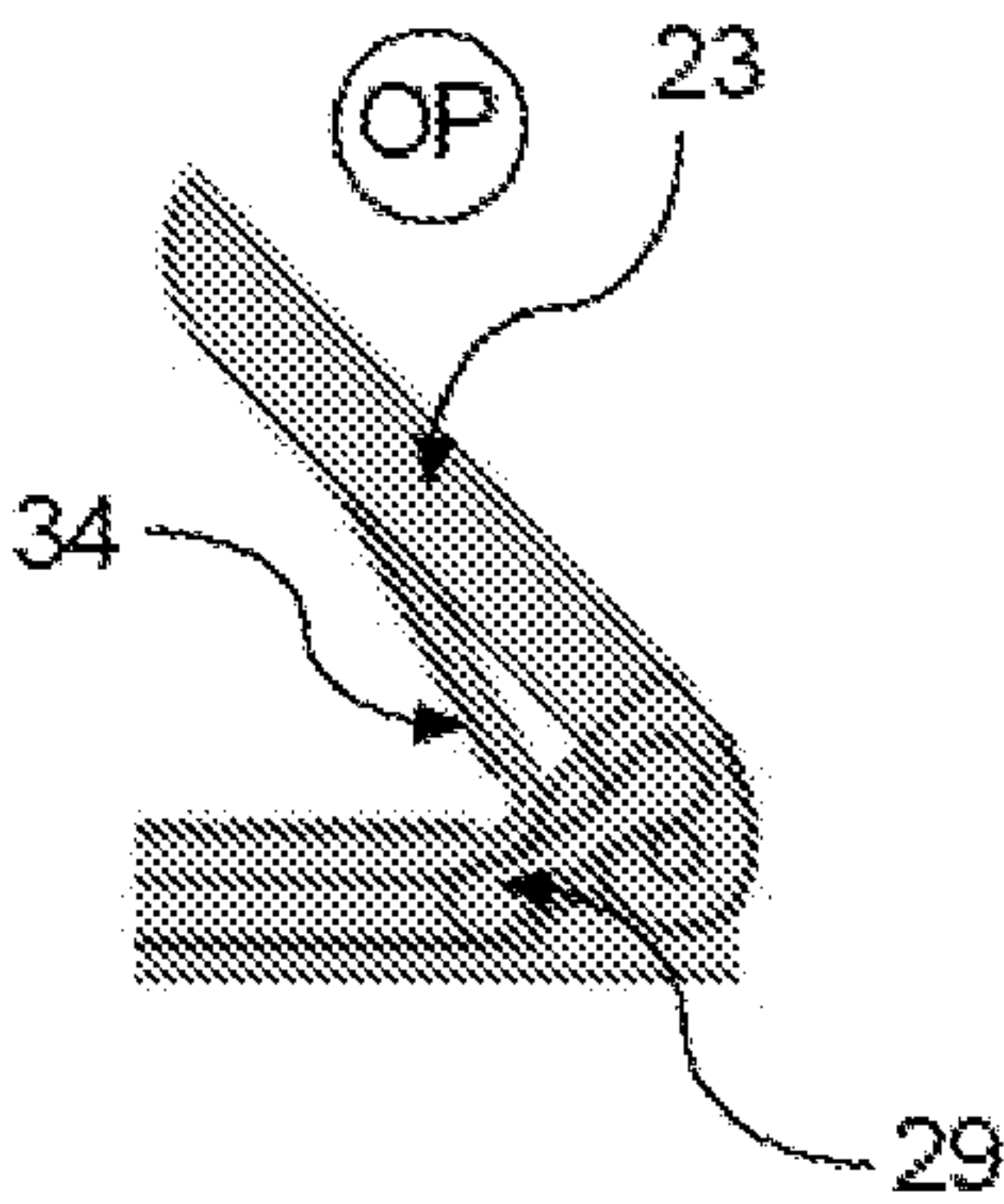


Fig. 17c

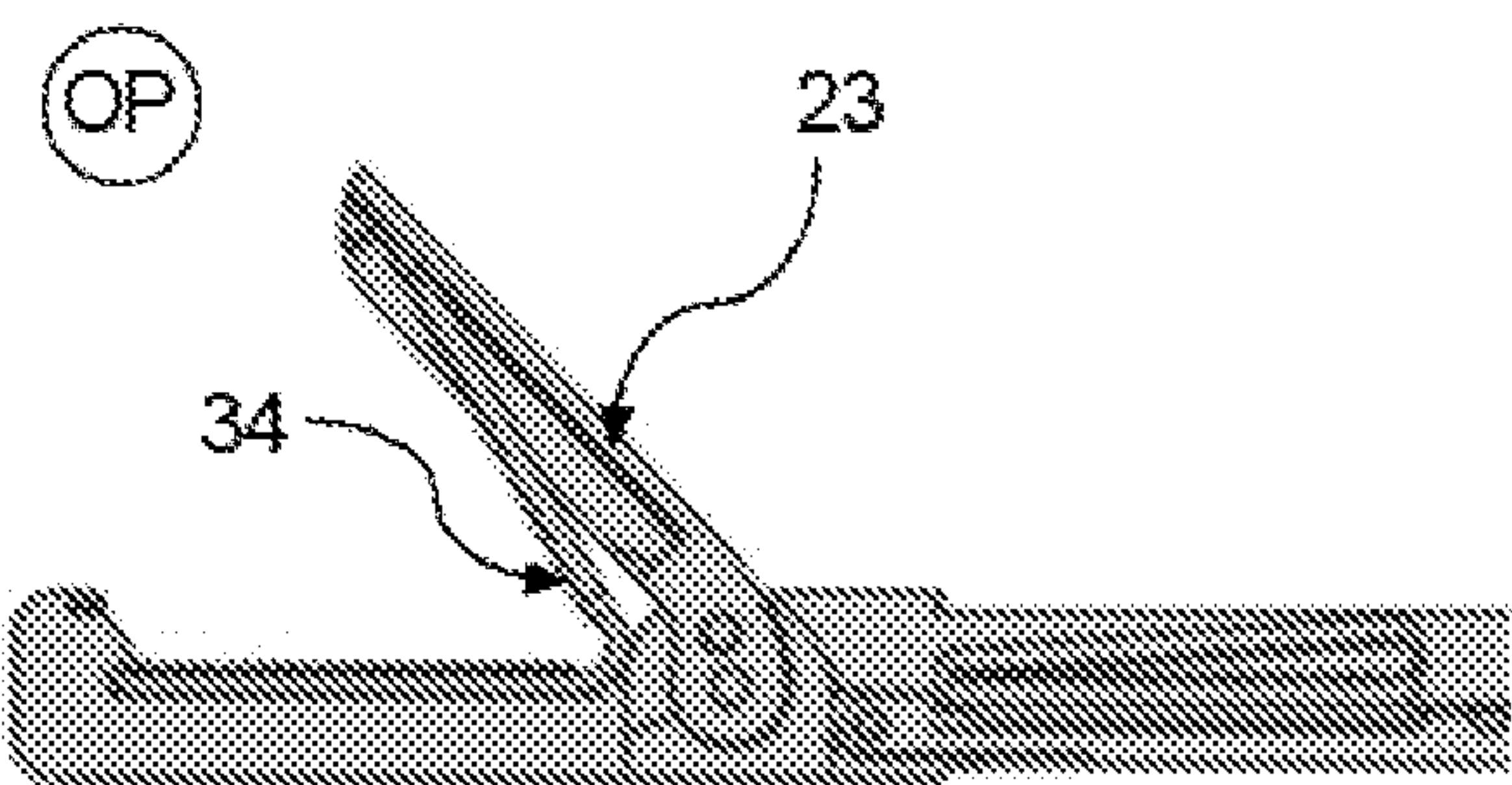


Fig. 17d

DANISH PATENT AND TRADEMARK OFFICE

ADDITIONAL SEARCH REPORT - PATENT		Application No. PA 2018 00717
A. CLASSIFICATION OF SUBJECT MATTER A61B17/94 (2006.01), A61B1/313 (2006.01), A61B17/29 (2006.01) According to International Patent Classification (IPC)		
B. FIELDS SEARCHED		
PCT-minimum documentation searched (classification system followed by classification symbols) IPC & CPC: A61B, F16C		
Documentation searched other than PCT-minimum documentation DK, NO, SE, FI: IPC-classes as above.		
Electronic database consulted during the search (name of database and, where practicable, search terms used) EPODOC, WPI, WPIAP, FULL TEXT: ENGLISH		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant for claim No.
X A	<u>US 2009/0054734</u> A1 (DESANTIS et al.) 2009.02.26 Figs. 1A-B, 2A and 8A-D, paragraphs [0061]-[0062], [0079] and [0081], claims 5 and 7.	1 2-13
☐ Further documents are listed in the continuation of box C.		
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Danish Patent and Trademark Office Helgeshøj Allé 81 2630 Taastrup Denmark Tel.: +45 4350 8000 Fax: +45 4350 8001		Date of completion of the search report 26 February 2020
		Authorized officer Henrik Engholt Telefon nr. +45 43 50 82 43

ADDITIONAL SEARCH REPORT - PATENT		Application No. PA 2018 00717
C (Continued). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant for claim No.