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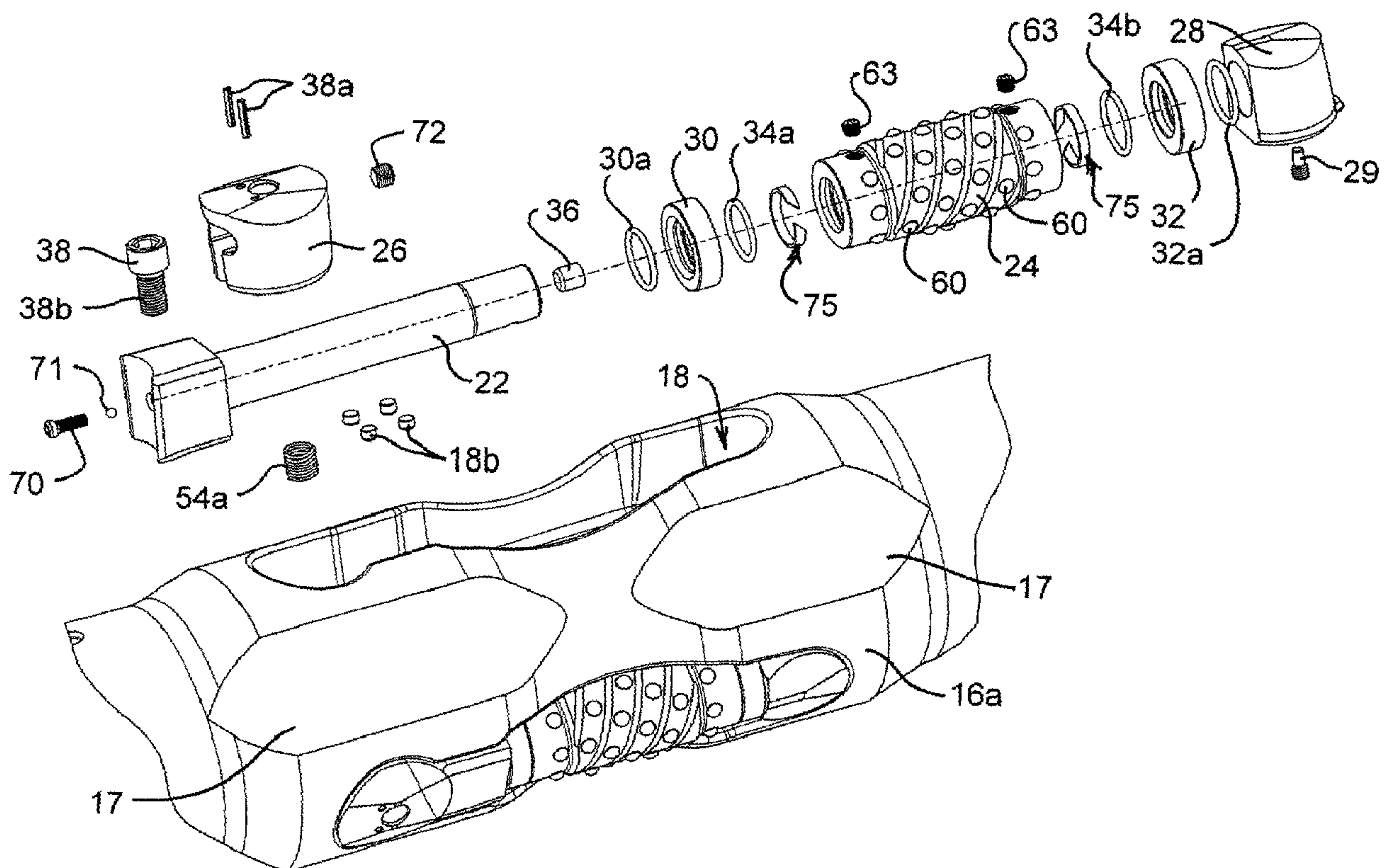
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(54) Title: AN IMPROVED ROTARY ROLLER REAMER



(57) **Abrégé/Abstract:**

The invention relates to a roller assembly (20) for a rotary roller reamer (10). The roller assembly (20) includes a roller pin (22) and a crushing roller (24). The crushing roller (24) is arranged to be mounted on the roller pin (22) and to rotate thereabout. The roller assembly (20) is connected together so as to form a single cartridge which can be inserted into a pocket (18) of the rotary roller reamer (10) and secured thereto using a single fastener device.

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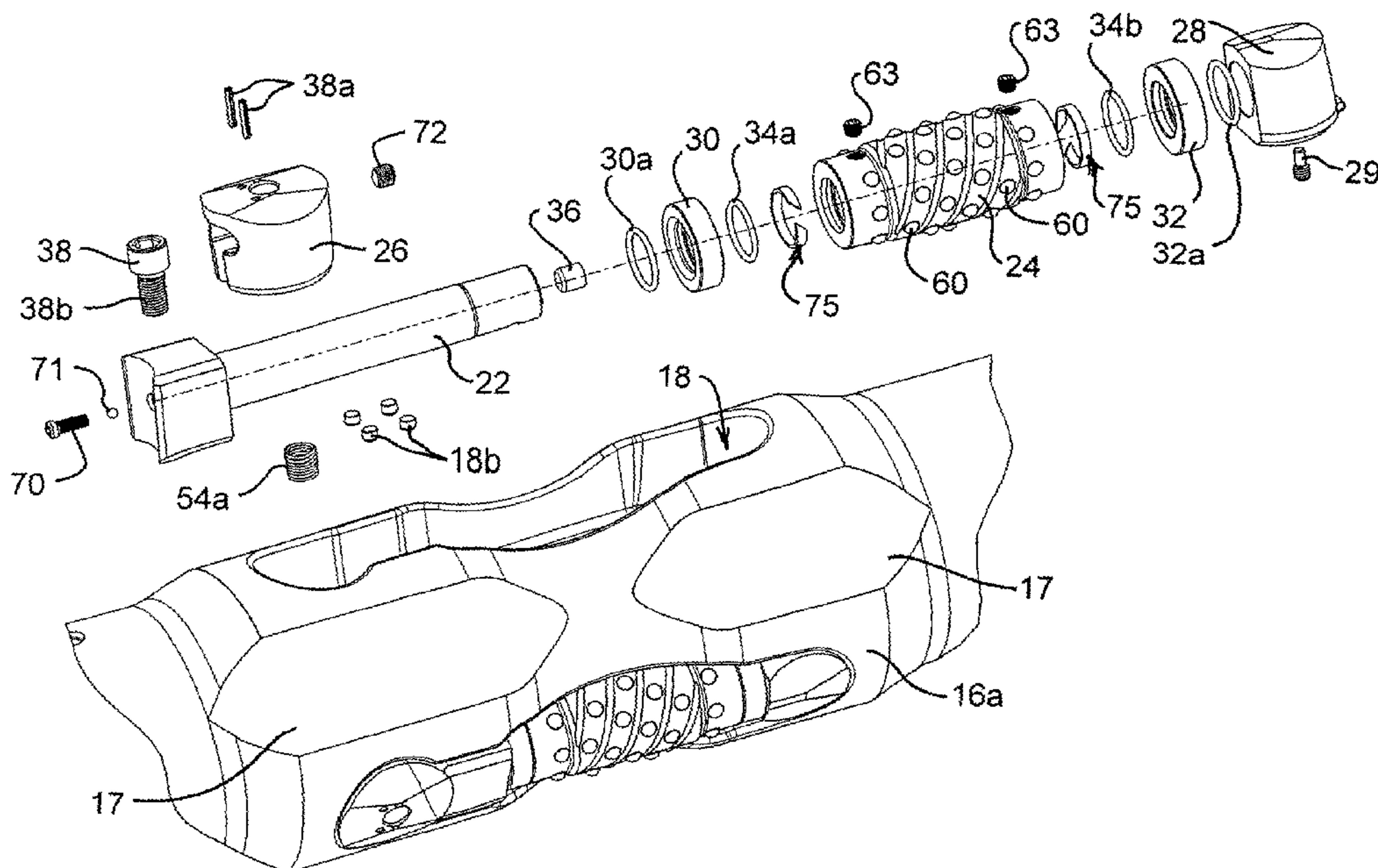
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(54) Title: AN IMPROVED ROTARY ROLLER REAMER



(57) Abstract: The invention relates to a roller assembly (20) for a rotary roller reamer (10). The roller assembly (20) includes a roller pin (22) and a crushing roller (24). The crushing roller (24) is arranged to be mounted on the roller pin (22) and to rotate thereabout. The roller assembly (20) is connected together so as to form a single cartridge which can be inserted into a pocket (18) of the rotary roller reamer (10) and secured thereto using a single fastener device.

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AN IMPROVED ROTARY ROLLER REAMER

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Field of the Invention

The present invention relates to an improved rotary roller reamer and to improvements to the various components thereof.

10

Background of the Invention

During drilling operations, the drill bit is subject to wear and thus the dimension of the drill hole will vary over time. To ensure that the dimension of the drill hole is held true, rotary roller reamers are located in the drill string and are used to ream out the drill hole to the required dimension. The inclusion of rotary roller reamers in the drill string enables the drill bit to be used for a longer period without changeover and this prevents considerable costly downtime.

20 The working environment of rotary roller reamers is very harsh. Consequently, the components of the roller reamer frequently need servicing, repair or replacement. As downtime for repairs is very costly, it is advantageous to extend the working life of such roller reamers and to thereby reduce down time due to repairs. It is also advantageous for the roller assemblies used in rotary roller reamers to be quickly and easily removed and replaced from their respective pockets in the reamer body.

25

The present invention seeks to provide an improved rotary roller reamer and various components thereof.

30

The present invention also seeks to provide a pressure equalisation means for a device.

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Summary of the Invention

According to a first aspect of the present invention there is provided a rotary roller reamer including a reamer body having at least one pocket for receiving a roller assembly and wherein said roller assembly includes a plurality of components which are connected together to form a single cartridge which can be inserted into said pocket.

Preferably, said cartridge is secured in said pocket by means of a single fastener device.

According to a second aspect of the invention there is provided a roller assembly for a rotary roller reamer, said roller assembly including a roller pin and a crushing roller arranged to be mounted on said roller pin and to rotate thereabout, and wherein the roller assembly is connected together so as to form a single cartridge which can be inserted into a pocket of the rotary roller reamer.

Preferably, the cartridge is arranged to be secured to the pocket by means of a single fastener device.

Preferably, said roller assembly further includes a first retaining means for retaining said roller pin within said pocket, said first retaining means including a first plug which is arranged to be connected to the roller pin so that the roller pin, crushing roller and first plug form said single cartridge which can be inserted into the pocket of the rotary roller reamer.

Preferably, the first plug has a first surface against which a first end of the roller pin mates and a second surface arranged to engage with a sidewall of said pocket, said sidewall of said pocket and said second surface of said first plug being configured so that the first plug is drawn into the pocket when said fastener device is used to secure the roller assembly to said pocket.

Preferably, the roller assembly further includes a second retaining means.

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Preferably, a first thrust ring is provided between the roller pin and a first end of the crushing roller and a second thrust ring is provided between a second end of the crushing roller and said second retaining means. The first and second
5 thrust rings are preferably sacrificial thrust rings arranged to accommodate thrust loads applied to the crushing roller during use of the rotary roller reamer.

Preferably, the first surface of the first plug is complimentary to the first end of the roller pin. The first end of the roller pin is preferably formed with an
10 enlarged head.

The roller pin preferably includes a shank having central longitudinal blind bore formed therein that opens through a second end of the roller pin. The bore forms a lubricant reservoir. The bore opens into a side port that extends
15 substantially perpendicular thereto and opens into a primary lubricant distribution groove. The primary lubricant distribution groove preferably extends substantially longitudinally of the roller pin and may adopt various configurations, for example, a "figure 8" configuration.

20 Lubricant can be supplied from the reservoir, through the side port and into the primary lubricant distribution groove during rotation of the crushing roller about the roller pin. The lubricant is distributed over the shank of the roller pin as the crushing roller rotates thereabout.

25 Seal means are preferably provided between the crushing roller and the shank of the roller pin to prevent escape of lubricant.

Preferably, pressure equalisation means is provided in the bore of the roller pin. The pressure equalisation means is arranged to equalize the pressure between
30 the drilling mud surrounding the body of the rotary roller reamer and the lubricant contained in the bore of the roller pin. The pressure equalisation means may include a filter, such as a sintered metal filter.

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In a preferred embodiment, the first plug is formed as a frustum having a base and a top. The frustum preferably has an angle of less than or equal to 7° to its central longitudinal axis. Preferably, this angle is approximately 3° . The base of the first plug is arranged to be positioned uppermost in the pocket. The base
5 has an outer diameter which is smaller than the outer diameter of the top.

The base of the first plug has an underside that is preferably shaped to engage with a mating portion of the pocket. The mating portion of the pocket preferably includes a post that includes a central threaded bore that is arranged to enable
10 the fastener to be screwed there into.

The first plug preferably includes a fastener-receiving cavity that opens through a sidewall of the first plug and also into the base of the first plug. The cavity is configured so that the fastener can be passed through the opening in the
15 sidewall and located there within. In this position, the leading end of the fastener extends through the opening in the base. In this manner, the leading end of the fastener can be screwed into the threaded bore formed in the post of the pocket.

20 The first plug preferably also includes an elongate screw connector slot formed in the sidewall thereof. The screw connector slot being configured to receive the head of a screw connected to the enlarged head of the roller pin.

An aperture is preferably formed in the top of the first plug and is arranged so
25 that a tool can be passed there through to enable the fastener to be screwed into the bore of the post.

In a particularly preferred form, the fastener is a socket head fastener and the socket head is arranged to be located within an upper portion of the fastener-receiving cavity. The upper portion of the cavity is configured so that when the
30 fastener is screwed into the post of the pocket, the first plug is drawn into the pocket, and when the fastener is unscrewed, the first plug is lifted out of the pocket.

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The second retaining means preferably includes a second plug which is formed as a frustum. The frustum preferably has an angle of less than or equal to 7° to its central longitudinal axis. Preferably, the angle is approximately 3° . The
5 second plug has a base, a top and a side wall. The base has a larger outer diameter than the top and is arranged to be positioned lowermost within the pocket.

A bore is formed in the second plug substantially perpendicular to the central
10 longitudinal axis of the second plug. The bore is arranged to receive the second end of the roller pin. Preferably, the bore is sized for a sliding fit with the second end of the roller pin.

A minor bore is also preferably provided in the sidewall of the second plug. The
15 minor bore is arranged to aid pressure equalization between the lubricant contained in the lubricant reservoir and the mud surrounding the roller assembly during use thereof.

Extending from the side wall of the second plug is a lug. The lug is arranged to
20 engage with a complimentary shaped recess formed in a portion of the pocket.

In accordance with a preferred embodiment of the invention, each pocket of the rotary roller reamer includes a lower tapered socket, a primary cavity, a secondary cavity and an upper tapered socket. The upper tapered socket is
25 preferably located at the up hole end of the rotary roller reamer and the lower tapered socket is preferably located at the down hole end of the rotary roller reamer.

The upper tapered socket is arranged to receive the first retaining means. The
30 upper tapered socket includes a semi-circular truncated conical seat of less than or equal to 7° angle to a normal axis of the socket (i.e. the axis normal to the longitudinal axis of the rotary roller reamer). Preferably, the angle is approximately 3° . The socket is tapered so that the smaller diameter of the

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socket forms part of the floor of the pocket. Tangential to the conical seat is an entrance guide-way having sides matching the taper of the conical seat. The seat extends for approximately 270° arc length, with the remainder of the arc length opening into the secondary cavity. Preferably, the seat extends for
5 greater than 180° arc length.

Located substantially centrally of the upper tapered socket is the post in which the fastener of the first plug is preferably arranged to be secured.

10 The primary cavity (or roller cavity) is preferably configured to provide operating clearance for the crushing roller mounted on the roller pin. The primary cavity is necked down as compared to the external diameter of the reamer body. This results in the primary cavity having a depth in the direction normal to the longitudinal axis of the reamer body which is less than the depth of the upper
15 and lower tapered sockets.

The secondary cavity is preferably formed as a flanked trapezium shape which narrows at the floor of the cavity. The secondary cavity forms a seat for the head of the roller pin.

20

The lower tapered socket is preferably arranged to receive the second retaining means. The lower tapered socket includes a semi-circular truncated conical seat of less than or equal to 7° angle to a normal axis of the socket (i.e. the axis normal to the longitudinal axis of the rotary roller reamer). Preferably, the angle
25 is approximately 3° . The socket is tapered so that the larger diameter of the socket forms part of the floor of the pocket.

Located in the sidewall portion of the lower tapered socket is a groove or ledge arranged to receive the security lug of the second plug. The groove or ledge is
30 preferably substantially crescent shaped.

According to a third aspect of the invention there is provided a crushing roller for a rotary roller reamer, said crushing roller including a central portion and first

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and second end portions, the central portion having an external diameter greater than the external diameter of the first and second portions, and wherein the central, first and second portions are studded with projection means.

5 The projection means are preferably arranged on the central portion so that a contact area of the projection means with a portion of a wall of a drill hole being reamed overlaps. The projection means may be arranged on at least one helix about the central portion of the crushing roller. The helix may advantageously be a left hand helix. Such an arrangement serves to reduce the thrust loading in the vertical plane during use of the crushing roller.

10

Preferably, each projection means includes a button mounted in a hole formed in the crushing roller. The button is preferably a domed shaped tungsten carbide button.

15 In accordance with one preferred form, the buttons on the central portion are arranged in four rows of eight and are set on a left-hand 3.31699" pitch helix. Each row is separated by 90° of angular rotation and the starting point for each row commences in a progressive step equal to $0.125 \times 1/9^{\text{th}}$ of the helical datum curve length. Each projection means is spaced at $1/9^{\text{th}}$ of the helical curve
20 length.

Preferably, located between each of the helically spaced rows are flutes which are generated on the same helical datum path as the projection means. The flutes are arranged to provide an increased mud flow past the roller and
25 increase the clearance through which the residue from the reamer can pass.

According to a fourth aspect of the present invention there is provided a rotary roller reamer including a reamer body having at least one pocket for receiving a roller assembly, said roller assembly including a pin and a crushing roller
30 arranged to be mounted on said pin, seal means between the pin and the crushing roller and means for retaining said pin within said pocket, and wherein the pin includes a bore having pressure equalisation means located there

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within, the pressure equalisation means serving to substantially equalize the pressure on the seal means.

Preferably, the pressure equalisation means serves to equalise the pressure
5 between the drilling mud surrounding the body of the rotary roller reamer during use and a lubricant contained in the bore of the roller pin.

The crushing roller is preferably arranged to rotate about the roller pin.

10 The pressure equalisation means may include a filter, such as a sintered metal filter.

According to a fifth aspect of the invention there is provided a rotary roller reamer including a reamer body having at least one pocket for receiving a roller
15 assembly, said roller assembly including a roller pin and a crushing roller arranged to be mounted on said roller pin, wherein the reamer body has a primary outer diameter in an area distal to the crushing roller and a secondary outer diameter in an area adjacent to the crushing roller, and wherein the secondary outer diameter is reduced as compared to the primary outer diameter
20 so as to provide stress relief.

According to a sixth aspect of the invention there is provided a pressure equalisation means for a device having at least one seal means for sealing a supply of lubricant located between a first and a second member of said device,
25 said pressure equalisation means being arranged to be mounted in said device and arranged so that it acts to equalise the pressure applied by the lubricant to a first side of said at least one seal means with the pressure of a fluid being applied on a second side of the at least one seal means.

30 Brief Description of the Drawings

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:-

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Figure 1 is a cut-away view of a rotary roller reamer according to an embodiment of the invention;

- 5 Figure 1A is an enlarged view of the central portion (i.e. the pocket and the roller assembly) of the rotary roller reamer shown in Figure 1;

Figure 2 is a partial assembly view of a roller assembly in accordance with an embodiment of the invention adjacent to a reamer body having multiple pockets;

10

Figure 3 is a central longitudinal cross sectional view of the roller assembly shown in Figure 2 mounted in a pocket of a rotary roller;

- 15 Figure 3A is a part cross sectional view of one end of the roller assembly along a line offset from the centre line of the rotary roller reamer;

Figure 4 is a longitudinal cross sectional view of the pocket of the rotary roller reamer shown in Figure 3;

- 20 Figures 5 to 8 are perspective views of a first retaining means in accordance with an embodiment of the invention;

Figures 9 to 11 are perspective views of a second retaining means in accordance with an embodiment of the invention;

25

Figure 12 is a side view of a crushing roller in accordance with an embodiment of the invention;

- 30 Figure 13 is a longitudinal cross sectional view of the crushing roller shown in Figure 12;

Figure 14 is an end view of the crushing roller shown in Figure 12;

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Figures 15 to 17 are views of a roller pin in accordance with an embodiment of the invention;

Figure 18 is a cross sectional view showing connection of the first retaining means to the connector screw which extends from the enlarged head of the roller pin;

Figure 19 is cross sectional view showing insertion of the retaining plug in the connector screw slot of the first retaining means;

Figure 20 is a partial cross sectional view showing insertion of a roller cartridge (i.e. the assembled roller assembly) into a pocket of the rotary reamer;

Figure 21 is a perspective view of the stabilization band shown in Figure 1A;

Figure 22 is a front view of the stabilization band shown in Figure 21; and

Figure 23 is a side view of the stabilization band shown in Figure 21.

Detailed Description of the Preferred Embodiments

Figures 1 and 1A illustrate a rotary roller reamer 10 in accordance with an exemplary embodiment of the invention. The rotary roller reamer 10 has a male end 12 and a female end 14. The rotary roller reamer 10 is arranged to be attached to a drill string (not shown). As shown in this embodiment, the male end 12 is located at the down hole end of the rotary roller reamer 10 and the female end 14 is located at the up hole end of the rotary roller reamer 10. It will of course be appreciated that the configuration or nature of the respective ends of the rotary roller reamer 10 may vary.

The rotary roller reamer 10 includes a tubular reamer body 16 which includes three circumferentially spaced pockets 18. Located within each pocket 18 is a roller assembly or roller cartridge 20. The pockets 18 as illustrated are equally

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spaced about the periphery of the reamer body 16 and are located in a section 16a of the body 16 that has a larger outer diameter than the remainder of the body 16. Although three pockets 18 are illustrated, it will be appreciated that arrangements with different numbers of pockets 18 and spacings are
5 envisaged.

Figure 2 better illustrates the pockets 18 formed in the reamer body 16. This figure also illustrates the cut away sections or mud ways 17 formed between adjacent pockets 18.

10

Figure 2 illustrates the roller assembly 20 in a disassembled condition. The roller assembly 20 includes a roller pin 22, a crushing roller 24, a first retaining means 26, a second retaining means 28, a retaining screw 29, a first thrust ring 30, a second thrust ring 32, a pair of seals 34a, 34b, a pressure equalisation
15 means 36, a fastener 38, a pair of self locking pins 38a, a connector screw 70 and a retaining plug 72.

When the components of the roller assembly 20 are assembled together they form a single cartridge which can be secured, using the fastener 38, in the
20 pocket 18 of the rotary roller 10. During use, the crushing roller 24 is arranged to rotate about the roller pin 22 so that it can be used to ream the sidewalls of the drill hole through which the rotary roller reamer 10 is passed. The nature of each of the components of the roller assembly 20 and the pockets 18 formed in the reamer body 16 will now be described in more detail.

25

Figures 3, 3A and 4 best illustrate the configuration of each of the pockets 18 and the engagement of the roller assembly 20 within its respective pocket 18. Each pocket 18 includes a lower tapered socket 40, a primary cavity 42, a secondary cavity 44 and an upper tapered socket 46. The lower tapered socket
30 40 is located at the down hole end of the rotary roller reamer 10, whilst the upper tapered socket 46 is located at the up hole end of the rotary roller reamer 10. The lower tapered socket 40 is arranged to receive the second retaining means 28, whilst the upper tapered socket 46 is arranged to receive the first

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retaining means 26. The primary cavity 42 is arranged to receive the roller pin 22 and the crushing roller 24 which is mounted thereon. The primary cavity 42 is sized and configured to provide operating clearance for the crushing roller 24 during use of the rotary roller reamer 10. The secondary cavity 44 forms a seat
5 for the head 22a of the roller pin 22.

The lower tapered socket 40 includes a semi-circular truncated conical seat of less than or equal to 7° angle to a normal axis of the socket 18 (i.e. the axis normal to the longitudinal axis of the rotary roller reamer 10). As illustrated, this
10 angle is approximately 3° . The lower tapered socket 40 is tapered so that the larger diameter of the socket 40 forms part of the floor 18a of the pocket 18. Tangential to the conical seat is an entrance guide way 40a having sides matching the taper of the conical seat.

15 Formed in the lower part of the lower tapered socket 40 and coincident with the floor 18a of the pocket 18, is a semi-circular recess 40b. This recess 40b is a security recess which is arranged to receive a complimentary shaped lug 28k formed on the second retaining means 28. The function of the security recess 40b and the lug 28k will be discussed in more detail subsequently.

20

Installed in a portion of the floor 18a of the lower tapered socket 40 so as to be positioned below the head 22a of the roller pin 22 are four carbide inserts 18b. The carbide inserts 18b are provided to prevent wear of the floor 18a of the pocket 18 due to movement of the head 22a during use of the rotary roller
25 reamer 10.

The primary cavity 42, as clearly illustrated in Figure 4, is necked down as compared to the external diameter of the reamer body 16. Additionally, the floor 18a of the primary cavity 42 steps downwardly in a direction towards the centre
30 line of the reamer body 16. Thus, the primary cavity 42 has a depth in a direction normal to the longitudinal axis that is sufficient to provide working clearance for the crushing roller 24. Additionally, the external diameter of the reamer body 16 in this area is reduced or "necked down" as compared to the

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external diameter of the reamer body 16 in the areas adjacent to the lower and upper tapered sockets 40, 46. This necked down configuration of the reamer body 16 provides stress relief in the area of the pockets 18.

- 5 The secondary cavity 44 is formed with a flanked trapezium shape which narrows at the down hole end of the cavity 44.

The upper tapered socket 46 includes a semi-circular truncated conical seat of less than or equal to 7° angle to the normal axis of socket 46. As illustrated,
10 this angle is approximately 3° . The upper socket 46 is tapered so that the smaller diameter of the socket 46 forms part of the floor 18a of the pocket 18. The seat extends for approximately 270° arc length, with the remainder of the arc length opening into the secondary cavity 44. Located substantially centrally of the upper tapered socket 46 is a post 52. The post 52 includes a bore 54
15 which is threaded so that it can receive the fastener 38. Alternatively, as illustrated, a threaded insert 54a may be located in the bore 54.

Figures 5 to 8 illustrate the first retaining means 26. The first retaining means 26 is formed as a first plug 26 and is arranged to be received within the upper
20 tapered socket 46. The first plug 26 is formed as a frustum. The frustum has an angle of less than or equal to 7° to its central longitudinal axis and includes a base 26a and a top 26b. As illustrated, the frustum has an angle of approximately 3° . The base 26a is arranged to be positioned lowermost in the lower tapered socket 46. The base 26a has an outer diameter which is smaller
25 than the outer diameter of the top 26b. The underside of the base 26a is shaped to engage with the floor 18a of the pocket 18 in the area of the upper tapered socket 46. In particular, the base 26a is shaped so that it will mate with the post 52.

- 30 The first plug 26 includes a fastener-receiving cavity 26c that opens through a sidewall 26d and also into the base 26a of the first plug. The cavity 26c is configured so that the fastener 38 can be positioned within and so that the leading end 38b of the fastener 38 can be secured within the bore 54 formed in

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the post 52. An aperture 26e is located in the top 26b of the first plug 26 and is configured so that the working end of a tool can be passed there through. This enables the fastener 38 to be screwed into and out of the bore 54 of the post 52.

5

Formed in the top 26a of the first plug 26 is a pair of bores arranged to receive the self locking pins 38a. The self locking pins 38a are configured to properly locate and lock the fastener 38 within the fastener-receiving cavity 26c.

10 The sidewall 26d of the first plug 26 also includes an elongate connector screw slot 26f which enables the first plug 26 to be connected to a connector screw 70 which extends from the enlarged head 22a of the roller pin 22. The connector screw slot 26f includes a threaded upper portion 26f' which is arranged to receive a threaded retaining plug 72 (Figure 19). Prior to receiving the retaining
15 plug 72, the threaded upper portion 26f' is sized to enable the head 70a of the connector screw 70 to pass there through. In this manner, the head 70a of the connector screw 70 can be inserted into the connector screw slot 26f and then the shank of the screw 70 can be moved along the length of the slot 26f. The connection between the screw 70 and the first plug 26 will be described in more
20 detail subsequently.

As best illustrated in Figure 3, the fastener 38 is a socket head fastener. The head of the fastener 38 is arranged to be located within an upper portion of the cavity 26c so that when the fastener 38 is screwed into the post 52, the first
25 retaining means 26 is drawn into the lower tapered socket 46 and when the fastener 38 is unscrewed, the first retaining means 26 is lifted out of the upper tapered socket 46. The configuration of the sidewalls of the lower tapered socket 46 and the shape of the head 22a of the roller pin 22 facilitate this action of the first retaining means 26. As the first retaining means 26 (first plug 26) is
30 connected to the roller pin 22, movement of the first plug 26 in and out of the upper tapered pocket 46 will result in movement of the entire roller cartridge 20 in and out of the pocket 18.

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Figures 9 to 11 illustrate the second retaining means 28. The second retaining means 28, or second plug, is formed as a frustum. The frustum has an angle of less than or equal to 7° to its central longitudinal axis. As illustrated, this angle is approximately 3° . The second plug 28 has a base 28b, a top 28c and a sidewall 28d. The base 28b has a larger external diameter than the top 28c and is arranged for positioning lowermost within the upper tapered socket 40. A bore 28e is formed in a flat portion of the sidewall 28d of the second plug 28. The bore 28e extends substantially perpendicular to the central longitudinal axis thereof. The bore 28e is arranged to receive a second end 22b of the roller pin 22. The bore 28e is sized for a sliding fit with the second end 22b of the roller pin 22.

A threaded aperture 28f is formed in the base 28b of the second plug 28. The threaded aperture 28f is arranged to receive a retaining screw 29 which locates the second end 22b of the roller pin 22 within the second plug 28. The engagement of the retaining screw 29 with the roller pin 22 will be described in more detail subsequently.

Formed in the sidewall 28d of the second plug 28 is a minor bore 28j. The function of the minor bore 28j will be explained subsequently.

As mentioned previously, the second plug 28 has a lug 28k formed on the lower part thereof. The lug 28k is arranged to engage within the security recess 40b formed in the lower tapered socket 40. This engagement serves to better retain the roller assembly 20 within the pocket 18.

Figures 12 to 14 illustrate the crushing roller 24. The crushing roller 24 is formed as a hollow cylindrical member having a central bore which is sized to receive the shank of the roller pin 22. The crushing roller 24 has reduced diameter portions at each end for primary engagement of the crushing roller 24 with the walls of the well bore. A secondary engagement diameter is formed therebetween and is studded with a plurality of buttons 60 (not shown in Figures 12 to 14). The buttons 60 are preferably domed shaped tungsten carbide

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buttons that are each mounted within an aperture 62. The carbide buttons 60, in accordance with a preferred embodiment, are arranged in four rows of eight and are set on a left-hand 3.31699" pitch helix. Each row is separated by 90° of angular rotation and the starting point for each row commences in a progressive
5 step equal to $0.125 \times 1/9^{\text{th}}$ of the helical datum curve length. Each button 60 is spaced at $1/9^{\text{th}}$ of the helical curve length.

It will be appreciated by those skilled in the art that the above arrangement of buttons 60 on the crushing roller 24 provides a very efficient use of the carbide
10 buttons and thus significantly less carbide is used. This reduction in carbide use is also expected to reduce the torque loading in the drill string. It will further be appreciated that other arrangements of the carbide buttons on the crushing roller are envisaged. Advantageously, the carbide buttons are arranged so that during use they provide substantially complete coverage of the portion of the
15 wall of the well or drill hole being reamed. In other words, the contact area of the various carbide buttons with the portion of the drill hole being reamed overlaps.

Located between each of helically spaced rows of buttons 60 are flutes 64.
20 There are four flutes 64 and they are generated on the same helical datum path as the apertures 62. The flutes 64 are arranged to enable increased mud flow past the crushing roller 24 and to increase the clearance through which the crushing residue from the rotary roller reamer 10 can pass.

25 The inclusion of primary engagement diameters at the respective ends 24a, 24b of the crushing roller 24 enables the rotary roller reamer 10 to be bi-directional (i.e. either up hole or down hole in its application). Seven holes 62a are located in each primary diameter for the insertion of further domed tungsten carbide buttons 60a. The holes 62a are equally spaced and circumferentially drilled on
30 the surfaces normal to the roller central axis.

As illustrated in Figure 12, a further hole 62b drilled through to the central bore is formed in each of the primary engagement diameters. Each hole 62b is

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tapped with a female thread and is arranged to receive a pressure plug 63. Each hole 62b has the dual function of a grease injection port and a purge port. The use of the pressure plugs 63 will be described in more detail subsequently.

- 5 As illustrated in Figure 13, a pair of seal retention grooves 66 is formed within the wall of the central bore of the crushing roller 24 and are arranged to receive respective seals 34a, 34b. As shown, the seals 34a, 34b are simple o-rings. However, the use of other types of seals is envisaged.
- 10 Also shown in Figure 13 are further annular grooves 24c intermediate the ends of the bore of the crushing roller 24. Each groove 24c is arranged to receive a stabilizing band 75. As best illustrated in Figure 21, each stabilization band 75 is a band which is broken at point A to provide a gap between the respective ends 75a, 75b of the band. The ends 75a, 75b terminate at an angle of about
- 15 45° (See Figure 23). Termination at other angles is envisaged.

Each stabilization band 75 is sized to provide a minimal running fit about the shank of the roller pin 22 and to float within its respective groove 24c. Thus, the stabilization band 75 may either be rotatable with the roller pin 22 or with the

20 crushing roller 24.

Such a stabilizing band 75 is preferably made of a material that is reasonably hard and has a relatively low coefficient of friction. This material may be a fluoropolymer selected from the range of polytetrafluoroethylenes (PTFE)

25 marketed by DuPont under the TEFLON® trade mark. However, more preferably, such a material will be strengthened by the addition of a filler, such as with a glass, bronze or nickel filler. Ideally, the material will be a bronze filled PTFE.

30 In this form, the stabilizing band 75 tends to assist in maintaining the rotation of the roller pin 22 substantially stable about its longitudinal axis and along its entire length. In this respect, in some situations, a seals 34a, 34b may be somewhat sensitive to end-to-end bounce of the roller pin 22, such as would

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normally be expected due to the reasonably severe impact compression encountered by the roller assembly 20 during operation. The additional use of a stabilizing band 75 of this general type will thus assist with the smooth operation of the roller assembly 20.

5

Figures 15 to 18 illustrate the roller pin 22. The roller pin 22 includes a central longitudinal bore 22c (best shown in Figures 3 and 15) that opens through the lower end 22b. The bore 22c in the shank of the roller pin 22 forms a lubricant reservoir. A side port 22d extends between the lubricant reservoir 22c and a
10 primary lubricant distribution groove 22e. The primary lubricant distribution groove 22e extends longitudinally of the roller pin 22. As best shown in Figures 16 and 17, the primary lubricant distribution groove 22e is formed in a "figure 8" configuration.

15 It will be appreciated that the lubricant reservoir 22c enables a lubricant to be stored in the roller pin 22 and subsequently supplied, via the side port 22d, to the distribution groove 22e during rotation of the crushing roller 24 about the roller pin 22. The lubricant is distributed over the shank of the roller pin 22 as the crushing roller 24 rotates thereabout. The seals 34a, 34b retain the
20 lubricant on the shank of the roller pin 22.

A second side port 22i is located adjacent the second end 22b of the roller pin 22 and intersects with the lubricant reservoir 22c. The side port 22i opens into a groove 22j. The function of the groove 22j and the side port 22i will be
25 described below.

Also formed adjacent the second end 22b of the roller pin 22 is a transverse retaining slot 22g. The retaining slot 22g is arranged so that the leading end of the retaining screw 29 in the second retaining means 28 can be located in the
30 retaining slot 22g. In this manner, the roller pin 22 can be oriented relative to the second retaining means 28. The use of a retaining slot 22g enables limited rotation of the roller pin 22 after connection to the second plug 28.

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As best shown in Figures 3 and 20, the pressure equalization means 36 is positioned against a counter bore formed in the lubricant reservoir 22c. When the roller cartridge 20 is located in the pocket 18, the portion of the lubricant reservoir 22c to the right side (as shown in Figure 3) of the pressure equalization means 36 opens into the bore 28e of the second plug 28. The second side port 22i of the roller pin 22 opens into the groove 22j (Figure 20) which in turn aligns with the minor bore 28j formed in the second plug 28. The minor bore 28j of the second plug 28 opens to the area surrounding the crushing roller 24. Thus, it will be appreciated that there is a pressure flow path from the area surrounding the crushing roller 24 to pressure equalization means 36.

The pressure equalization means 36 acts to ensure that the pressure of the lubricant within the bearing cavity (i.e. the clearance between the roller pin 22 and the crushing roller 24) is substantially equal to the pressure of the drilling mud which completely envelopes the rotary roller reamer 10 during a reaming operation. It is important to equalize this pressure so as to prevent the seals 34a, 34b from blowing in or out.

The pressure equalization means may take the form of a filter 36. In one embodiment, the filter 36 may be a sintered metal filter. The sintered metal filter may have an alloy composition of 68% copper, 27% nickel and 5% tin and a micron capture equal to or about 30 μm . The pressure equalisation means may adopt other configurations.

As best illustrated in Figures 3, 18 and 19 the head 22a of the roller pin 22 is shaped to mate with the sidewall 26b of the first plug 26. Thus, the head 22a is configured as a flanked trapezium shaped solid with a conical cut in its outer face.

The head 22a includes a blind bore 22f which is coincident with the elongate axis of the roller pin 22. The bore 22f is threaded to enable connection of the

- 20 -

connector pin 70 thereto. This connection will be described in detail subsequently.

5 The first thrust ring 30 is formed as a solid ring of low friction metal or reinforced polymer which bears against the roller side face of the head 22a of the roller pin 22 and the face of the first end 24a of the crushing roller 24. The first thrust ring 30 is designed to accept the vertical thrust imparted from the sidewalls of the drill hole on the crushing roller 24 as a result of the rotating upward travel of the rotary roller reamer 10. The first thrust ring 30 is a sacrificial thrust ring.

10

The first thrust ring 30 has an internal o-ring seal 30a arranged to provide a small amount of shock absorption between the inside diameter of the thrust ring 30 and the shank of the roller pin 22. The o-ring seal 30a also acts as a barrier to the flow of drilling mud.

15

The second thrust ring 32 is a solid ring of low friction metal or reinforced polymer which bears against the second end 24b of the crushing roller 24 and the face of the second plug 28. The second thrust ring 32 is designed to accommodate the vertical thrust imparted from the sidewalls of the drill hole on the crushing roller 24 as a result of the rotating downward travel of the rotary roller reamer 10 within the hole being drilled. The second thrust ring 32 is a sacrificial thrust ring.

20

The second thrust ring 32 has an internal o-ring seal 32a arranged to provide a small amount of shock absorption between the inside diameter of the thrust ring 32 and the shank of the roller pin 22. The o-ring seal 32a also acts as a barrier to the flow of drilling mud.

25

The o-ring seals 32a, 32b are preferably made of a fluoroelastomeric compound.

30

The assembly process for a roller assembly 20 is as follows. A first thrust ring 30 is slid along the shank of the roller pin 22 until it abuts the head 22a of the roller pin 22. A crushing roller 24 with seals 34a, 34b and stabilization bands 75

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in position and carbide tips 60 fitted, is then slid onto the shank of the roller pin 22 until the first end 24a of the crushing roller 24 abuts the first thrust ring 30. The filter 36 is then seated against the counter bore of the lubricant reservoir 22c.

5

At this stage, grease is injected into the crushing roller 24 via one of the holes 62b ("the first hole 62b"). The grease is injected until grease flows through the hole 62b (the "second hole 62b") in the other primary engagement diameter of the crushing roller 24. A pressure plug 63 is then installed to seal off the
10 second hole 62b.

Grease injection is continued until lubricant flows through the lubricant reservoir 22c and out through the pressure equalization filter 36. At this point, the grease injection equipment is removed and a pressure plug 63 is fitted in the first hole
15 62b.

The second thrust ring 32 is then positioned on the shank of the roller pin 22 until it abuts with the second end 24b of the crushing roller 24. Finally, the second plug 28 is slid onto the end of the roller pin 22 so that the trailing end of
20 the second thrust ring 32 is located flush against the flat portion of the sidewall 28d of the second plug 28. The retaining screw 29 is then located in the threaded aperture 28f and screwed inwardly so that it locates within the retaining slot 22g formed in the shank of the roller pin 22.

25 The fastener 38 is then inserted in the fastener-receiving cavity 26c of the first plug 26 and held in position by the self locking pins 38a.

A steel ball 71 is then dropped in the blind bore 22f. A connector screw 70 is then screwed into the bore 22f until it is firmly set against the steel ball 71. This
30 action ensures a constant depth of engagement of the first plug 26 to the roller pin 22. The head 70a of the connector screw 70 is then passed through the upper portion 26f' of the connector screw slot 26f in the first plug 26. Connection between the first plug 26 and the roller pin 22 is maintained by

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inserting a retaining plug 72 in the threaded upper portion 26f' of the connector screw slot 26f. The retaining plug 72 prevents the head 70a of the connector screw 70 from inadvertently withdrawing from the connector screw slot 72.

- 5 The positioning of the connector screw 70 in the connector screw slot 26f of the first plug 26 is best illustrated in Figure 18. The insertion of the retaining plug 72 in the threaded upper portion 26f' of the connector screw slot 26f is best illustrated in Figure 19.
- 10 As will be apparent, the connection between the head 22a of the roller pin 22 and the first plug 26 is such as to allow limited articulation of the first plug 26 relative to the roller pin 22, whilst still ensuring proper alignment of the plug 26 relative to the roller pin 22 when the roller cartridge 20 is fitted into a pocket 18 of the rotary roller reamer 10.
- 15 Once the components of the roller assembly 20 have been assembled, the roller cartridge, as it is then known, forms a single cartridge which is ready for insertion into a pocket 18 of the rotary reamer 10.
- 20 A roller cartridge 20 is fitted within a pocket 18 of the rotary roller reamer 10 as follows. Firstly, the roller cartridge 20 is held horizontally so that the second plug 28 is located in a forward position facing the end of the lower tapered socket 40. The roller cartridge 20 is then tilted towards the floor 18a of the pocket 18. It is then lowered into the pocket 18 until the second plug 28
- 25 contacts the floor 18a of the pocket 18. The roller cartridge 20 is then slid forward and down into the pocket 18 until the second plug 28 is seated in the lower tapered socket 40.
- 30 During positioning of the second plug 28 in the lower tapered socket 40, the first plug 26 aligns itself relative to the roller pin 22 and the upper tapered socket 46 so that it is properly positioned within the pocket 18 ready to be fastened in position by the fastener 38. This "self aligning" characteristic of the first plug 26

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is a consequence of the nature of the connection between the first plug 26, the connector screw 70, the steel ball 71 and the head 22a of the roller pin 22.

5 A hex driver is then inserted through the aperture 26d in the first plug 26 and the fastener 38 is screwed into the threaded bore 54 of the post 52 formed in the floor 18a of the pocket 18. As the fastener 38 is screwed into the bore 54 the first plug 26 is drawn into the upper tapered socket 46. Figure 20 illustrates a roller cartridge 20 being fitted into a pocket 18 of a rotary roller reamer 10.

10 It will be appreciated by those skilled in the art that different numbers of pockets 18 may be provided on the reamer body 16. Additionally, although the pockets 18 are described as being equally spaced about the periphery of the reamer body, this need not always be the case. They may for example be spaced by an exponential or logarithmic value.

15

It will also be appreciated that the crushing roller 24 may include different arrangements and numbers of primary engagement diameters (i.e. may adopt a multi step form), carbide buttons, flutes and helixes.

20 The described embodiment of the invention is advantageous because:

1. Each roller cartridge 20 is retained in its respective pocket 18 using a single locking device (e.g. the bolt 38).
- 25 2. Each roller cartridge 20 can be easily fitted and removed from its respective pocket 18 because the roller cartridge 20 is fitted as a single "one" piece assembly. This enables quick insertion and removal of the roller cartridge 20 from a pocket 18 and thus helps minimise down time of a rotary reamer 10 due to maintenance requirements.
- 30 3. The arrangement of the first retaining means (first plug) 26 is such that tightening of the fastener 38 draws the first retaining means 26 into the pocket 18 and loosening of the fastener lifts the first retaining means 26

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and thus the entire roller assembly 20 out of the pocket 18. This ensures easy removal of the roller cartridge 20 even in the worst of on-site conditions.

- 5 4. The necked down portion of the reamer body 16 adjacent the crushing roller 24 facilitates relief of torsional stress that would otherwise be concentrated in this area of the reamer body 16. The necked down portion also enable superior mud flow through the primary mud ways milled between the pockets 18 and through and over the pockets 18.
10 The necked down portion also provides a uni-directional path linking each mud way should any one be obstructed during use of the rotary roller reamer 10.
- 15 5. The arrangement of the carbide buttons 60, 60a on the crushing roller 24 reduces the amount of carbide used whilst maintaining required performance. Additionally, it is envisaged that the arrangement of carbide buttons may serve to reduce the torque loading in the drill string.
- 20 6. The described pressure equalisation arrangement and in particular, the use of the filter 36 in the lubricant cavity 22c, improves the operational life of the roller assembly 20.
- 25 7. The load forces on the rotary roller reamer are all substantially longitudinal in direction rather than transversally. This results in a longer working life for the rotary roller reamer.
- 30 8. During use, the rotary roller reamer will rotate towards the right (i.e. clockwise when viewed looking down the well bore). The crushing rollers 24 on engagement with the well bore will rotate towards the left. As the drill bit on the end of the drill string loses diameter through normal operational wear, the reamer will through its rolling and crushing action ensure the integrity of the gauge size of the well bore diameter for a period in excess of the drill bits ability to maintain the required bore

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gauge. Hence, the use of rotary reamers in accordance with embodiments of the invention reduces the frequency of complete removal of the drill string from the well bore in order to change out the drill bit.

5

9. The roller cartridge 20 can be supplied on site, ready for use, without any further component assembly required.

The embodiments have been described by way of example only and
10 modifications within the spirit and scope of the invention are envisaged.

CLAIMS

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A roller assembly for a rotary roller reamer, said roller assembly including a roller pin, a roller arranged to be mounted on said roller pin, first retaining means and second retaining means, said roller pin having a head arranged for articulated connection to said first retaining means and an end arranged to be received in an aperture formed in the second retaining means, said end being secured to said second retaining means by securing means, and wherein said roller pin, roller, first retaining means and second retaining means are arranged to be connected together so as to form a cartridge that can be inserted into a pocket of the rotary roller reamer.
2. A roller assembly according to claim 1 wherein the cartridge is arranged to be secured to the pocket by means of a single fastener device.
3. A roller assembly according to claim 1 or claim 2 wherein said first retaining means includes a first plug which is arranged to be connected to the roller pin so that the roller pin, crushing roller and first plug form said single cartridge which can be inserted into the pocket of the rotary roller reamer.
4. A roller assembly according to claim 3 wherein the first plug has a first surface against which a first end of the roller pin mates and a second surface arranged to engage with a sidewall of said pocket, said sidewall of said pocket and said second surface of said first plug being configured so that the first plug is drawn into the pocket when said single fastener device is used to secure the cartridge to said pocket.
5. A roller assembly according to any one of claims 1 to 4 further including a first thrust ring located between the roller pin and a first end of the crushing roller and a second thrust ring located between a second end of the crushing roller and said

second retaining means.

6. A roller assembly according to claim 5 wherein the first and second thrust rings are sacrificial thrust rings.

7. A roller assembly according to claim 5 or claim 6 wherein the first surface of the first plug is complimentary to the first end of the roller pin.

8. A roller assembly according to claim 7 wherein the roller pin includes a shank having central longitudinal blind bore formed therein that opens through a second end of the roller pin.

9. A roller assembly according to claim 8 wherein the bore forms a lubricant reservoir and includes a side port that extends substantially perpendicular thereto and opens into a primary lubricant distribution groove.

10. A roller assembly according to claim 9 wherein the primary lubricant distribution groove extends substantially longitudinally of the roller pin.

11. A roller assembly according to claim 8 further including seal means provided between the crushing roller and the shank of the roller pin.

12. A roller assembly according to any one of claims 3 to 11 wherein the first plug includes a base having an underside shaped to engage with a mating portion of the pocket.

13. A roller assembly for a rotary roller reamer, said roller assembly including a roller pin, a roller arranged to be mounted on the roller pin, a first retaining means and a second retaining means, the roller pin having an enlarged head arranged for connection to said first retaining means and an end arranged to be received in an aperture formed within the second retaining means, said end being secured to said second retaining means by a retaining screw that engages within a lot formed in the roller pin, and wherein the roller pin, roller, first retaining means and second retaining means form a cartridge can be inserted into a pocket of the rotary roller

reamer and secured thereto by a single fastener that engages with said first retaining means.

14. A roller assembly according to claim 13 wherein the first retaining means includes a first plug having a fastener-receiving cavity that opens through a sidewall and base thereof, said fastener-receiving cavity being arranged to receive the fastener.

15. A roller assembly according to claim 14 wherein the first plug further includes an elongated screw connector slot formed in the sidewall thereof, said screw connector slot being configured to receive a head of a screw arranged to be connected to a head of the roller pin.

16. A roller assembly according to claim 15 wherein the first plug further includes an aperture opening into said fastener-receiving cavity which is arranged so that a tool can be passed there through to enable the fastener to be screwed into a mating portion of the pocket.

17. A roller assembly according to claim 13 wherein the second retaining means includes a second plug having a major bore formed substantially perpendicular to the central longitudinal axis of the second plug, said major bore being arranged to receive an end of the roller pin.

18. A roller assembly according to claim 17 wherein the second plug further includes a minor bore having a first end opening into said major bore and a second end opening onto an area surrounding the roller when the roller assembly is fitted in a rotary roller reamer.

19. A roller assembly according to claim 17 or claim 18 wherein the second plug further includes a lug arranged to engage with a complimentary shaped recess formed in a portion of the pocket.

20. A roller assembly according to claim 18 wherein the roller pin includes a side port which extends between the lubricant reservoir and the minor bore in the second plug.

21. A roller assembly according to any one of claims 1 to 20 wherein said roller includes a central portion and first and second end portions, the central portion having an external diameter greater than the external diameter of the first and second portions, and wherein the central, first and second portions are studded with projection means.

22. A roller assembly according to claim 21 wherein projection means are positioned about the central portion so a contact area of the projection means with a portion of a wall of a drill hole being reamed overlaps.

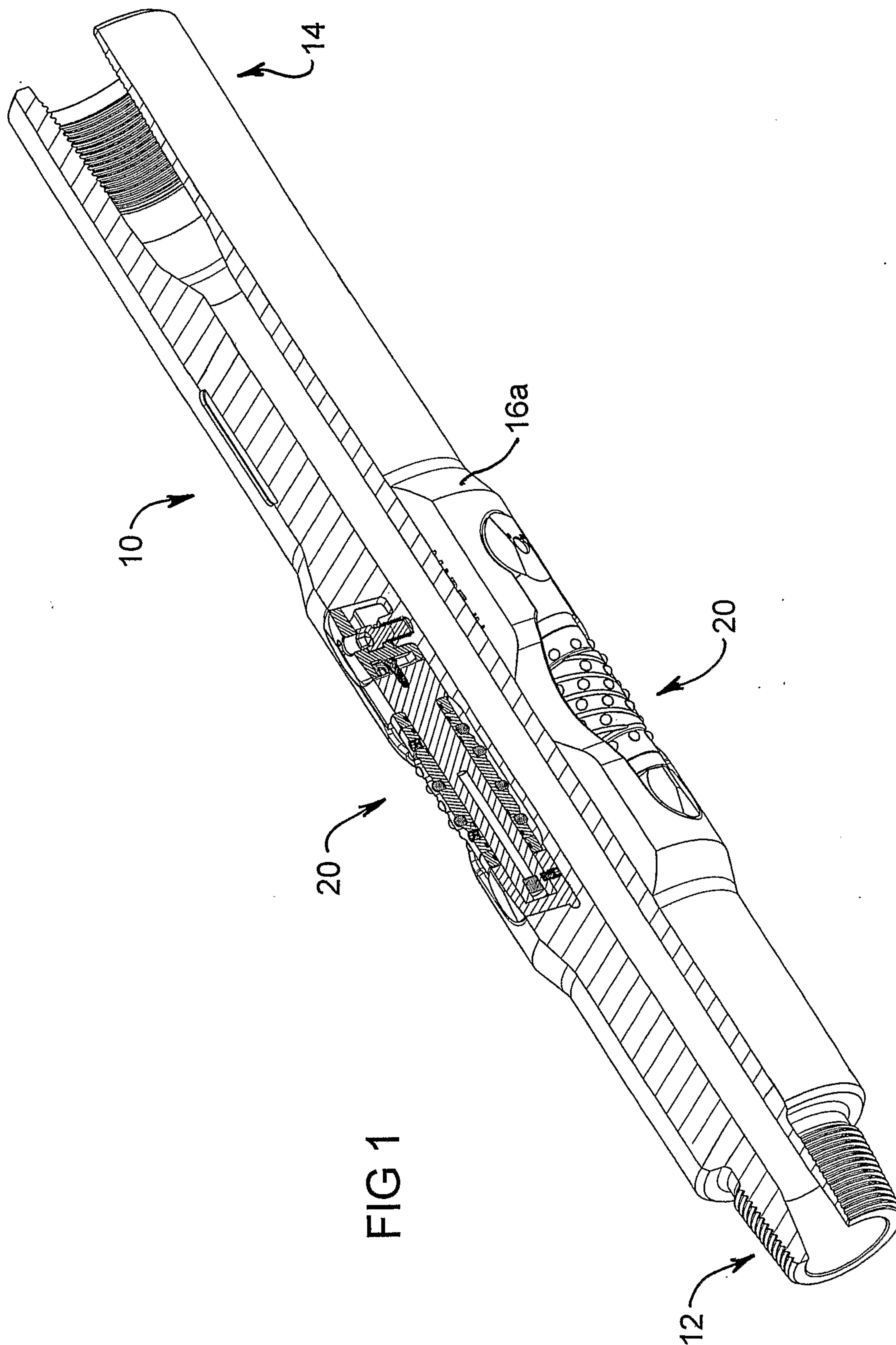
23. A roller assembly according to claim 21 or claim 22 wherein the projection means on the central portion are arranged in four rows of eight and are set on a left-hand 3.31699" pitch helix, each row is separated by 90° of angular rotation, the starting point for each row commences in a progressive step equal to $0.125 \times 1/9^{\text{th}}$ of the helical datum curve length and each projection means is spaced at $1/9^{\text{th}}$ of the helical curve length.

24. A roller assembly according to claim 23 wherein a flute is located between each of the helically spaced rows which are generated on the same helical datum path as the projection means.

25. A roller assembly according to any one claims 1 to 24 wherein the roller includes at least one lubricant entry hole and plug means for plugging said lubricant entry hole, said lubricant entry hole being arranged so that lubricant can be supplied to the roller pin.

26. A rotary roller reamer including a reamer body and at least one roller assembly in accordance with any one of claims 1 to 25 and wherein said reamer body has at least one pocket for receiving said at least one roller assembly.

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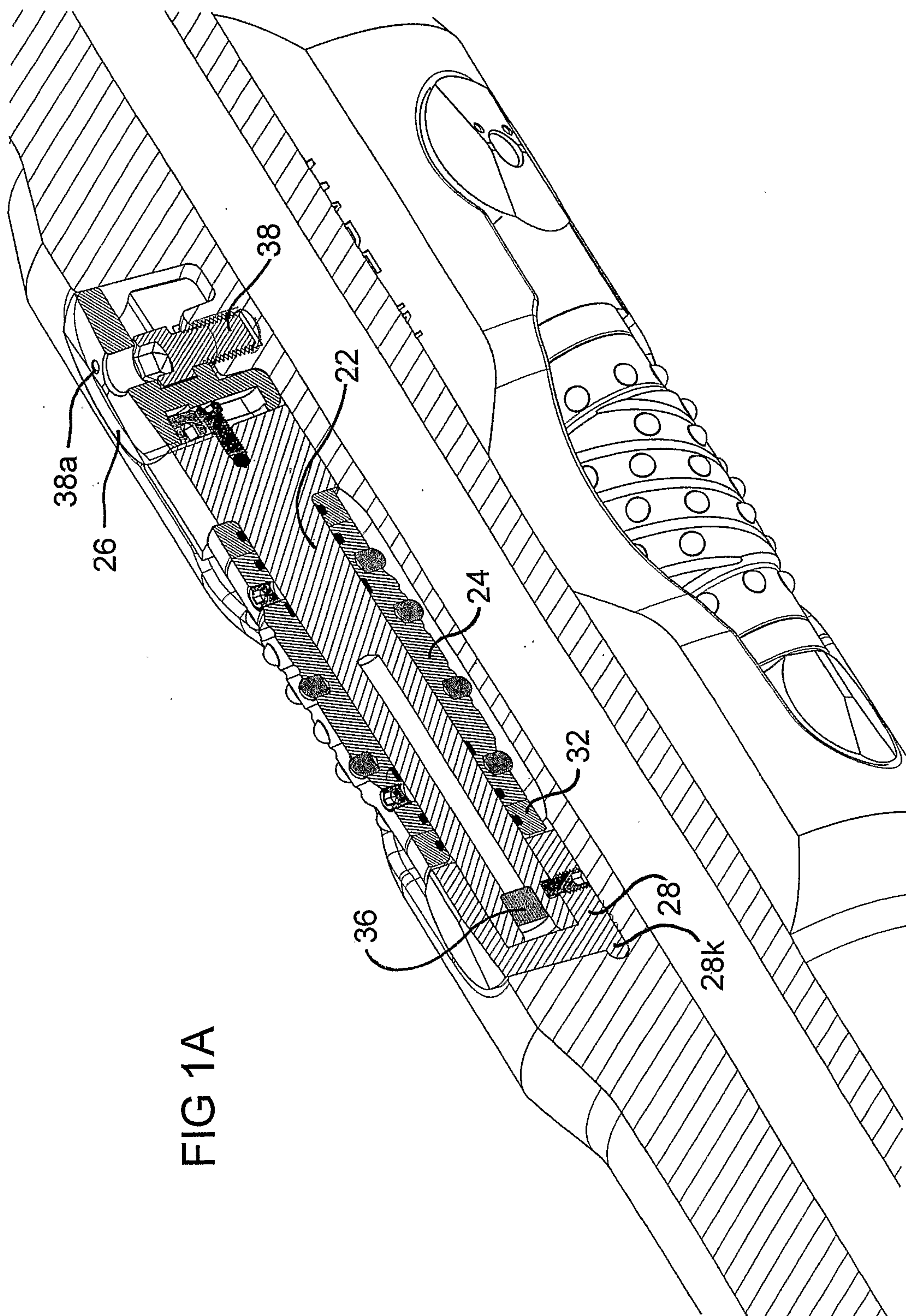


FIG 1A

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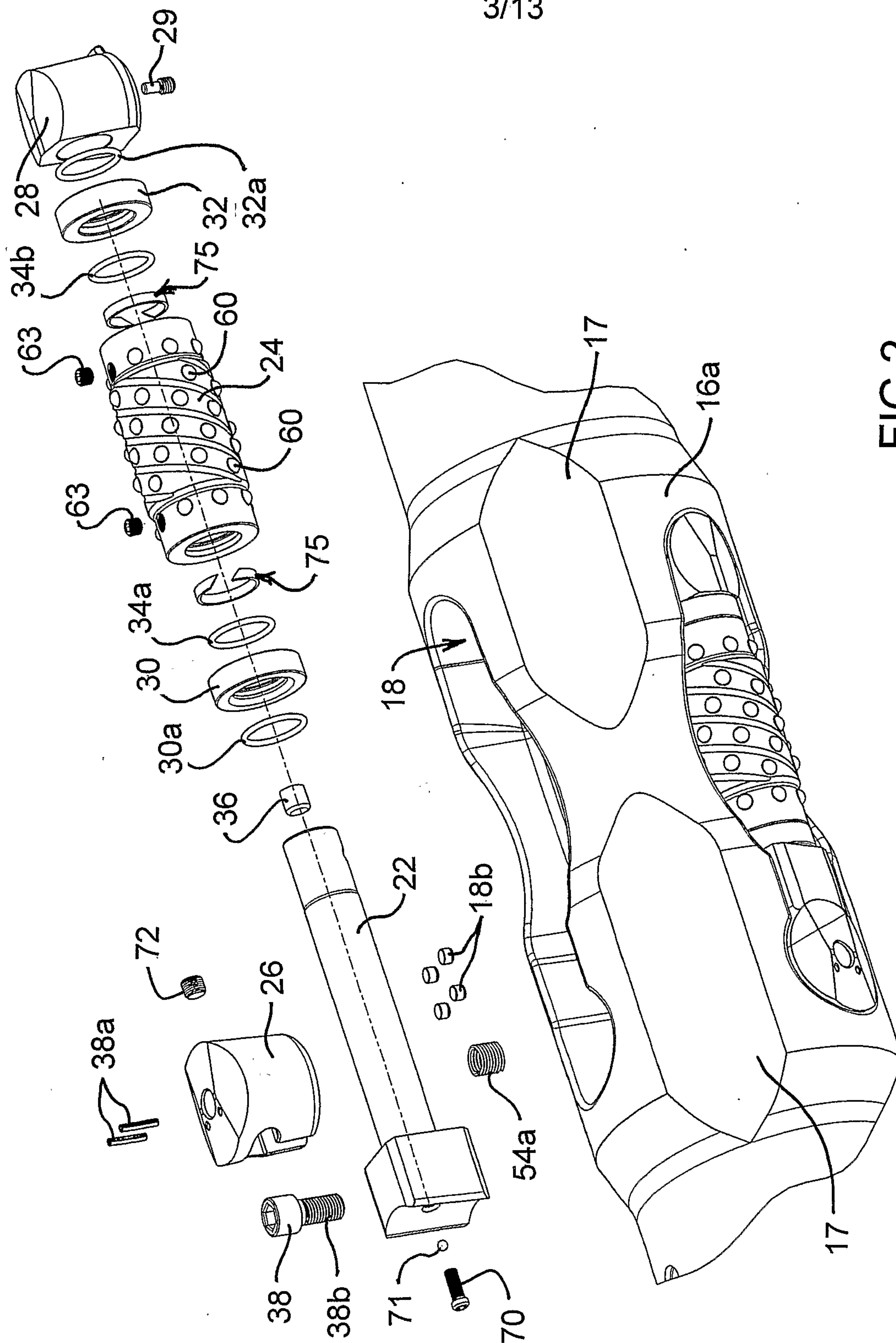
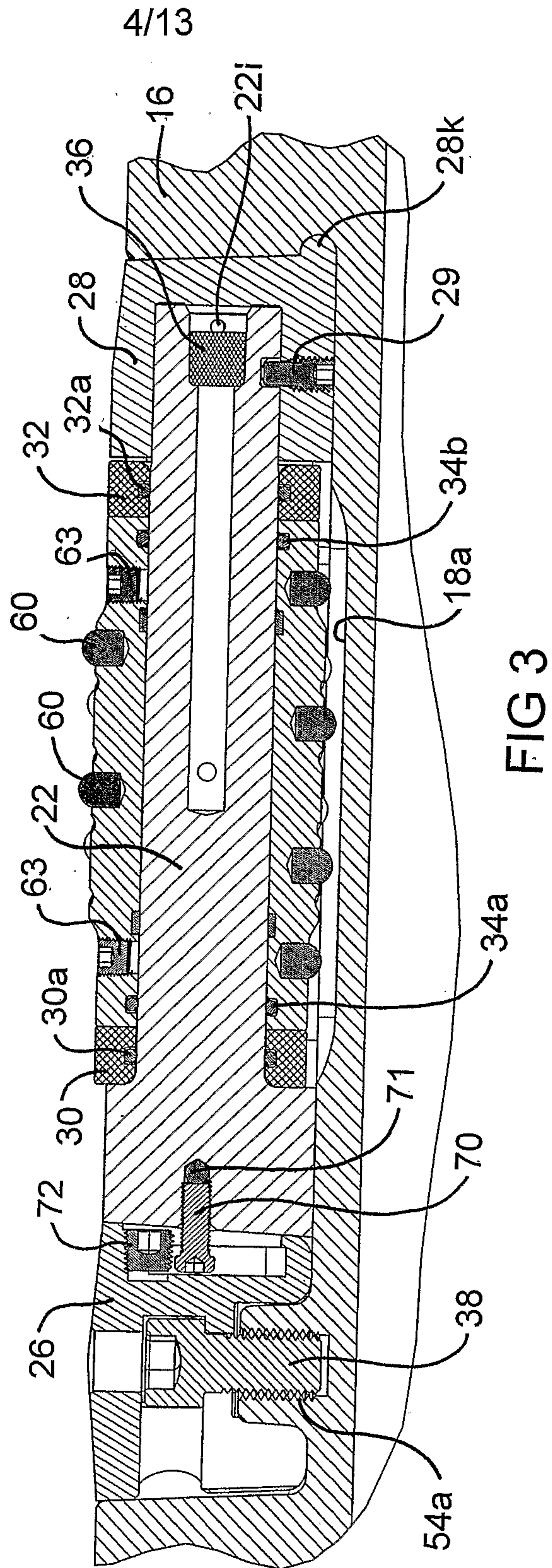
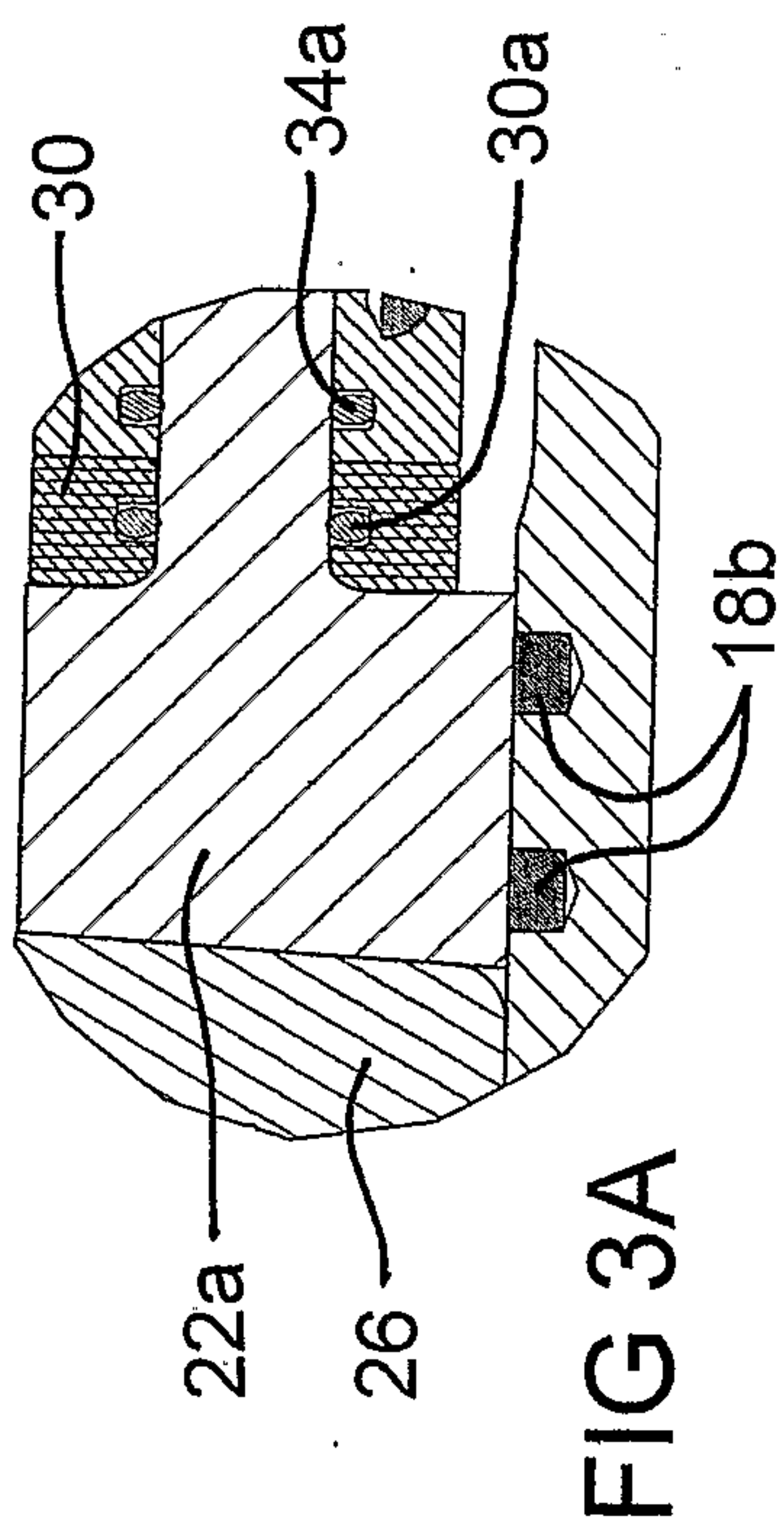
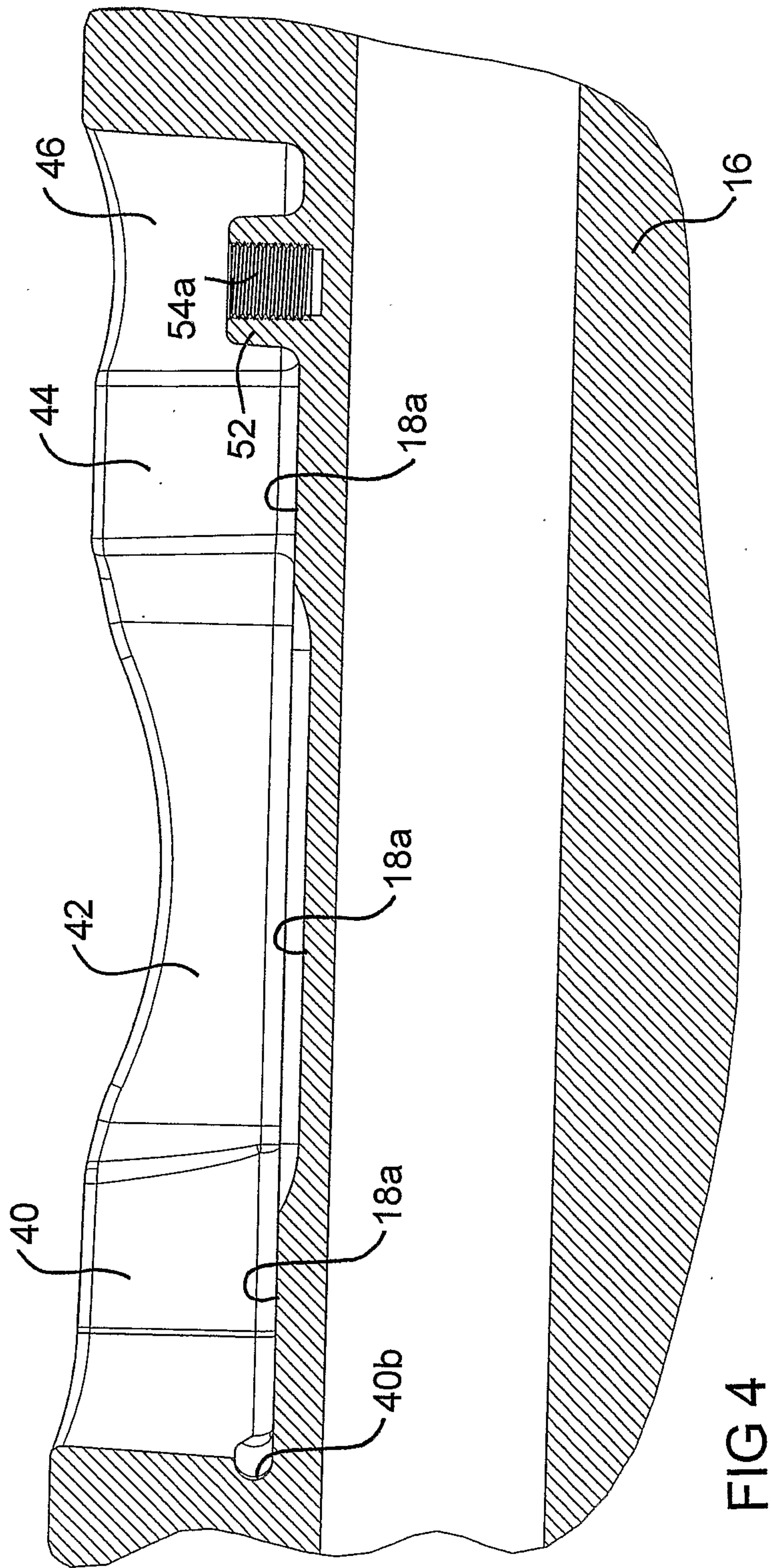


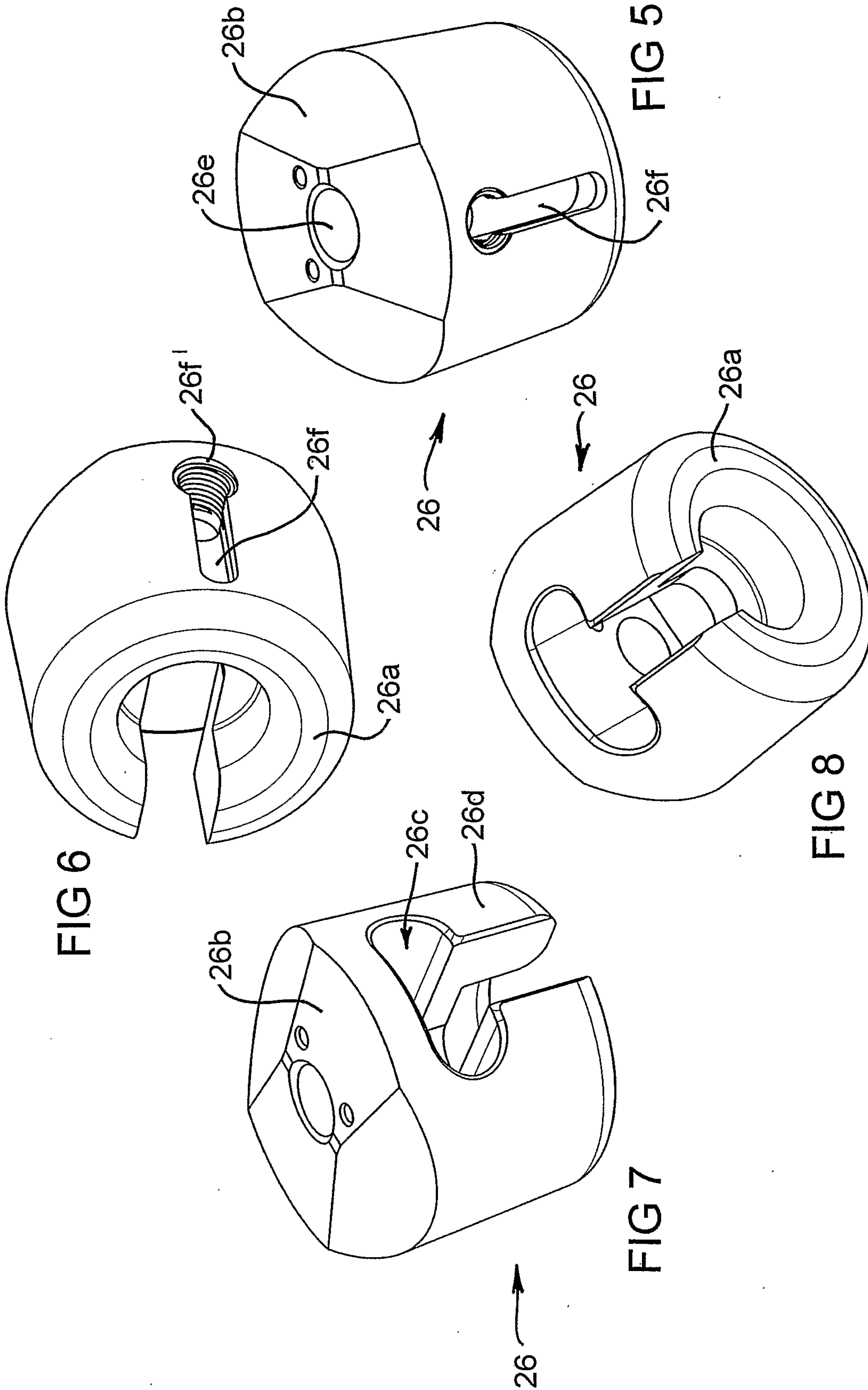
FIG 2



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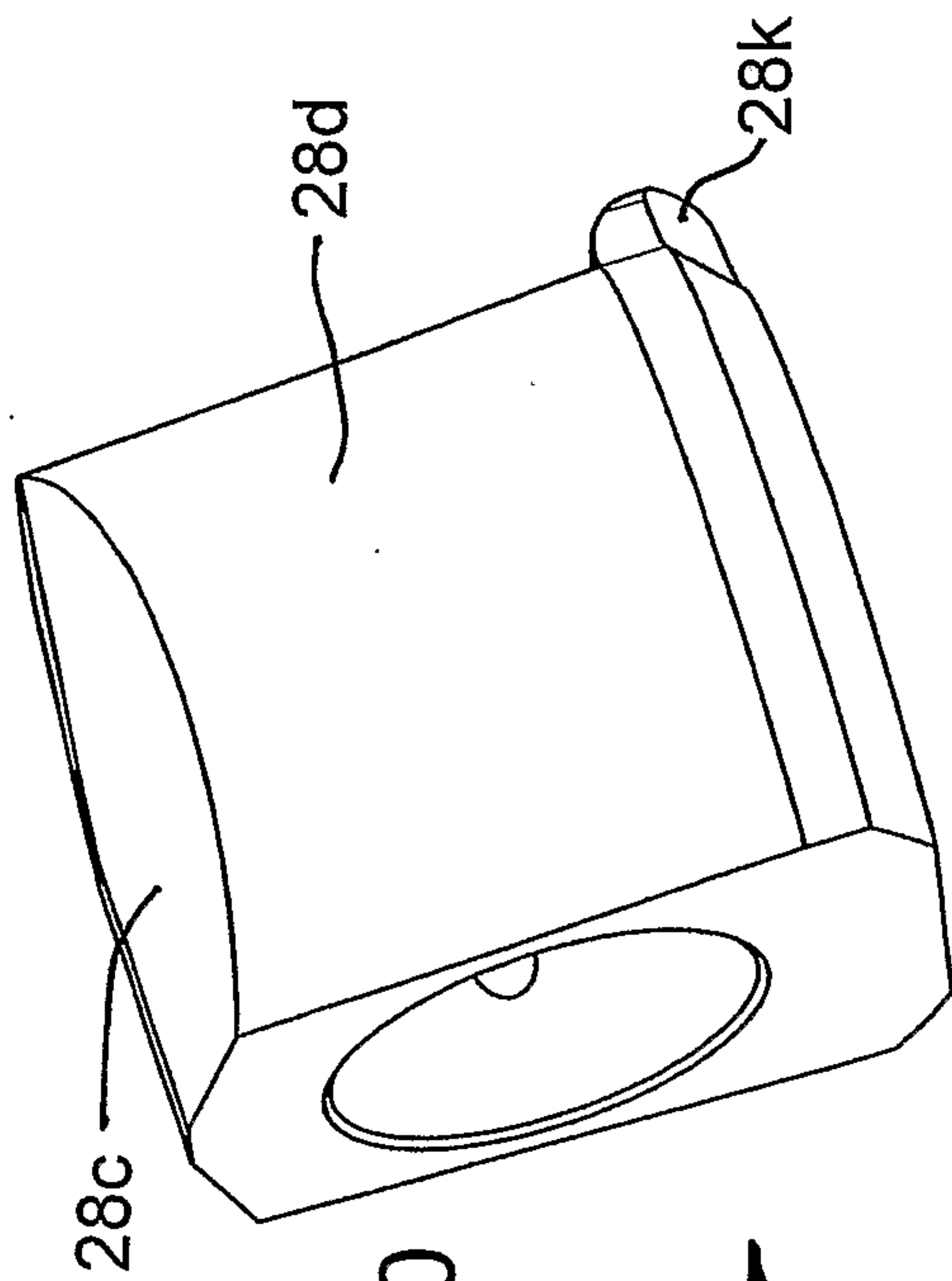


FIG 10

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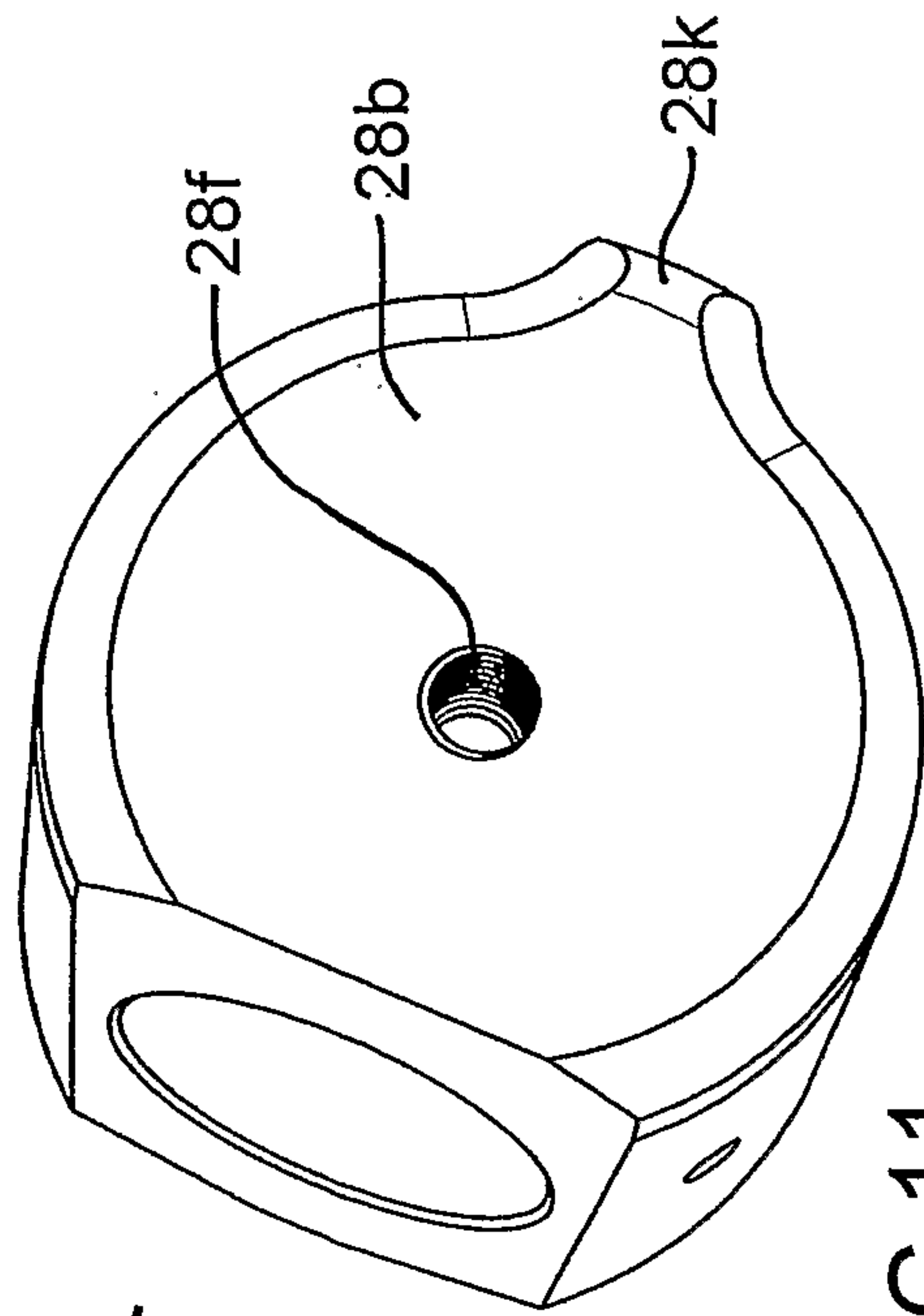


FIG 11

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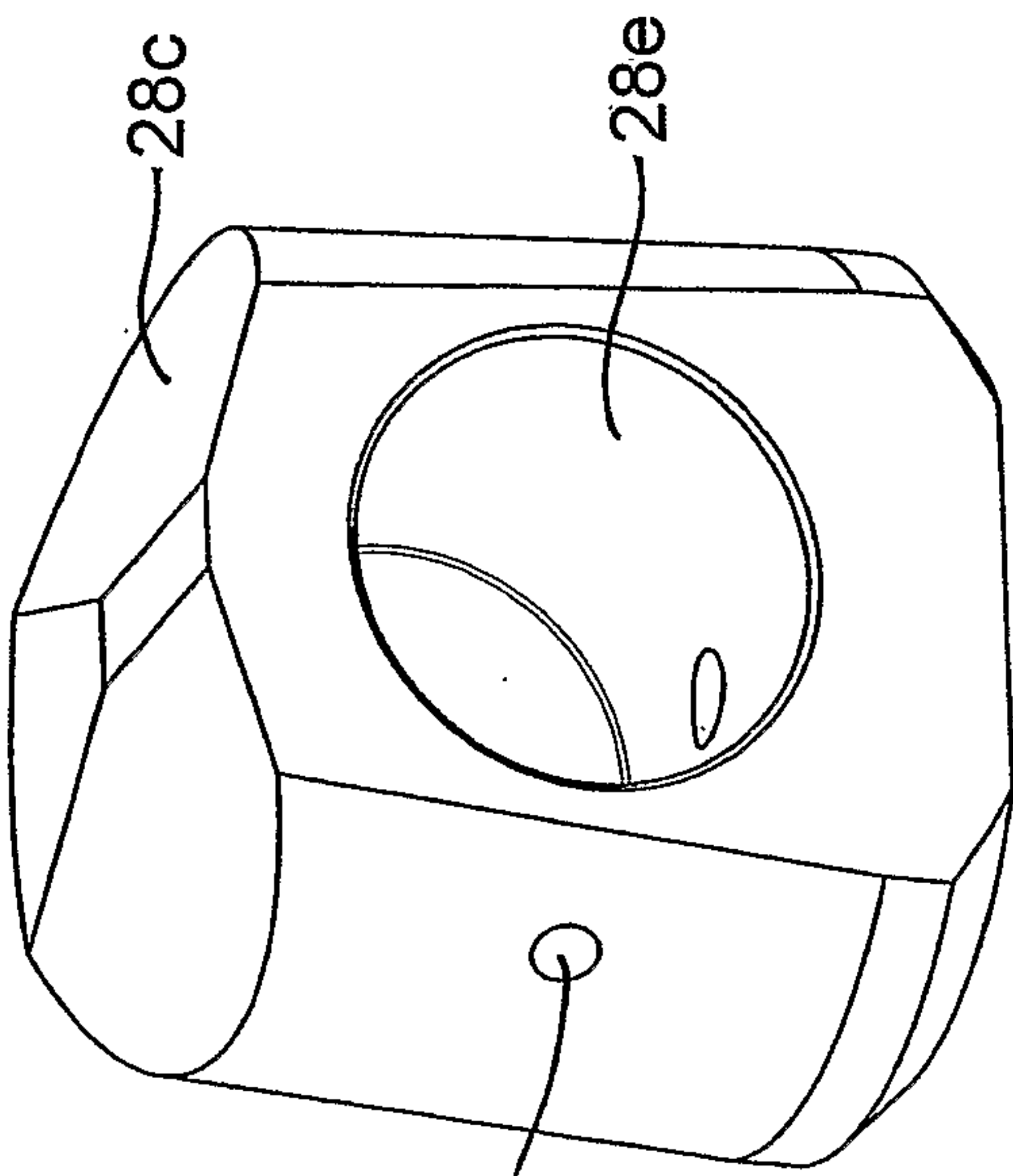
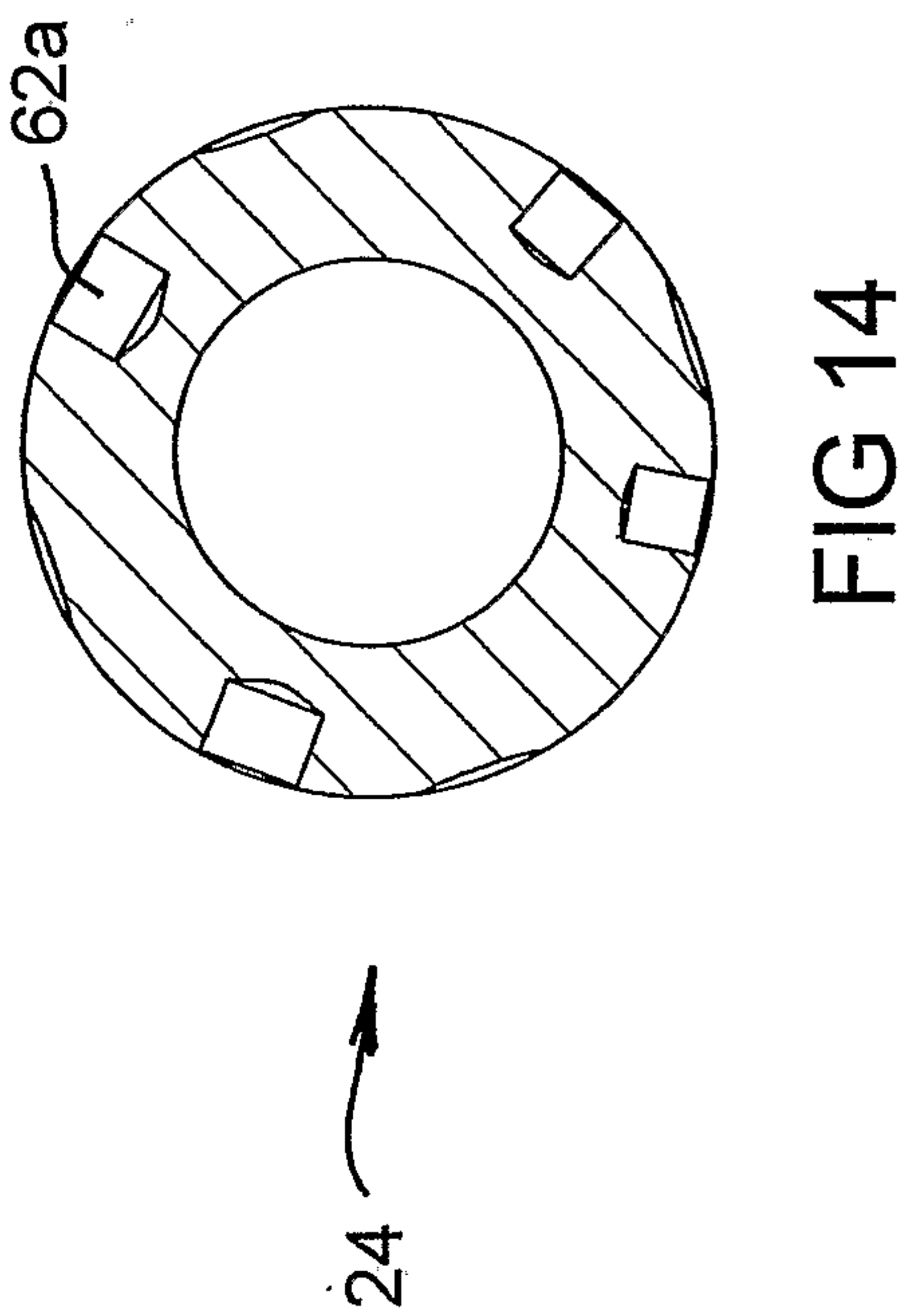
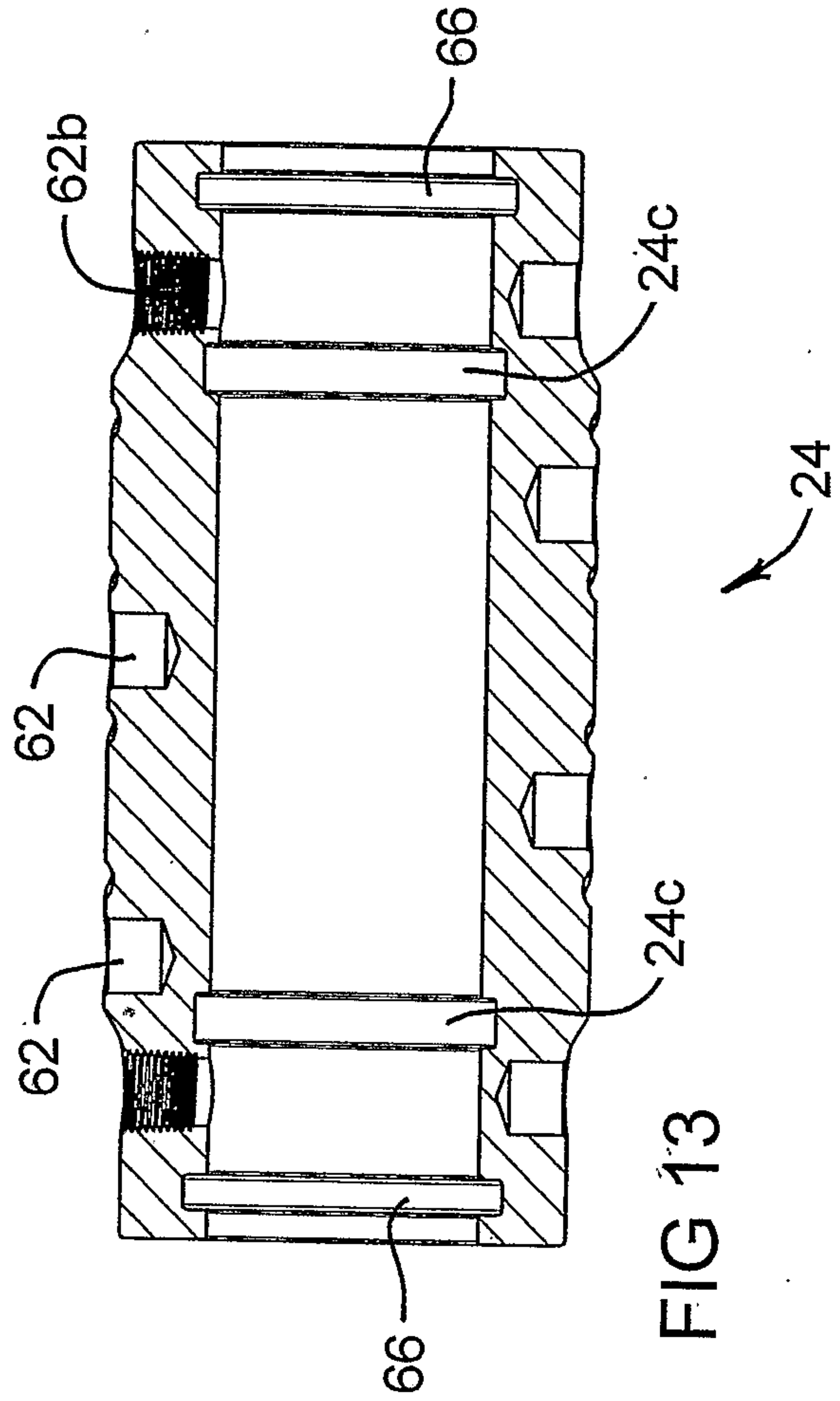
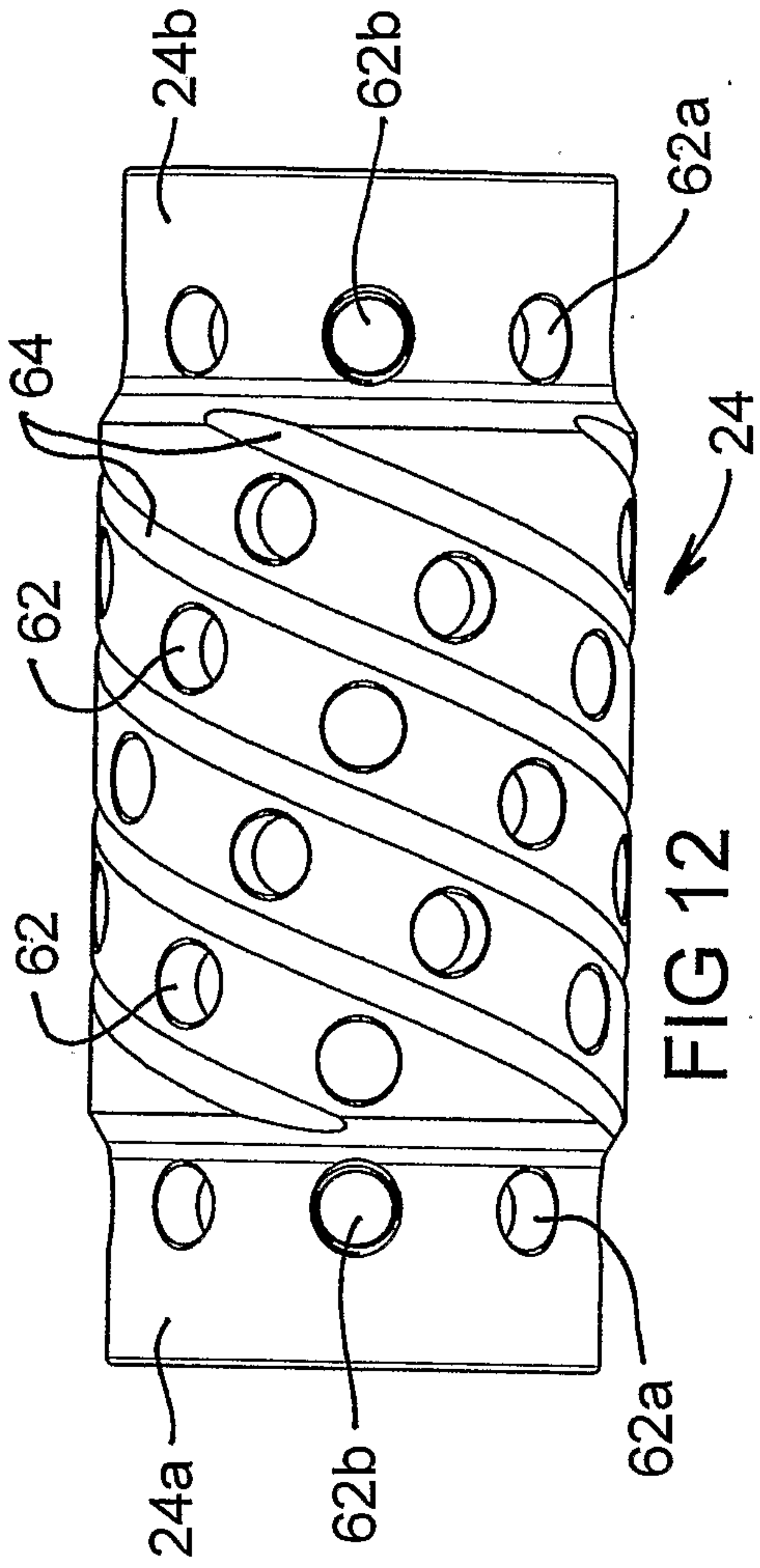


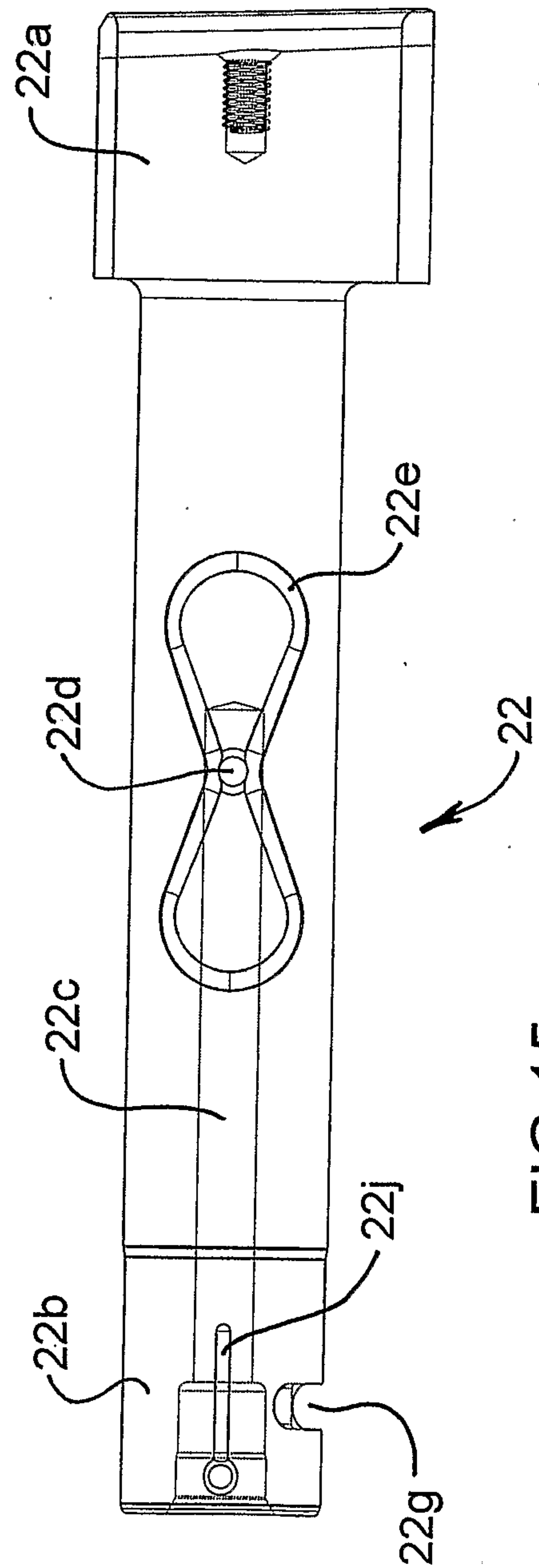
FIG 9

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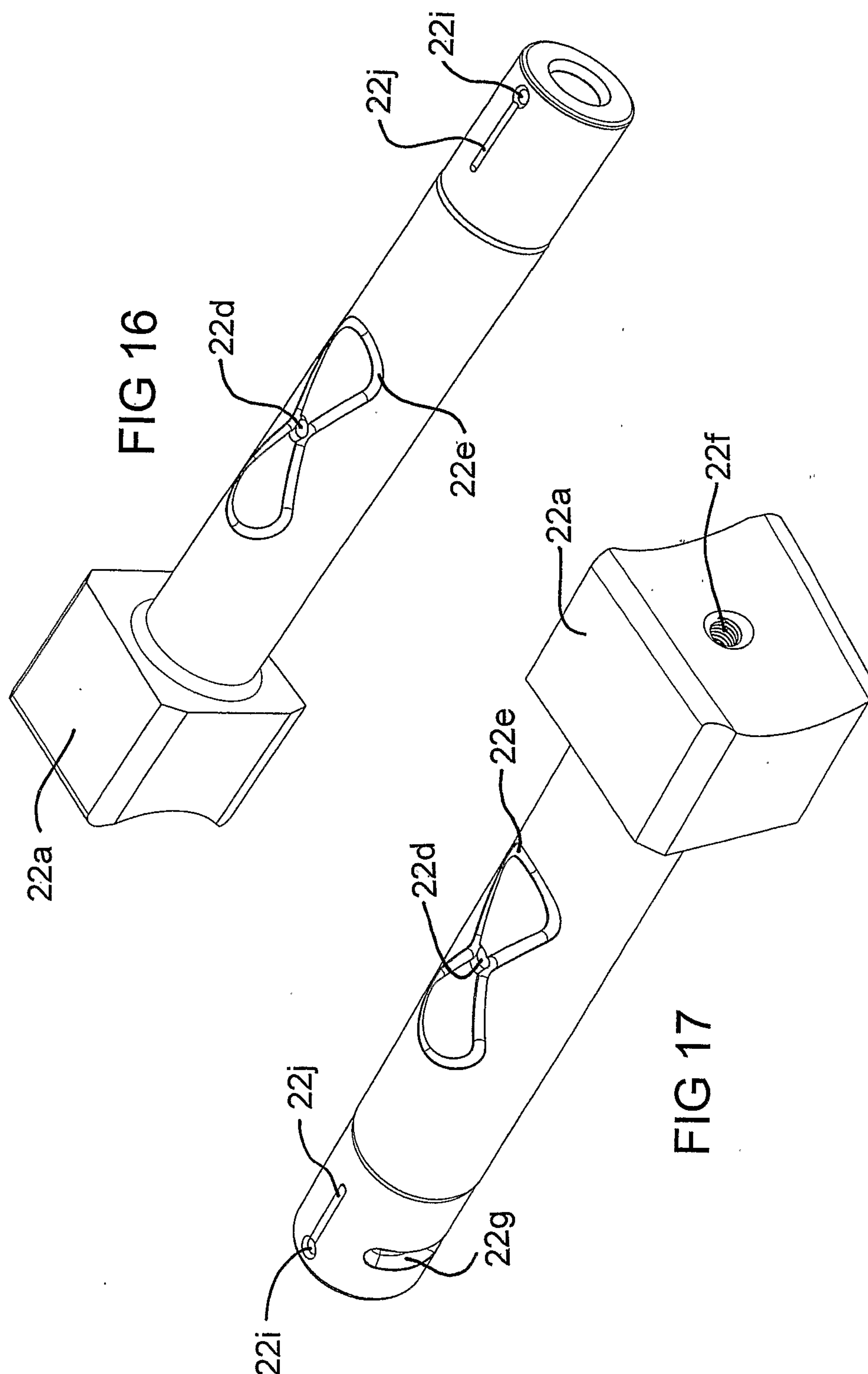
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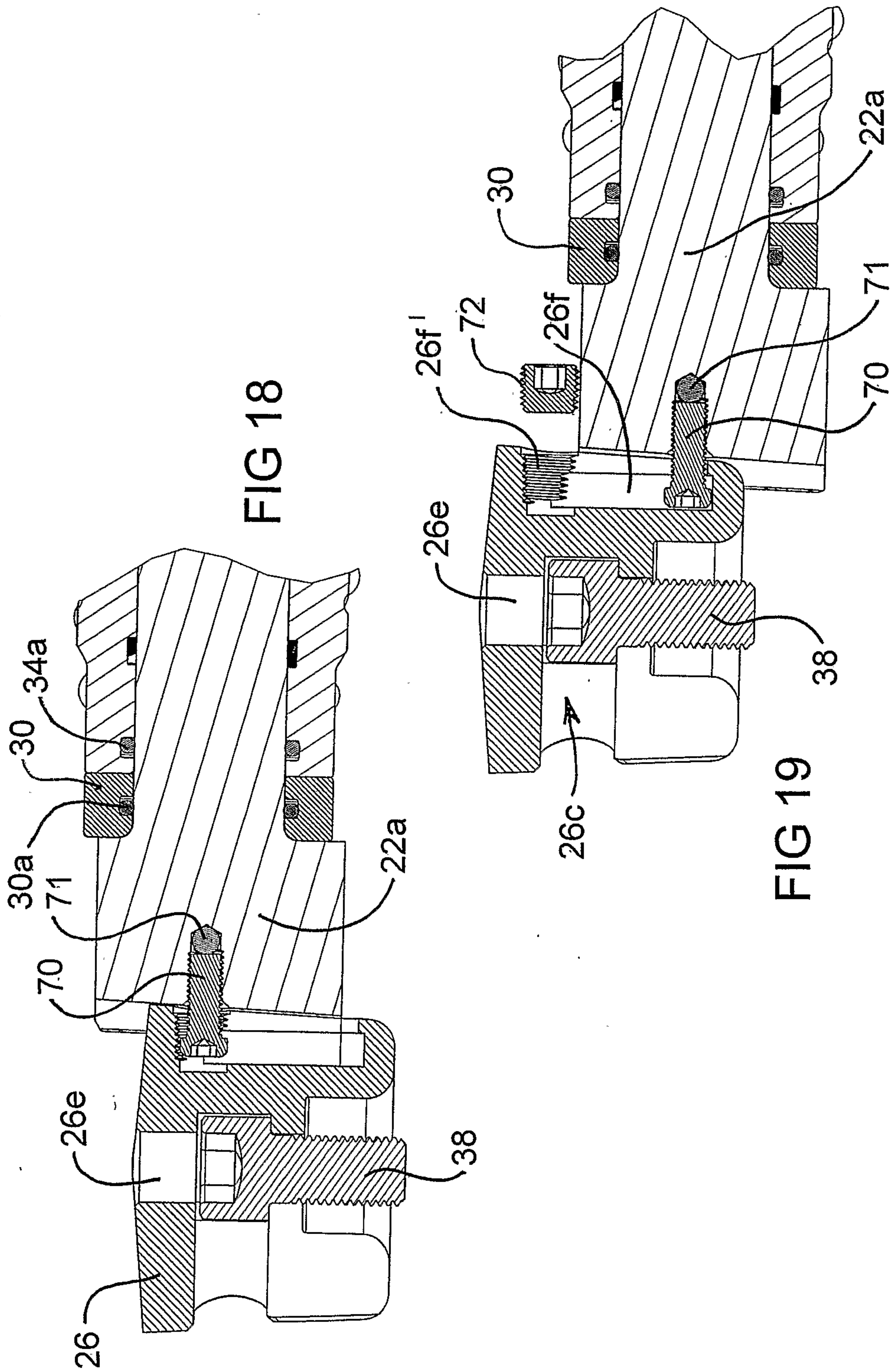
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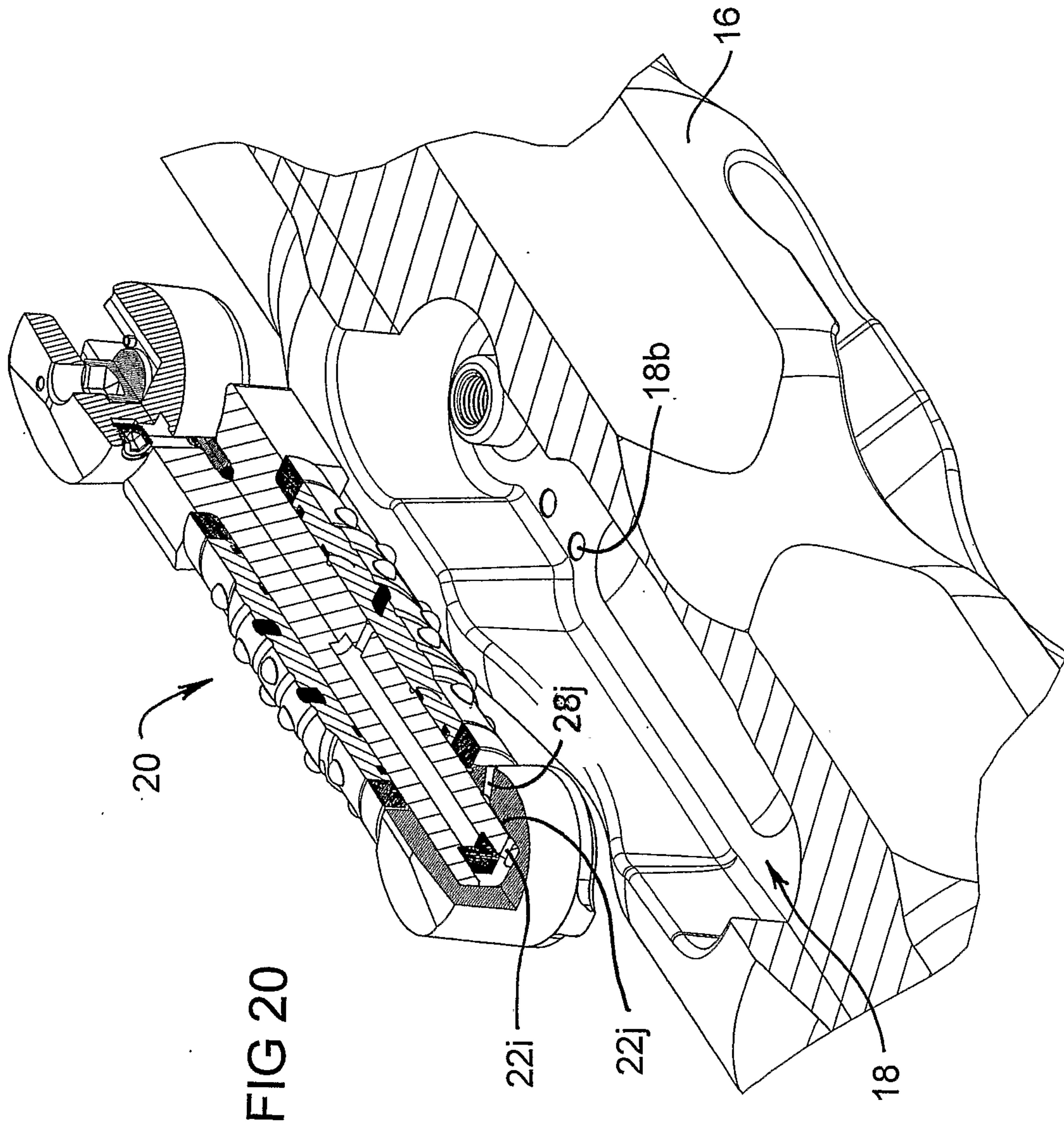
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