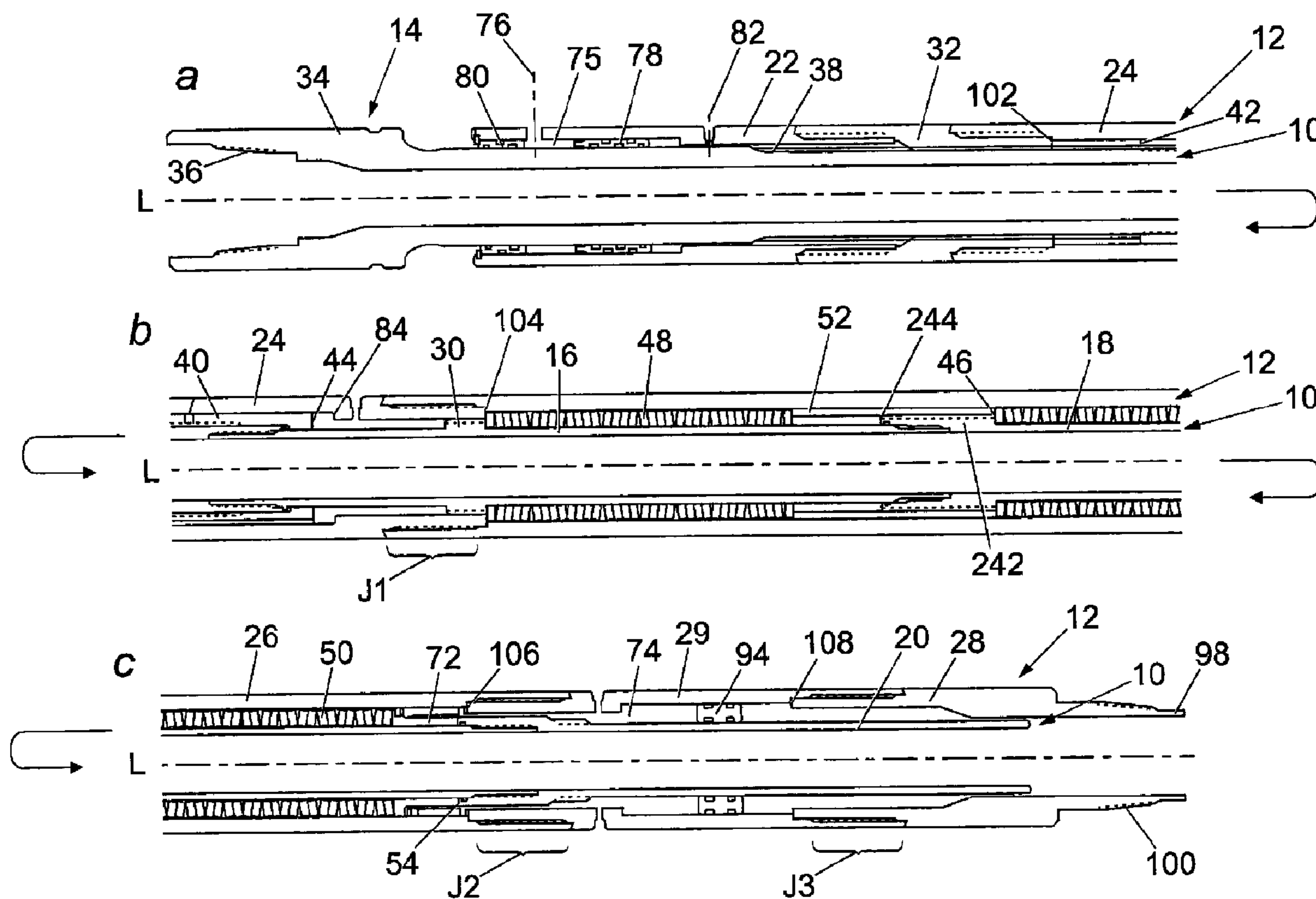




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 (72) Inventeurs/Inventors:
 SHEARS, CARL, GB;
 SOLEM, SIGURD, DK
 (73) Propriétaire/Owner:
 PEDEM LIMITED, GB
 (74) Agent: GOWLING LAFLEUR HENDERSON LLP

(54) Titre : APPAREIL ET METHODE AMELIORANT L'EFFET D'IMPACT
 (54) Title: IMPACT ENHANCING APPARATUS AND METHOD



(57) Abrégé/Abstract:

The invention provides an impact enhancer apparatus comprising a substantially tubular inner member (10), a substantially tubular outer member (12) which is axially movable in relation to the inner member (10), a primary energy storage device (50) adapted to store energy when the inner member (10) is moved in either of first and second axial directions with respect to the outer member (12) and a secondary energy storage device (48) adapted to store energy when the inner member (10) is moved in a first axial direction with respect to the outer member (12). The primary energy storage device (50) can comprise a primary biasing device.

(57) **Abrégé(suite)/Abstract(continued):**

The secondary energy storage device can comprise a secondary biasing device. The primary and/or secondary biasing devices can be a spring device selected from the group consisting of: disk springs; coiled springs; fluid and gas springs. The impact enhancing devices preferably comprise tubulars having double shoulder high torque connections (J1, J2, J3).

1 ABSTRACT, Fig. 1

2

3 Impact Enhancing Apparatus and Method

4

5 The invention provides an impact enhancer apparatus
6 comprising a substantially tubular inner member
7 (10), a substantially tubular outer member (12)
8 which is axially movable in relation to the inner
9 member (10), a primary energy storage device (50)
10 adapted to store energy when the inner member (10)
11 is moved in either of first and second axial
12 directions with respect to the outer member (12) and
13 a secondary energy storage device (48) adapted to
14 store energy when the inner member (10) is moved in
15 a first axial direction with respect to the outer
16 member (12). The primary energy storage device (50)
17 can comprise a primary biasing device. The
18 secondary energy storage device can comprise a
19 secondary biasing device. The primary and/or
20 secondary biasing devices can be a spring device
21 selected from the group consisting of: disk springs;
22 coiled springs; fluid and gas springs. The impact
23 enhancing devices preferably comprise tubulars
24 having double shoulder high torque connections (J1,
25 J2, J3).

26

27

1 "Impact Enhancing Apparatus and Method"

2

3 The present invention relates to a method and
4 apparatus for enhancing the impact created by a
5 drilling jar used downhole when the drill string
6 becomes stuck.

7

8 Drilling jars are used widely in the drilling
9 industry to allow a jarring impact to be transmitted
10 to the drill string when, for example, the drill
11 string becomes stuck in the borehole in which the
12 drilling operation is being performed.

13

14 Typically, drilling jars are incorporated into a
15 bottom hole assembly of a drill string and comprise
16 an outer tubular housing which surrounds an inner
17 tubular member. The outer tubular housing is
18 typically connected at its lower end to the lower
19 portion of the drill string whilst the upper end of
20 the inner tubular member is connected to the upper
21 portion of the drill string. The inner member and
22 outer housing are telescopically connected such that

1 one may move axially with respect to the other.
2 Generally, the inner member of a drilling jar has an
3 abutment which acts as a hammer and coincides with
4 an internal shoulder provided on the outer housing
5 of the jar which acts as an anvil such that the free
6 stroke of the inner member with respect to the outer
7 housing causes the hammer to impact against the
8 anvil. This impact causes the lower drill string
9 portion to jar.

10

11 The impact force created by the jar is the speed of
12 the hammer multiplied by the hammer weight at the
13 time of impact, where the hammer weight is the
14 weight of any drill collars and/or heavy weight pipe
15 located between the jar hammer and drill pipe or
16 energiser.

17

18 The impact force between the hammer and anvil may be
19 increased using an impact enhancing tool which
20 employs energy storage means that can be used to
21 store energy which when suddenly released causes the
22 inner member of the jar to accelerate with respect
23 to the outer housing of the jar whilst the hammer is
24 moving toward the anvil.

25

26 According to the first aspect of the present
27 invention, there is provided an impact enhancer
28 apparatus comprising:-

29

a substantially tubular inner member;

30

a substantially tubular outer member which is

31

axially movable in relation to the inner member; and

1 a primary energy storage means adapted to store
2 energy when the inner member is moved in either of
3 first and second axial directions with respect to
4 the outer member; and

5 a secondary energy storage means adapted to
6 store energy when the inner member is moved in a
7 first axial direction with respect to the outer
8 member.

9
10 Preferably, the primary energy storage means
11 comprises a primary resilient means which may
12 comprise a primary biasing means which may be any
13 one of a spring means (such as disk springs, coiled
14 springs, fluid or gas springs, etc.). Preferably,
15 the secondary energy storage means comprises a
16 secondary resilient means which may comprise a
17 secondary biasing means which may be any one of a
18 spring means (such as disk springs, coiled springs,
19 fluid or gas springs, etc.).

20
21 Typically, the primary energy storage means is
22 adapted to store energy when compressed by movement
23 of the inner member in either of the first and
24 second axial direction with respect to the outer
25 member.

26
27 Typically, the secondary energy storage means is
28 adapted to store energy when compressed by movement
29 of the inner member in the first axial direction
30 with respect to the outer member.

31

1 Preferably, the primary and secondary energy storage
2 means are adapted to resist movement (and thereby
3 store energy) of the inner member in the upward
4 direction with respect to the outer member with a
5 relatively large resistive force. More preferably,
6 the primary energy storage means is adapted to
7 resist movement (and thereby store energy) of the
8 inner member in the downward direction with respect
9 to the outer member with a relatively weak resistive
10 force and most preferably, only the primary energy
11 storage means is adapted to resist movement (and
12 thereby store energy) of the inner member in the
13 downward direction with respect to the outer member
14 with a relatively weak resistive force.

15

16 Preferably, the primary energy storage means is
17 adapted to resist upward movement of the inner
18 member with respect to the outer member by a first
19 resilient force when the inner member is displaced
20 to an upward displacement boundary and the secondary
21 energy storage means is adapted to resist upward
22 movement of the inner member with respect to the
23 outer member by a second resilient force when the
24 inner member is displaced past the upward
25 displacement boundary.

26

27 Preferably, the primary and secondary energy storage
28 means comprise a plurality of resilient disks.
29 Alternatively, the primary and secondary energy
30 storage means comprise any suitable resilient member
31 such as a coiled spring or the like.

32

1 Preferably, the primary energy storage means is
2 adapted to provide a lower level of resistive force
3 to compression than that provided by the secondary
4 energy storage means.

5
6 Typically, the difference in the level of resistive
7 force provided by the energy storage means is
8 determined due to the orientation of the energy
9 storage means which selectively results in a greater
10 or lesser compression displacement when
11 substantially the same force is placed upon the
12 energy storage means.

13
14 Preferably, the primary energy storage means
15 comprises a plurality of spring disks (such as two)
16 oriented in the same direction as one another.
17 Preferably, the plurality of disks in the primary
18 resilient means are arranged with two disks oriented
19 in one direction alternating with two disks oriented
20 in the other direction.

21
22 Preferably, the secondary energy storage means
23 comprises a plurality of spring disks (such as four)
24 oriented in the same direction as one another.
25 Preferably, the plurality of disks in the secondary
26 energy storage means are arranged with a greater
27 number (such as twice the number) of disks of the
28 primary energy storage means oriented in one
29 direction alternating with the same greater number
30 of spring disks oriented in the other direction.

31

1 Typically, movement of the inner member in the
2 upward direction causes the primary and secondary
3 energy storage means to be compressed until the
4 upward displacement limit is reached at which point
5 further upward movement of the inner member only
6 causes the secondary energy storage means to be
7 compressed further.

8
9 Typically, movement of the inner member in the
10 downward direction will cause only the primary
11 energy storage means to be compressed, the secondary
12 energy storage means typically being allowed to move
13 with the inner member without being compressed.

14
15 Typically, the energy storage means is/are located
16 in an annulus formed between the inner and outer
17 members.

18
19 Preferably, the primary energy storage means are
20 located within the annulus and are further located
21 between a second arrangement of upper and lower
22 shoulders formed on the inner member and preferably
23 are further located between a lower shoulder formed
24 on the outer member and a lower shoulder formed on
25 the moveable member.

26
27 Typically, the secondary energy storage means are
28 located within the annulus and are further located
29 between a first arrangement of upper and lower
30 shoulders formed on the inner member and preferably
31 are further located between an upper shoulder formed
32 on the outer member and an upper shoulder formed on

1 a moveable member preferably also located in the
2 annulus.

3

4 Typically, the moveable member is located in the
5 annulus between the primary and secondary energy
6 storage means and preferably comprises a greater
7 axial extent and thus a greater distance between
8 it's upper and lower shoulders than the distance
9 between the inner member lower shoulder of the first
10 arrangement and the inner member upper shoulder of
11 the second arrangement.

12

13 Preferably, the impact enhancing apparatus is
14 arranged such that, in the absence of compression to
15 the energy storage means, the distance between the
16 upper shoulder of the first arrangement and the
17 upper shoulder of the second arrangement
18 substantially equals the distance between the upper
19 shoulder of the outer member and the lower shoulder
20 of the moveable member.

21

22 According to the first aspect of the present
23 invention, there is also provided a method
24 of increasing the jarring force imparted by a jar
25 apparatus comprising:-

26 providing a substantially tubular inner member;

27 providing a substantially tubular outer member;

28 providing an energy storage means capable of storing
29 greater energy therein due to upward movement of the
30 inner member with respect to the outer member.

31

1 According to a second aspect of the present
2 invention, there is provided connection means
3 adapted to allow connection of one substantially
4 tubular member to another substantially tubular
5 member, the connection means comprising:-
6 a male connecting member;
7 a female connecting member; and
8 co-operable attachment means provided on the
9 male and female connecting members;
10 wherein the male and female connecting members
11 each comprise at least one primary surface adapted
12 to form a primary joint and further each comprise at
13 least one secondary surface adapted to form a
14 secondary joint.

15
16 According to the second aspect of the present
17 invention, there is also provided a male connecting
18 member for a substantially tubular member which is
19 arranged for connection to a female connecting
20 member of another substantially tubular member, the
21 male connecting member comprising:-
22 an attachment means co-operable with an
23 attachment means provided on the female connecting
24 member;
25 and at least one primary surface adapted to
26 form a primary joint with at least one primary
27 surface provided on the female member; and
28 at least one secondary surface adapted to form
29 a secondary joint with at least one secondary
30 surface provided on the female member.

31

1 According to the second aspect of the present
2 invention, there is also provided a female
3 connecting member for a substantially tubular member
4 which is arranged for connection to a male
5 connecting member of another substantially tubular
6 member, the female connecting member comprising:-

7 an attachment means co-operable with an
8 attachment means provided on the male connecting
9 member;

10 and at least one primary surface adapted to
11 form a primary joint with at least one primary
12 surface provided on the male member; and

13 at least one secondary surface adapted to form
14 a secondary joint with at least one secondary
15 surface provided on the male member.

16

17 Typically, the tubular member connects with another
18 tubular member in accordance with the first aspect
19 of the present invention to form at least part of
20 the outer housing of a downhole tool for
21 incorporation into a string of downhole tubulars
22 such as drill string.

23

24 Typically, an end the male member is adapted for
25 insertion into an end of the female member.

26

27 Preferably, the at least one primary surface is
28 adapted to form a primary load bearing shoulder
29 joint and more preferably, the at least one
30 secondary surface is adapted to form a secondary
31 load bearing shoulder joint. Typically, the primary
32 and secondary joints are formed between the male and

1 female connecting members when the male and female
2 connecting members are connected to one another.

3
4 Typically, the co-operable attachment means of the
5 male and female connecting members retain the
6 primary surface of the male connecting member in
7 abutment with the primary surface of the female
8 connecting member.

9
10 Typically, the co-operable attachment means of the
11 male and female connecting members retain the
12 secondary surface of the male connecting member in
13 abutment with the secondary surface of the female
14 connecting member.

15
16 Preferably, the co-operable attachment means of the
17 male and female connecting members retain the
18 primary and secondary surfaces of the male
19 connecting member in abutment with the respective
20 primary and secondary surfaces of the female
21 connecting member, typically in order to create the
22 respective primary and secondary joints between the
23 male and female members. More preferably, at least
24 one of the primary and secondary joints at least
25 partially resist rotation of one of the connecting
26 members with respect to the other in at least one
27 direction.

28
29 This has the advantage that embodiments of the
30 invention provide a pair of butting surfaces
31 (between each pair of primary and secondary
32 surfaces) between the male and female members which

1 resist rotation of the members with respect to one
2 another.

3
4 Preferably, the attachment means comprises a thread
5 on the male member which is co-operable with a
6 corresponding thread on the female member. More
7 preferably the thread forces the or each primary
8 and/or secondary surface of the connecting members
9 into abutment with the corresponding surface of the
10 other connecting member. Preferably, the thread
11 provided on the male and female members comprises a
12 substantially parallel thread which typically
13 comprises a longitudinal axis which is substantially
14 parallel to a longitudinal axis of the respective
15 tubular member. This provides the advantage that
16 the attachment means has a minimised radial extent
17 which means that the inner bore of the connection
18 members is substantially unrestricted at the
19 location of the connection members. Optionally in
20 alternative embodiments, the thread provided on the
21 male and female members may comprise a linearly
22 tapered thread which is at an angle to the central
23 longitudinal axis of the respective tubular member,
24 where the thread angle is typically arranged with
25 one end of the thread radially closer to the central
26 longitudinal axis of the connecting members than the
27 other end of the thread.

28
29 Preferably, the primary surface of the female member
30 is located radially outwardly of the secondary
31 surface; the secondary surface of the female member
32 is located closer to the central longitudinal axis

1 of the female connecting member than the primary
2 surface.

3

4 Preferably, the primary surface of the male member
5 is located radially outwardly of the secondary
6 surface; the secondary surface of the male member is
7 located closer to the central longitudinal axis of
8 the male connecting member than the primary surface.

9

10 Typically, the respective attachment means of the
11 male and female members are located in between the
12 respective primary and secondary surfaces.

13

14 Preferably, the primary surface of the female member
15 comprises a longitudinally outermost end of the
16 female member and may be provided at an end of the
17 female member which is longitudinally and radially
18 outer of the female member attachment means.

19 Typically, the secondary surface of the female
20 member is distal of the longitudinally outermost end
21 of the female member and may be provided radially
22 and longitudinally inner of the female member
23 attachment means.

24

25 Preferably, the secondary surface of the male member
26 comprises a longitudinally outermost end of the male
27 member and may be provided at an end of the male
28 member which is radially inner and longitudinally
29 outer of the male member attachment means.

30 Typically, the primary surface of the male member is
31 distal of the longitudinally outermost end of the
32 male member and may be provided radially outer and

1 longitudinally inner of the male member attachment
2 means.

3
4 Preferably, the primary surface of the male member
5 comprises an at least partially tapered end which
6 typically forms a shoulder portion and which may
7 comprise a tapered portion angled with respect to an
8 axis perpendicular to the longitudinal axis of the
9 male member. The said tapered portion of the male
10 member primary surface shoulder portion is
11 preferably angled, from radially innermost to
12 outermost, in the direction toward the rest of the
13 male connecting member and which more preferably is
14 angled, from radially innermost to outermost, in the
15 direction toward the male member attachment means.
16 The said tapered angle may be in the region of 1
17 degree to 45 degrees and is preferably in the region
18 of 10 to 20 degrees.

19
20 Preferably, the primary surface of the female member
21 comprises a female shoulder portion and which may
22 comprise a tapered portion angled with respect to an
23 axis perpendicular to the longitudinal axis of the
24 female member. The said tapered portion of the
25 female member primary surface shoulder portion is
26 preferably angled, from radially innermost to
27 outermost, in the direction toward the rest of the
28 female connecting member and which more preferably
29 is angled, from radially innermost to outermost, in
30 the direction toward the female member attachment
31 means, preferably by a substantially similar angle
32 as that of the tapered portion of the male member

1 primary surface shoulder portion such that the
2 female member, and more preferably, the
3 longitudinally outermost end of the female member is
4 typically substantially prevented from moving
5 radially outward when connected to the male member.

6
7 Preferably, the secondary surface of the male member
8 comprises an at least partially tapered end which
9 typically forms a shoulder portion and which may
10 comprise a tapered portion angled with respect to an
11 axis perpendicular to the longitudinal axis of the
12 male member. The said tapered portion of the male
13 member secondary surface shoulder portion is
14 preferably angled, from radially innermost to
15 outermost, away from the rest of the male connecting
16 member and which more preferably is angled, from
17 radially innermost to outermost, away from the male
18 member attachment means. The said tapered angle may
19 be in the region of 1 degree to 45 degrees and is
20 preferably in the region of 10 to 20 degrees.

21
22 Preferably, the secondary surface of the female
23 member comprises a female shoulder portion and which
24 may comprise a tapered portion angled with respect
25 to an axis perpendicular to the longitudinal axis of
26 the female member. The said tapered portion of the
27 female member secondary surface shoulder portion is
28 preferably angled, from radially innermost to
29 outermost, away from the rest of the female
30 connecting member and which more preferably is
31 angled, from radially innermost to outermost, away
32 from the female member attachment means, preferably

1 by a substantially similar angle as that of the
2 tapered portion of the male member such that the
3 male member, and more preferably, the longitudinally
4 outermost end of the male member is typically
5 substantially prevented from moving radially inward
6 when connected to the female member.

7
8 Preferably, the primary and secondary surfaces of
9 the male and female connecting members further
10 comprise support means which may further comprise a
11 support platform or ledge adapted to support the
12 respective longitudinally outermost ends of the male
13 and female members when the connection means is
14 engaged such that the male member is substantially
15 prevented from moving radially outward and the
16 female member is preferably substantially prevented
17 from moving radially inward. The support means is
18 typically provided in the form of a surface, which
19 may be a platform or ledge and which is preferably
20 arranged to lie on an axis substantially parallel or
21 co-axial to the longitudinal axis of the respective
22 male and female connecting members.

23
24 Preferably, the support means of the primary surface
25 of the male member is arranged radially inwardly of
26 and longitudinally outwardly of the male member
27 primary surface tapered portion and is further
28 arranged radially outwardly of and longitudinally
29 inwardly of the male member attachment means.
30 Preferably, the support means of the secondary
31 surface of the male member is arranged radially
32 outwardly of and longitudinally inwardly of the male

1 member secondary surface tapered portion and is
2 further arranged radially inwardly of and
3 longitudinally outwardly of the male member
4 attachment means.

5
6 Preferably, the support means of the primary surface
7 of the female member is arranged radially inwardly
8 of and longitudinally inwardly of the female member
9 primary surface tapered portion and is further
10 arranged radially outwardly of and longitudinally
11 outwardly of the female member attachment means.

12 Preferably, the support means of the secondary
13 surface of the female member is arranged radially
14 outwardly of and longitudinally outwardly of the
15 female member secondary surface tapered portion and
16 is further arranged radially inwardly of and
17 longitudinally inwardly of the female member
18 attachment means.

19
20 The combined effect of the support means and tapered
21 surfaces has the advantage that they substantially
22 prevent movement (such as buckling when the
23 connection means is being made up to high levels of
24 torque) of the male and female connection members in
25 the radial direction.

26
27 Optionally, the male connection member may be
28 provided on one end of a body member and the female
29 member provided on the other thereby creating a
30 double shouldered connection which is capable of
31 remaining engaged when a high torque is applied to
32 it. Alternatively, one of a male or female member

1 may be provided on one end of the member only, or in
2 a further alternative, either a male or female
3 member may be provided on each end of the body
4 member.

5
6 Typically, the substantially tubular members are
7 members which are included in or make up a drill
8 string and may be members provided on or in a
9 drilling jar, impact enhancing tool, drill pipe,
10 flow circulation tool, shock tools, thrusters and
11 bumper subs or other suitable tools such as any
12 suitable Bottom Hole Assembly (BHA) tools.

13
14 An embodiment of the present invention will now be
15 described, by way of example only, with reference to
16 the accompanying drawings, in which:-

17
18 Fig. 1A is a cross sectional view of the upper
19 third of impact enhancer apparatus in accordance
20 with the first aspect of the present invention;
21 Fig. 1B is a cross sectional view of the middle
22 third of impact enhancer apparatus in accordance
23 with the first aspect of the present invention;
24 Fig. 1C is a cross sectional view of the lower
25 third of impact enhancer apparatus in accordance
26 with the first aspect of the present invention;
27 Fig. 2A is a cross sectional view of a female
28 end connector utilised in the impact enhancer
29 apparatus of Fig. 1 which is also in accordance
30 with the second aspect of the present invention;

1 Fig. 2B is a further cross sectional view of a
2 the female end of Fig. 2A in accordance with the
3 second aspect of the present invention;
4 Fig. 2C is a detailed view of the internal screw
5 thread of the female connector of Figs. 2A and
6 2B;
7 Fig. 3A is a cross sectional view of a male end
8 connector to be used in conjunction with the
9 female end connector of Fig. 2 in accordance
10 with the present invention;
11 Fig. 3B is a further cross sectional view of a
12 male end connector to be used in conjunction
13 with the female end connector of Fig. 2 in
14 accordance with the present invention;
15 Fig. 3C is a detailed view of the external screw
16 thread of the male connector of Figs. 3A and 3B;
17 and
18 Fig. 4 is a detailed schematic diagram of a
19 parallel threaded shoulder joint in accordance
20 with the second aspect of the present invention.

21
22 When viewed in conjunction with one another, Figs.
23 1A, 1B and 1C show an impact enhancer apparatus in
24 accordance with the first aspect of the present
25 invention as indicated by the connecting arrows.

26
27 The impact enhancer apparatus shown in Figs. 1A, 1B
28 and 1C comprises an internal member or mandrel 10
29 surrounded by an external member or housing 12. The
30 internal mandrel 10 is arranged such that it may
31 move axially with respect to the outer housing 12.

32

1 The internal mandrel 10 is a substantially tubular
2 member which spans the majority of the length from
3 the upper to the lower end of the impact enhancer
4 apparatus. The internal mandrel 10 comprises an
5 uppermost connecting mandrel 14 connected at its
6 lower end to an upper abutment mandrel 16, which
7 leads on to a lower abutment mandrel 18 that finally
8 connects to a lowermost end mandrel 20.

9
10 The external housing 12 comprises an uppermost seal
11 housing 22 connected to an upper abutment housing 24
12 which leads on to a lower abutment housing 26
13 connected to a lock housing 26 which finally
14 connects to a lowermost connecting housing 28. It
15 should be noted that the uppermost seal housing 22
16 is connected to the upper abutment housing 24 via a
17 double shouldered spline 32 which will be described
18 in more detail subsequently. Also, in the
19 embodiment shown each of the joints J1, J2 and J3
20 comprise corresponding threaded sections which are
21 substantially parallel to the longitudinal axis L of
22 the impact enhancer apparatus.

23
24 The uppermost connecting mandrel 14 of the internal
25 mandrel 10 has a box section 34 provided with a
26 standard tapered thread portion 36 which allows
27 connection to a pin section of the lower end of an
28 upper portion of a drill string (not shown). The
29 box section 34 decreases in diameter in order to
30 allow the connecting mandrel 14 to enter the
31 external housing 12. Such box sections 34 are
32 common in the industry and suitable box sections

1 include the HT-50 and XT56 connections provided by
2 Grant and Prideco and the WT-58 provided by Hydril.
3 The mandrel 14 continues along the internal bore of
4 the housing 12 until it reaches an indented portion
5 38 which comprises an arrangement of longitudinally
6 extending and circumferentially spaced grooves which
7 telescopically engage with internally projecting
8 splines mounted on the spline 32 to prevent rotation
9 occurring between the internal mandrel 10 and
10 external housing 12. At the lower portion of the
11 connecting mandrel 14 a double headed hammer 40 is
12 attached to the outer circumference of the mandrel
13 14. The stop 40 comprises a collar 40 which has
14 upper 42 and lower 44 stroke limiting surfaces which
15 act to prevent overstressing of the springs as will
16 be described subsequently.

17

18 Referring to Fig. 1b, the upper abutment mandrel 16
19 has a shoulder 30 formed around the circumference of
20 the mandrel 16.

21

22 The lower abutment mandrel 18 is provided with a
23 female end socket 242 which creates upper 244 and
24 lower 46 shoulders.

25

26 In the annulus created between the inner mandrel 10
27 and the external housing 12, resilient means or
28 energy storage means comprising an upper compression
29 spring stack 48 and lower compression spring stack
30 50 is provided. A cylindrical spacer collar 52 is
31 provided between the upper 48 and lower 50 stacks.
32 The stacks 48, 50 are held within the annulus by a

1 force that can be varied by either screwing in or
2 out an adjuster 72 (which is coupled to the internal
3 mandrel 10 by screw threads) in order to increase or
4 decrease (as desired) the initial compression force
5 acting on the stacks 48, 50.

6
7 The secondary (upper) spring stack 48 comprises a
8 hard spring and in the specific example given herein
9 comprises a number of disk springs 48 (such as
10 Belleville springs) stacked adjacent each other.
11 Each disk spring 48 comprises a toroid made from a
12 suitable material e.g. hardened steel, which has
13 been pressed into a dish shape during manufacture.
14 When a load is exerted on each disk spring 48 it
15 will tend to flatten out of the disk shape imparted
16 on it during manufacture. In this embodiment, the
17 upper spring stack 48 comprises disks which
18 alternate between four consecutive disks having
19 their dish camber in one direction and four
20 consecutive disks having their dish camber in the
21 opposite direction.

22
23 The lower spring stack 50 also comprises a number of
24 disk springs 50 stacked adjacent each other;
25 however, the lower spring stack 50 comprises disks
26 which alternate between two consecutive spring disks
27 having their dish camber in one direction and two
28 consecutive disks having their dish camber in the
29 opposite direction. The purpose of the differing
30 spring orientation between the upper and lower
31 stacks 48, 50 will be described subsequently.

32

1 The end mandrel 20 (shown in Fig. 1C) creates a
2 chamber 74 between the end mandrel 20 outer
3 circumference and the external housing 12 and
4 provides additional weight, which enhances the
5 acceleration produced by the impact enhancer
6 apparatus in order to increase impact force
7 generated by a drilling jar also located in the
8 drill string.

9
10 The uppermost seal housing 22 of the external
11 housing 12 provides a fluid chamber 75 that is
12 provided with a moveable balance piston 78 and a
13 seal 80. A fluid port 76 which is open to the
14 surrounding wellbore is also provided through the
15 wall of the uppermost seal housing 22. A plug 82 is
16 provided on the seal housing 22 to obturate another
17 part but which is located below the balance piston
18 78, such that hydraulic fluid can be inserted into
19 the annulus between the external housing 12 and
20 internal mandrel 10. This arrangement prevents any
21 pressure differential from building up across the
22 wall of apparatus since any relative increase in
23 pressure below the piston 78 will be compensated for
24 by the piston 78 moving upwardly and any relative
25 decrease in pressure below the piston 78 will be
26 compensated for by the piston 78 moving downward.
27 This has the advantage of preventing the build up of
28 a pressure differential (which may damage or
29 otherwise adversely affect operation of the tool)
30 across the wall of the apparatus whilst avoiding
31 hydraulic fluid in the apparatus from mixing with
32 the oil/other material surrounding the apparatus.

1

2 The upper abutment housing 24 is provided with an
3 internal shoulder 84 which is positioned such that
4 it provides an impact surface 84 against which the
5 lower impact surface 44 of the stop 40 may come to
6 rest. (A shoulder 102 is provided on the spline 32
7 to provide an impact surface against which the upper
8 impact surface 42 of the stop 40 may come to rest;
9 this will be described in more detail subsequently).

10

11 The lower abutment housing 26 comprises a
12 substantially tubular member having a constant inner
13 circumference within which the compression stacks
14 48, 50 are located.

15

16 The lower seal housing 29 provides a fluid chamber
17 74, which has a moveable balance piston 94. The
18 lower seal housing 29 arrangement prevents any
19 pressure differential from building up across the
20 wall of apparatus by providing a similar
21 compensation system to that previously described for
22 the upper seal housing 22.

23

24 The lowermost connecting housing 28 has a pin
25 section 98 provided with a standard tapered thread
26 portion 100 which allows connection to a standard
27 box section of the upper end of a lower portion of
28 the drill string (not shown).

29

30 It should be noted that a series of inwardly
31 protruding shoulders 102, 104, 106 and 108 are
32 created by the connections between each of the

1 components making up the external housing 12.
2 Outwardly projecting shoulder 54 is also created on
3 the internal mandrel 10 by the connection between
4 lower abutment mandrel 18 and lowermost end mandrel
5 20 of the internal mandrel 10.

6
7 With reference to Figs. 2, 3 and 4, one embodiment
8 of a connection means in accordance with the second
9 aspect of the present invention will now be
10 described; in this embodiment the connection means
11 is incorporated into the impact enhancer apparatus
12 10; 12 of Figs. 1A to 1C. The connection means
13 comprises an inner or male pin 114 which when
14 connected resides within an outer or female box 116.
15 A threaded portion 118 is provided on the outer
16 circumference of the pin 114 and is formed such that
17 it co-operates with a corresponding threaded portion
18 120 formed on the inner circumference of the box
19 116. As shown in Figs. 2c and 3c, the threaded
20 portions 118, 120 typically comprise a 'v' shaped
21 profile but could, in alternative embodiments
22 comprise square form, buttress, trapezoided or acme
23 type threads.

24
25 The threaded portions 118 and 120 are at or near
26 parallel with the longitudinal axis L of the
27 apparatus upon which the connection means is
28 provided and thus are referred to as parallel
29 threads (as opposed to tapered threads commonly
30 used, for instance, in drill pipe connections). The
31 pin 114 has a shallow 'v' shaped or gull winged
32 shaped indentation 122, 124 on its longitudinally

1 outermost end face (i.e. the leftmost portion of the
2 pin shown in Fig. 4) which comprises a tapered wall
3 122 and a flat wall 124 as shown in Fig. 4 and which
4 will provide a secondary shoulder surface as will be
5 described subsequently. The tapered wall 122 is
6 angled with respect the perpendicular axis to the
7 longitudinal axis L of the male pin 114. As shown
8 in Fig. 4, the tapered wall 122 is angled at
9 approximately 15 degrees, from radially innermost to
10 outermost, away from the rest of the pin 114 (i.e.
11 the rest of the pin 114 to the right of the flat
12 wall 124) and so is angled, from radially innermost
13 to outermost, away from the parallel thread 118.

14

15 Pin 114 also has a box receiving shoulder 128 which
16 is distal of the tapered wall 122 and which is
17 located radially outer and longitudinally inner of
18 the thread 118, where the shoulder 128 will provide
19 a primary shoulder surface as will be described
20 subsequently. The shoulder 128 is angled with
21 respect the perpendicular axis to the longitudinal
22 axis L of the male pin 114 at approximately 15
23 degrees, from radially innermost to outermost,
24 toward the rest of the pin 114 (i.e. the rest of the
25 pin 114 to the left of the shoulder 128) and so is
26 angled, from radially innermost to outermost, toward
27 the parallel thread 118.

28

29 Accordingly, the thread 118 is located radially and
30 longitudinally between the shoulder 128 and the
31 tapered wall 122.

32

1 The outer box 116 has a single tapered face 126
2 which provides a primary shoulder surface and which
3 is angled with respect to an axis perpendicular to
4 the longitudinal axis L of the outer female box 116.
5 The tapered face 126 is angled at approximately 15
6 degrees, from radially innermost to outermost,
7 toward the rest of the outer female box 116 (i.e.
8 the rest of the box 116 to the left of the tapered
9 face 126) and so is angled, from radially innermost
10 to outermost, toward the parallel thread 120 by
11 substantially the same angle as that of the box
12 receiving shoulder 128. The outer box 116 also has
13 tapered pin receiving shoulder 130 which is distal
14 of the tapered face 126 and which is located
15 radially and longitudinally inner of the female
16 thread 120 and which will provide a secondary
17 shoulder surface. As shown in Fig. 4, the pin
18 receiving shoulder 130 is angled at approximately 15
19 degrees, from radially innermost to outermost, away
20 from the rest of the box 116 (i.e. the rest of the
21 box 116 to the right of the pin receiving shoulder
22 130) and so is angled, from radially innermost to
23 outermost, away from the parallel thread 120.
24 Thus the tapered pin receiving shoulder 130 is
25 provided with a substantially similar taper angle as
26 that of tapered wall 122.

27

28 Accordingly, the thread 120 is located radially and
29 longitudinally between the tapered face 126 and the
30 tapered pin receiving shoulder 130.

31

1 It should be noted that box 116 is at least equal
2 to, or preferably slightly longer than the length of
3 inner pin 114 as will be discussed subsequently.

4
5 As shown in Fig. 1a, the connection means may be
6 provided on both ends of a double shouldered spline
7 32. Each double shouldered spline 32 comprises a
8 pin 114 and box section 116 which respectively
9 connect to a box and pin section in accordance with
10 the first aspect of the present invention of another
11 component of the apparatus upon which the spline 32
12 is installed.

13
14 Referring to Fig. 4, pin 114 is screwed into the box
15 section 116 when the impact enhancing tool is
16 assembled and threads 120 and 118 co-operate to
17 cause tapered face 126 of the box 116 to abut
18 against box receiving shoulder 128 and thereby
19 provides a primary (external of the thread) shoulder
20 junction. This creates a metal to metal seal
21 between the tapered face 126 and the shoulder 128
22 and also provides a primary shoulder between the pin
23 114 and box 116 into which torque can be delivered
24 and stored.

25
26 Tapered wall 122 also abuts against pin receiving
27 shoulder 130 thereby creating a secondary (internal
28 of the thread) metal to metal seal between the
29 tapered face 126 and the shoulder 128 and also
30 providing a secondary shoulder joint between the pin
31 114 and box 116 into which torque can be delivered
32 and stored; however, as discussed previously, the

1 length of box 116 is manufactured such that it is at
2 least equal to that of pin 114, and is preferably
3 slightly longer (in the order of 0.15 mm) than the
4 length of pin 114. This ensures that the seal
5 created between face 126 and shoulder 128 is made
6 before the seal between wall 122 and shoulder 130
7 and thus the seal between face 126 and shoulder 128
8 is regarded as the primary shoulder joint and the
9 internal seal between the wall 122 and shoulder 130
10 is regarded as the secondary shoulder joint.

11
12 When the impact enhancing tool is located in a drill
13 string along with a drilling jar and the drill
14 string is compressed when, for example, downward
15 jarring is required (or tensioned when, for example,
16 upward jarring is required) pin 114 is prevented
17 from splaying inwardly toward the longitudinal axis
18 L of the apparatus upon which the connection means
19 is provided due to the abutment between the tapers
20 on wall 122 and shoulder 130. The pin 114 is also
21 prevented from diving outwardly (away from the
22 longitudinal axis L) due to a support means in the
23 form of support ledge 140 on the box section 116,
24 where the support ledge 140 is arranged to lie on an
25 axis substantially parallel and co-axial to the
26 longitudinal axis L of the female box section 116.
27 As shown in Fig. 6, the support ledge 140 is
28 arranged radially outwardly of and longitudinally
29 outwardly of the pin receiving shoulder 130 and is
30 therefore located radially inwardly of and
31 longitudinally inwardly of the female thread 120.

32

1 Box section 116 is prevented from splaying outwardly
2 away from the longitudinal axis L of the apparatus
3 due to the taper on wall 126 and shoulder 128. The
4 box 116 is also prevented from diving inwardly
5 (toward longitudinal axis L) due to a support ledge
6 142 on the pin section 114. As shown in Fig. 6, the
7 support ledge 142 is arranged radially inwardly of
8 and longitudinally outwardly of the male shoulder
9 128 and is therefore located radially outwardly of
10 and longitudinally inwardly of the male thread 118.

11
12 This provides a very secure joint which will
13 withstand very high torsional forces without the pin
14 114 or box 116 sections splaying or diving
15 inwardly/outwardly since the combined effect of the
16 support ledges 140, 142 and tapered surfaces 122,
17 130; 126, 128 substantially prevents movement of the
18 male pin 114 and female box 116 in the radial
19 direction. The joint created by the connection
20 means also discourages unintentional backing off
21 (i.e. unscrewing) of the components of the apparatus
22 upon which the connection means is provided since a
23 large rotational force would be required in order to
24 overcome the friction between the primary or
25 external shoulder joint 126; 128 (face 126 and wall
26 128) and secondary or internal shoulder joint 122;
27 130 (face 122 and wall 130) once the desired make up
28 torque has been applied to the connection.

29
30 The parallel arrangement of threaded portions 118
31 and 120 allow a secure connection to be created
32 between two tubulars whilst using a minimal amount

1 of borehole space/radial distance i.e. the joints do
2 not encroach on the internal bore more than
3 absolutely necessary since no taper is required on
4 the threaded portions 118 and 120.

5
6 In addition, the connection means prevents over
7 stretching of the pin 114 and box 116 sections
8 (which often occurs in standard tapered thread pin
9 and box joints) occurring both during connection of
10 the tubulars and during operation of the drill
11 string. Any tendency for the pin 114 or box 116 to
12 over stretch is avoided by the inability of the pin
13 114 and box 116 to increase in length due to the
14 respective shoulders 122; 130 and 126; 128.

15
16 Accordingly, the connection means permit a much
17 higher level of torque to be applied to itself when
18 screwing the connections together when compared to
19 conventional connections which is particularly
20 useful in extended reach/horizontal wells.

21
22 The connection means is not limited to use on the
23 spline 32 and indeed the impact enhancing apparatus
24 shown in Figs. 1a, 1b and 1c is provided with
25 further joints J1, J2, J3 and J4 which each have a
26 similarly tapered arrangement and threaded portions
27 which are substantially parallel to the longitudinal
28 axis L of the impact enhancing apparatus.

29 Furthermore, the connection means is not limited to
30 use on an impact enhancing apparatus and indeed it
31 may be used on virtually any tool or tubular where a
32 high torque connection between tubular members may

1 be required e.g. drilling jar, accelerators, drill
2 pipe, flow circulation tools, shock tools, thrusters
3 and bumper subs etc. and any other suitable BHA
4 tools.

5
6 In operation, the impact enhancer apparatus is
7 installed in the drill string prior to inserting the
8 drill string downhole, and is normally installed
9 above a drilling jar (not shown). In the event that
10 the drill string becomes stuck downhole (due to, for
11 example, the drill bit becoming lodged in the
12 formation being drilled) the impact enhancer helps
13 free the drill string by increasing the jarring
14 force exerted by the jar apparatus.

15
16 Depending upon the nature of the jam between the
17 drill string and the formation, the operator may
18 chose to jar the drill string in the upward or the
19 downward direction, or by alternating between both
20 directions. When jarring the drill string in the
21 upward direction, it is desirable that the impact
22 enhancer is capable of storing a large amount of
23 energy since drill strings are inherently able to
24 withstand high tensile forces. However, when
25 jarring the drill string in the downward direction
26 it is desirable that a smaller amount of energy be
27 stored in the impact enhancer apparatus since drill
28 strings are inherently less able to withstand high
29 compressive forces. Conventional double acting
30 impact enhancers allow this to be done; however,
31 such conventional impact enhancers require complete
32 compression of the resilient means when the high

1 compressive force is exerted on the drill string.
2 This is undesirable since such complete compression
3 is likely to result in buckling of the drill string.
4

5 When jarring the drill string in the upward
6 direction, the upper portion of the drill string is
7 pulled upwardly by the operator via the drilling rig
8 (not shown). This exerts an upward force on the
9 internal mandrel 10 with respect to the external
10 housing 12 (which is prevented from moving upwardly
11 due to the stuck drill bit (not shown)). The upward
12 movement of the internal mandrel 10 causes outwardly
13 projecting shoulder 54 on lowermost end mandrel 20
14 to abut against adjuster 72 which causes the lower
15 spring stack 50 to be forced against spacer collar
16 52. Spacer collar 52 in turn pushes upper spring
17 stack 48 against inwardly protruding shoulder 104 on
18 the external housing 12. The skilled reader will
19 therefore note that at this point both the upper 48
20 and lower 50 spring stacks are being compressed as
21 the inner mandrel 10 moves upwardly, and thus
22 storage of energy is built up within both lower 48
23 and upper 50 spring stacks. However, the
24 arrangement of the disk springs on the lower spring
25 stack 50 allows the lower spring stack 48 to be
26 compressed more easily than the upper spring stack
27 50, therefore the lower spring stack 48 will tend to
28 compress far more under pressure than the upper
29 spring stack 48 at this point.

30

31 Referring to Figs. 1a to 1c, the arrangement of the
32 spring stacks 48 and 50 will now be described. The

1 upper spring stack 48 comprises sets of four disks
2 arranged adjacent each other in parallel. For
3 illustrative purposes only, if the maximum
4 compression allowable by each disk is say 10mm, then
5 the total compression distance available by
6 completely flattening all eight disks in each pair
7 of four disks is 20mm. However, if the disks are
8 arranged in sets of two in parallel in the lower
9 spring stack 50, the total compression distance
10 available by completely flattening four disks (i.e.
11 two sets of two disks in parallel) is 20mm but only
12 requires half the compression force. Therefore when
13 the primary stack 50 is compressed by a force F , the
14 resulting compression displacement will be the same
15 as the secondary stack under twice the force F .

16
17 Whilst each spring stack 48, 50 is being compressed,
18 the lower shoulder 46 on the female socket 242 of
19 the lower abutment mandrel 18 gradually moves away
20 from the lower spring stack 50 and toward the upper
21 spring stack 48. When the upper shoulder 244 meets
22 the upper stack 48, further compression of the lower
23 stack 50 is avoided since further upward movement of
24 the internal mandrel 10 allows the spacer collar 52
25 to move upward since the lower end of the upper
26 spring stack 48 is now forced upward by and thus is
27 supported by surface shoulder 244 of the female end
28 socket 242. Thus, continued upward movement of the
29 internal mandrel 10 results in continued compression
30 of the upper spring stack 48 but no further
31 compression of the lower spring stack 50. This is
32 advantageous since total compression of the disk

1 springs of the lower spring stack 50 is avoided. As
2 will be understood by the skilled reader, pulling
3 against the large resilient force provided by the
4 stacks 48, 50 requires very large forces to be
5 exerted on internal mandrel 10. This force is
6 provided by pulling upon the internal mandrel 10 via
7 the drill string using the drill rig (not shown).

8
9 When the jar apparatus (not shown) located in line
10 with the present impact enhancer apparatus is fired
11 in the upward direction, the energy stored within
12 the upper and lower stacks 48 and 50 is released due
13 to the disk springs wishing to return to their
14 relaxed configuration as shown in Figs. 1a to 1c.
15 This release of energy will act on the inner mandrel
16 10 to provide a large acceleration force on the
17 external housing 12 which accelerates the inner
18 mandrel of the jar apparatus causing a far greater
19 impact to occur between the hammer and anvil (or
20 other) on the jar apparatus. In this regard it
21 should be noted that the outer housing 12 of the
22 impact enhancer is connected to the inner mandrel of
23 the jar apparatus.

24
25 When jarring the drill string in the downward
26 direction, the upper portion of the drill string is
27 effectively pushed downwardly by the operator via
28 the drilling rig (not shown) by letting off weight
29 at the drilling rig. This exerts a downward force
30 on the internal mandrel 10 with respect to the
31 external housing 12 (which is prevented from moving
32 downwardly due to the stuck drill bit (not shown)).

1 The downward movement of the internal mandrel 10
2 causes lower shoulder 46 on the female end socket
3 242 to compress lower spring stack 50 against the
4 adjuster 72 (adjuster 72 being prevented from moving
5 any further down the apparatus due to inwardly
6 projecting shoulder 106 on the external housing 12).
7 The upper spring stack 48 is not compressed by
8 downward movement of the inner mandrel 10 since the
9 lower spring stack is compressed by shoulder 46.
10 Therefore, the upper spring stack 48 simply moves
11 along with shoulders 30, 46 and spacer collar 52
12 without being compressed therebetween.

13

14 When the jar apparatus (not shown) located in line
15 with the present impact enhancer apparatus is fired
16 in the downward direction, only the resilient force
17 from the energy stored in the lower stack 50 acts on
18 the external housing 12 to provide an acceleration
19 force on the external housing 12 which accelerates
20 the inner mandrel of the jar apparatus thereby
21 causing a far greater impact to occur between the
22 hammer and anvil (or other) on the jar apparatus.

23

24 It should be noted that the double headed hammer 40
25 acts in conjunction with shoulders 84 and 102 to act
26 as stroke limiters which prevent over stressing of
27 spring stacks 48 and 50.

28

29 The stroke length of the impact enhancer apparatus
30 is designed such that it is less than the stroke
31 length of the jar apparatus with which it is used.
32 This ensures that the impact enhancer imparts all of

1 its acceleration force upon the hammer (not shown)
2 of the jar apparatus before the jarring impact
3 occurs.

4
5 Modifications and improvements may be made to the
6 foregoing without departing from the scope of the
7 present invention. For instance, the parallel
8 threads 118, 120 could in certain circumstances, be
9 replaced by linearly tapering threads if, for
10 instance, increasing the radial extent of the
11 connection was acceptable in a given downhole tool
12 or other tubular member. It should also be noted
13 that the outer circumference of the tubular members
14 described herein, whilst nearly always being
15 circular in cross section, need not be so since they
16 could have, for instance, a square, hexagonal or
17 other cross section, particularly in the areas in
18 between the connection means.

19

CLAIMS

1. An impact enhancer apparatus comprising:
 - a substantially tubular inner member;
 - a substantially tubular outer member which is axially movable in relation to the inner member; and
 - a primary energy storage device adapted to store energy when the inner member is moved in either of upward and downward axial directions with respect to the outer member; and
 - a secondary energy storage device adapted to store energy when the inner member is moved in the upward axial direction with respect to the outer member;wherein the primary and secondary energy storage device are adapted to resist movement of the inner member in the upward axial direction with respect to the outer member with a larger resistive force than when the primary energy storage device resists movement of the inner member in the downward axial direction with respect to the outer member.
2. An impact enhancer apparatus according to claim 1, wherein the primary energy storage device comprises a primary biasing device.
3. An impact enhancer apparatus according to claim 2, wherein the primary biasing device is any one of a spring device selected from the group consisting of: disk springs; coiled springs; fluid and gas springs.
4. An impact enhancer apparatus according to claim 1, wherein the secondary energy storage device comprises a secondary biasing device.
5. An impact enhancer apparatus according to claim 4, wherein the secondary biasing device is any one of a spring device selected from the group consisting of: disk springs; coiled springs; fluid and gas springs.

6. An impact enhancer apparatus according to claim 1, wherein the primary energy storage device is adapted to store energy when compressed by movement of the inner member in either of the first and second axial directions with respect to the outer member.
7. An impact enhancer apparatus according to claim 1, wherein the secondary energy storage device is adapted to store energy when compressed by movement of the inner member in the first axial direction with respect to the outer member.
8. An impact enhancer apparatus according to claim 1, wherein the primary energy storage device is adapted to resist upward movement of the inner member with respect to the outer member by a first resilient force when the inner member is displaced to an upward displacement boundary.
9. An impact enhancer apparatus according to claim 8, wherein the secondary energy storage device is adapted to resist upward movement of the inner member with respect to the outer member by a second resilient force when the inner member is displaced past the upward displacement boundary.
10. An impact enhancer apparatus comprising:
 - a substantially tubular inner member;
 - a substantially tubular outer member which is axially movable in relation to the inner member; and
 - a primary energy storage device adapted to store energy when the inner member is moved in either of upward and downward axial directions with respect to the outer member; and
 - a secondary energy storage device adapted to store energy when the inner member is moved in the upward axial direction with respect to the outer member;wherein the primary energy storage device is adapted to provide a lower level of resistive force to compression than that provided by the secondary energy storage device.

11. An impact enhancer apparatus according to claim 10, wherein the difference in the level of resistive force provided by the energy storage device is determined due to the orientation of the energy storage device which selectively results in a greater or lesser compression displacement when substantially the same force is placed upon the energy storage device.

12. An impact enhancer apparatus comprising:

a substantially tubular inner member;

a substantially tubular outer member which is axially movable in relation to the inner member; and

a primary energy storage device adapted to store energy when the inner member is moved in either of upward and downward axial directions with respect to the outer member; and

a secondary energy storage device adapted to store energy when the inner member is moved in the upward axial direction with respect to the outer member;

wherein the primary energy storage device comprises a plurality of spring disks oriented in the same direction as one another;

wherein the plurality of disks in the primary energy storage device are arranged with a number of disks oriented in one direction alternating with a number of disks oriented in the other direction.

13. An impact enhancer apparatus according to claim 12, wherein the secondary energy storage device comprises a plurality of spring disks oriented in the same direction as one another.

14. An impact enhancer apparatus according to claim 13, wherein the plurality of disks in the secondary energy storage device are arranged with a greater number of disks of the primary energy storage device oriented in one direction alternating with the same greater number of spring disks oriented in the other direction.

15. An impact enhancer apparatus comprising:

a substantially tubular inner member;

a substantially tubular outer member which is axially movable in relation to the inner member; and

a primary energy storage device adapted to store energy when the inner member is moved in either of upward and downward axial directions with respect to the outer member; and

a secondary energy storage device adapted to store energy when the inner member is moved in the upward axial direction with respect to the outer member;

wherein the primary and secondary energy storage devices are located in a respective annulus formed between the inner and outer members;

wherein the primary energy storage device is further located between a second arrangement of upper and lower shoulders formed on the inner member and a lower shoulder formed on the outer member and a lower shoulder formed on a moveable member;

wherein the secondary energy storage device is further located between a first arrangement of upper and lower shoulders formed on the inner member and an upper shoulder formed on the outer member and an upper shoulder formed on a moveable member;

wherein the moveable member is located in the annulus located between the primary and secondary energy storage devices; and

wherein the moveable member comprises a greater axial extent and thus a greater distance between its upper and lower shoulders than the distance between the inner member lower shoulder of the first arrangement and the inner member upper shoulder of the second arrangement.

16. An impact enhancer apparatus according to claim 15, wherein the impact enhancing apparatus is arranged such that, in the absence of compression to the energy storage device, the distance between the upper shoulder of the first arrangement and the upper shoulder of the second arrangement substantially equals the distance between the upper shoulder of the outer member and the lower shoulder of the moveable member.

17. A method of increasing the jarring force imparted by a jar apparatus comprising:
providing a substantially tubular inner member;
providing a substantially tubular outer member;
providing an energy storage device capable of storing greater energy therein due to upward movement of the inner member with respect to the outer member;
wherein the energy storage device comprises a primary and a secondary energy storage device;
moving the inner member in the upward direction to thereby cause the primary and secondary energy storage device to be compressed;
including moving the inner member in the downward direction and moving the secondary energy storage device with the inner member to thereby cause only the primary energy storage device to be compressed.
18. A method according to claim 17, including providing an upward displacement limit so that on reaching the upward displacement limit, further upward movement of the inner member causes the secondary energy storage device to be compressed further.
19. An impact enhancer apparatus comprising:
a substantially tubular inner member;
a substantially tubular outer member which is axially movable in relation to the inner member; and
a compressible primary energy storage device comprising a level of resistive force to compression and in which energy is stored due to compression thereof when the inner member is moved in either of first and second axial directions with respect to the outer member;
a compressible secondary energy storage device comprising a level of resistive force to compression and in which energy is stored due to compression thereof but only when the inner member is moved in the first axial direction with respect to the outer member;
wherein the apparatus permits more energy to be stored, in both the primary and secondary energy storage devices, when the inner member is moved in the first axial

direction over a certain distance with respect to the outer member compared with the amount of energy permitted to be stored in the primary energy storage device when the inner member is moved in the second axial direction over the same distance.

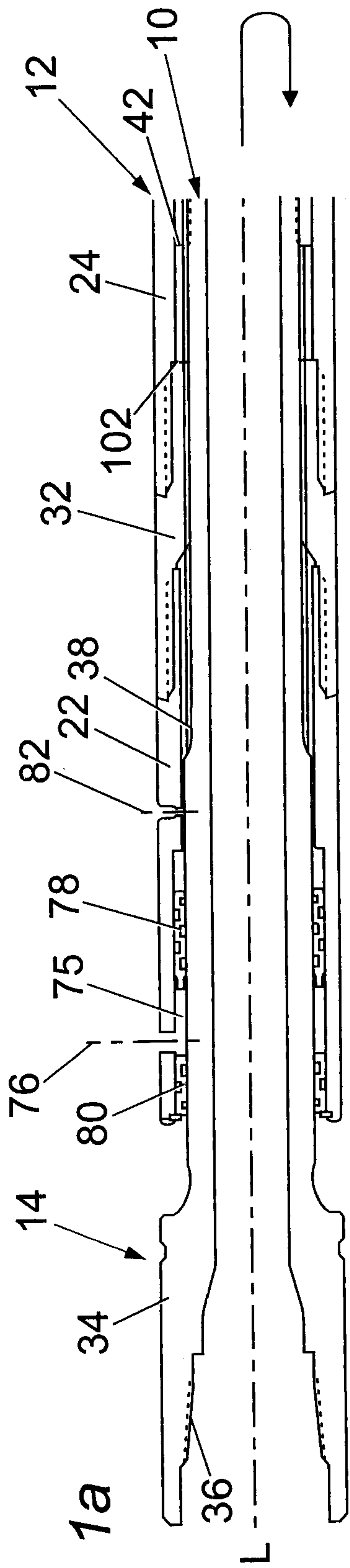


Fig. 1a

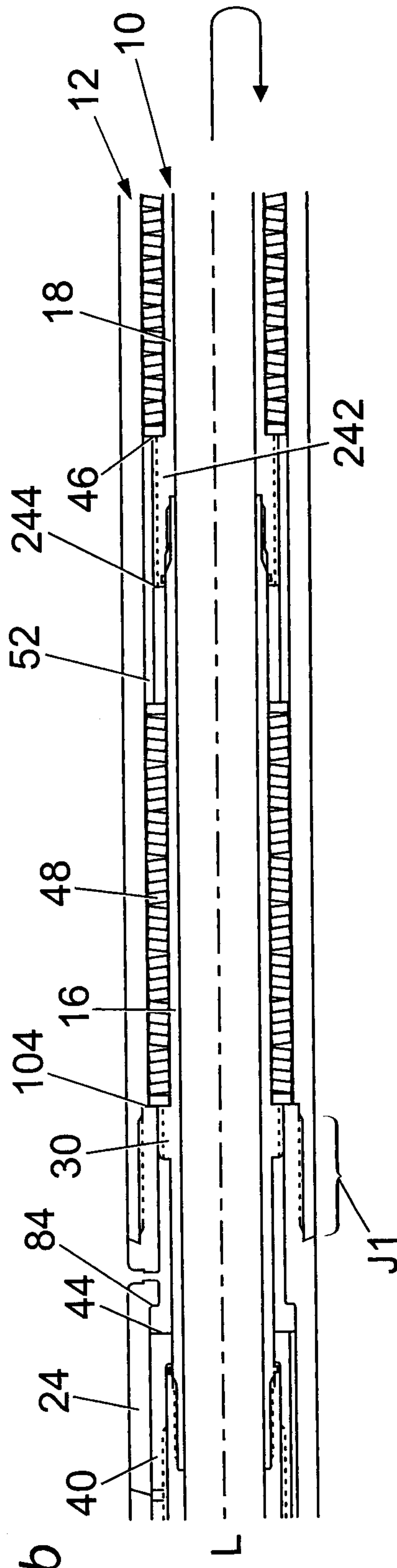


Fig. 1b

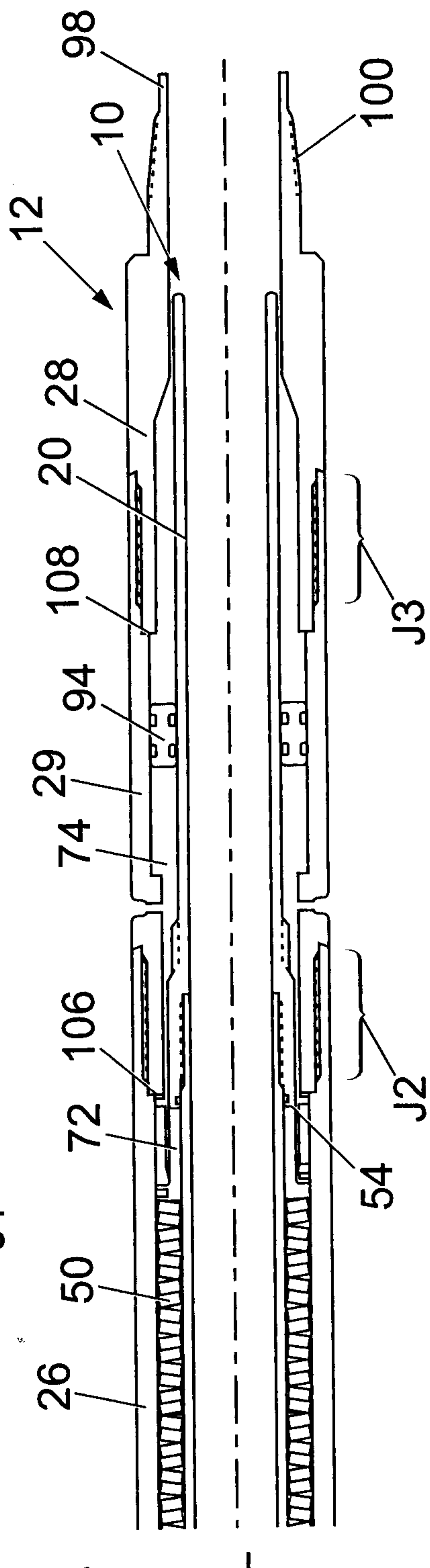


Fig. 1c

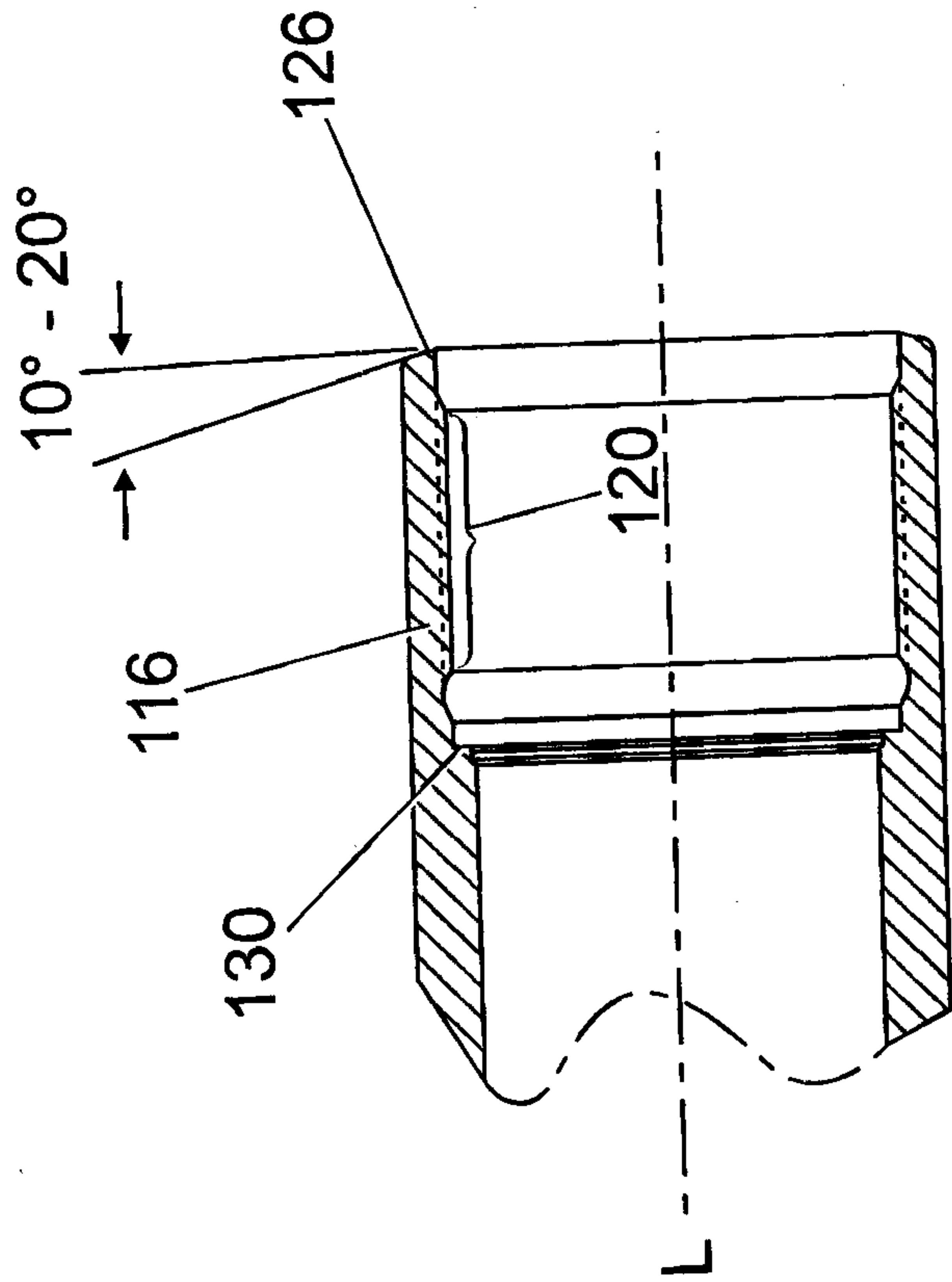


Fig. 2a

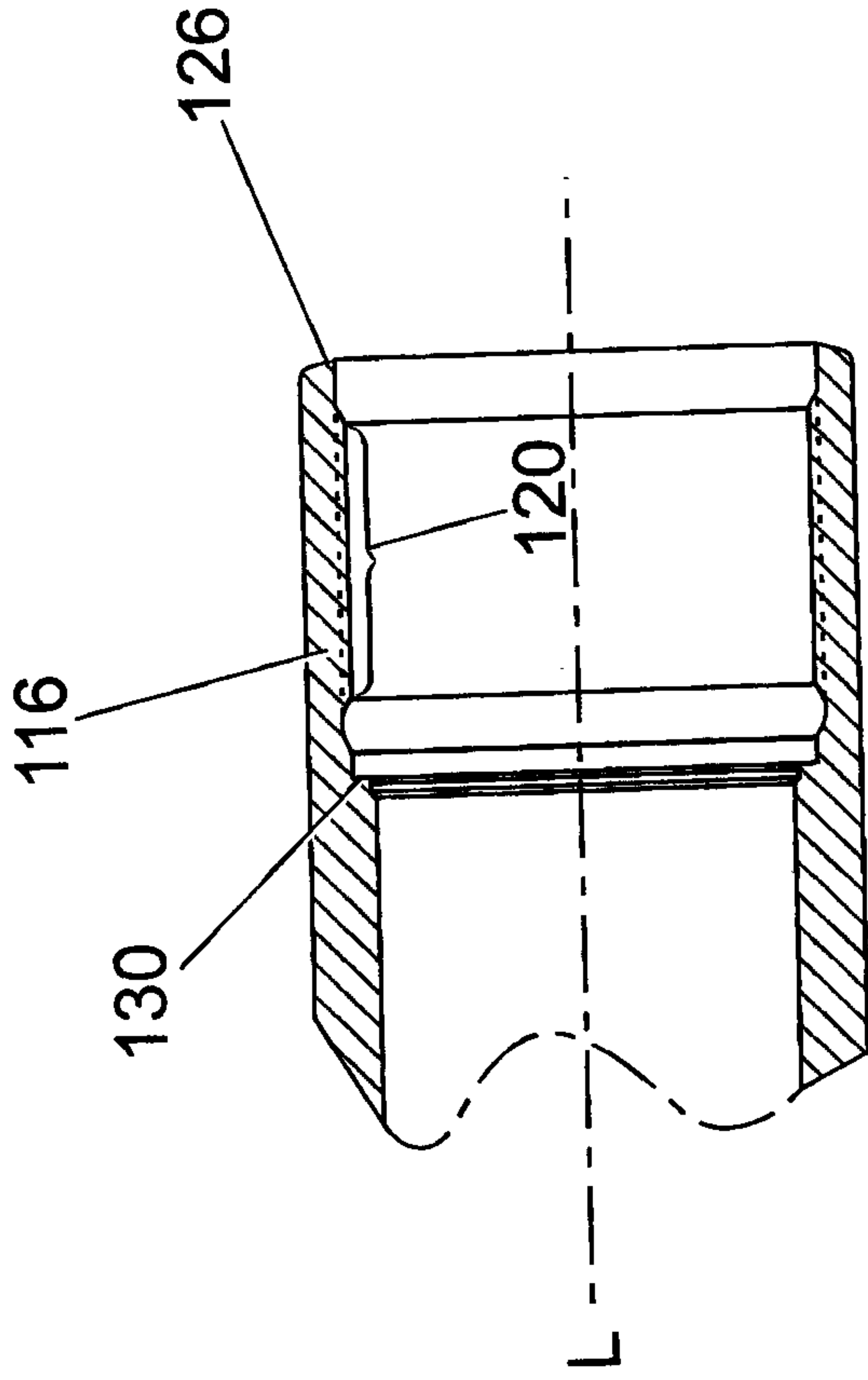


Fig. 2b

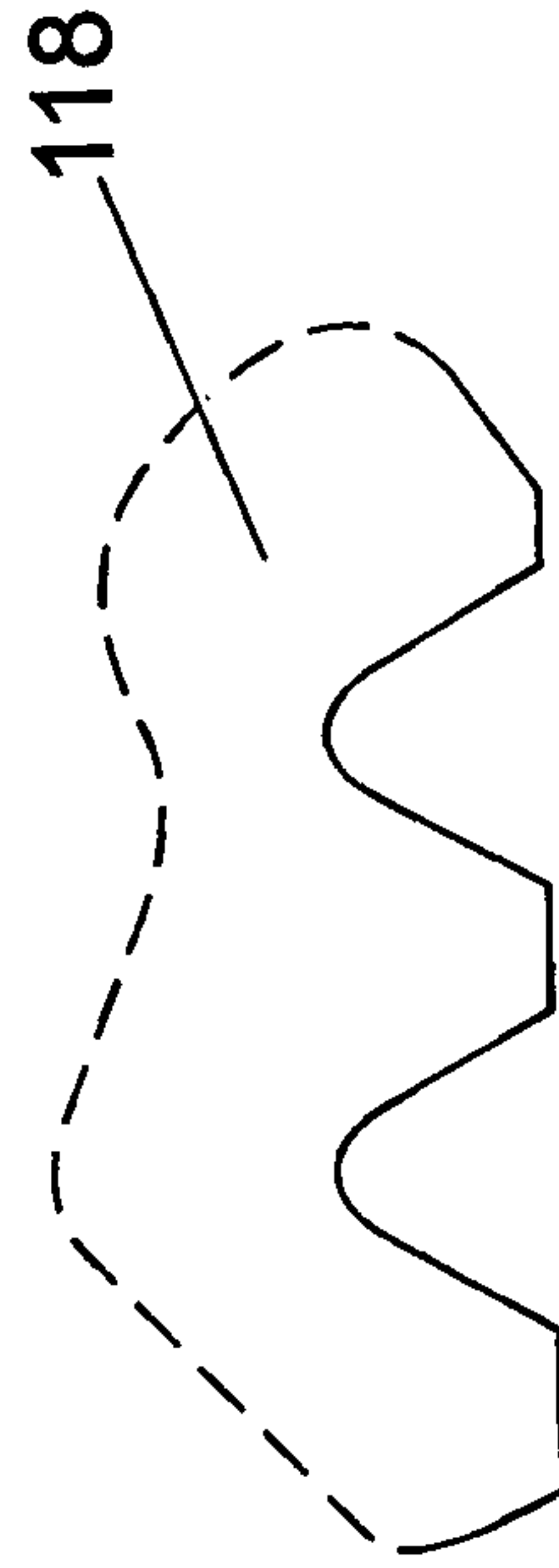


Fig. 2c

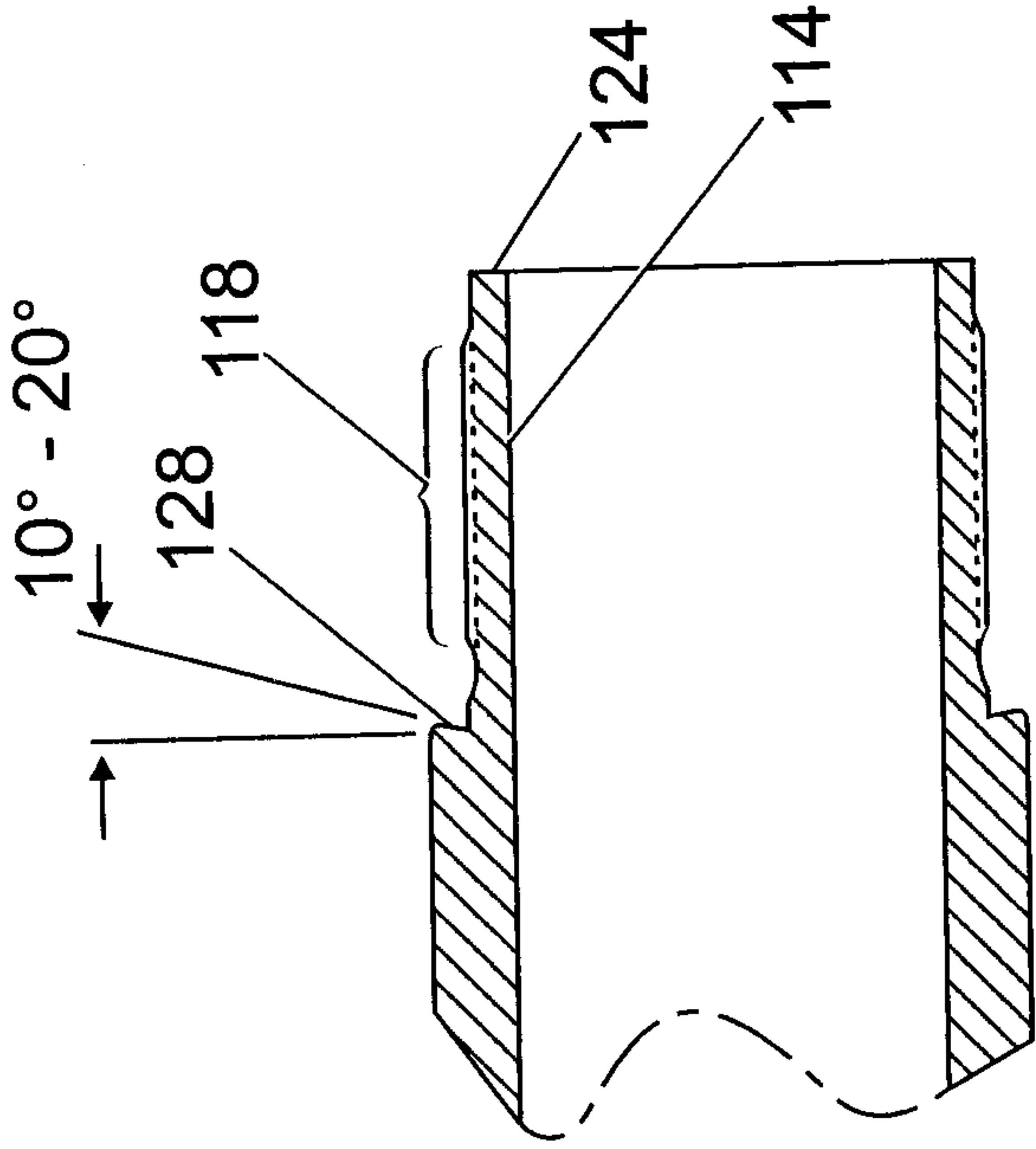


Fig. 3a

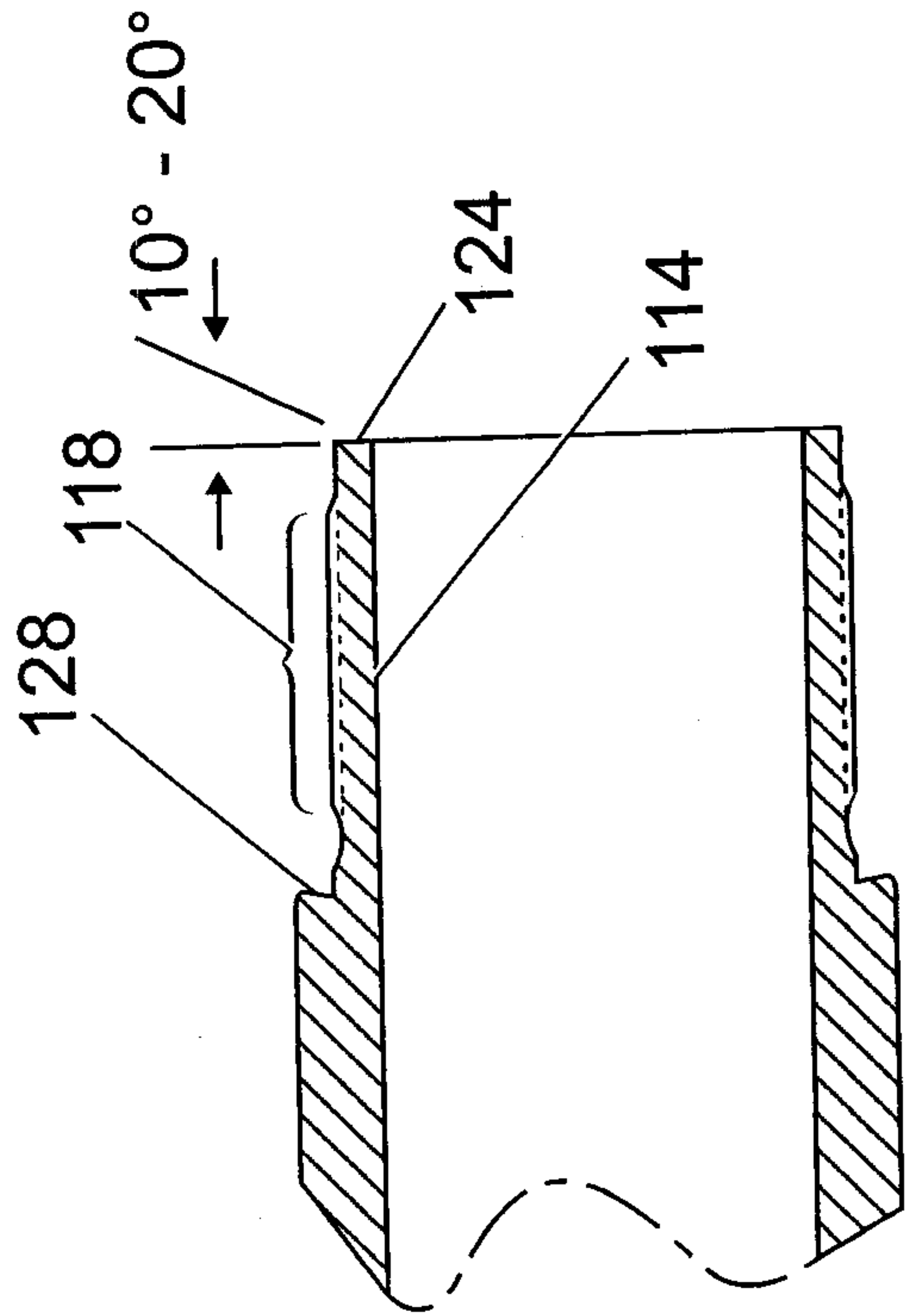


Fig. 3b

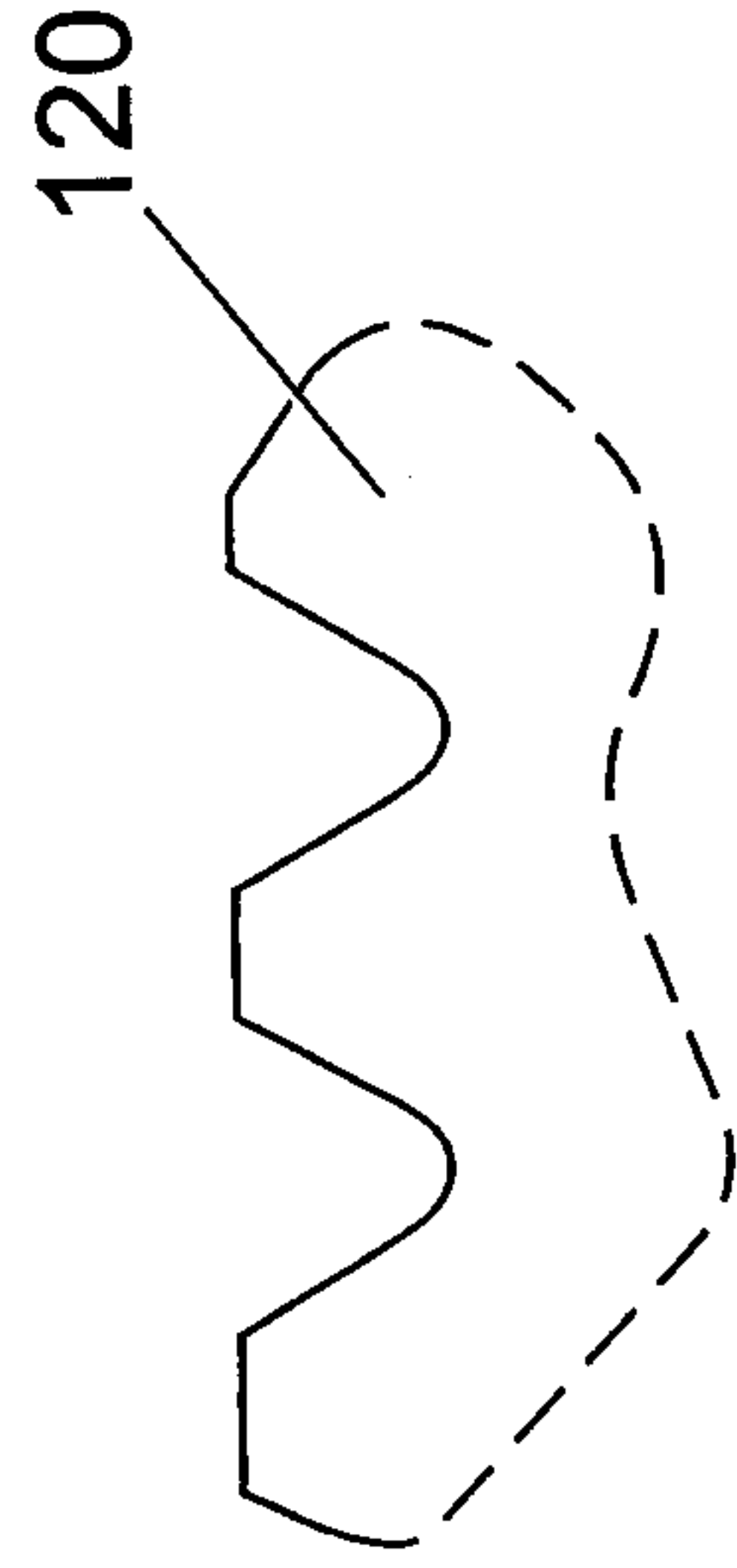


Fig. 3c

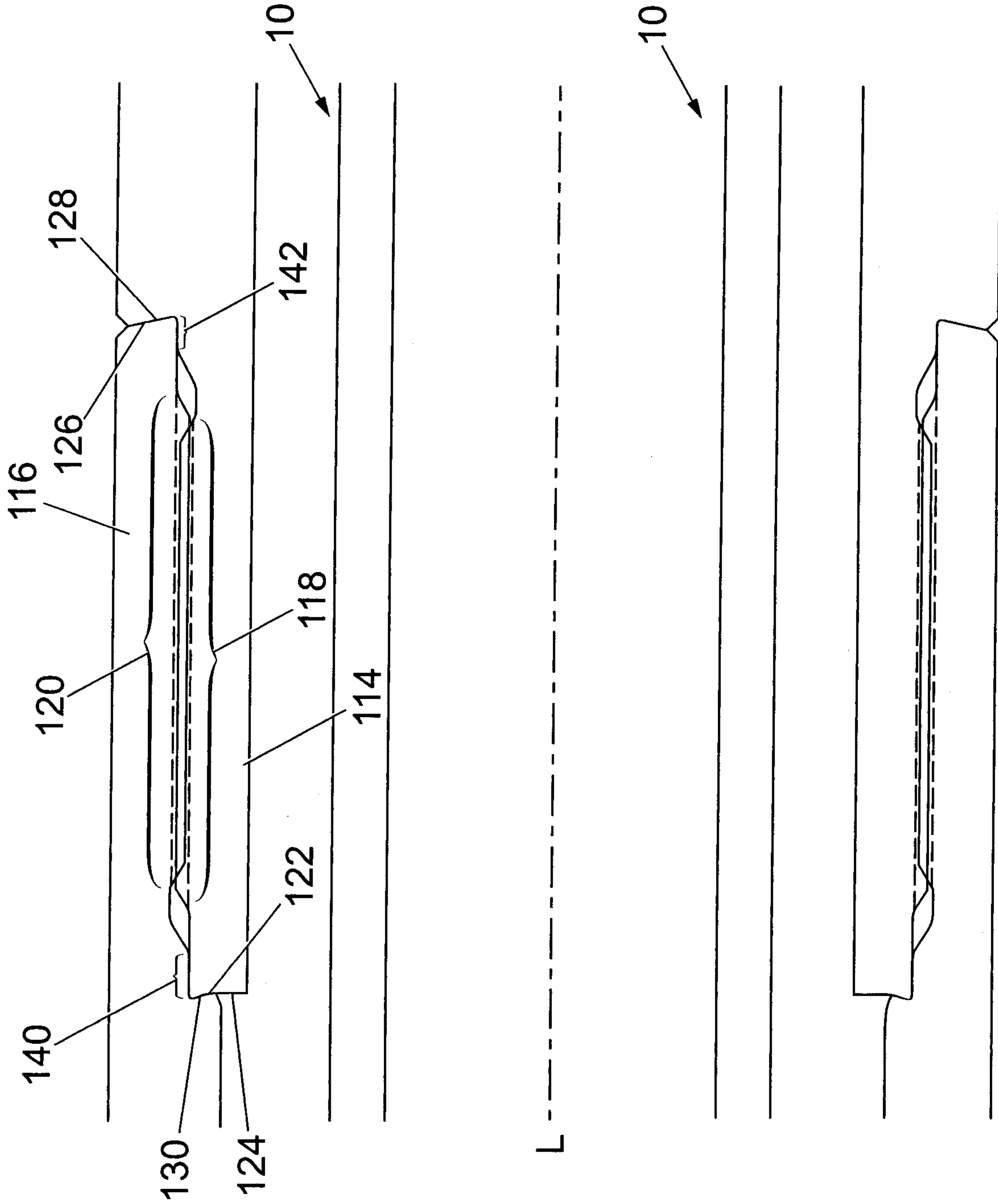


Fig. 4

