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(72) Inventeurs/Inventors:

WELLS, LAWRENCE E., US;

WALLIHAN, BRETT GREGORY, US

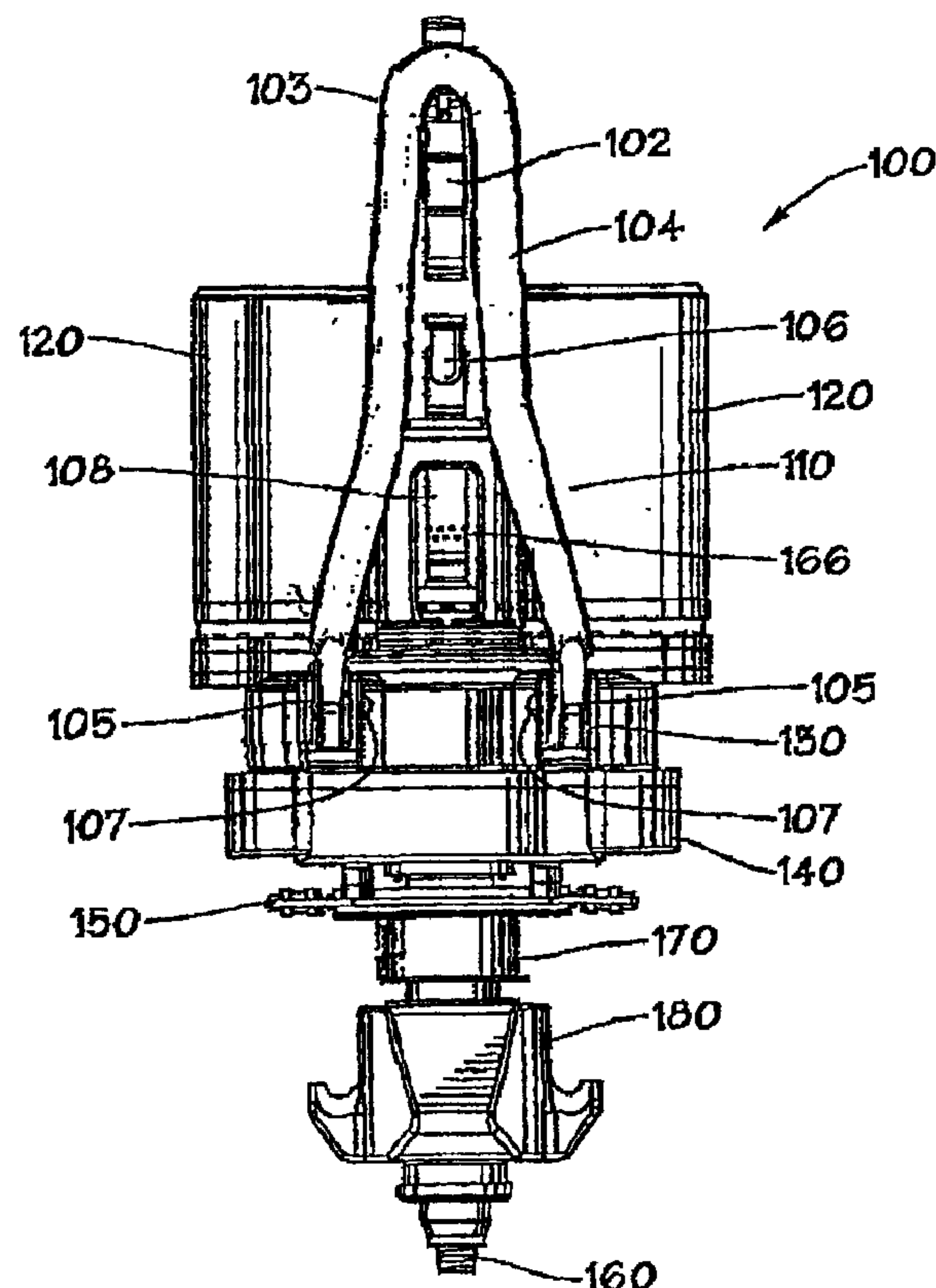
(73) Propriétaire/Owner:

NATIONAL OILWELL VARCO, L.P., US

(74) Agent: MCFADDEN, FINCHAM

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(57) Abrégé/Abstract:

A bail for suspending a top drive, characterised in that the bail comprises a first upper leg portion (16) extending down from a head portion (14) and a second upper leg portion (16a) extending down from the head portion (14), a first lower leg portion (18)

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

extending down from the first upper leg portion (16) and a second lower leg portion (18a) extending down from said second upper leg portion (16a), said first lower leg portion at an angle to said first upper leg portion and said second lower leg portion at an angle to said second upper leg portion.

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(71) Applicants (for all designated States except US): **NATIONAL OILWELL VARCO, L.P.** [US/US]; 7909 Parkwood Circle Drive, Houston, Texas 77036 (US). **LUCAS, Brian** [GB/GB]; Lucas & Co., 135 Westhall Road, Warlingham Surrey CR6 9HJ (GB).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **WELLS, Lawrence, E.** [US/US]; 4421 Ohio Street, Yorba Linda, CA 92886 (US). **WALLIHAN, Brett Gregory** [US/US]; 16191 Waikiki Lane, Huntington Beach, CA 92649 (US).

(74) Agent: **LUCAS, Phillip, Brian**; Lucas & Co., 135 Westhall Road, Warlingham Surrey CR6 9HJ (GB).

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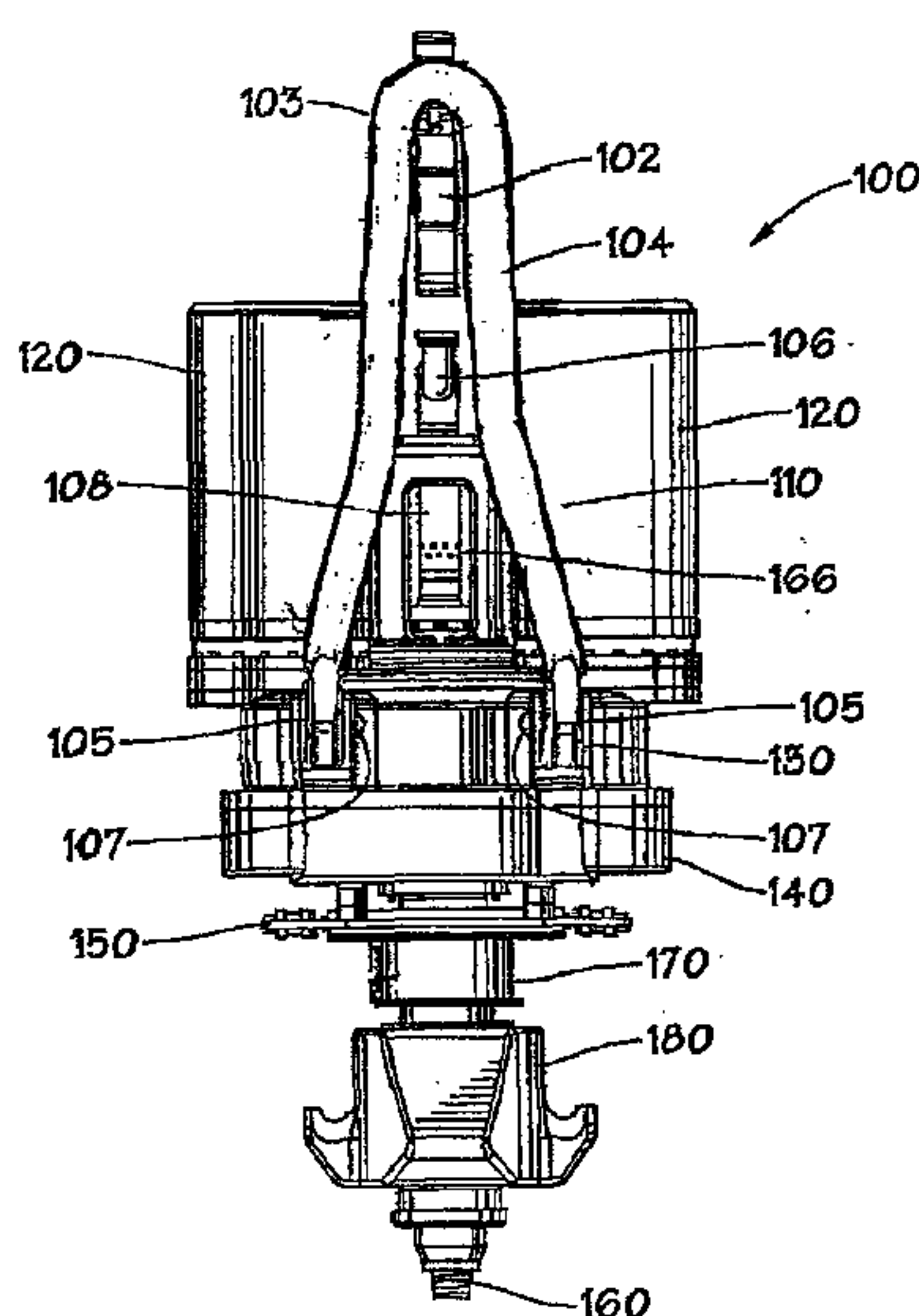
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(54) Title: TOP DRIVE APPARATUS AND BAILS THEREFOR

Fig. 1A



(57) Abstract: A bail for suspending a top drive, characterised in that the bail comprises a first upper leg portion (16) extending down from a head portion (14) and a second upper leg portion (16a) extending down from the head portion (14), a first lower leg portion (18) extending down from the first upper leg portion (16) and a second lower leg portion (18a) extending down from said second upper leg portion (16a), said first lower leg portion at an angle to said first upper leg portion and said second lower leg portion at an angle to said second upper leg portion.

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5 TOP DRIVE APPARATUS AND BAILS THEREFOR

The present invention relates to top drive apparatus and bails therefor, and a method for suspending a top drive particularly, but not exclusively, for use in drilling oil and gas wells.

10 In the drilling of a borehole in the construction of an oil or gas well, a drill bit is arranged on the end of a drill string, which is rotated to bore the borehole through a formation. A drilling fluid known as "drilling mud" is pumped through the drill string to the drill bit
15 to lubricate the drill bit. The drilling mud is also used to carry the cuttings produced by the drill bit and other solids to the surface through an annulus formed between the drill string and the borehole. The density of the drilling mud is closely controlled to inhibit the borehole
20 from collapse and to ensure that drilling is carried out optimally. The density of the drilling mud effects the rate of penetration of the drill bit. By adjusting the density of the drilling mud, the rate of penetration changes at the possible detriment of collapsing the
25 borehole. The drilling mud contains expensive synthetic oil-based lubricants and it is normal therefore to recover and re-use the used drilling mud, but this requires the solids to be removed from the drilling mud.

A top drive apparatus for drilling bore holes, such
30 as oil and gas wells, is one of two common types of apparatus for drilling bore holes, the other being a rotary table apparatus. A top drive apparatus generally comprises a main body which houses a motor for rotating a drive shaft which has a sub connectable to a single, stand
35 or string of tubulars. The tubulars may be any of: drill pipe, casing, liner, premium tubular or any other such tubular used in the construction, maintenance and repair of wellbores, such as oil and gas wells. A top drive apparatus is generally arranged on a substantially

5 vertical track on a derrick of a rig. The top drive
apparatus is lifted and lowered on the track with a line
over a crown block on a travelling block connected to the
top drive apparatus. The line is reeled in and let out
using a winch commonly known as a drawworks. The top drive
10 apparatus can thus be used to trip tubulars in and out of
the wellbore; turn the drill string to facilitate drilling
the wellbore; and turn a single or stand of tubulars in
relation to a string of tubulars hung in the wellbore to
threadly connect or disconnect tubulars from a string of
15 tubulars in the drill string to lengthen or shorten the
string of tubulars. An elevator generally depends on
links attached to the top drive to facilitate handling of
tubulars and alignment with the sub for connection and
disconnection therewith. A top drive apparatus may also be
20 used in conjunction with a passive or active spider and/or
with rotary tongs to facilitate connection and
disconnection of tubulars from the string of tubulars.

The prior art discloses a variety of top drive
systems; for example, and not by way of limitation, the
25 following U.S. Patents present exemplary top drive systems
and components thereof: 4,458,768; 4,807,890; 4,984,641;
5,433,279; 6,276,450; 4,813,493; 6,705,405; 4,800,968;
4,878,546; 4,872,577; 4,753,300; 6,007,105; 6,536,520;
6,679,333; 6,923,254.

30 Certain typical prior art top drive drilling systems
have a derrick supporting a top drive which rotates
tubulars, e.g., drill pipe. The top drive is supported by
bails, often on a bucket suspended beneath a travelling
block beneath a crown block. A drawworks on a rig floor
35 raises and lowers the top drive.

Certain prior art bails for supporting top drives
have straight legs in which a three-cornered bail shape
imparts stress-inducing bending moments throughout a bail
when it is under load often with concentrated high stress

5 locations at lower pin lugs and at a topmost upper bend.
As larger and larger top systems have evolved, bails have
simply been enlarged and made more massive to accommodate
heavier system.

10 In accordance with the present invention, there is
provided a bail for suspending a top drive, characterised
in that the bail comprises a first upper leg portion
extending down from a head portion and a second upper leg
portion extending down from the head portion, a first
15 lower leg portion extending down from the first upper leg
portion and a second lower leg portion extending down from
the second upper leg portion, the first lower leg portion
at an angle to the first upper leg portion and the second
lower leg portion at an angle to the second upper leg
portion.

20 Preferably, the first upper leg portion diverges from
the second upper leg portion from the head portion to the
first and second lower leg portions. Advantageously, the
upper leg portion diverges from the second upper leg
portion at an angle of between 4 degrees and 14 degrees.
25 Preferably, the upper leg portion diverges from the second
upper leg portion at an angle of 11.8 degrees.

Preferably, the first lower leg portion diverges from
the second lower leg portion from the first and second
upper leg portions. Advantageously, the first lower leg
30 portion diverges from the second lower leg portion at an
angle of between 24 and 32 degrees. Preferably, the first
lower leg portion diverges from the second lower leg
portion at an angle of 27.2 degrees.

the head portion, first and second upper leg portions and
35 first and second lower leg portions are all formed
integrally out of a single piece of material.

Advantageously, each of the first and second lower
leg portions each have a lower lug portion to facilitate
connection to a top drive. Preferably, the lug is angled

5 to facilitate a connection with the top drive, advantageously, the lug has a face with a hole therein, the face forming a plane, the plane lying substantially vertical.

Preferably, each of the lugs has a hole therein to
10 facilitate connection to a top drive.

Advantageously, at least one of the first and second upper leg portion and the first and second lower leg portion is of oval cross-section.

Preferably, the head portion has a head portion
15 cross-sectional area, the first and second upper leg portions each have an upper portion cross-sectional area and the first and second lower leg portions each have a lower portion cross-sectional area, the head portion cross-sectional area the same as the upper portion cross-sectional area and the same as the lower portion cross-sectional area. Alternatively, the head portion has a head
20 portion cross-sectional area, the first and second upper leg portions each have an upper portion cross-sectional area and the first and second lower leg portions each have a lower portion cross-sectional area, the head portion cross-sectional area larger than the upper portion cross-sectional area or lower portion cross-sectional area.

Advantageously, a bend is formed at an interface between each of the first and second upper leg portion
30 with each of the first and second lower leg portion, the bend located to balance bending moments in the bail.

Preferably, the angle between the first lower leg portion and the first upper leg portion and the angle between the second lower leg portion and the second upper
35 leg portion forms a reverse bend.

The present invention also provides a top drive apparatus comprising a top drive and a pair of bails, each bail of the pair of bails as claimed in any preceding claim.

5 Preferably, the angle between the first lower leg portion and the first upper leg portion and the angle between the second lower leg portion and the second upper leg portion forms a reverse bend located to balance bending moments in the bail.

10 The present invention also provides a method for suspending a top drive, the method comprising the steps of suspending the top drive from a pair of bails, each bail of the pair of bails in accordance with the present invention, each bail suspended from a becket or travelling
15 hook.

 The present invention, in certain aspects, provides a top drive system for wellbore operations, which is suspended by bails having integral dual section legs with adjacent sections at angles to each other (a "reverse
20 bend") to create opposite bending moments which counteract the effects of each other, thereby reducing stress in the bail.

 In certain aspects, the present invention discloses a bail with opposed upper leg portions each of which is at
25 an angle (a reverse bend) to a corresponding lower leg portion.

 In certain top drives support bails connect to main body lugs of a main body of the top drive using bails in accordance with the present invention with reverse bends
30 results in less stress on the main body lugs.

 In certain aspects, bails in accordance with the present invention with bends in the legs take up less vertical space than similar bails with straight legs. In certain aspects bails in accordance with the present
35 invention which can handle a particular load and/or level of stress have a smaller cross-section than straight-legged bails.

 In certain aspects, different parts of a bail in accordance with the present invention are, optionally,

5 larger or more massive in cross-section than other parts;
e.g., a top curved portion may be larger in cross-section
than leg portions below the top portion.

In certain aspects, using bail legs with bends
between leg portions reduces over all stresses in the bail
10 legs and stresses on a main body to which leg lugs are
connected are reduced.

Such systems with bails with legs with a reverse bend
or dual leg sections at angles to each other and,
optionally, with bottom lugs on each leg at an angle to
15 the leg.

For a better understanding of the present invention,
reference will now be made, by way of example, to the
accompanying drawings, in which:

Figure 1A is a side view of a top drive apparatus in
20 accordance with the present invention comprising a support
bail in accordance with the present invention;

Figure 1B is a front view of the top drive apparatus
shown in Figure 1A;

Figure 2A is a front view of the support bail in
25 accordance with the present invention;

Figure 2B is a cross sectional view of the support
bail taken along line 2B-2B shown in Figure 2A;

Figure 2C shows cross-sectional shapes for parts of
the support bail in accordance with the present invention;

30 Figure 3A is a side view of the support bail shown in
Figure 1A;

Figure 3B is a front view of the support bail shown
in Figure 3A;

Figure 3C is a side view (opposite the side of Figure
35 3A) of the bail shown in Figure 3A;

Figure 3D is a rear view of the support bail shown in
Figure 3A;

Figure 3E is a top view of the support bail shown in
Figure 3A;

5 Figure 3F is a bottom view of the support bail shown in Figure 3A;

 Figure 3G is a cross-section view taken along line 3G-3G of Figure 3D;

 Figure 4A is a perspective view of a top drive
10 apparatus in accordance with the present invention comprising a support bail in accordance with the present invention;

 Figure 4B is a front view of the top drive apparatus shown in Figure 4A; and

15 Figure 4C is a side view of the top drive apparatus shown in Figure 4A.

 Figures 1A and 1B illustrate a top drive apparatus 100 in accordance with the present invention which has support bails 104 in accordance with the present invention
20 suspended from a becket 102. Motors 120 which rotate a main shaft 160 are supported on a main body 130. A bonnet 110 supports a gooseneck 106 and a washpipe 108 through which fluid is pumped to and through the top drive apparatus 100.

25 A gear system housing 140 is below the motors 120.

 A ring gear housing 150 encloses a ring gear 152 and associated components.

 An optional drag chain system 170 below the gear
30 system encloses a drag chain and associated components including hoses and cables. Instead of the drag chain system, a rotating head system may be used to provide sufficient rotation for reorientation of a link adapter 180 and items connected thereto.

 Upper parts of the support bails 104 extend over and
35 are supported by arms 103 of the becket 102. Each support bail 104 has two spaced-apart lower ends 105 pivotably connected by pins 107 to the body 130. Such a use of two support bails 104 distributes the support load on the main body 130 and provides a four-point support for this load.

5 Figures 2A and 2B show a bail 10 in accordance with
the present invention (like the bails 104, Figures 1A and
1B) with a body 12 having an upper head 14, a first upper
leg portion 16 and a second upper leg portion 16a, a first
lower leg portions 18 and a second lower leg portion 18a.
10 First and second lower leg portions 18, 18a each have a
bottom lug 20 with pin holes 21 therethrough. The upper
head portion 14 is curved to accommodate a becket 102 or
other support. The curve circums an angle of slightly less
than 180 degrees. The upper leg portions 16 are at an
15 angle A with respect to a centreline C of the bail and the
first and second lower leg portions 18, 18a are at an
angle B to the centerline C. As shown the angle A is 3.5
degrees and the angle B is 13.6 degrees. In certain
aspects, and as is true for any bail in accordance with
20 the present invention, the angle A can range between 2
degrees and 7 degrees. In certain aspects, and as is true
for any bail in accordance with the present invention, the
angle B can range between 12 degrees and 16 degrees. A
reverse bend N is formed between the upper leg portions 16
25 and the lower leg portions 18. As is true of any bail in
accordance with the present invention, the reverse bend N
may be anywhere along the length of the bail legs (i.e.,
near the top, near the bottom, or anywhere in between).
As is true for any bail in accordance with the present
30 invention, the radius of the reverse bend N can vary
between a sharp bend radius (radius = 0) to a large radius
that eliminates straight segments of the legs. The
curvature (length/radius) of the legs without straight
sections can be as small as zero (straight leg, infinite
35 radius). The overall height of any bail in accordance
with the present invention may be any desired height and
the bail width may be any desired width suitable for
application to particular equipment, e.g. particular
hoisting equipment. The first and second upper and lower

5 leg portions 16,16a,18,18a are symmetrical about the centreline.

The bottom lugs 20 are parallel to the centreline C. The bottom lugs are at an angle D to the lower leg portions 18. D may range, in certain aspects, between one
10 and forty-five degrees. The bail 10 as shown has a cross-section CS which is generally oval. It is within the scope of the present invention for this cross-section to be any desirable shape (e.g., the shapes shown in Figure 2C), such as circular, square, triangular, hexagonal,
15 rectangular, pointed or any geometric shape with curved sides and/or rounded corners. This cross-sectional shape may be any shape which satisfies known stiffness and strength criteria based on standard beam design practice. The top curved part is, in certain aspects, curved to
20 match a saddle of a supporting becket 102. Upper leg portions may have a cross-sectional shape different from that of the lower leg portions.

Figures 3A to 3F show a bail 50 in accordance with the present invention which is like the bails of Figures
25 1A and 2A. The bail 50 has a top curved part 52, upper leg portions 54, lower leg portions 56 and lugs 58 with pin holes 59. As shown in Figure 3G, the bail has a generally oval cross-sectional shape. In certain aspects for the bail 50 the angle A is 5.9 degrees and the angle B
30 is 14.5 degrees; or the angle A is 5.9 degrees and the angle B is 13.8 degrees.

The reverse bends S in the legs create opposite bending moments throughout the bail, partially counteracting the effect of the bending moments which
35 would be present if the legs were straight. The bends create local stresses where they are located, but these are relatively low stresses. By increasing the stresses at the bend locations, the overall maximum stresses (at the lower-leg-/upper-leg-portion interfaces portion and at

5 the lower lugs) are reduced significantly (for example, in some aspects, by 33%). This allows the use of smaller cross-sections, an overall lighter part using less steel, and one that is, therefore, more economical to manufacture.

10 As shown in Figure 3G the bails have an oval cross-section. Any suitable cross-section shape may be used including circular (e.g. see Figure 2C).

Figures 4A to 4C show a system 140 in accordance with the present invention with bails 150 in accordance with
15 the present invention. The bails 150 pinned with pins 142 to a main body 104 of a top drive apparatus 146. The top drive apparatus 146 includes motors 148, a gooseneck 141, a washpipe 143, a bonnet 145, and a gear system 147. A top drive shaft 136 is turned by the motors 148.

20 Each bail 150 has a body 152 with a top curved part 154, upper leg portions 156, lower leg portions 158, and lugs 159. There is a reverse bend between the leg portions 156 and 158. The pins 142 extend through holes 157 in the lugs 159; through holes 139 in projections 137
25 of the main body 144; and into holes 149 of the main body 104. The top curved part 154 is shown to be of larger dimensions and cross sectional area than the cross sectional area of the upper and lower leg portions 158, 159. In other embodiments, the top curved part may be of
30 the same cross sectional area as the cross sectional area of the upper and lower leg portions.

It is within the scope of the present invention for the cross-sections of parts of the bails to be similar throughout (top curved part, upper leg portions, lower leg
35 portions); or, as shown in Figures 4A and 4B, the top curved part, e.g. part 154, may be larger or more massive in cross-section than the leg portions. In certain aspects, the geometry of the bend is designed to balance the bending moments in the bail ("geometry" refers to the

5 vertical location of the bend and the offset of the bend
and "offset" is the distance from the apex of the bend to
the theoretical centerline of the leg that would exist if
the leg were straight). In such a case when the geometry
of the bend balances the bending moments in the bail, the
10 cross-section is constant. In other cases of bend
location, e.g. with the bend in a non-ideal location that
makes the moments higher at the top of the bail than at
the bottom or vice versa, the cross-section at the high
moment area (e.g. at or near the top of the bail) is
15 increased to keep the stresses down.

The present invention, therefore, provides in some,
but not in necessarily all, embodiments a top drive system
for wellbore operations, the top drive system including a
top drive apparatus, bails for supporting the top drive
20 apparatus and from which the top drive apparatus is
suspended, the bails comprising a first bail and a second
bail, each of the first bail and second bail has a body
with an upper head portion, the body having two spaced-
apart legs, each leg with an upper leg portion and a lower
25 leg portion, the two upper leg portions connected to the
upper head portion and projecting down therefrom, the
upper leg portions non-parallel to each other and each
upper leg portion extending from the upper head portion at
an upper angle to a centerline of the bail, and each lower
30 leg portion extending down from a corresponding upper leg
portion, each lower leg portion at an angle to its
corresponding upper leg portion, and projecting out from
the centerline of the bail in a reverse bend with respect
to its corresponding upper leg portion, each lower leg
35 portion having a bottom end.

The present invention, therefore, provides in some,
but not in necessarily all, embodiments a bail for
supporting an item, the bail including a body with an
upper head portion; the body having two spaced-apart legs,

5 each leg comprising an upper leg portion and a lower leg
portion; the two upper leg portions connected to the upper
head portion and projecting down therefrom, the upper leg
portions non-parallel to each other and each upper leg
portion extending from the upper head portion at an upper
10 angle to a centerline of the bail; and each lower leg
portion extending down from a corresponding upper leg
portion, each lower leg portion at an angle to its
corresponding upper leg portion, and projecting out from
the centerline of the bail in a reverse bend with respect
15 to its corresponding upper leg portion, each lower leg
portion having a bottom end. Such bail may have one or
some, in any possible combination, of the following: each
leg body having an oval shape in cross-section; wherein
the upper angle ranges between 2 degrees and 7 degrees;
20 wherein each lower leg portion extends down at a lower
angle to the centerline of the bail and the lower angle
ranges between 12 and 16 degrees; wherein a bend is formed
at an interface of each upper leg portion and lower leg
portion, the bend located to balance bending moments in
25 each bail; wherein each bail has a constant size cross-
section throughout the bail body; wherein a first portion
of each bail body has a first cross-section size and a
second portion of the bail body has a second cross-section
size, the first cross-section size different from the
30 second cross-section size; and/or wherein the first
portion is located in an area of the bail at a top of the
bail that is an area of relatively high bending moment and
the first cross-section size is larger than the second
cross-section size.

35 The present invention, therefore, provides in some,
but not in necessarily all, embodiments a bail for
supporting a top drive for well operations, the bail
including a body with an upper head portion; the body
having two spaced-apart legs, each leg comprising an upper

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5 leg portion and a lower leg portion; the two upper leg
portions connected to the upper head portion and
projecting down therefrom, the upper leg portions non-
parallel to each other and each upper leg portion
extending from the upper head portion at an upper angle to
10 a centerline of the bail; each lower leg portion extending
down from a corresponding upper leg portion, each lower
leg portion at an angle to its corresponding upper leg
portion, and projecting out from the centerline of the
bail at a lower angle in a reverse bend with respect to
15 its corresponding upper leg portion; wherein the upper
angle ranges between 2 degrees and 7 degrees; wherein the
lower angle ranges between 12 and 16 degrees; and the
reverse bend located to balance bending moments in each
bail.

WHAT IS CLAIMED IS:

1. A bail for suspending a top drive, characterised in that the bail comprises a first upper leg portion extending down from a head portion and a second upper leg portion extending down from the head portion, a first lower leg portion extending down from the first upper leg portion and a second lower leg portion extending down from said second upper leg portion, said first lower leg portion at an angle to said first upper leg portion and said second lower leg portion at an angle to said second upper leg portion characterised in that said angle between said first lower leg portion and said first upper leg portion and the angle between said second lower leg portion and said second upper leg portion forms a reverse bend.

2. The bail as claimed in Claim 1, wherein the first upper leg portion diverges from the second upper leg portion from the head portion to the first and second lower leg portions.

3. The bail as claimed in Claim 2, wherein the upper leg portion diverges from the second upper leg portion at an angle of between 4 degrees and 14 degrees.

4. The bail as claimed in Claim 2, wherein the upper leg portion diverges from the second upper leg portion at an angle of 11.8 degrees.

5. The bail as claimed in any one of Claims 1 to 4, wherein the first lower leg portion diverges from the second lower leg portion.

6. The bail as claimed in Claim 5, wherein the first lower leg portion diverges from the second lower leg portion at an angle of between 24 and 32 degrees.

7. The bail as claimed in Claim 5, wherein the first lower leg portion diverges from the second lower leg portion at an angle of 27.2 degrees.

8. The bail as claimed in any one of Claims 1 to 7, wherein the head portion, first and second upper leg portions and first and second lower leg portions are all formed integrally out of a single piece of material.

9. The bail as claimed in any one of Claims 1 to 8, wherein each of the first and second lower leg portions each have a lower lug portion to facilitate connection to a top drive.

10. The bail as claimed in Claim 9, wherein each of said lower lug portion has a hole therein to facilitate connection to a top drive.

11. The bail as claimed in Claim 9, wherein said lower lug portion is angled to facilitate a connection with the top drive.

12. The bail as claimed in Claim 9, said lower lug portion has a face with a hole therein, the face forming a plane, the plane lying substantially vertical.

13. The bail as claimed in any one of Claims 1 to 12, wherein at least one of said first and second upper leg portion and said first and second lower leg portion is of oval cross-section.

14. The bail as claimed in any one of Claims 1 to 13, wherein said head portion has a head portion cross-sectional area, said first and second upper leg portions each have an upper portion cross-sectional area and said first and second lower leg portions each have a lower portion cross-sectional area, said head portion cross-sectional area the same as the upper portion cross-sectional area and the same as the lower portion cross-sectional area.

15. The bail as claimed in any one of Claims 1 to 12, wherein said head portion has a head portion cross-sectional area, said first and second upper leg portions each have an upper portion cross-sectional area and said first and second lower leg portions each have a lower portion cross-sectional area, said head portion cross-sectional area larger than the upper portion cross-sectional area or lower portion cross-sectional area.

16. A bail as claimed in any one of Claims 1 to 15, wherein a bend is formed at an interface between each of the first and second upper leg portion with each of the first and second lower leg portion, the bend located to balance bending moments in said bail.

17. A top drive apparatus comprising a top drive and a pair of bails, each bail of the pair of bails as claimed in any one of Claims 1 to 15.

18. The top drive apparatus as claimed in Claim 17, wherein said angle between said first lower leg portion and said first upper leg portion and the angle between said second lower leg portion and said second upper leg portion forms a reverse bend located to balance bending moments in said bail.

19. The top drive as claimed in Claim 17, wherein said first and second lower leg portions provide a four-point support for said top drive.

20. A method for suspending a top drive, the method comprising the steps of suspending the top drive from a pair of bails, each bail of the pair of bails as claimed in any one of Claims 1 to 15, each bail suspended from a becket or travelling hook.

21. The method in accordance with Claim 20, wherein said pair of bails provide a four-point support for said top drive, the method further comprising the step of supporting the top drive with a four-point support.

Fig. 1B

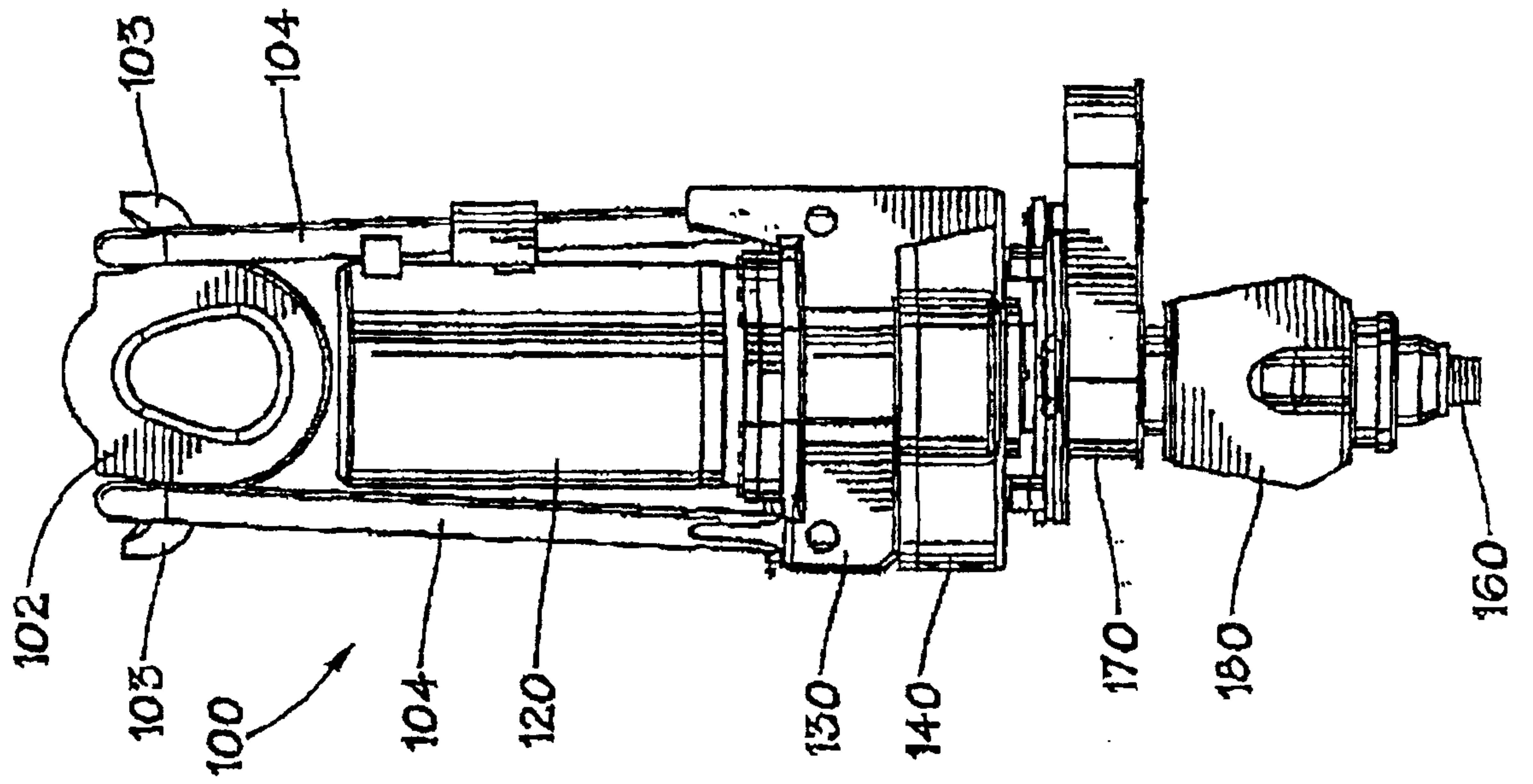


Fig. 1A

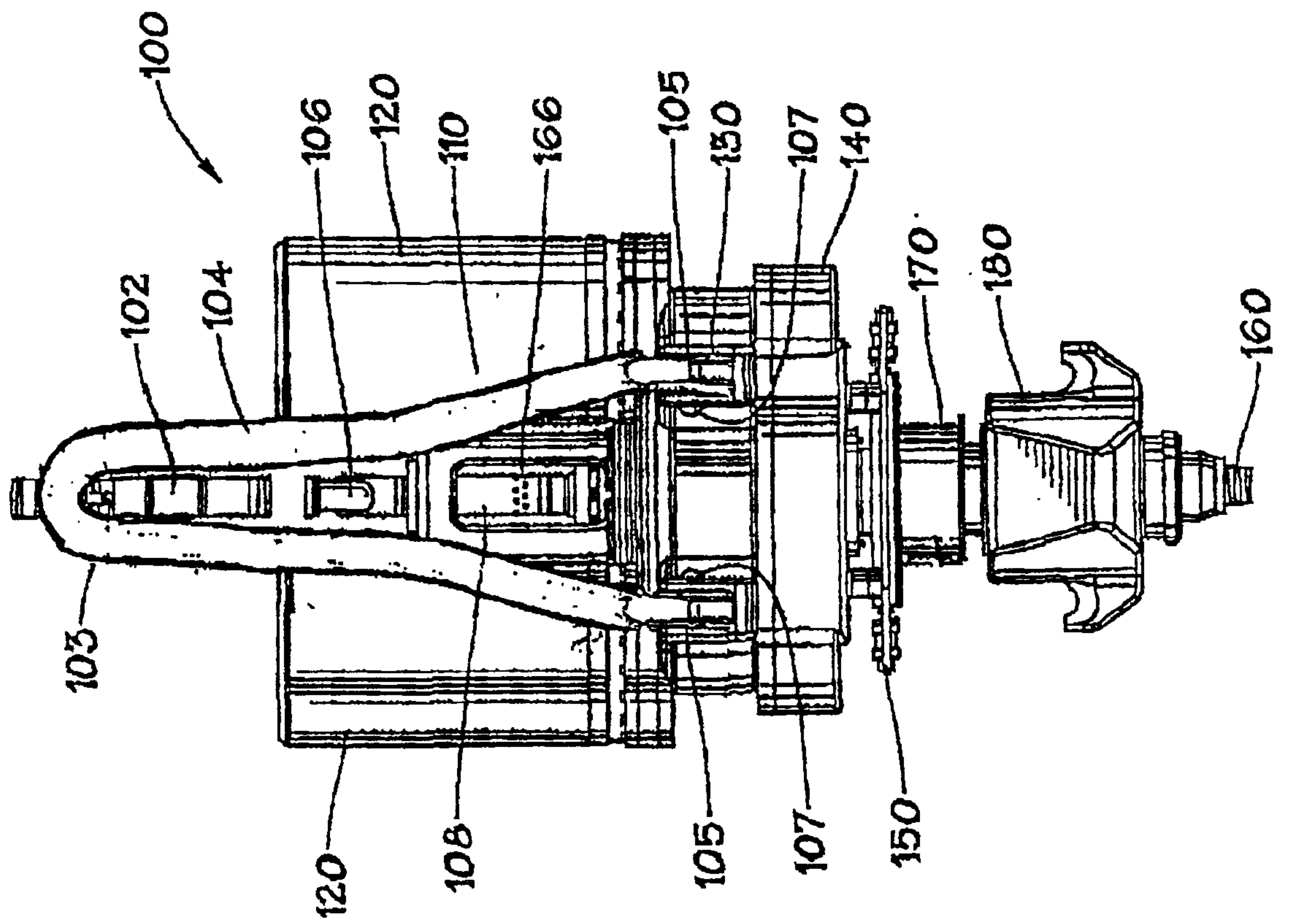


Fig. 2A

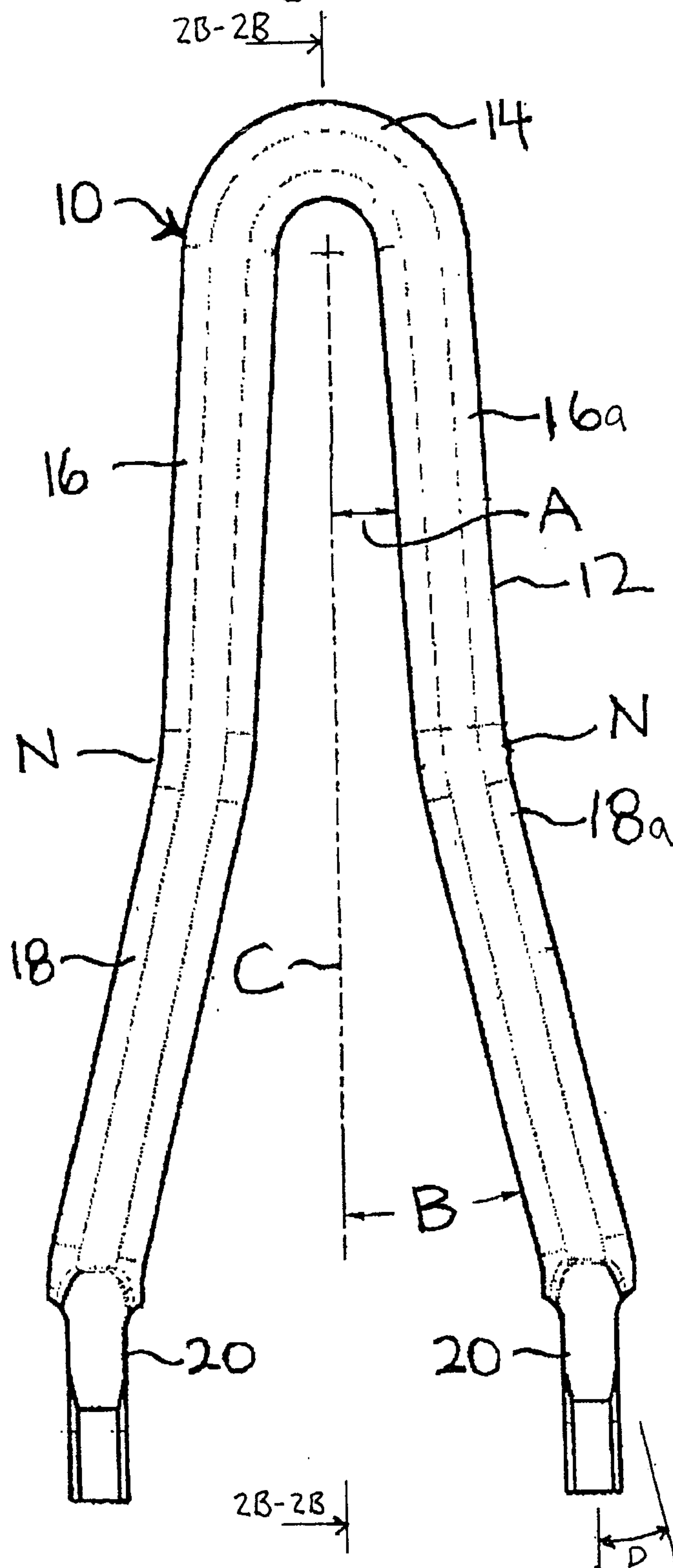


Fig. 2B

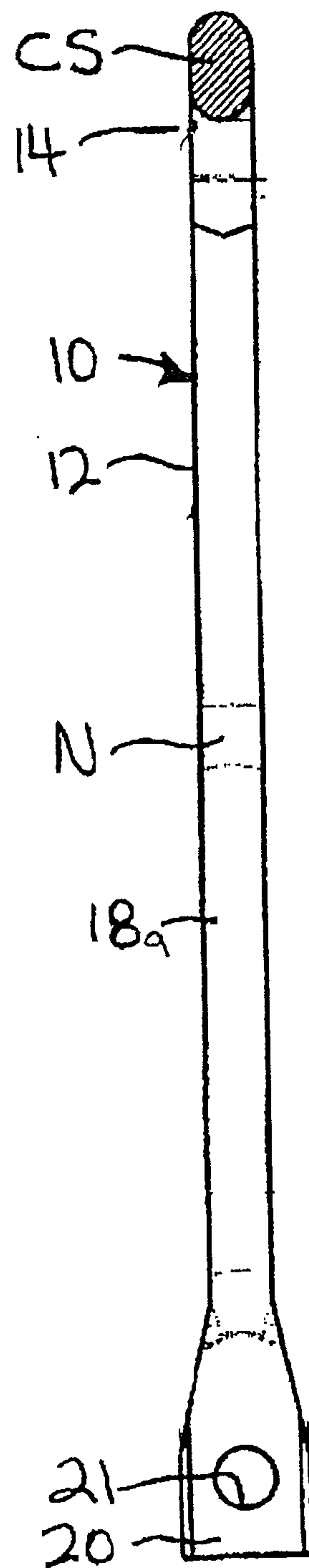


Fig. 2C

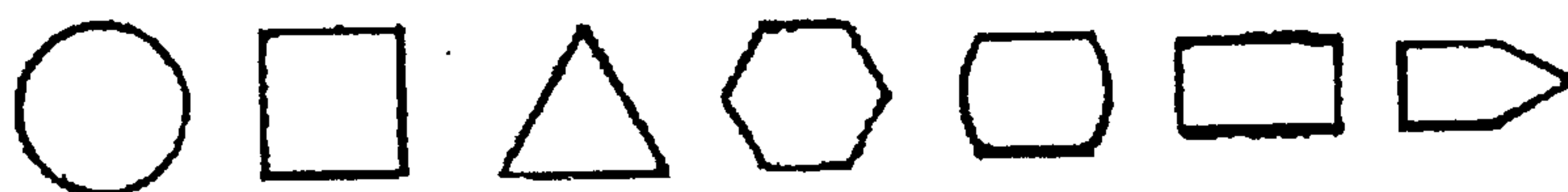




FIG. 3E

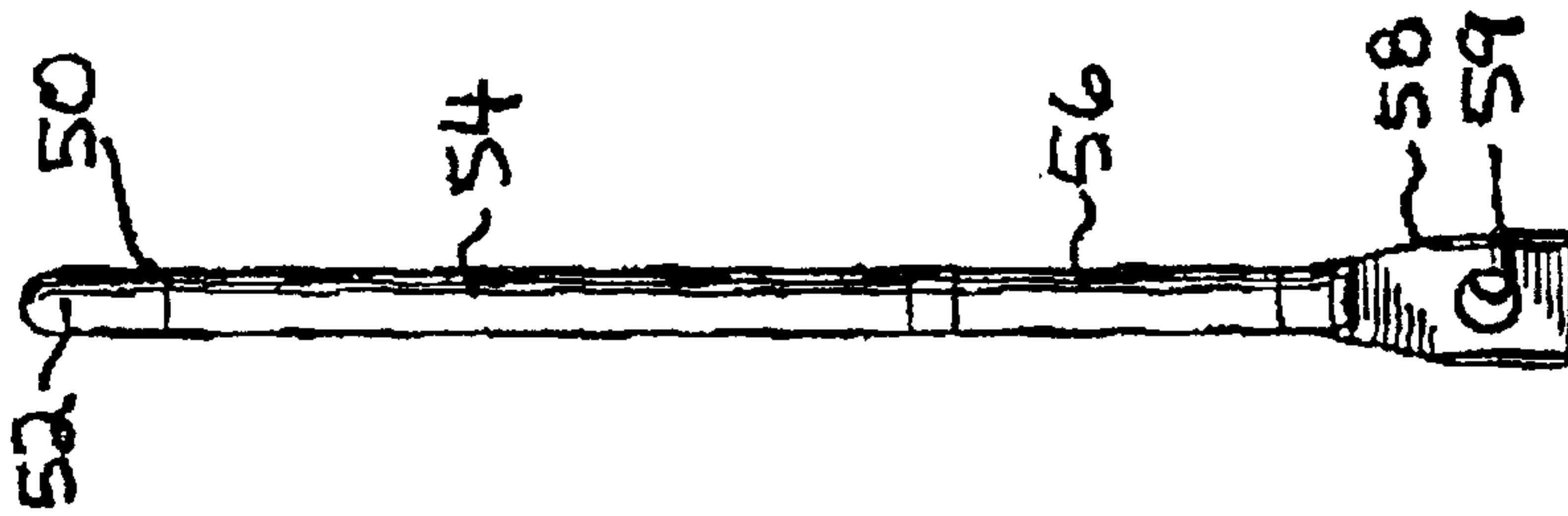


FIG. 3A

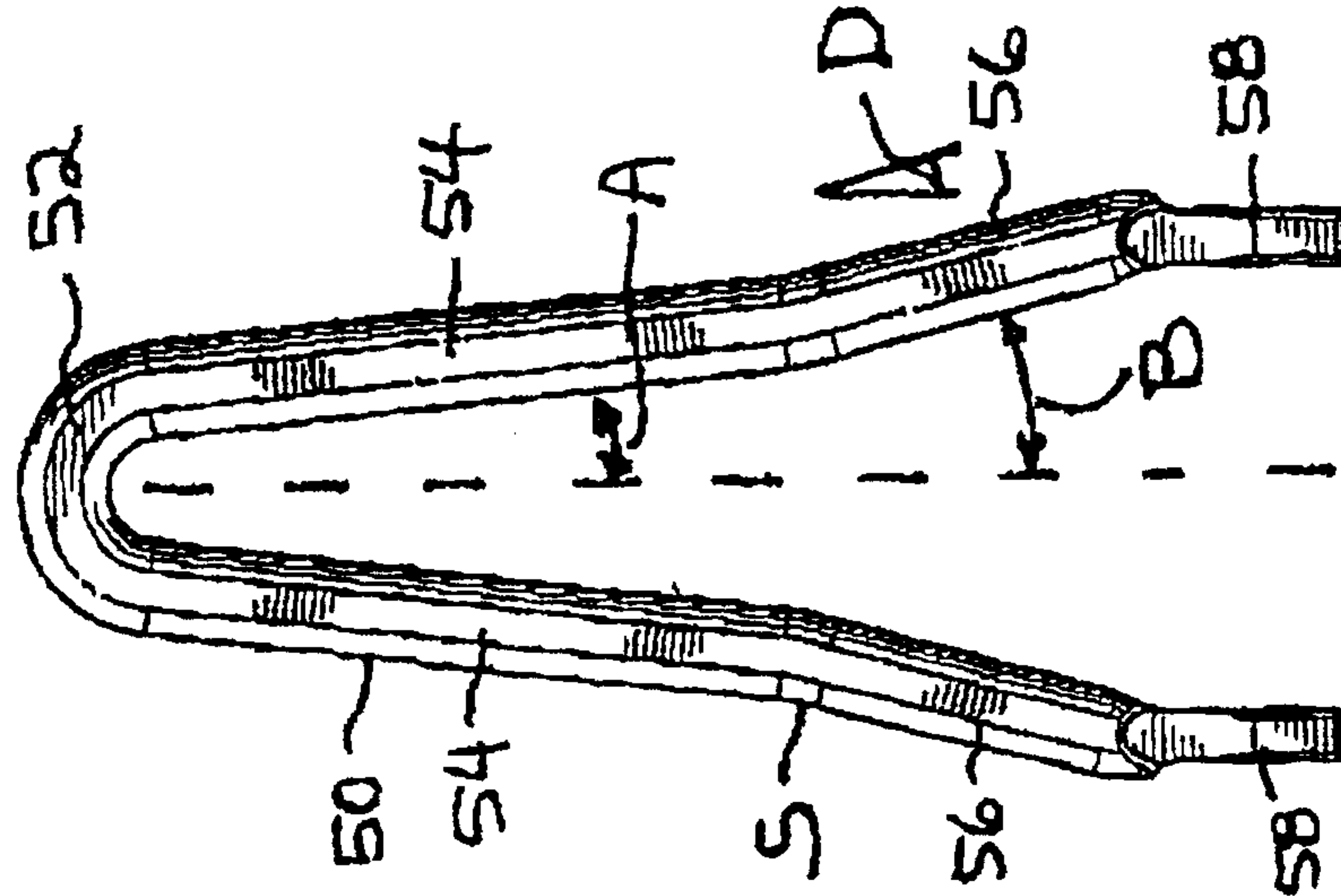


FIG. 3B

FIG. 3G

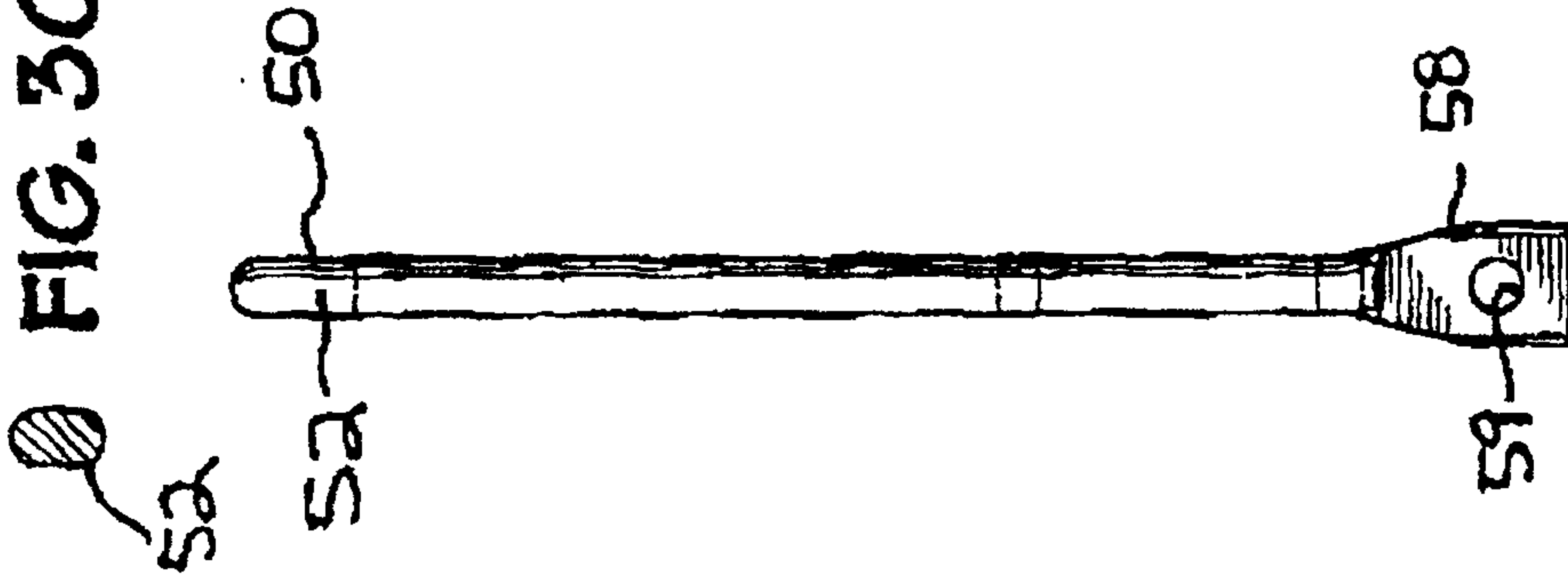


FIG. 3C

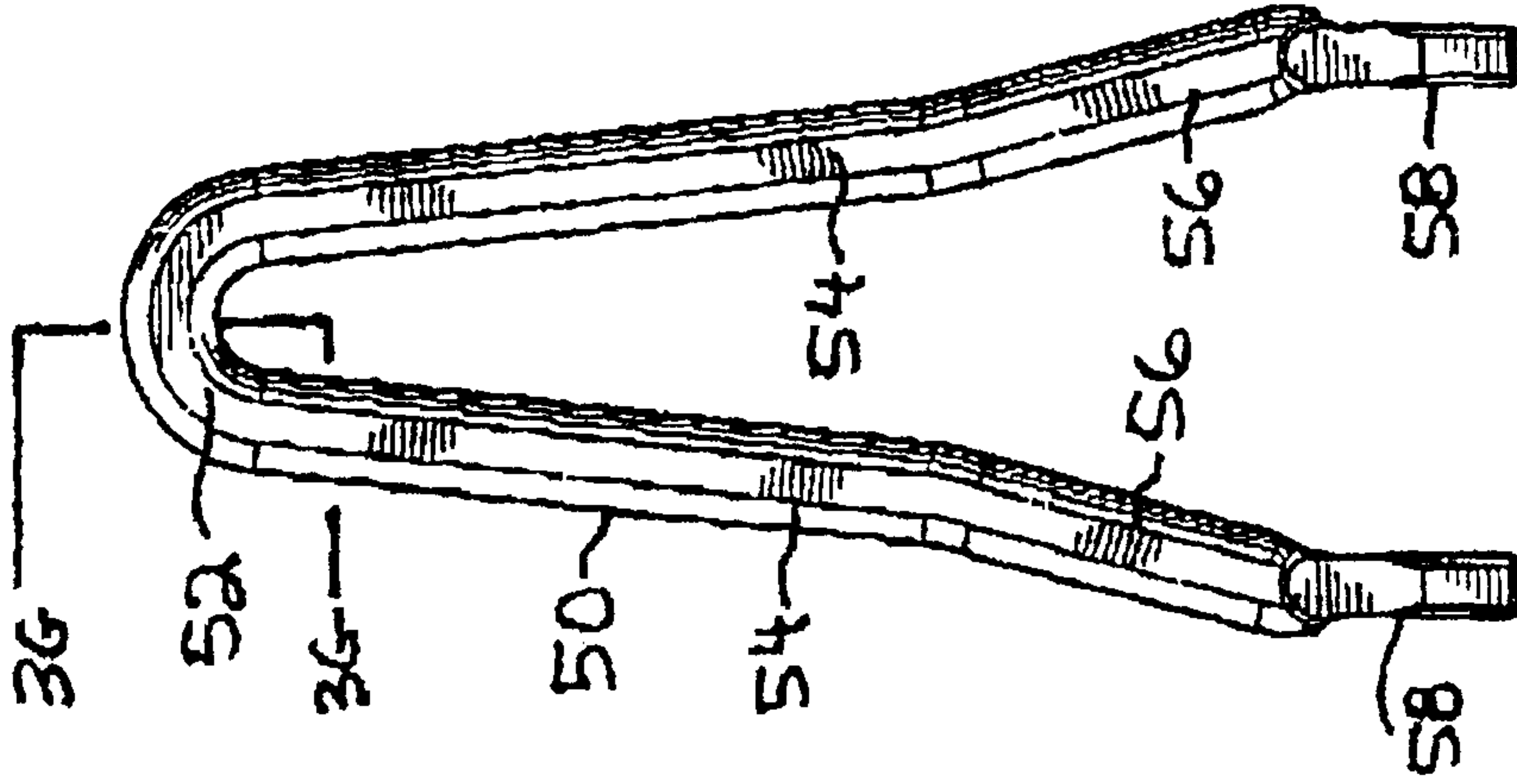


FIG. 3D

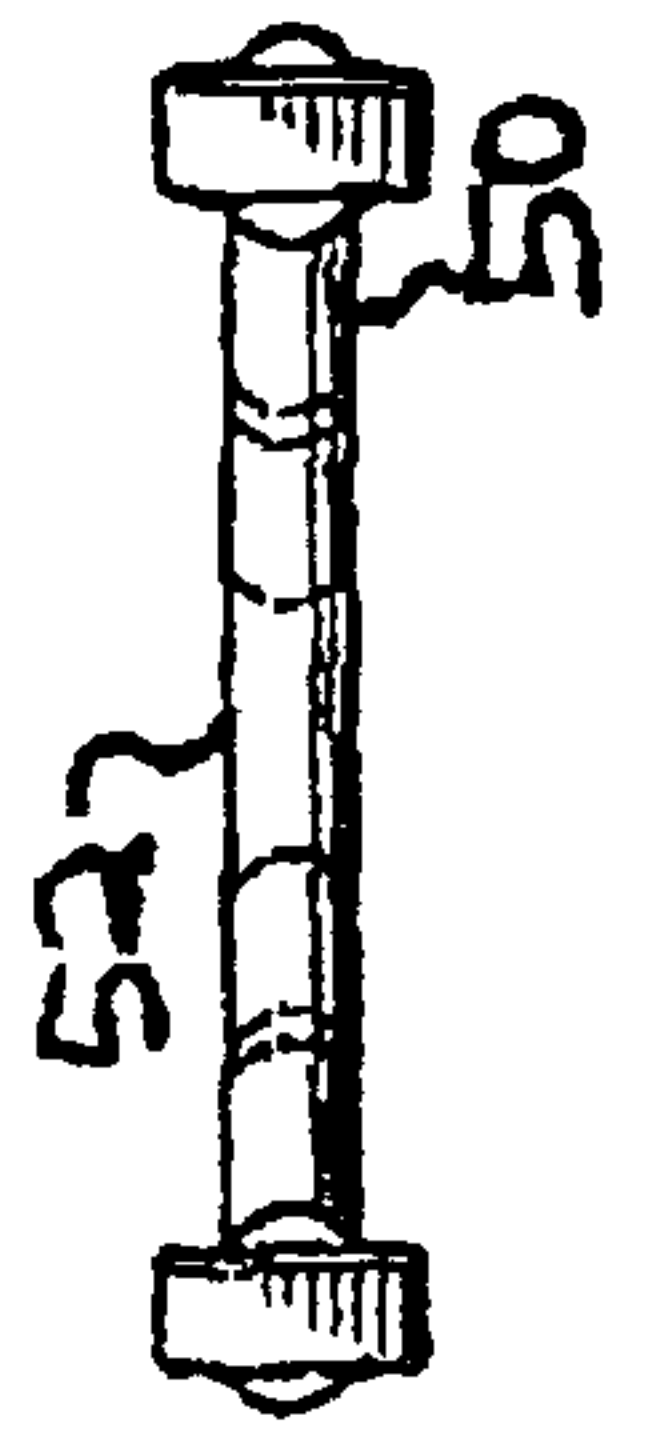


FIG. 3F

Fig. 4A

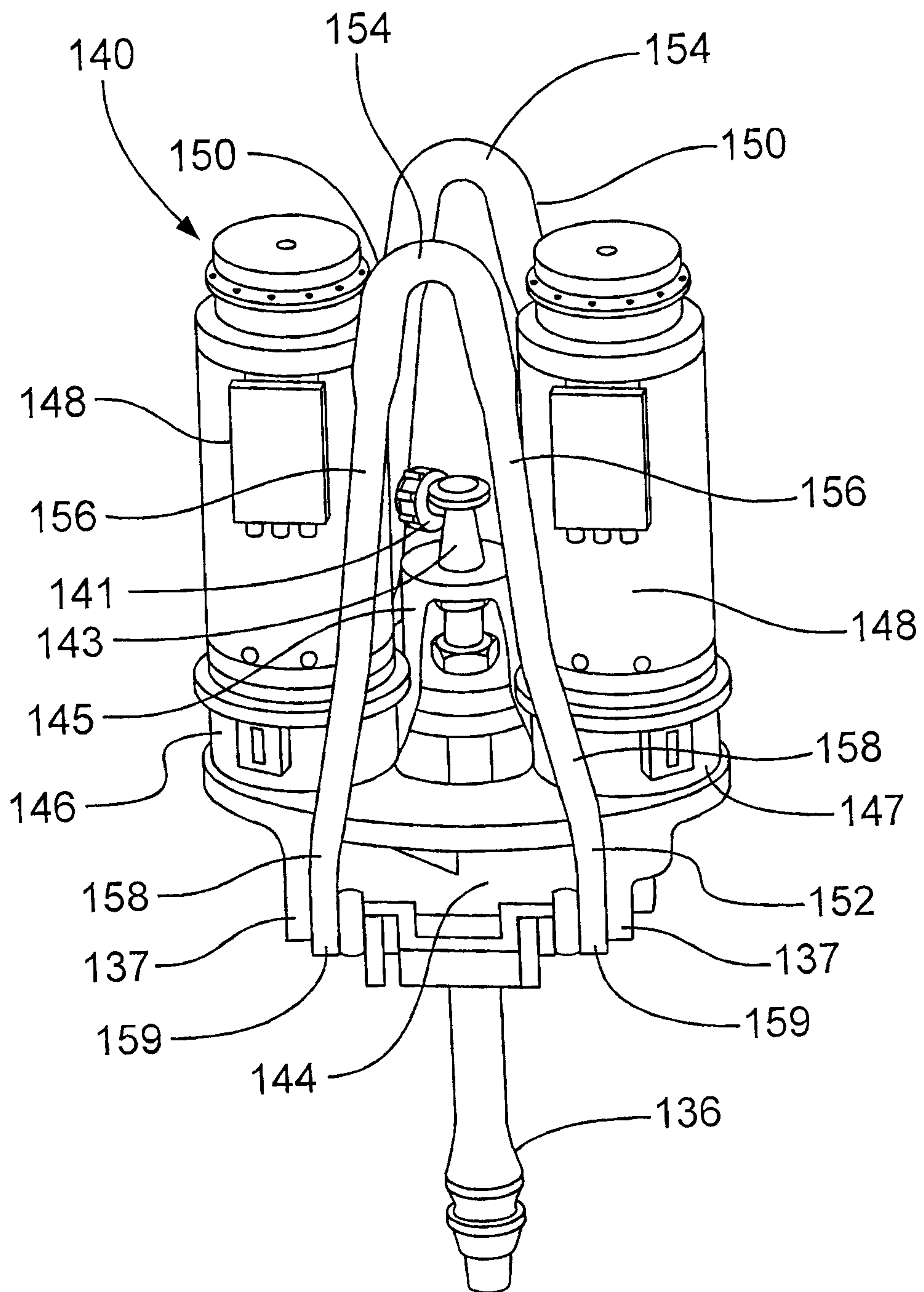


Fig. 4B

Fig. 4C

