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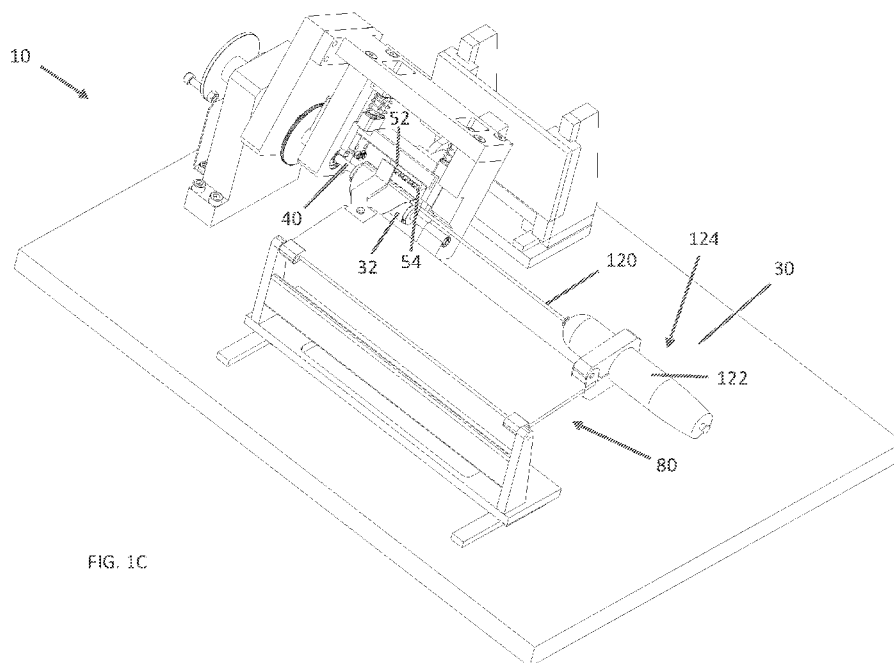


FIG. 1C

(57) Abstract: An apparatus for rolling a bladder includes a support structure, a rolling pin, and a bladder-mounting pin. The apparatus optionally includes a rolling initiator. Rolling a bladder includes inserting the bladder while unrolled into an apparatus for rolling a bladder, inserting the bladder between a rolling pin and a bladder-mounting pin of the rolling machine, and rotating the rolling pin to (a) advance a portion of the bladder between the rolling pin and the bladder-mounting pin, (b) roll the portion of the bladder around the bladder-mounting pin, and (c) drive the bladder-mounting pin to rotate in an opposite direction from that of the rolling pin.



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BLADDER ROLLING MACHINE**CROSS REFERENCE TO RELATED APPLICATION**

This application claims the benefit of U.S.
5 Provisional Application No. 62/510,100, filed May 23,
2017, the content of which Application is incorporated
herein by reference in its entirety.

TECHNICAL FIELD

The present invention relates generally to
10 manufacturing equipment, and specifically to machines and
methods for folding balloons.

BACKGROUND

Inflatable members, such as balloons, are sometimes
rolled, such as for medical applications, such as
15 insertion into an implantation site in a human body,
e.g., a joint, such as the shoulder joint, the prostate,
or the stomach, or for non-medical applications, such as
for toys.

Through repeated strenuous motion, sensitive soft
20 tissues often suffer wear and tear injuries from
repeatedly rubbing against one another and/or hard
tissues, such as bone. Tears of rotator cuff tendons and
articular capsule disintegration are examples of this
type of injury. In addition, these tissues can be
25 adversely affected by inflammation, infection, disease
and/or genetic predispositions which lead to degeneration
of these tissues.

SUMMARY

A bladder rolling machine for rolling a bladder is
30 described. The bladder rolling machine includes:

- a support structure;
- a rolling pin, which is mounted to the support structure such that the rolling pin is rotatable about a first axis, and which is optionally shaped so as to define a plurality of grooves;
- a bladder-mounting pin, which is removably mounted to the support structure such that the bladder-mounting pin is rotatable about a second axis that is non-coaxial with and parallel to the first axis; and
- optionally, a rolling initiator, which is (a) shaped so as to define a shim that defines a plurality of teeth having concavely curved surfaces, and (b) mounted to the support structure such that the shim of the rolling initiator is disposable partially between the rolling pin and the bladder-mounting pin.

For some applications in which the rolling machine includes the rolling initiator, the rolling initiator, the rolling pin, and the bladder-mounting pin are arranged such that when the rolling initiator is disposed partially between the rolling pin and the bladder-mounting pin:

- the teeth are disposed partially within the grooves of the rolling pin, respectively, and
- the concavely curved surfaces face and partially surround the second axis of the bladder-mounting pin.

As a result, the rolling initiator is configured to insert an edge of the bladder between the rolling pin and

the bladder-mounting pin and partially roll the bladder around the bladder-mounting pin.

The rolling pin and the bladder-mounting pin hold the bladder in place during the rolling process. The rolling pin and the bladder-mounting pin are arranged such that rotation of the rolling pin (a) advances, by friction, a portion of the bladder (which is currently unrolled) between the rolling pin and the bladder-mounting pin, (b) rolls the portion of the bladder around the bladder-mounting pin, and (c) drives the bladder-mounting pin to rotate in an opposite direction from that of the rolling pin.

For some applications, the bladder-mounting pin is a first bladder-mounting pin, which is removably mounted to the support structure at a pin mount of the support structure, and the rolling machine includes a second bladder-mounting pin that is mountable to the rolling machine at the pin mount after the first bladder-mounting pin is dismounted from the pin mount, such that the second bladder-mounting pin is rotatable about the second axis.

For some applications, the bladder is rolled, using a two-phase rolling process, about two different axes (defined by the first and the second bladder-mounting pins before they are removed), rather than about a single central axis. Such two-axis rolling facilitates easy unrolling of the two portions (e.g., halves) of the bladder in small and narrow spaces, e.g., spaces in human joints, such as between a ball and socket. For some applications, the first portion and the second portion are rolled in the same direction around their respective central axes, such that the bladder is rolled in an

overly curled S-shape. For other applications, the first portion and the second portion are rolled in opposite directions around their respective central axes, such that the bladder is rolled in a cassette-tape-like configuration.

There is therefore provided apparatus including a rolling machine for rolling a bladder, the rolling machine including:

a support structure;
10 a rolling pin, which is mounted to the support structure such that the rolling pin is rotatable about a first axis, and which is shaped so as to define a plurality of grooves;

a bladder-mounting pin, which is removably mounted
15 to the support structure such that the bladder-mounting pin is rotatable about a second axis that is non-coaxial with and parallel to the first axis; and

a rolling initiator, which is (a) shaped so as to define a shim that defines a plurality of teeth having
20 concavely curved surfaces, and (b) mounted to the support structure such that the shim of the rolling initiator is disposable partially between the rolling pin and the bladder-mounting pin,

wherein the rolling initiator, the rolling pin, and
25 the bladder-mounting pin are arranged such that when the rolling initiator is disposed partially between the rolling pin and the bladder-mounting pin, the teeth are disposed partially within the grooves of the rolling pin, respectively, and the concavely curved surfaces face and
30 partially surround the second axis of the bladder-mounting pin, such that the rolling initiator is configured to insert an edge of the bladder between the

rolling pin and the bladder-mounting pin and partially roll the bladder around the bladder-mounting pin, and

wherein the rolling pin and the bladder-mounting pin are arranged such that rotation of the rolling pin (a) advances, by friction, a portion of the bladder between the rolling pin and the bladder-mounting pin, (b) rolls the portion of the bladder around the bladder-mounting pin, and (c) drives the bladder-mounting pin to rotate in an opposite direction from that of the rolling pin.

For some applications, a radius of curvature of the concavely curved surfaces of the teeth equals between 50% and 150% of a radius of the bladder-mounting pin.

For some applications, the rolling initiator, the rolling pin, and the bladder-mounting pin are arranged such that when the rolling initiator is disposed partially between the rolling pin and the bladder-mounting pin, respective portions of the concavely curved surfaces are flush with or recessed with respect to an outer surface of the rolling pin axially between the grooves.

For some applications, the rolling machine further includes a feeding unit, which is configured to removably hold the bladder during rolling of the bladder around the bladder-mounting pin.

For some applications, a radius of the bladder-mounting pin is no more than 50% of a radius of the rolling pin. Alternatively or additionally, for some applications, a radius of the bladder-mounting pin is between 0.8 and 4 mm.

For some applications, a radius of the rolling pin is between 8 and 25 mm.

For some applications, the rolling machine further includes one or more gears that are arranged to rotate the rolling pin.

For some applications, the apparatus further
5 includes a clamp, which is configured to hold the bladder in a partially rolled state around the bladder-mounting pin.

For some applications:

the bladder-mounting pin is a first bladder-mounting
10 pin, which is removably mounted to the support structure at a pin mount of the support structure, and

the rolling machine includes a second bladder-mounting pin that is mountable to the rolling machine at the pin mount after the first bladder-mounting pin is
15 dismantled from the pin mount, such that the second bladder-mounting pin is rotatable about the second axis.

For some applications, the rolling machine is configured to maintain a predetermined air temperature range in a vicinity of the rolling pin. For some
20 applications, the predetermined air temperature range has a low end of between 40 and 53 degrees C and a high end of between 50 and 65 degrees C. For some applications, the predetermined air temperature range has a low end of between 50 and 51.5 degrees C and a high end of between
25 50.5 and 53 degrees C.

There is further provided a method for rolling a bladder, the method including:

inserting the bladder while unrolled into a rolling machine;

30 using a rolling initiator, which is mounted to a support structure of the rolling machine, to insert an edge of the bladder between a rolling pin and a bladder-

mounting pin of the rolling machine, wherein the rolling pin is mounted to the support structure such that the rolling pin is rotatable about a first axis, and the bladder-mounting pin is removably mounted to the support
5 structure such that the bladder-mounting pin is rotatable about a second axis that is non-coaxial with and parallel to the first axis; and

rotating the rolling pin to (a) advance, by friction, a portion of the bladder between the rolling
10 pin and the bladder-mounting pin, (b) roll the portion of the bladder around the bladder-mounting pin, and (c) drive the bladder-mounting pin to rotate in an opposite direction from that of the rolling pin.

For some applications, the bladder includes a
15 medical device.

For some applications:

the rolling initiator is mounted to the support structure such that the rolling initiator is disposable partially between the rolling pin and the bladder-
20 mounting pin,

the rolling pin is shaped so as to define a plurality of grooves,

the rolling initiator is shaped so as to define a shim that defines a plurality of teeth having concavely
25 curved surfaces,

the rolling initiator, the rolling pin, and the bladder-mounting pin are arranged such that when the rolling initiator is disposed partially between the rolling pin and the bladder-mounting pin, the teeth are
30 disposed partially within the grooves of the rolling pin, respectively, and the concavely curved surfaces face and partially surround the second axis of the bladder-mounting pin, and

rotating the rolling pin includes rotating the rolling pin such that the rolling initiator partially rolls the bladder around the bladder-mounting pin when inserting the edge of the bladder between the rolling pin
5 and the bladder-mounting pin.

For some applications, a radius of curvature of the concavely curved surfaces of the teeth equals between 50% and 150% of a radius of the bladder-mounting pin.

For some applications, the rolling initiator, the
10 rolling pin, and the bladder-mounting pin are arranged such that when the rolling initiator is disposed partially between the rolling pin and the bladder-mounting pin, respective portions of the concavely curved surfaces are flush with or recessed with respect to an
15 outer surface of the rolling pin axially between the grooves.

For some applications, inserting the bladder into the rolling machine includes removably coupling the bladder to a feeding unit of the rolling machine, which
20 is configured to removably hold the bladder during rolling of the bladder around the bladder-mounting pin.

For some applications, a radius of the bladder-mounting pin is no more than 50% of a radius of the rolling pin. Alternatively or additionally, for some
25 applications, a radius of the bladder-mounting pin is between 0.8 and 4 mm.

For some applications, a radius of the rolling pin is between 8 and 25 mm.

For some applications, rotating the rolling pin
30 includes using one or more gears of the rolling machine to rotate the rolling pin.

For some applications, the method further includes, after rotating the rolling pin, using a clamp to hold the bladder in a partially rolled state around the bladder-mounting pin.

- 5 For some applications, the method further includes:
removing the bladder-mounting pin from the rolled portion of the bladder; and
inserting the bladder into a delivery sheath.

- For some applications, rotating the rolling pin
10 includes rotating the rolling pin while maintaining a predetermined air temperature range in a vicinity of the rolling pin. For some applications, the predetermined air temperature range has a low end of between 40 and 53 degrees C and a high end of between 50 and 65 degrees C.
15 For some applications, the predetermined air temperature range has a low end of between 50 and 51.5 degrees C and a high end of between 50.5 and 53 degrees C.

For some applications:

- the bladder-mounting pin is a first bladder-mounting
20 pin, the edge of the bladder is a first edge of the bladder, and the portion of the bladder is a first portion of the bladder,

- using the rolling initiator includes using the rolling initiator to insert the first edge of the bladder
25 between the first rolling pin and the first bladder-mounting pin,

- rotating the rolling pin includes rotating the rolling pin to (a) advance, by friction, the first portion of the bladder between the rolling pin and the
30 first bladder-mounting pin, and (b) roll the first portion of the bladder around the first bladder-mounting pin, and

the method further includes, after rotating the rolling pin to roll the first portion of the bladder around the first bladder-mounting pin:

5 dismounting the first bladder-mounting pin from the rolling machine;

mounting a second bladder-mounting pin to the rolling machine such that the second bladder-mounting pin is rotatable about the second axis;

10 using the rolling initiator to insert a second edge of the bladder between the rolling pin and the second bladder-mounting pin; and

rotating the rolling pin to (a) advance, by friction, a second portion of the bladder between the rolling pin and the second bladder-mounting pin, and (b)
15 roll the second portion of the bladder around the second bladder-mounting pin.

For some applications, the first portion of the bladder includes between 20% and 50% of a total surface area of the unrolled bladder, and the second portion of
20 the bladder includes between 20% and 50% of a total surface area of the unrolled bladder.

For some applications, the bladder is removably coupled to an inflation rod, and the first and the second portions are on opposite sides of a central longitudinal
25 axis of the inflation rod.

For some applications, the method further includes, after the first portion of the bladder is rolled around the first bladder-mounting pin, and before the second edge of the bladder is inserted between the rolling pin
30 and the second bladder-mounting pin, using a clamp to hold the first rolled part rolled in place about the first bladder-mounting pin.

For some applications, the method further includes:
removing the first and the second bladder-mounting
pins from the first and the second rolled portions of the
bladder; and

5 inserting the bladder into a delivery sheath.

For some applications, rotating the rolling pin to
roll the first and the second portions includes rolling
the first and the second portions such that the first and
the second portions are rolled in a same direction around
10 respective central axes of the first and the second
portions.

For some applications, rotating the rolling pin to
roll the first and the second portions includes rolling
the first and the second portions such that the first and
15 the second portions are rolled in opposite directions
around respective central axes of the first and the
second portions.

For some applications:

the edge of the bladder is a first edge of the
20 bladder, and the portion of the bladder is a first
portion of the bladder,

using the rolling initiator includes using the
rolling initiator to insert the first edge of the bladder
between the first rolling pin and the bladder-mounting
25 pin,

rotating the rolling pin includes rotating the
rolling pin to (a) advance, by friction, the first
portion of the bladder between the rolling pin and the
bladder-mounting pin, and (b) roll the first portion of
30 the bladder around the bladder-mounting pin, and

the method further includes, after rotating the rolling pin to roll the first portion of the bladder around the bladder-mounting pin:

removing the bladder-mounting pin from the first
5 rolled portion of the bladder;

using the rolling initiator to insert a second edge of the bladder between the rolling pin and the bladder-mounting pin; and

rotating the rolling pin to (a) advance, by
10 friction, a second portion of the bladder between the rolling pin and the bladder-mounting pin, and (b) roll the second portion of the bladder around the bladder-mounting pin.

For some applications, the first portion of the
15 bladder includes between 20% and 50% of a total surface area of the unrolled bladder, and the second portion of the bladder includes between 20% and 50% of a total surface area of the unrolled bladder.

For some applications, removing the bladder-mounting
20 pin from the first rolled portion of the bladder includes:

dismounting the bladder-mounting pin from the rolling machine;

thereafter, removing the bladder-mounting pin from
25 the first rolled portion of the bladder; and

thereafter, mounting the bladder-mounting pin to the rolling machine such that the bladder-mounting pin is rotatable about the second axis.

For some applications, the bladder is removably
30 coupled to an inflation rod, and the first and the second portions are on opposite sides of a central longitudinal axis of the inflation rod.

For some applications, the method further includes:
removing the bladder-mounting pin from the second
rolled portion of the bladder; and
inserting the bladder into a delivery sheath.

5 For some applications, rotating the rolling pin to
roll the first and the second portions includes rolling
the first and the second portions such that the first and
the second portions are rolled in a same direction around
respective central axes of the first and the second
10 portions.

For some applications, rotating the rolling pin to
roll the first and the second portions includes rolling
the first and the second portions such that the first and
the second portions are rolled in opposite directions
15 around respective central axes of the first and the
second portions.

There is further provided a method for rolling a
bladder, the method including:

inserting the bladder while unrolled into a rolling
20 machine;

inserting a first edge of the bladder between a
rolling pin and a first bladder-mounting pin of the
rolling machine, wherein the rolling pin is mounted to a
support structure of the rolling machine such that the
25 rolling pin is rotatable about a first axis, and the
first bladder-mounting pin is removably mounted to the
support structure such that the first bladder-mounting
pin is rotatable about a second axis that is non-coaxial
with and parallel to the first axis;

30 rotating the rolling pin to (a) advance, by
friction, a first portion of the bladder between the
rolling pin and the first bladder-mounting pin, (b) roll

the first portion of the bladder around the first bladder-mounting pin, and (c) drive the first bladder-mounting pin to rotate in an opposite direction from that of the rolling pin;

5 dismounting the first bladder-mounting pin from the rolling machine;

 mounting a second bladder-mounting pin to the rolling machine such that the second bladder-mounting pin is rotatable about the second axis;

10 inserting a second edge of the bladder between the rolling pin and the second bladder-mounting pin; and

 rotating the rolling pin to (a) advance, by friction, a second portion of the bladder between the rolling pin and the second bladder-mounting pin, and (b)

15 roll the second portion of the bladder around the second bladder-mounting pin.

 For some applications, the first portion includes between 20% and 50% of a total surface area of the unrolled bladder, and the second portion includes between
20 20% and 50% of the total surface area of the unrolled bladder.

 For some applications, the bladder is removably coupled to an inflation rod, and the first and the second portions are on opposite sides of a central longitudinal
25 axis of the inflation rod.

 For some applications, the method further includes, after the first portion of the bladder is rolled around the first bladder-mounting pin, and before the second edge of the bladder is inserted between the rolling pin
30 and the second bladder-mounting pin, using a clamp to hold the first rolled part rolled in place about the first bladder-mounting pin.

For some applications, the method further includes:
removing the first and the second bladder-mounting
pins from the first and the second rolled portions of the
bladder; and

5 inserting the bladder into a delivery sheath.

For some applications, rotating the rolling pin to
roll the first and the second portions includes rolling
the first and the second portions such that the first and
the second portions are rolled in a same direction around
10 respective central axes of the first and the second
portions.

For some applications, rotating the rolling pin to
roll the first and the second portions includes rolling
the first and the second portions such that the first and
15 the second portions are rolled in opposite directions
around respective central axes of the first and the
second portions.

Implementations will be more fully understood from
the following detailed description, taken together with
20 the drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1A-G are schematic illustrations of a bladder rolling machine for rolling a bladder;

Fig. 2 is a schematic illustration of several
5 components of the bladder rolling machine of Fig. 1;

Figs. 3A and 3B are schematic illustrations of two rolling arrangements of the bladder of Fig. 1;

Fig. 4 is a schematic illustration of the bladder of
Figs. 1A-G rolled and inserted into a delivery sheath;
10 and

Fig. 5 includes additional illustrations of the bladder rolling machine of Figs. 1A-G.

DETAILED DESCRIPTION

15 Figs. 1A-G are schematic illustrations of a bladder rolling machine 10 for rolling a bladder 20. Figs. 1A-B show bladder rolling machine 10 without bladder 20, and Figs. 1C-G show rolling machine 10 with bladder 20. Fig. 1G is a cross-sectional view. For some applications,
20 bladder 20 includes an inflatable balloon, which may be elastic or generally non-compliant at the pressures ordinarily used. For some applications, bladder 20 includes a medical device, such as a joint spacer for treatment of a joint of a human subject, such as a
25 subacromial spacer, a glenohumeral spacer, or a spacer for another joint, such as a knee, hip, ankle, or hand (e.g., CMC1) joint. The joint spacer may implement techniques described in the patents and patent application publications incorporated by reference
30 hereinbelow. For some applications, bladder 20 includes

a polymer, which, for example, may be crystalline or semi-crystalline, or a flexible metal.

Reference is still made to Figs. 1A-G, and is additionally made to Fig. 2, which is a schematic illustration of several components of bladder rolling machine 10. Bladder rolling machine 10 includes:

- a support structure 30;
- a rolling pin 32, which is mounted to support structure 30 such that rolling pin 32 is rotatable about a first axis 34 (labeled in Fig. 1B), and which is optionally shaped so as to define a plurality of grooves 36 (labeled in Fig. 2);
- a bladder-mounting pin 40, which is removably mounted to support structure 30 such that bladder-mounting pin 40 is rotatable about a second axis 42 (labeled in Fig. 1B) that is non-coaxial with and parallel to first axis 34; and
- optionally, a rolling initiator 50, which (a) is shaped so as to define a shim 52 that defines a plurality of teeth 54 having concavely curved surfaces 56 (labeled in Fig. 1B), and (b) optionally is mounted to support structure 30 such that shim 52 of rolling initiator 50 is disposable partially between rolling pin 32 and bladder-mounting pin 40 (as shown in Fig. 2); for some applications, a radius of curvature of concavely curved surfaces 56 of teeth 54 equals between 50% and 150% (e.g., between 80% and 120%) of a radius of bladder-mounting pin 40.

For applications in which rolling machine 10 includes rolling initiator 50, rolling initiator 50 is

partially inserted between rolling pin 32 and bladder-mounting pin 40, either manually by manually by the operator of bladder rolling machine 10, or automatically by bladder rolling machine 10. For some applications in
5 which rolling machine 10 includes rolling initiator 50, rolling initiator 50, rolling pin 32, and bladder-mounting pin 40 are arranged such that when rolling initiator 50 is disposed partially between rolling pin 32 and bladder-mounting pin 40:

- 10 • teeth 54 are disposed partially within grooves 36 of rolling pin 32, respectively, and
- concavely curved surfaces 56 face and partially surround second axis 42 of bladder-mounting pin 40.

As a result, rolling initiator 50 is configured to
15 insert an edge 60 of bladder 20 (labeled in Fig. 2) between rolling pin 32 and bladder-mounting pin 40 and partially roll bladder 20 around bladder-mounting pin 40, such as around at least 90 degrees, e.g., at least 180 degrees, such as at least 270 of bladder-mounting pin 40,
20 e.g., at least 360 degrees, typically no more than 375 degrees. After bladder 20 has been partially rolled around bladder-mounting pin 40, rolling initiator 50 is moved away from rolling pin 32 and bladder-mounting pin 40, either manually by the operator of bladder rolling
25 machine 10, or automatically by bladder rolling machine 10. Typically, rolling initiator 50 is used for only one or two seconds during the rolling process.

Alternatively, bladder rolling machine 10 does not necessarily include rolling initiator 50, and rolling pin
30 32 is soft, flexible, and thick, so as to serve as a pillow that has sufficient curvature to enable the first round of rolling.

Rolling pin 32 and bladder-mounting pin 40 hold bladder 20 in place during the rolling process. Rolling pin 32 and bladder-mounting pin 40 are arranged such that rotation of rolling pin 32 (a) advances, by friction, a portion 62 of bladder 20 (which is currently unrolled) between rolling pin 32 and bladder-mounting pin 40, (b) rolls portion 62 of bladder 20 (labeled in Fig. 1G) around bladder-mounting pin 40, and (c) drives bladder-mounting pin 40 to rotate in an opposite direction from that of rolling pin 32. Typically, rolling pin 32 has a high coefficient of friction, and may include, for example, smooth or rough stainless steel, which is optionally coated with a polymer, e.g., in a vulcanization process. Typically, rolling machine 10 further includes one or more gears 90 that are arranged to rotate rolling pin 32. Bladder-mounting pin 40 is configured to maintain a desired rolling diameter.

For some applications, rolling initiator 50, rolling pin 32, and bladder-mounting pin 40 are arranged such that when rolling initiator 50 is disposed partially between rolling pin 32 and bladder-mounting pin 40, respective portions of concavely curved surfaces 56 are flush with or recessed with respect to an outer surface 70 of rolling pin 32 axially between grooves 36 (labeled in Fig. 2).

For some applications, rolling machine 10 further includes a feeding unit 80, which is configured to removably hold bladder 20 during rolling of bladder 20 around bladder-mounting pin 40. Typically, feeding unit 80 maintains tension of bladder 20 during the rolling process to allow tight and stable rolling.

For some applications, a radius of bladder-mounting pin 40 is no more than 50%, such as no more than 40%, of a radius of rolling pin 32, and/or at least 3% (e.g., at least 4%) of the radius of rolling pin 32. For some applications, the radius of bladder-mounting pin 40 is at least 0.8 mm, no more than 4 mm, and/or between 0.8 and 4 mm, such as 1.3 mm. Alternatively or additionally, for some applications, the radius of rolling pin 32 is at least 8 mm, no more than 25 mm, and/or between 8 and 25 mm.

For some applications, bladder-mounting pin 40 is a first bladder-mounting pin 40, which is removably mounted to support structure 30 at a pin mount 110 of support structure 30 (labeled in Fig. 1A), and rolling machine 10 includes a second bladder-mounting pin 40 that is mountable to rolling machine 10 at pin mount 110 after first bladder-mounting pin 40 is dismounted from pin mount 110, such that second bladder-mounting pin 40 is rotatable about second axis 42.

For some applications, rolling machine 10 is configured to maintain a predetermined air temperature range in a vicinity of rolling pin 32. For some applications, the predetermined air temperature range has a low end of between 40 and 53 degrees C and a high end of between 50 and 65 degrees C, such as a low end of between 50 and 51.5 degrees C and a high end of between 50.5 and 53 degrees C, e.g., the range is 51 to 53 degrees C. For some applications, the predetermined temperature range is above the glass transition of a polymer of bladder 20. Typically, the predetermined air temperature range is adjustable by an operator of rolling machine 10.

Typically, rolling machine 10 is suitable for use in a clean room. Typically, rolling machine 10 is capable of rolling bladders 20 of different sizes, and thus, for example, pin mount 110 is typically able to accommodate
5 different rolling pin diameters.

A method of rolling bladder 20 using bladder rolling machine 10 is provided.

Bladder 20 is inserted while unrolled into rolling machine 10. For some applications, bladder 20 is
10 inserted into rolling machine 10 by removably coupling bladder 20 to feeding unit 80.

Rolling initiator 50 is used to insert edge 60 of bladder 20 between rolling pin 32 and bladder-mounting pin 40. Before insertion between the pins, edge 60 may
15 be flat (unrolled), or slightly rolled to aid with this initial rolling of the edge around bladder-mounting pin 40. The arrangement of grooves 36 and teeth 54, described hereinabove with reference to Figs. 1AG and 2 may aid with this insertion.

Rolling pin 32 is rotated to (a) advance, by friction, portion 62 of bladder 20 (which is currently unrolled) between rolling pin 32 and bladder-mounting pin 40, (b) roll portion 62 of bladder 20 around bladder-mounting pin 40, and (c) drive bladder-mounting pin 40 to
20 rotate in an opposite direction from that of rolling pin 32. It is noted that grooves 36 are too small to interfere with the rolling of bladder 20.

For some applications, the rolling is performed in two phases, in each of which a portion (typically about
30 half) of bladder 20 is rolled around respective bladder-mounting pins 40. For these applications, bladder-mounting pin 40 is a first bladder-mounting pin 40, edge

60 of bladder 20 is a first edge 60A of bladder 20 (labeled in Fig. 2), and portion 62 of bladder 20 is a first portion 62A of bladder 20 (labeled in Fig. 2), which typically includes between 20% and 60% (e.g.,
5 between 20% and 50% (such as between 35% and 45%), or between 45% and 55%) of a total surface area of the unrolled bladder.

For some applications, a first clamp is provided and used to hold bladder 20 in a partially rolled state
10 around first bladder-mounting pin 40.

After rolling pin 32 is rotated to roll first portion 62A of bladder 20 around the first bladder-mounting pin, first bladder-mounting pin 40 is dismounted from pin mount 110 of rolling machine 10. A second
15 bladder-mounting pin 40 is mounted to pin mount 110 of rolling machine 10 such that second bladder-mounting pin 40 is rotatable about second axis 42. Rolling initiator 50 is used to insert a second edge 60B of bladder 20 (labeled in Fig. 2) between rolling pin 32 and second
20 bladder-mounting pin 40. Before insertion between the pins, second edge 60B may be flat (unrolled), or slightly rolled to aid with this initial rolling of the second edge around second bladder-mounting pin 40. The arrangement of grooves 36 and teeth 54, described
25 hereinabove with reference to Figs. 1A-G and 2 may aid with this insertion.

Rolling pin 32 is rotated to (a) advance, by friction, second portion 62B of bladder 20 between rolling pin 32 and second bladder-mounting pin 40, and
30 (b) roll second portion 62B of bladder 20 around second bladder-mounting pin 40. Typically, second portion 62B of bladder 20 includes between 20% and 60% (e.g., between

20% and 50% (such as between 35% and 45%), or between 45% and 55%) of the total surface area of the unrolled bladder. Alternatively or additionally, bladder 20 is removably coupled to a delivery rod 120 (labeled in
5 Figs. 1C, 1D, and 1F), and first and second portions 62A and 62B are on opposite sides of a central longitudinal axis of delivery rod 120. For some applications, delivery rod 120 is used to inflate the bladder after implantation of the bladder in the human body. (Figs.
10 1C, 1D, and 1F also show a handle 122 of a delivery system 124 used for implanting bladder 20.)

First and second bladder-mounting pins 40 are removed from the first and the second rolled portions of bladder 20, and bladder 20 is inserted into a delivery
15 sheath 130, such as shown in Fig. 4, described hereinbelow. The pins may be removed before or after insertion of the bladder into the delivery sheath.

Alternatively, for some applications, a single bladder-mounting pin 40 is used for rolling both first
20 and second portions 62A and 62B of bladder 20. After rolling first portion 62A, bladder-mounting pin 40 is removed from first rolled portion 62A of bladder 20 (either while bladder-mounting pin 40 is mounted on rolling machine 10, or after temporarily dismounting
25 bladder-mounting pin 40 from rolling machine 10), and second portion 62B is rolled around bladder-mounting pin 40.

Reference is made to Figs. 3A and 3B, which are schematic illustrations of two rolling arrangements of
30 bladder 20. As a result of the two-phase rolling process described hereinabove, bladder 20 is rolled about two different axes (defined by first and second bladder-

mounting pins 40 before they are removed), rather than about a single central axis. Such two-axis rolling facilitates easy unrolling of the two portions (e.g., halves) of bladder 20 in small and narrow spaces, e.g.,
5 spaces in human joints, such as between a ball and socket.

For some applications, such as shown in Fig. 3A, first portion 62A and second portion 62B are rolled in the same direction around their respective central axes
10 140A and 140B, such that bladder 20 is rolled in an overly curled S-shape. For some applications, in order to produce this rolling arrangement, rolling pin 32 is rotated to roll first portion 62A in a rotational direction around first bladder-mounting pin 40, the
15 partially-rolled bladder 20 is turned over (such that the remaining unrolled surface that faced downward now faces upward), second portion 62B is inserted between rolling pin 32 and second bladder-mounting pin 40, and rolling pin 32 is rotated to roll second portion 62B in the same
20 rotational direction around second bladder-mounting pin 40. The direction may be either clockwise or counterclockwise. For some applications, to turn over partially-rolled bladder 20, the bladder is rotated about an axis of delivery rod 120.

25 For some applications, such as shown in Fig. 3B, first portion 62A and second portion 62B are rolled in opposite directions around their respective central axes 140A and 140B, such that bladder 20 is rolled in a cassette-tape-like configuration.

30 For some applications, in order to produce the rolling arrangement shown in Fig. 3B, rolling pin 32 is rotated to roll first portion 62A in a rotational

direction around first bladder-mounting pin 40, second portion 62B is inserted between rolling pin 32 and second bladder-mounting pin 40 (without turning over the partially-rolled bladder 20), and rolling pin 32 is
5 rotated to roll second portion 62B in the same rotational direction around second bladder-mounting pin 40. The direction may be either clockwise or counterclockwise. For some of these applications, in order to insert second portion 62B between the pins, delivery rod 120 is
10 reoriented to extend 180 degrees in the opposite direction from its initial direction during rolling of first portion 62A (e.g., in Fig. 1C, delivery rod 120 extends down and to the right of bladder 20 during rolling of first portion 62A, and up and to the left of
15 bladder during rolling of second portion 62B); feeding unit 80 may optionally be reoriented together with delivery rod 120 (and handle 122).

For other applications, in order to produce the rolling arrangement shown in Fig. 3B:

- 20 • rolling pin 32 is rotated to roll first portion 62A in a first rotational direction around first bladder-mounting pin 40 (either clockwise or counterclockwise),
- 25 • second bladder-mounting pin 40 is mounted to support structure 30 on an opposite vertical side of rolling pin 32 from the vertical side during rolling of first portion 62A (e.g., below rolling pin 32 if mounted above rolling pin 32 during rolling of first portion 62A, such as shown in the figures),
- 30 • the partially-rolled bladder 20 is turned over (such that the remaining unrolled surface that faced downward now faces upward) (for some applications,

to turn over partially-rolled bladder 20, the bladder is rotated about an axis of delivery rod 120), and

- second portion 62B is inserted between rolling pin 32 and second bladder-mounting pin 40, and rolling pin 32 is rotated to roll second portion 62B around second bladder-mounting pin 40 in a second rotational direction, opposite the first rotational direction.

For applications in which rolling initiator 50 is used, the rolling initiator is typically turned over before being used to initiate the rolling of second portion 62B.

Reference is made to Fig. 4, which is a schematic illustration of bladder 20 rolled and inserted into delivery sheath 130. For example, delivery sheath 130 may have a circular, elliptical, or oval cross section.

Reference is made to Fig. 5, which includes additional illustrations of bladder rolling machine 10.

Although bladder rolling machine 10 has been generally described herein as useful for folding joint spacer bladders, bladder rolling machine 10 may also be used for rolling other medical bladders and balloons, such for implantation in other sites in the human body, e.g., the prostate, the stomach, or for separation between soft tissues. Bladder rolling machine 10 may also be used for non-medical bladders and balloons, such as in toys.

In some implementations, techniques and apparatus described in one or more of the following applications

are combined with techniques and apparatus described herein:

- US 8,221,442 to Domb et al.
- US 8,480,647 to Shohat et al.
- 5 • US 8,753,390 to Shohat
- US 8,894,713 to Shohat et al.
- US 2008/0033471 to Paz et al.
- US 2010/0137999 to Shohat
- US 2012/0330340 to Shohat
- 10 • PCT Publication WO 2008/111073 to Shohat
- PCT Publication WO 2010/097724 to Shohat
- PCT Publication WO 2012/017438 to Shohat et al.
- PCT Publication WO 2013/057566 to Shohat

It will be appreciated by persons skilled in the art
15 that the present implementations are not limited to what
has been particularly shown and described hereinabove.
Rather, implementations include both combinations and
subcombinations of the various features described
hereinabove, as well as variations and modifications
20 thereof that are not in the prior art, which would occur
to persons skilled in the art upon reading the foregoing
description.

CLAIMS

1. An apparatus comprising a rolling machine for rolling a bladder, the rolling machine comprising:
- a support structure;
 - 5 a rolling pin, which is mounted to the support structure such that the rolling pin is rotatable about a first axis, and which is shaped so as to define a plurality of grooves;
 - a bladder-mounting pin, which is removably mounted
 - 10 to the support structure such that the bladder-mounting pin is rotatable about a second axis that is non-coaxial with and parallel to the first axis; and
 - a rolling initiator, which is (a) shaped so as to define a shim that defines a plurality of teeth having
 - 15 concavely curved surfaces, and (b) mounted to the support structure such that the shim of the rolling initiator is disposable partially between the rolling pin and the bladder-mounting pin,
 - wherein the rolling initiator, the rolling pin, and
 - 20 the bladder-mounting pin are arranged such that when the rolling initiator is disposed partially between the rolling pin and the bladder-mounting pin, the teeth are disposed partially within the grooves of the rolling pin, respectively, and the concavely curved surfaces face and
 - 25 partially surround the second axis of the bladder-mounting pin, such that the rolling initiator is configured to insert an edge of the bladder between the rolling pin and the bladder-mounting pin and partially roll the bladder around the bladder-mounting pin, and
 - 30 wherein the rolling pin and the bladder-mounting pin are arranged such that rotation of the rolling pin (a) advances, by friction, a portion of the bladder between the rolling pin and the bladder-mounting pin, (b) rolls

the portion of the bladder around the bladder-mounting pin, and (c) drives the bladder-mounting pin to rotate in an opposite direction from that of the rolling pin.

2. The apparatus according to claim 1, wherein a radius
5 of curvature of the concavely curved surfaces of the teeth equals between 50% and 150% of a radius of the bladder-mounting pin.

3. The apparatus according to claim 1, wherein the
10 rolling initiator, the rolling pin, and the bladder-mounting pin are arranged such that when the rolling initiator is disposed partially between the rolling pin and the bladder-mounting pin, respective portions of the concavely curved surfaces are flush with or recessed with respect to an outer surface of the rolling pin axially
15 between the grooves.

4. The apparatus according to claim 1, wherein the rolling machine further comprises a feeding unit, which is configured to removably hold the bladder during rolling of the bladder around the bladder-mounting pin.

20 5. The apparatus according to claim 1, wherein a radius of the bladder-mounting pin is no more than 50% of a radius of the rolling pin.

6. The apparatus according to claim 1, wherein a radius of the bladder-mounting pin is between 0.8 and 4 mm.

25 7. The apparatus according to claim 1, wherein a radius of the rolling pin is between 8 and 25 mm.

8. The apparatus according to claim 1, wherein the rolling machine further comprises one or more gears that are arranged to rotate the rolling pin.

30 9. The apparatus according to claim 1, further comprising a clamp, which is configured to hold the

bladder in a partially rolled state around the bladder-mounting pin.

10. The apparatus according to claim 1,

5 wherein the bladder-mounting pin is a first bladder-mounting pin, which is removably mounted to the support structure at a pin mount of the support structure, and

10 wherein the rolling machine comprises a second bladder-mounting pin that is mountable to the rolling machine at the pin mount after the first bladder-mounting pin is dismounted from the pin mount, such that the second bladder-mounting pin is rotatable about the second axis.

11. The apparatus according to claim 1, wherein the rolling machine is configured to maintain a predetermined air temperature range in a vicinity of the rolling pin.
15

12. The apparatus according to claim 11, wherein the predetermined air temperature range has a low end of between 40 and 53 degrees C and a high end of between 50 and 65 degrees C.

20 13. The apparatus according to claim 12, wherein the predetermined air temperature range has a low end of between 50 and 51.5 degrees C and a high end of between 50.5 and 53 degrees C.

14. A method for rolling a bladder, the method comprising:
25

inserting the bladder while unrolled into a rolling machine;

30 using a rolling initiator, which is mounted to a support structure of the rolling machine, to insert an edge of the bladder between a rolling pin and a bladder-mounting pin of the rolling machine, wherein the rolling

pin is mounted to the support structure such that the rolling pin is rotatable about a first axis, and the bladder-mounting pin is removably mounted to the support structure such that the bladder-mounting pin is rotatable
5 about a second axis that is non-coaxial with and parallel to the first axis; and

rotating the rolling pin to (a) advance, by friction, a portion of the bladder between the rolling pin and the bladder-mounting pin, (b) roll the portion of
10 the bladder around the bladder-mounting pin, and (c) drive the bladder-mounting pin to rotate in an opposite direction from that of the rolling pin.

15. The method according to claim 14, wherein the bladder comprises a medical device.

15 16. The method according to claim 14,
wherein the rolling initiator is mounted to the support structure such that the rolling initiator is disposable partially between the rolling pin and the bladder-mounting pin,

20 wherein the rolling pin is shaped so as to define a plurality of grooves,

wherein the rolling initiator is shaped so as to define a shim that defines a plurality of teeth having concavely curved surfaces,

25 wherein the rolling initiator, the rolling pin, and the bladder-mounting pin are arranged such that when the rolling initiator is disposed partially between the rolling pin and the bladder-mounting pin, the teeth are disposed partially within the grooves of the rolling pin,
30 respectively, and the concavely curved surfaces face and partially surround the second axis of the bladder-mounting pin, and

wherein rotating the rolling pin comprises rotating the rolling pin such that the rolling initiator partially rolls the bladder around the bladder-mounting pin when inserting the edge of the bladder between the rolling pin and the bladder-mounting pin.

17. The method according to claim 16, wherein a radius of curvature of the concavely curved surfaces of the teeth equals between 50% and 150% of a radius of the bladder-mounting pin.

18. The method according to claim 16, wherein the rolling initiator, the rolling pin, and the bladder-mounting pin are arranged such that when the rolling initiator is disposed partially between the rolling pin and the bladder-mounting pin, respective portions of the concavely curved surfaces are flush with or recessed with respect to an outer surface of the rolling pin axially between the grooves.

19. The method according to claim 14, wherein inserting the bladder into the rolling machine comprises removably coupling the bladder to a feeding unit of the rolling machine, which is configured to removably hold the bladder during rolling of the bladder around the bladder-mounting pin.

20. The method according to claim 14, wherein a radius of the bladder-mounting pin is no more than 50% of a radius of the rolling pin.

21. The method according to claim 14, wherein a radius of the bladder-mounting pin is between 0.8 and 4 mm.

22. The method according to claim 14, wherein a radius of the rolling pin is between 8 and 25 mm.

23. The method according to claim 14, wherein rotating the rolling pin comprises using one or more gears of the rolling machine to rotate the rolling pin.

24. The method according to claim 14, further comprising, after rotating the rolling pin, using a clamp to hold the bladder in a partially rolled state around the bladder-mounting pin.

25. The method according to claim 14, wherein the method further comprises:

10 removing the bladder-mounting pin from the rolled portion of the bladder; and
 inserting the bladder into a delivery sheath.

26. The method according to claim 14, wherein rotating the rolling pin comprises rotating the rolling pin while
15 maintaining a predetermined air temperature range in a vicinity of the rolling pin.

27. The method according to claim 26, wherein the predetermined air temperature range has a low end of between 40 and 53 degrees C and a high end of between 50
20 and 65 degrees C.

28. The method according to claim 27, wherein the predetermined air temperature range has a low end of between 50 and 51.5 degrees C and a high end of between 50.5 and 53 degrees C.

25 29. The method according to claim 14,
 wherein the bladder-mounting pin is a first bladder-mounting pin, the edge of the bladder is a first edge of the bladder, and the portion of the bladder is a first portion of the bladder,

30 wherein using the rolling initiator comprises using the rolling initiator to insert the first edge of the

bladder between the first rolling pin and the first bladder-mounting pin,

wherein rotating the rolling pin comprises rotating the rolling pin to (a) advance, by friction, the first
5 portion of the bladder between the rolling pin and the first bladder-mounting pin, and (b) roll the first portion of the bladder around the first bladder-mounting pin, and

wherein the method further comprises, after rotating
10 the rolling pin to roll the first portion of the bladder around the first bladder-mounting pin:

dismounting the first bladder-mounting pin from the rolling machine;

mounting a second bladder-mounting pin to the
15 rolling machine such that the second bladder-mounting pin is rotatable about the second axis;

using the rolling initiator to insert a second edge of the bladder between the rolling pin and the second bladder-mounting pin; and

20 rotating the rolling pin to (a) advance, by friction, a second portion of the bladder between the rolling pin and the second bladder-mounting pin, and (b) roll the second portion of the bladder around the second bladder-mounting pin.

25 30. The method according to claim 29, wherein the first portion of the bladder includes between 20% and 50% of a total surface area of the unrolled bladder, and the second portion of the bladder includes between 20% and 50% of a total surface area of the unrolled bladder.

30 31. The method according to claim 29, wherein the bladder is removably coupled to an inflation rod, and wherein the first and the second portions are on opposite

sides of a central longitudinal axis of the inflation rod.

32. The method according to claim 29, wherein the method further comprises, after the first portion of the bladder is rolled around the first bladder-mounting pin, and before the second edge of the bladder is inserted between the rolling pin and the second bladder-mounting pin, using a clamp to hold the first rolled part rolled in place about the first bladder-mounting pin.

33. The method according to claim 29, wherein the method further comprises:

removing the first and the second bladder-mounting pins from the first and the second rolled portions of the bladder; and

inserting the bladder into a delivery sheath.

34. The method according to claim 29, wherein rotating the rolling pin to roll the first and the second portions comprises rolling the first and the second portions such that the first and the second portions are rolled in a same direction around respective central axes of the first and the second portions.

35. The method according to claim 29, wherein rotating the rolling pin to roll the first and the second portions comprises rolling the first and the second portions such that the first and the second portions are rolled in opposite directions around respective central axes of the first and the second portions.

36. The method according to claim 14,
wherein the edge of the bladder is a first edge of the bladder, and the portion of the bladder is a first portion of the bladder,

wherein using the rolling initiator comprises using the rolling initiator to insert the first edge of the bladder between the first rolling pin and the bladder-mounting pin,

5 wherein rotating the rolling pin comprises rotating the rolling pin to (a) advance, by friction, the first portion of the bladder between the rolling pin and the bladder-mounting pin, and (b) roll the first portion of the bladder around the bladder-mounting pin, and

10 wherein the method further comprises, after rotating the rolling pin to roll the first portion of the bladder around the bladder-mounting pin:

removing the bladder-mounting pin from the first rolled portion of the bladder;

15 using the rolling initiator to insert a second edge of the bladder between the rolling pin and the bladder-mounting pin; and

rotating the rolling pin to (a) advance, by friction, a second portion of the bladder between the rolling pin and the bladder-mounting pin, and (b) roll the second portion of the bladder around the bladder-mounting pin.

37. The method according to claim 36, wherein the first portion of the bladder includes between 20% and 50% of a total surface area of the unrolled bladder, and the
25 second portion of the bladder includes between 20% and 50% of a total surface area of the unrolled bladder.

38. The method according to claim 36, wherein removing the bladder-mounting pin from the first rolled portion of
30 the bladder comprises:

dismounting the bladder-mounting pin from the rolling machine;

thereafter, removing the bladder-mounting pin from the first rolled portion of the bladder; and

thereafter, mounting the bladder-mounting pin to the rolling machine such that the bladder-mounting pin is
5 rotatable about the second axis.

39. The method according to claim 36, wherein the bladder is removably coupled to an inflation rod, and wherein the first and the second portions are on opposite sides of a central longitudinal axis of the inflation
10 rod.

40. The method according to claim 36, wherein the method further comprises:

removing the bladder-mounting pin from the second rolled portion of the bladder; and
15 inserting the bladder into a delivery sheath.

41. The method according to claim 36, wherein rotating the rolling pin to roll the first and the second portions comprises rolling the first and the second portions such that the first and the second portions are rolled in a
20 same direction around respective central axes of the first and the second portions.

42. The method according to claim 36, wherein rotating the rolling pin to roll the first and the second portions comprises rolling the first and the second portions such
25 that the first and the second portions are rolled in opposite directions around respective central axes of the first and the second portions.

43. A method for rolling a bladder, the method comprising:
30 inserting the bladder while unrolled into a rolling machine;

inserting a first edge of the bladder between a rolling pin and a first bladder-mounting pin of the rolling machine, wherein the rolling pin is mounted to a support structure of the rolling machine such that the rolling pin is rotatable about a first axis, and the first bladder-mounting pin is removably mounted to the support structure such that the first bladder-mounting pin is rotatable about a second axis that is non-coaxial with and parallel to the first axis;

rotating the rolling pin to (a) advance, by friction, a first portion of the bladder between the rolling pin and the first bladder-mounting pin, (b) roll the first portion of the bladder around the first bladder-mounting pin, and (c) drive the first bladder-mounting pin to rotate in an opposite direction from that of the rolling pin;

dismounting the first bladder-mounting pin from the rolling machine;

mounting a second bladder-mounting pin to the rolling machine such that the second bladder-mounting pin is rotatable about the second axis;

inserting a second edge of the bladder between the rolling pin and the second bladder-mounting pin; and

rotating the rolling pin to (a) advance, by friction, a second portion of the bladder between the rolling pin and the second bladder-mounting pin, and (b) roll the second portion of the bladder around the second bladder-mounting pin.

44. The method according to claim 43, wherein the first portion includes between 20% and 50% of a total surface area of the unrolled bladder, and the second portion includes between 20% and 50% of the total surface area of the unrolled bladder.

45. The method according to claim 43, wherein the bladder is removably coupled to an inflation rod, and wherein the first and the second portions are on opposite sides of a central longitudinal axis of the inflation
5 rod.

46. The method according to claim 43, wherein the method further comprises, after the first portion of the bladder is rolled around the first bladder-mounting pin, and before the second edge of the bladder is inserted between
10 the rolling pin and the second bladder-mounting pin, using a clamp to hold the first rolled part rolled in place about the first bladder-mounting pin.

47. The method according to claim 43, wherein the method further comprises:
15 removing the first and the second bladder-mounting pins from the first and the second rolled portions of the bladder; and
inserting the bladder into a delivery sheath.

48. The method according to claim 43, wherein rotating
20 the rolling pin to roll the first and the second portions comprises rolling the first and the second portions such that the first and the second portions are rolled in a same direction around respective central axes of the first and the second portions.

25 49. The method according to claim 43, wherein rotating the rolling pin to roll the first and the second portions comprises rolling the first and the second portions such that the first and the second portions are rolled in opposite directions around respective central axes of the
30 first and the second portions.

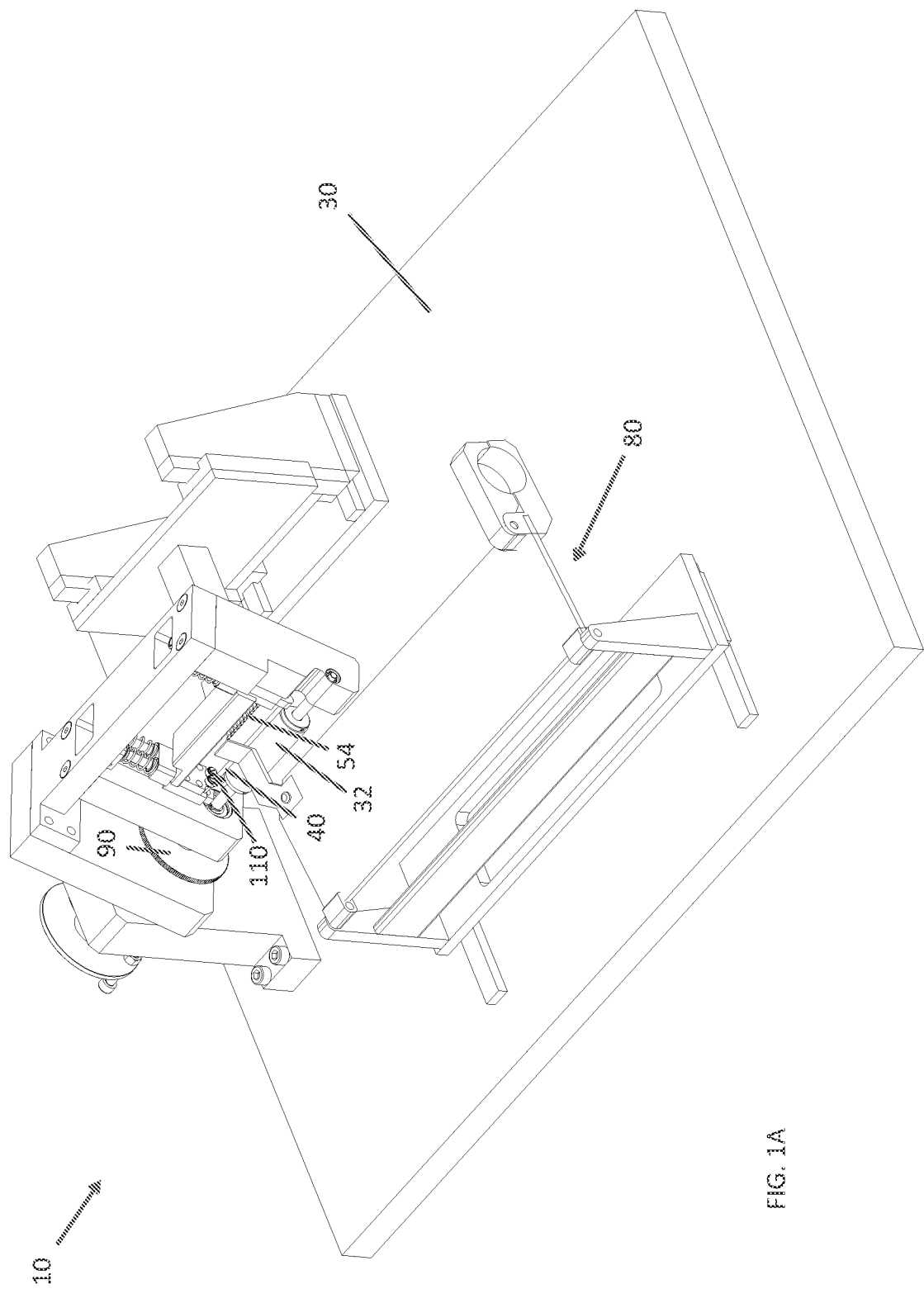
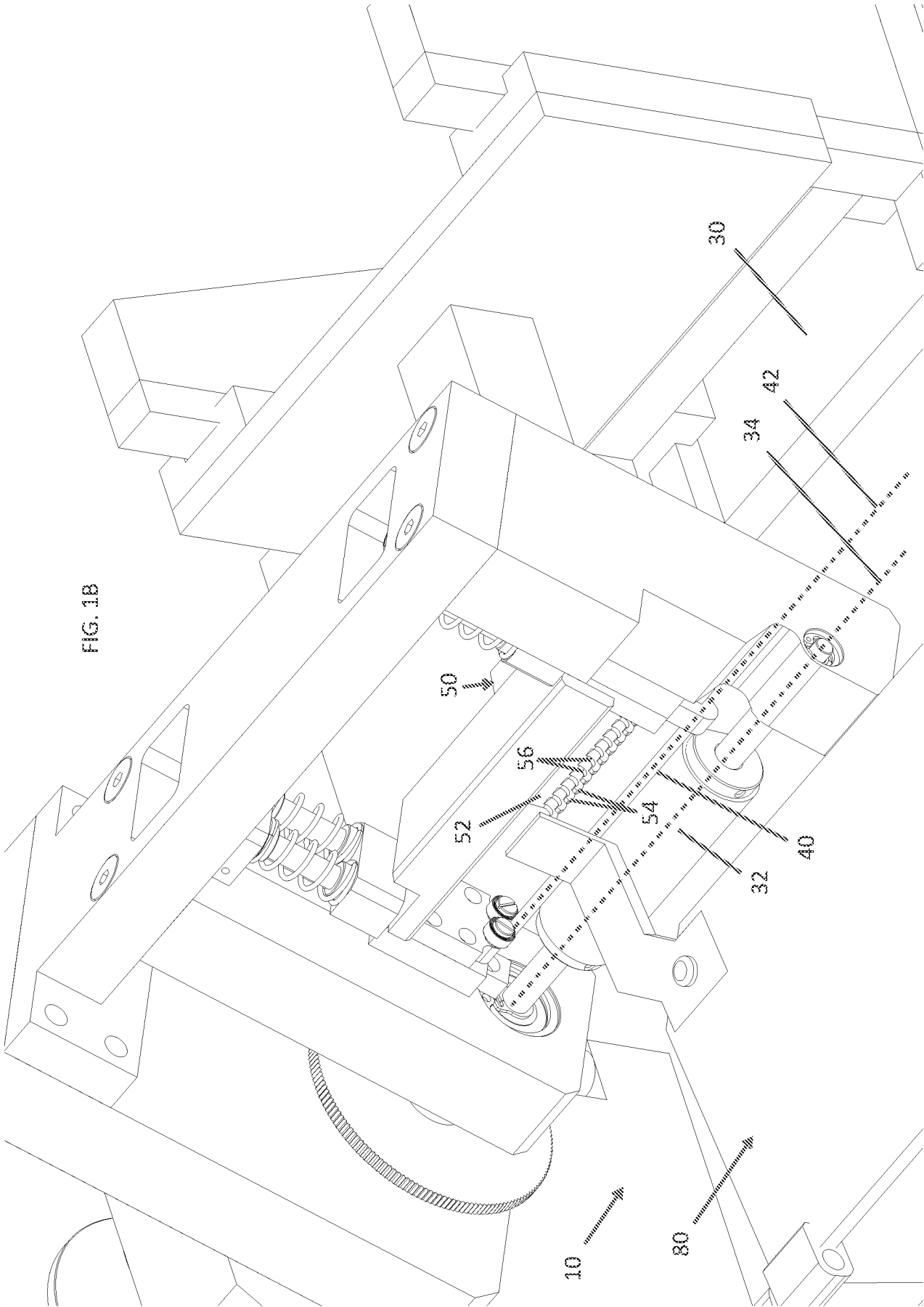


FIG. 1A



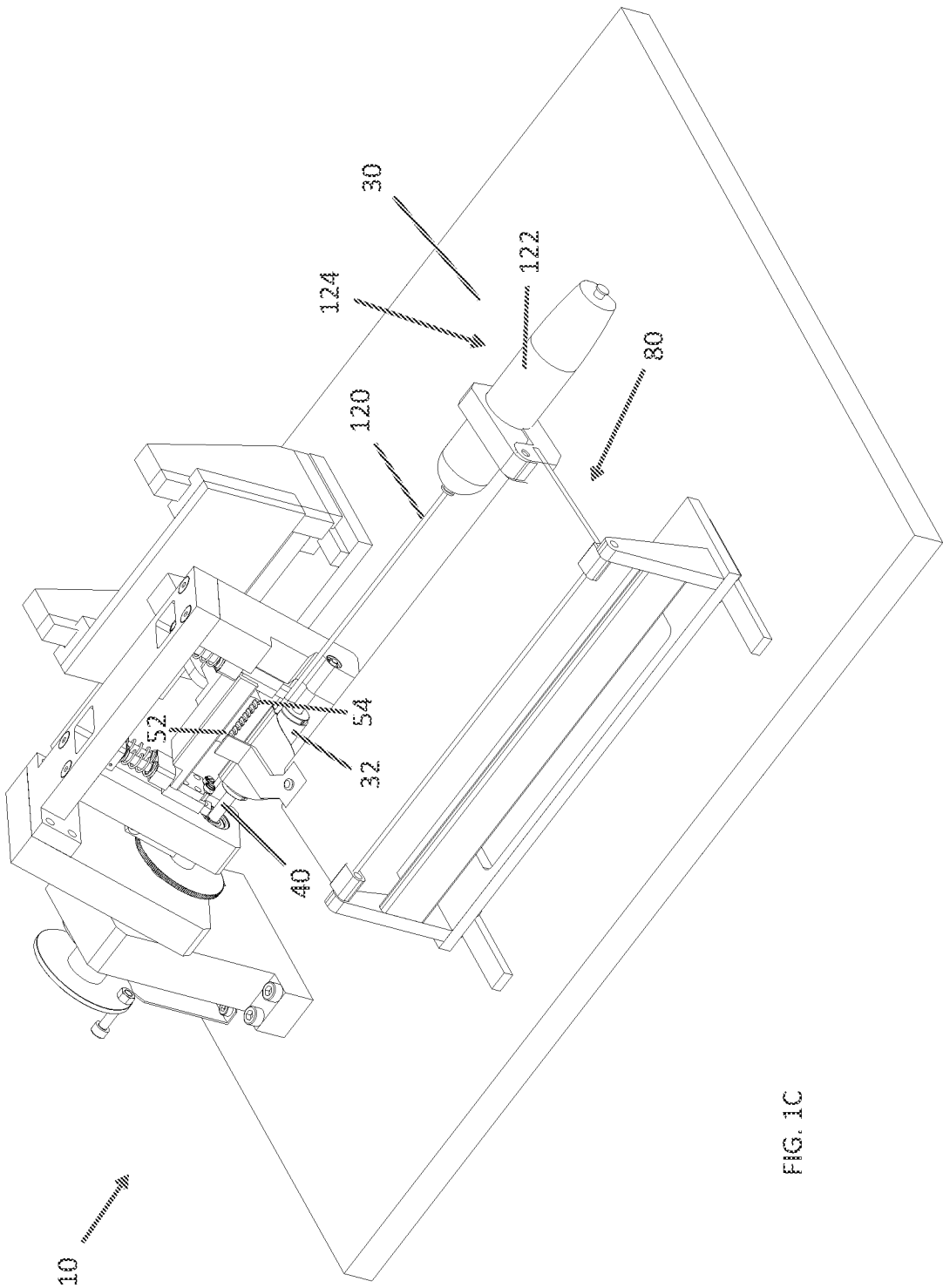
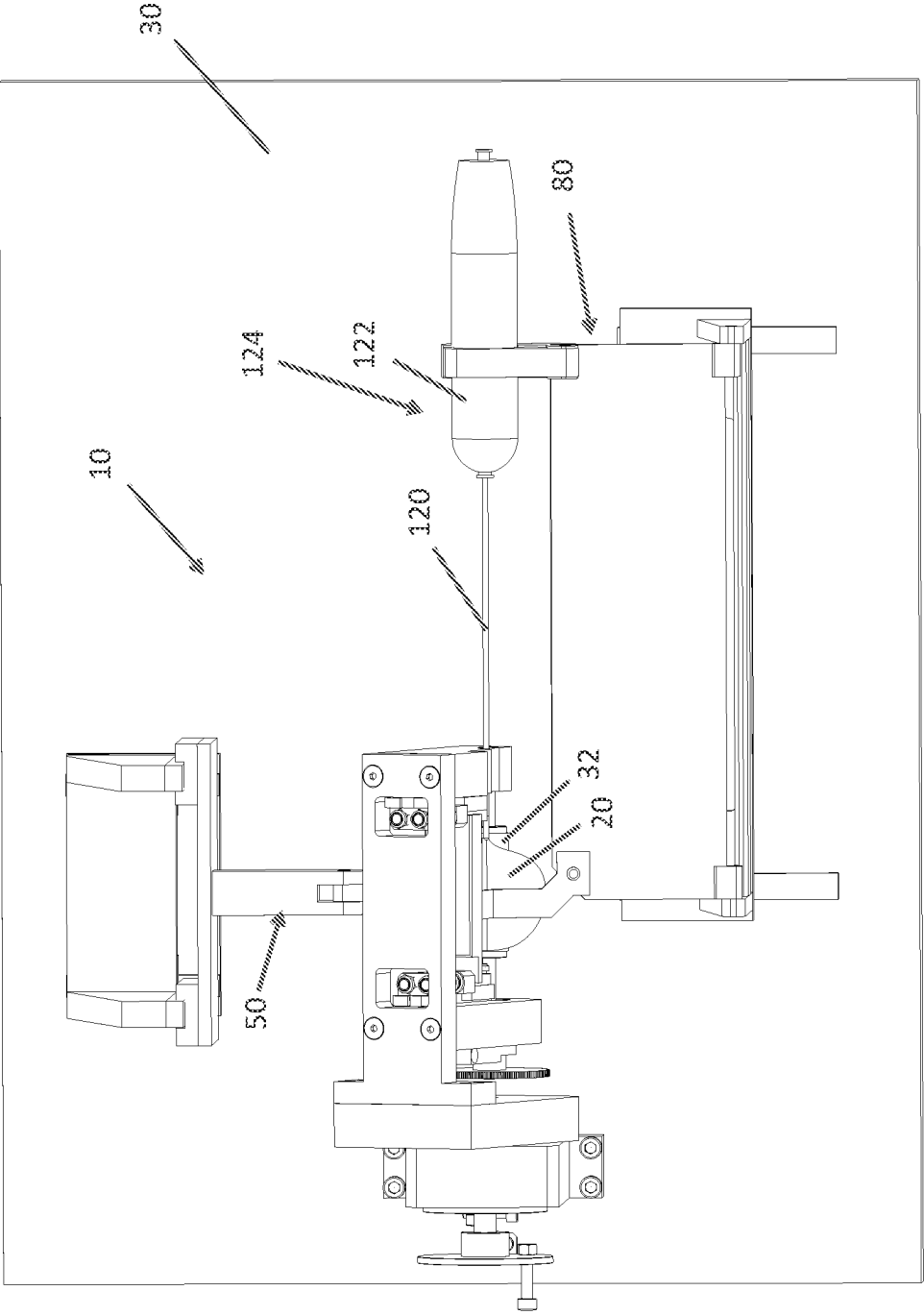
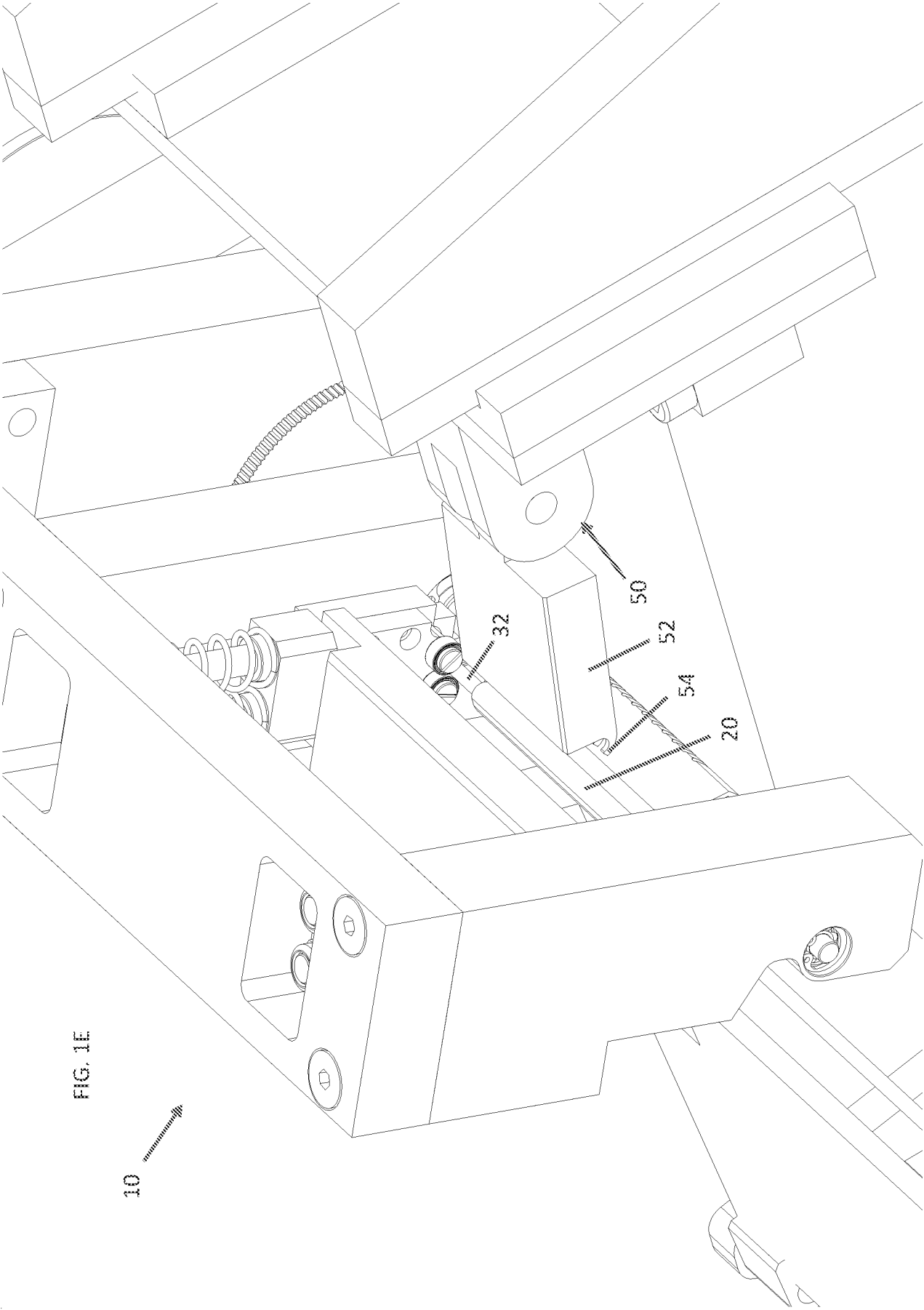
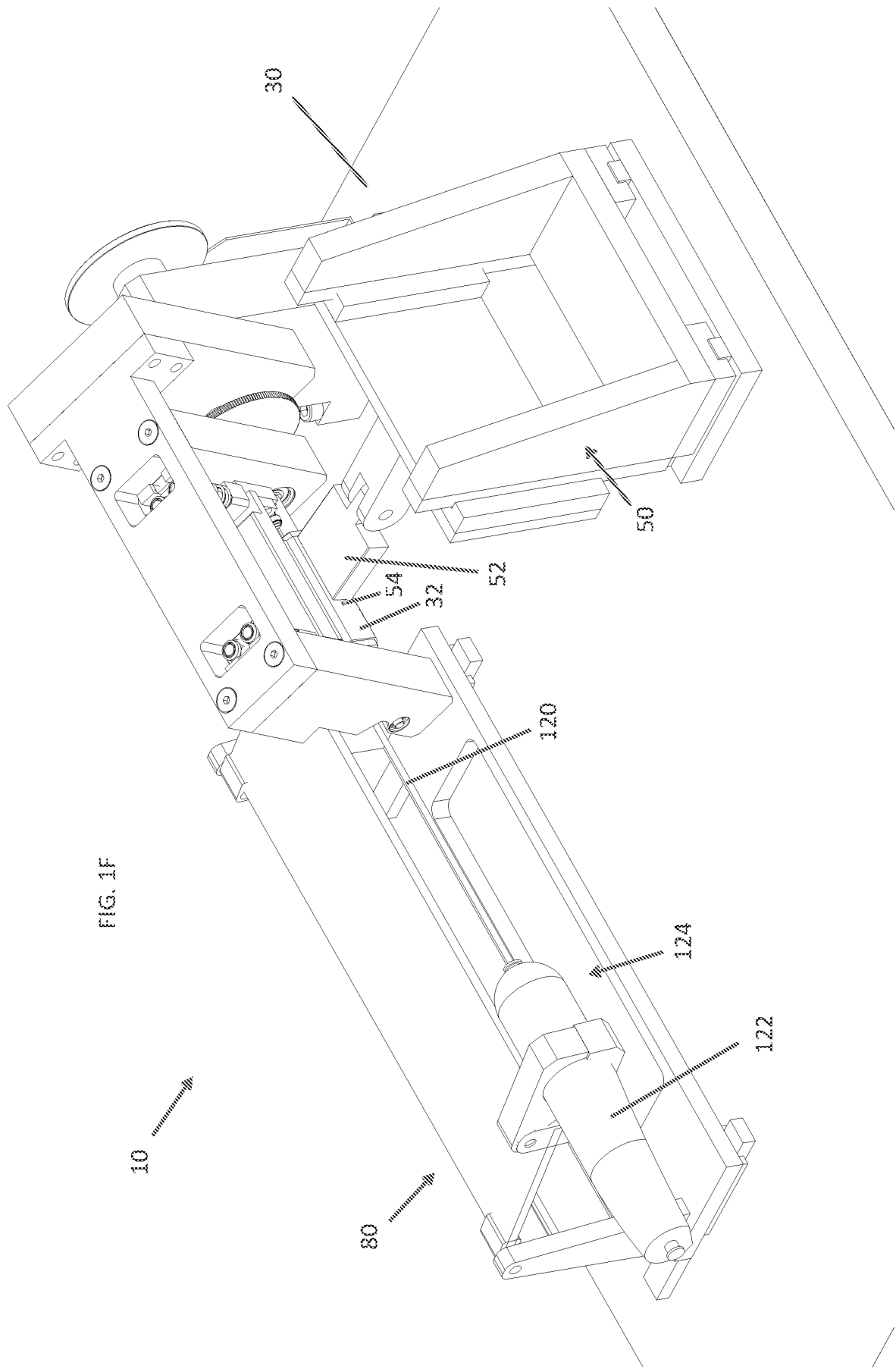


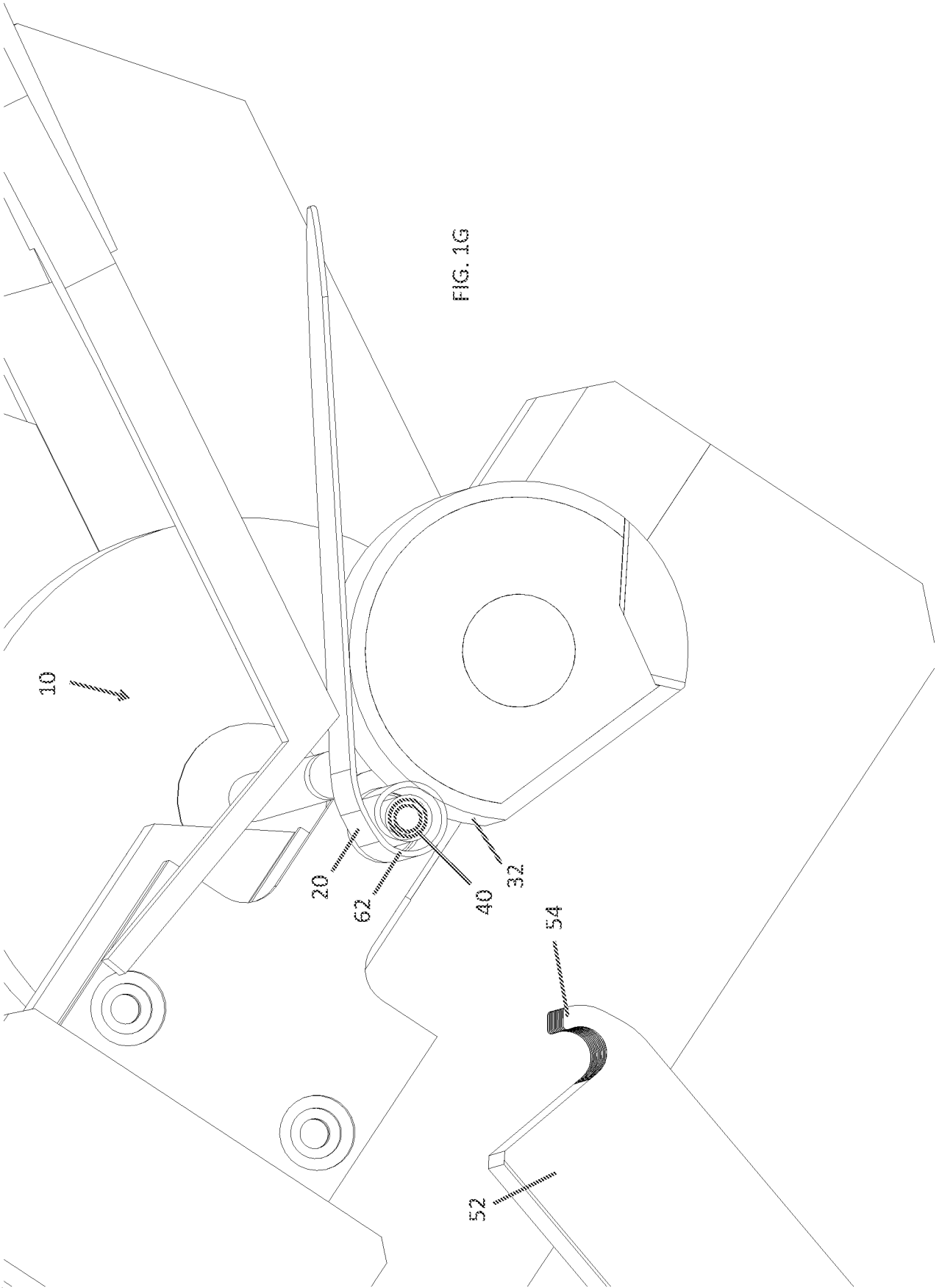
FIG. 1C

FIG. 1D









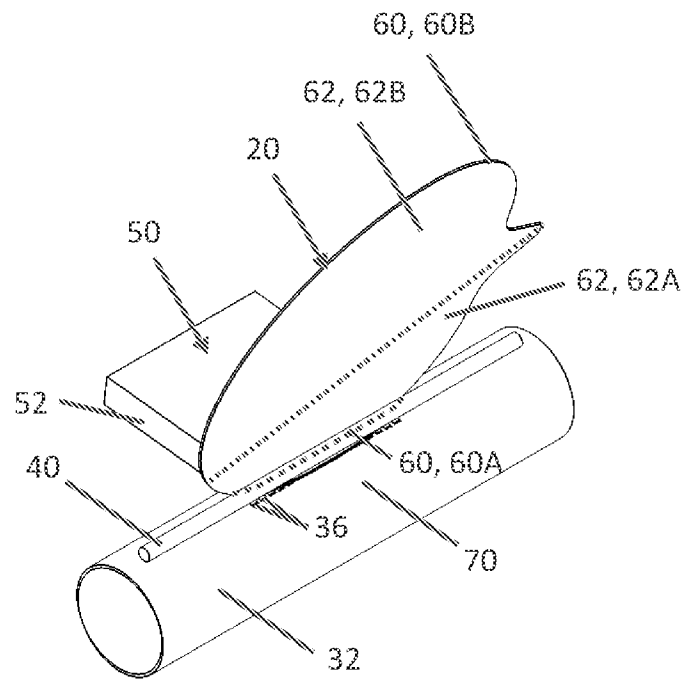


FIG. 2

FIG. 3A

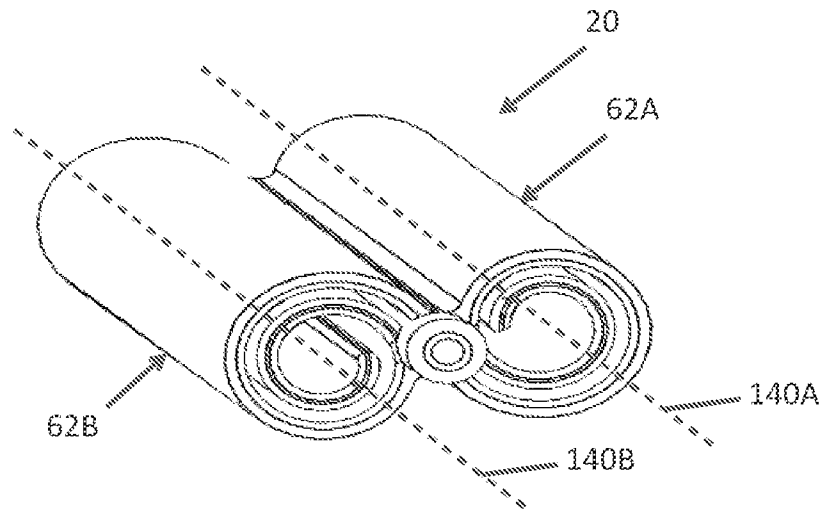
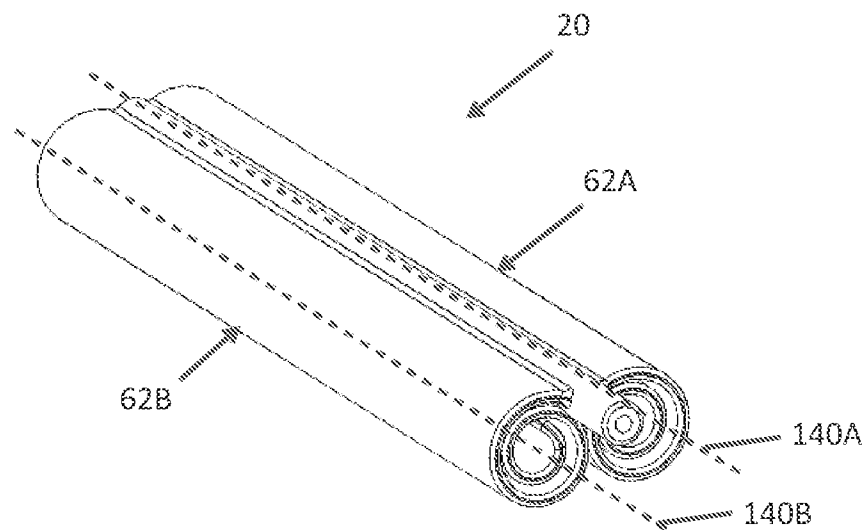


FIG. 3B



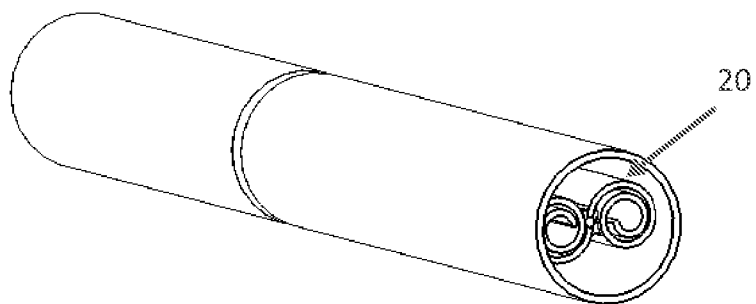


FIG. 4

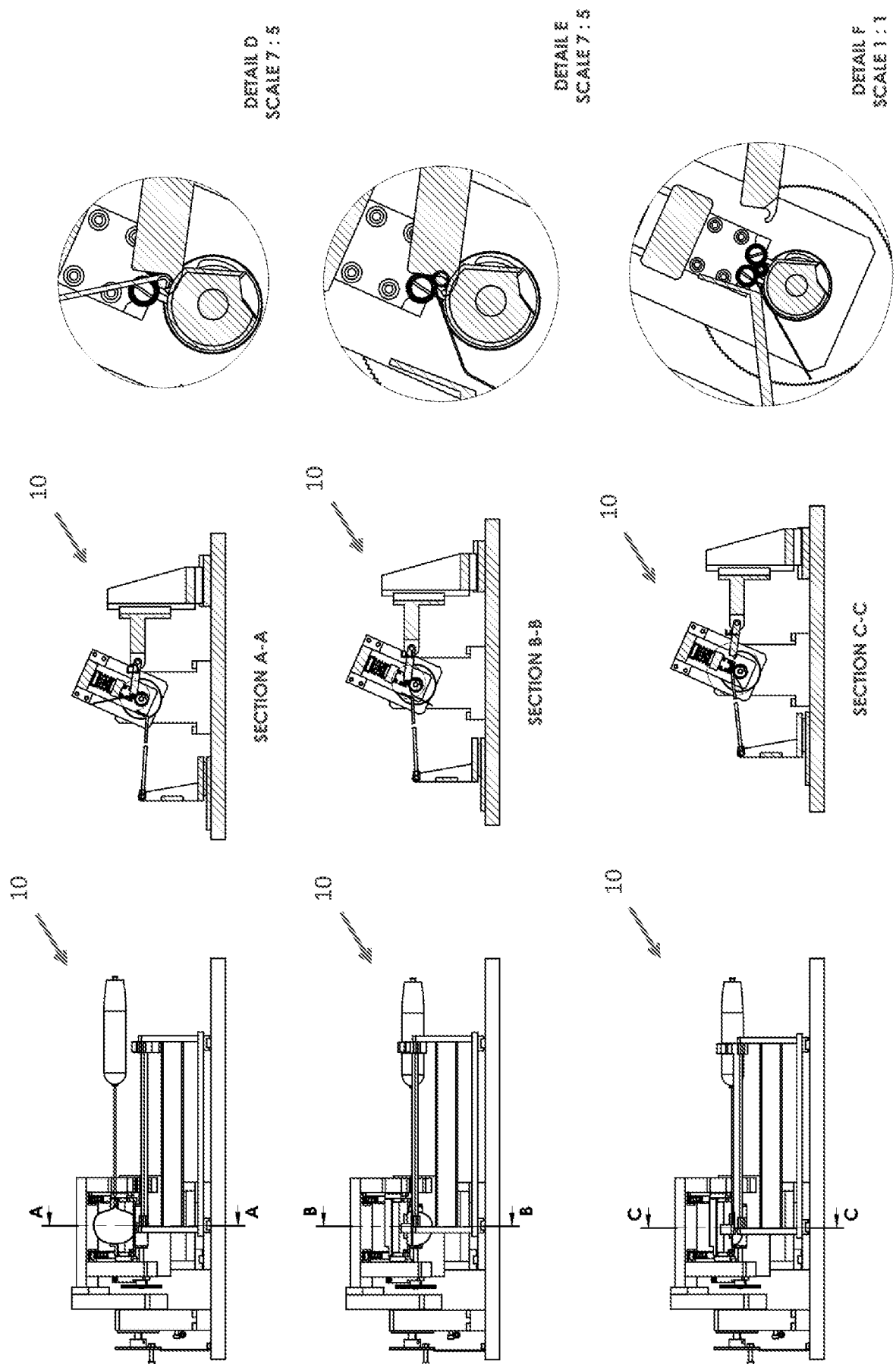


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB18/53533

A. CLASSIFICATION OF SUBJECT MATTER

IPC - A61B 17/135; A61F 2/958; A61M 25/10; B65H 18/08, 18/10, 18/12, 18/16, 18/20 (2018.01)

CPC - A61B 17/12136; A61F 2/958; A61M 25/1038; B65H 18/08, 18/085, 18/10, 18/12, 18/14, 18/16, 18/20

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,839,680 A (BIAGIOTTI G.) November 24, 1998; abstract; figures 13-16; column 7, lines 51-61; column 8, lines 27-39; column 9, lines 52-62	1-49
A	US 4,415,128 A (HEYMANNS W.) November 15, 1983; abstract; figures 1-3; column 2, lines 46-52	1-49
A	JP 09-240597 A (HAYASHI M.) September 16, 1997; abstract; figures 1-5; paragraphs [0007]-[0012]	1-49
A	US 5,232,173 A (PLANETA M.) August 3, 1993; abstract; column 3, lines 10-45	1-49
A	JP 2006-271678 A (NAKA ECO KEIEI KENKYUSHO:KK) October 12, 2006; entire document	1-49

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

13 September 2018 (13.09.2018)

Date of mailing of the international search report

26 SEP 2018

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