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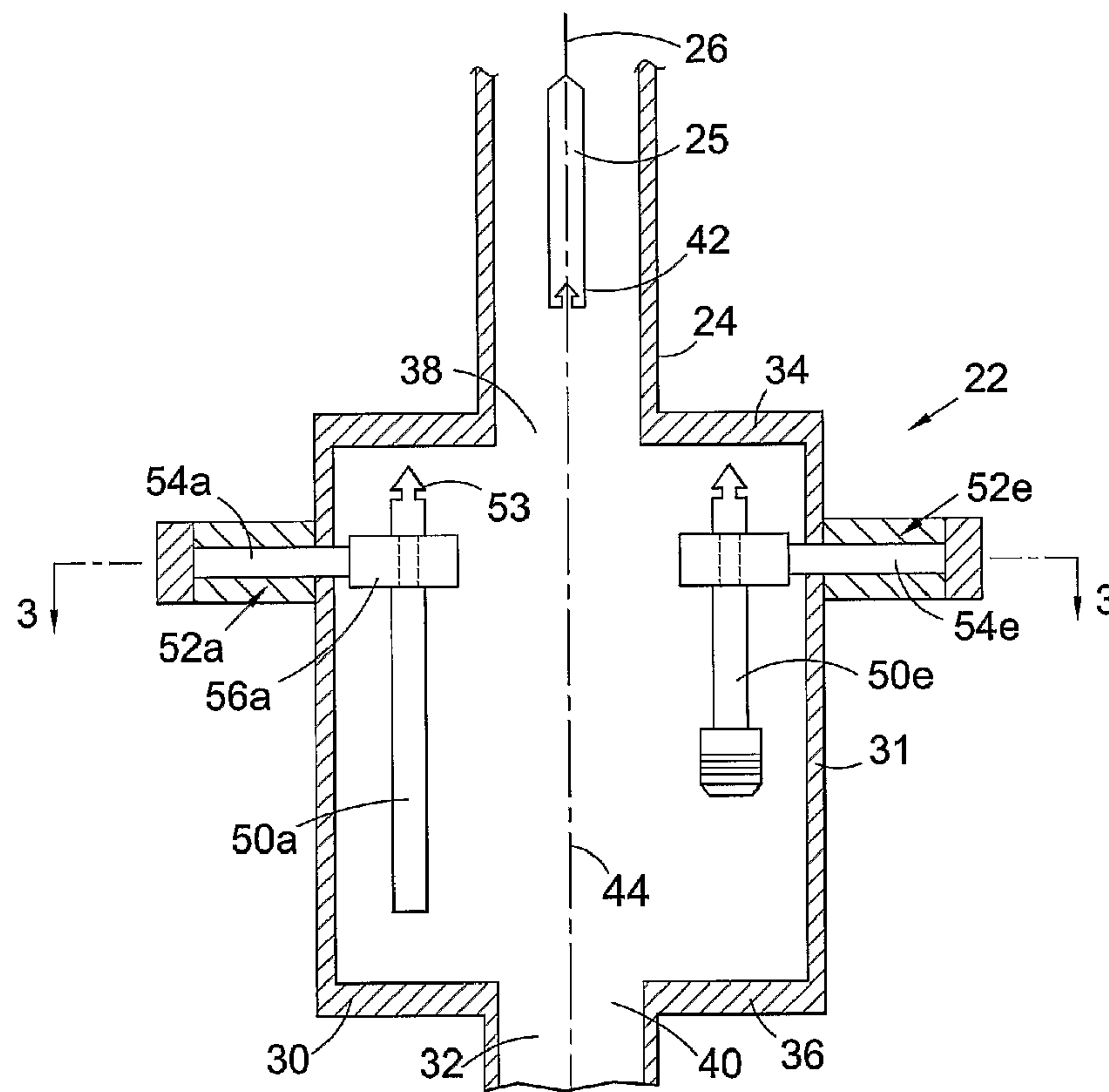
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(54) Titre : AMELIORATIONS APPORTEES A UN SYSTEME DE STOCKAGE D'OUTILS D'ENTRETIEN ET DE REPARATION DE PUITIS POUR DES INTERVENTIONS DANS DES PUITIS SOUS-MARINS

(54) Title: IMPROVED WELL SERVICING TOOL STORAGE SYSTEM FOR SUBSEA WELL INTERVENTION



(57) **Abrégé/Abstract:**

A well servicing tool storage system for subsea well intervention is disclosed which provides a tool storage means as part of the intervention system and which has a plurality of tool storage arms deployed around the tool storage means. Each arm has a clamp

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

capable of clamping a tool, and moving the clamped tool between a stored position near the perimeter of the tool storage means, and a deployed position in the centre of the tool storage means where the tool can be made up into a wireline connection.

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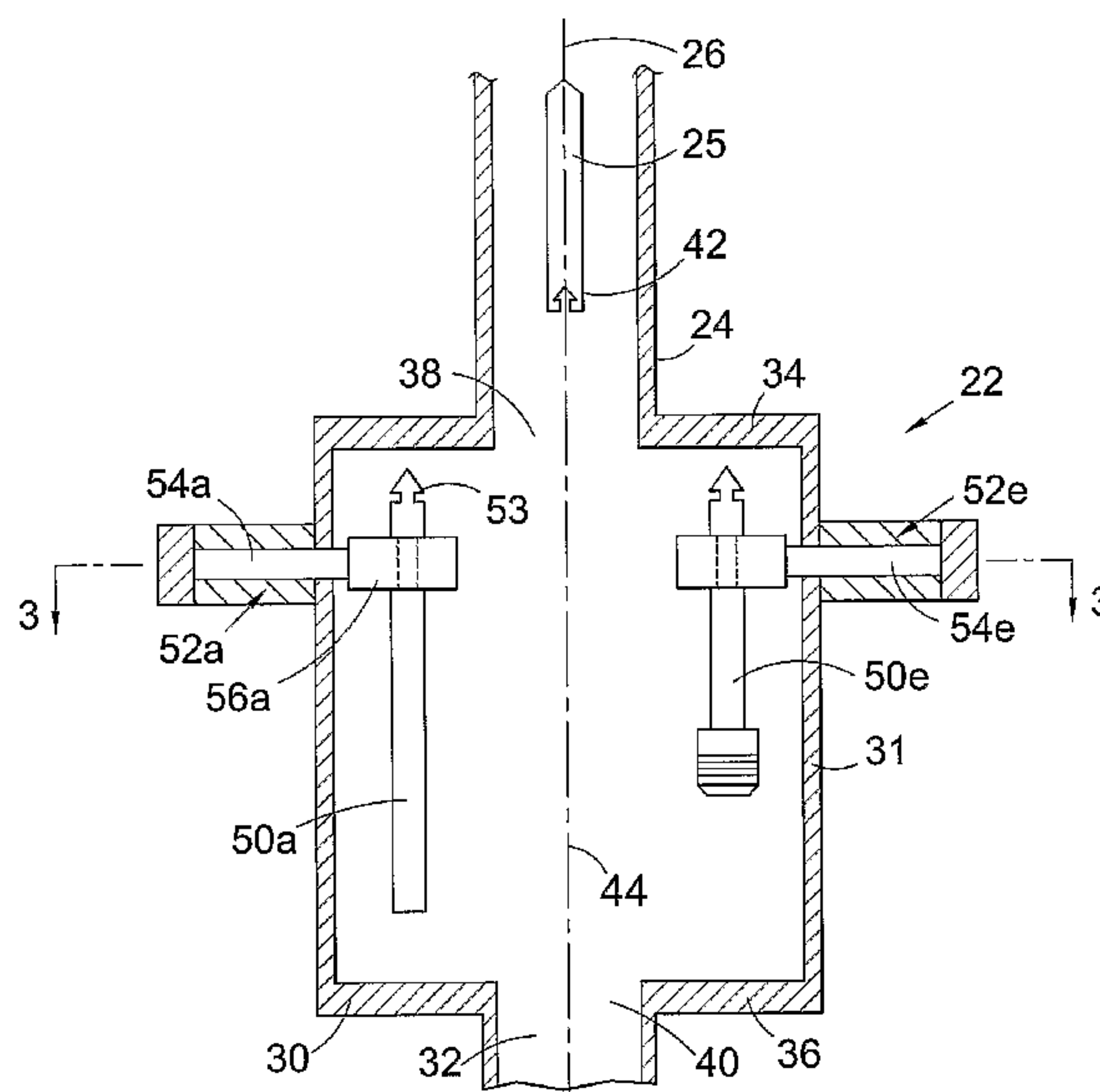
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(54) Title: IMPROVED WELL SERVICING TOOL STORAGE SYSTEM FOR SUBSEA WELL INTERVENTION



(57) Abstract: A well servicing tool storage system for subsea well intervention is disclosed which provides a tool storage means as part of the intervention system and which has a plurality of tool storage arms deployed around the tool storage means. Each arm has a clamp capable of clamping a tool, and moving the clamped tool between a stored position near the perimeter of the tool storage means, and a deployed position in the centre of the tool storage means where the tool can be made up into a wireline connection.

WO 2006/003362 A1

IMPROVED WELL SERVICING TOOL STORAGE SYSTEM FOR SUBSEA
WELL INTERVENTION

The present invention relates to subsea well intervention systems, and particularly, but not
5 exclusively, to an improved well servicing tool storage system with subsea well intervention systems.

The applicant's co-pending International application PCT/GB200/000138 discloses a system for the storage and deployment of wireline conveyed well
10 intervention tooling using a subsea intervention device. The number of such tool storage systems have been disclosed such as in the applicant's above-mentioned PCT application or in PCT application number PCT/US01/23518 but neither are optimised for storing
15 and deploying wireline or coil tubing in the case of PCT/US01/23518 tools using an autonomous, remote system. The aforementioned systems have some disadvantages. Firstly in the case of PCT/GB2004/000138 it may not be possible to deploy longer rigid tools
20 because of the geometry of getting the tool from the angled pocket into the well centre-line where it has to be made up in the vertical plane, while a portion of the tool remains in the angled pocket. In the case of PCT/US01/23518, the eccentric (ie. to the wellbore
25 centre-line) carousel system results in a badly balanced system when installing it onto a subsea Christmas tree using an ROV assistance especially given the wall thickness needed for the carousel to withstand internal oil pressure. It is an object of an
30 aspect of the present invention to provide an improved well servicing tool storage system for subsea

well intervention, which obviates or mitigates at least one of the aforementioned disadvantages.

This is achieved in its broadest concept by providing a tool storage means as part of the intervention system and deploying a plurality of tool storage arms around the tool storage means, each arm having a clamp capable of clamping a tool, and moving the tool between a stored position near the perimeter of the tool storage means, and a deployed position in the centre of the tool storage means whereby the tool can be made up into a wireline connection.

In accordance with the first aspect of the present invention there is provided a well intervention system for storage and deployment of wireline tooling, the system comprising:

a tool storage chamber having a plurality of tool storage clamping means disposed about the periphery of the chamber, each tool storage clamping means being capable of retaining a tool in a storage position, and being moveable from the storage position to a deployment position where the tool may be coupled and decoupled to a connection tool from above, said tool storage means having a storage clamp at its free end, said clamp being moveable between a closed position for retaining tool in said stored position and for holding the tool as it is moved between the deployment position and the storage position, and an open position when the tool is in the deployment position to allow the tool to be coupled and uncoupled to said connection tool.

Preferably the storage clamp has a fully closed position and a partially closed position, the clamp being moveable to the partially closed position when retrieving

the tool from the well source to locate the tool in the correct position for full recovery. Once the tool is located in the correct position, the clamp is fully closed so that the connection means can be released and the tool
5 disconnected and returned to the storage position by the tool storage clamping means.

Preferably also the storage chamber is cylindrical, said plurality of tool storage clamp means are disposed around the circumference of a cylindrical storage chamber
10 and the clamping means are moveable radially.

Preferably eight tool storage and clamping means are disposed around the periphery of the storage chamber. Alternatively any number of tools up to twelve can be stored in the chamber.

15 Advantageously each clamp has two jaws which are moveable between open and closed or partially closed positions, the jaws being hydraulically or electrically actuatable.

Conveniently each clamp includes a fixed portion and
20 a moveable portion, the moveable portion comprising a pair of jaws which are moveable towards each other to clamp the tool, and away from each other to release the tool, said clamp actuating means being located within the fixed portion.

25 According to a further aspect of the present invention there is provided a method in deploying a tool from a tool storage system for subsea well intervention in a subsea well, as set forth above, said method comprising:

storing a plurality of oil intervention tools within
30 a tool storage chamber so that the tools are substantially vertically aligned within said chamber when in said storage position;

selecting a tool for deployment;

moving said selected tool transversely to a tool deployment position, said tool deployment position being
5 substantially coaxial with said subsea well;

coupling a connection tool from above to the top of the selected tool; and

releasing the selected tool and deploying the selected tool in said well.

10 Preferably the method includes arranging the centre line of the storage chamber to be coaxial with the subsea well, and radially moving the tools between the storage position and the deployment position in said centre line.

According to a further aspect of the present
15 invention there is provided a method of storing a tool used for subsea well intervention within a well storage system after the tool has been deployed in the well, said method comprising:

returning the deployed tool to a first position
20 within the tool storage chamber, said first position being substantially coaxial with said subsea well;

engaging the deployed tool in a second position, said second position still being coaxial with said subsea well;

25 clamping said tool in the second position; and

decoupling the tool from a wireline connection system and moving the decoupled tool from the deployed position to a tool storage position.

Preferably the method includes arranging the centre
30 line of the storage chamber to be coaxial with the subsea well, and radially moving the tools between the storage position and the deployment position in said centre line.

According to a further aspect of the present invention, there is provided a tool storage and deployment mechanism for use with a subsea well intervention system, said tool storage and deployment
5 mechanism comprising:

tool storage clamping means being capable of retaining a tool in a storage position, and being moveable from the storage position to a deployment position where the tool may be coupled and decoupled
10 to a connection tool from above, said tool storage means having a storage clamp at its free end, said clamp being moveable between a closed position for retaining tool in said stored position and for holding the tool as it is moved between the deployment
15 position and the storage position, and an open position when the tool is in the deployment position to allow the tool to be coupled and uncoupled to said connection tool.

Preferably the tool storage and deployment
20 mechanism has eight clamping means disposed about the periphery of the tool storage chamber. Alternatively there may be one to twelve clamping means.

Conveniently, each clamp has two jaws and the jaws are electrically or hydraulically actuatable.

These and other aspects of the present invention will become apparent from the following description when taken in combination with the accompanying drawings in which:

5 Figure 1 is a diagrammatic view of a subsea intervention system in accordance with an embodiment of the present invention depicting the main components of the intervention system disposed on top of a subsea Christmas tree;

10 Figure 2 is an enlarged side view of the tool storage and deployment chamber showing two separate tools stored in the chamber for deployment into the wellbore;

15 Figure 3 is a cross-sectional view taken in the lines 3:3 in Figure 2, and depicts how the tool storage clamps are radially disposed around the circumference tool storage chamber;

Figure 4 is a view similar to part of Figure 2, but showing the tool in a deployed position and made up onto

the selected wireline connection tool ready for deployment or recovery;

Figure 5 depicts an enlarged plan view of a clamp used to retain wireline tools, the clamp being shown in a closed position;

Figure 6 is a view similar to Figure 5, but with the clamps shown in the open position;

Figure 7 is a view similar to Figure 4, but depicts the initial position of the clamping arrangement of the wireline tool after the wireline has pulled the tool back into said chamber but prior to the movement of the tool to the stored position;

Figure 8 shows the clamp jaws in the partially closed position with the wireline tool no-go sitting on top of the clamp jaws, and

Figures 9 (a), (b) and (c) depict various stages in the connection make-up between the wireline connection tool and the wireline tool with Figure 9(a) depicting the tools prior to connection, with Figure 9(b) depicting the tools made up, but not locked, and Figure 9(c) depicting the made up tools in a mechanically locked position and electrically connected.

Reference is first made to Figure 1 of the drawings which depicts a typical autonomous subsea well intervention system in accordance with an embodiment of the present invention, and generally indicated by reference numeral 10. The system is shown installed on top of a subsea Christmas tree 12. The principal components of the intervention system are: a main system connector 14 which interfaces with the Christmas tree 12, a Blow-Out Preventer 16 (BOP) or flow control valves to affect closure of well and isolation from the environment

in an emergency, or in the event having to remove the upper package from the intervention system; an intermediate connector 18 coupled to the top of the BOP
5 connector;

a housing 20 containing a coaxial wireline winch 21 (shown in broken outline) coupled to the top of the intermediate connector 4, and disposed axially around the wellbore; a tool storage system 22 as will be later
10 described in detail, and

a lubricator or riser section 24 containing a connection tool 25 (in broken outline) for connecting a wire 26 from the wireline winch 21 to the tool (not shown) on the storage system via a wireline lubricator
15 28.

Reference is now made to Figures 2 and 3 of the drawings which depict enlarged diagrammatic side and plan views of the tool storage unit 20 shown in Figure 1. It will be seen that the storage system 22 comprises a
20 cylindrical chamber 30, the cylindrical wall 31 (and end walls) of which are designed to withstand the internal pressure of the well when the chamber 30 is open to the wellbore 32 (best seen in Figure 1). The cylindrical chamber 30 is concentric with the wellbore 32, as best
25 seen in Figure 3. The chamber 30 has top and bottom faces 34 and 36, and has apertures 38 and 40 in these faces respectively, to allow the wireline 26 to run into the wellbore 32 from the lubricator riser section 24 above the cylindrical storage system 30.

30 The wireline 26 from the wireline winch 21 is connected to the wireline connection tool 25, which is normally disposed in the lubricator section 24 when not being used to deploy tools into the well. The wireline

connection tool has at its lower end 25, an automatic connection device 42 designed to connect or disconnect from wireline tools held in the storage chamber 30, which will be later described in detail.

The wireline tools generally indicated by reference numerals 50a to 50h are held in the chamber 30 in storage clamping units 52a to 52h. As best seen in Figure 3, eight clamping units are disposed circumferentially around the tool storage chamber 30, and two of the clamping units 52a and 52e are shown in solid outline. In the position shown in Figures 2 and 3, the clamping units are holding the tools in the storage position, i.e. away from the wellbore centre line and near the wall 31 of the chamber 30.

The structure and operation of one clamping unit 52a will be described in detail, although it will be understood that the structure and operation of all clamping units is identical.

Referring again to Figure 2 of the drawings, it will be seen that the clamping unit 52a retains the wireline tool 50a in the vertical position near to the periphery of the storage unit 28. The storage clamping unit 52a comprises a hydraulically actuatable ram 54a, at the end of which is a clamp 56a. Actuation of the clamping unit 52a causes the ram 54a to move radially between the stored position shown in Figure 2 and the deployed position shown in Figure 4, where the wireline tool is disposed on the well centre line 44.

When the tool is selected for use in the intervention system, for example, in this case tool 50a, an appropriate signal is sent to the clamping storage means 52a, such that the ram or hydraulic piston is

actuated to move the clamping unit 52a from a position shown in Figure 2 radially inwards until the tool 50a and clamping unit 56a are on the tool centre line 44 as shown in Figure 4. The position shown in Figure 4 is a deployment position. Once the wireline tool is in the deployment position the winch 21 is actuated to lower the connection tool 25 from the position shown in Figure 2 to connect with the top 53 of the wireline tool 50a held in the clamp 56a on the wellbore centre line in Figure 4 as will be later described in detail.

Once the connection is made as shown on Figure 4 and the wireline tool 50a is securely held by the connection tool 44, the clamp 56a is ready to be released.

Reference is now made to Figures 5 and 6 of the drawings, which depict the clamp 56a in greater detail. The clamp 56a consists of two clamp jaws 58a and 58b which are hydraulically moveable towards and away from each other. In Figure 5 jaws 58a and 58b are shown closed, and in Figure 6 the jaws 56a and 56b are shown separated. Movement of the jaws is achieved by means of a hydraulic actuator 60, which is shown in broken outline in clamp support 62.

When in the position shown in Figure 4 the hydraulic actuator 62 is activated to open the jaws to the position shown in Figure 6. When in this position the hydraulic ram 54a is actuated to be withdrawn from the centre line position 44 shown in Figure 4 back to the storage position shown in Figure 2. This allows the wireline deployment full and unfettered access to the wellbore 32, and the selected well servicing tool 50a can then be lowered into the wellbore 32 by the wireline 25.

Once the tool has completed its operation it requires to be retrieved and returned to the storage position. In order to recover the wireline tool into the storage position as shown in Figure 2, the wireline tool connector and wireline tool 50a assembly is pulled by the wireline winch 21 back into the lubricator riser section 24, so that the wireline tool 50a can be relocated within the storage section 30.

Figure 7 depicts the initial position of the ram and clamp arrangement on the wireline tool assembly 25, 50a, after the wireline winch 21 has pulled the wireline tool 50a back into the lubricator riser, and prior to the recovery of the tool 50a into the tool storage system 30.

The wireline tool 50a attached to the wireline 26 through the connection tool 25 is pulled back into the lubricator riser 24 so that a profile 63 in the wireline tool 50a that is designed to fit into the clamp 56a, is disposed above the clamp 56a. The hydraulic ram 54a is then activated so as to move the clamp from the storage position shown in Figure 2, and towards the wireline tool assembly which is now on the wellbore centre line 44. Prior to the clamp 56a reaching the wireline tool 58a, the jaws 58a, 58b of the clamp 56a are open to the fullest extent to allow the clamp to move either side of the wireline tool 50a to be recovered as the clamp 56a is further advanced by the ram 54a. The jaws 58a, 58b of the clamp 56a are then closed to a position (partially closed) that allows most of the length of the body of the tool a to move through the partially closed jaws 58a, 58b, but does not allow a portion of increased diameter, known as a no-go 65, on the body of the wireline tool 50a to move through the partially closed jaws 58a, 58b.

The wireline winch 21 is now actuated to lower the wireline 26 attached connection tool 25 and the wireline tool 50a until the no-go 65 lands on top of the clamp jaws 58a, 58b. Reference is again made to Figure 8 of the drawing which depicts the clamp jaws in the partially closed position, with the wireline tool no-go 65 sitting on top of the clamp jaws 58a, 58b. With the wireline tool 50a in the correct position for recovery, the clamp jaws 58a, 58b are then fully closed onto the profile 63 to hold the tool firmly and ready for recovery. The connector tool 25 is then energised, as will be later described, to release the connection between the connector tool 25 and the wireline tool 50a, allowing the wireline winch 21 to pull the connector tool 25 back into the lubricator riser 24, with the wireline tool 50a now firmly held in the clamp system 56a. With the wireline and connector tool 44 now clear of the top of the wireline tool 50a, the ram 52a is then actuated so as to retrieve the clamp 56a with a wireline tool 50a, and the jaws 58a, 58b back into the storage position as shown in Figure 2.

It will be understood that the deployment and retrieving arrangement can be repeated for any other tool held in the tool storage system such as tool 50e.

Reference is now made to Figures 9a, 9b and 9c of the drawings, which depicts the connection assembly which operates between the connector 25 and each of the wireline tools 50a to 50h. It will be understood that the tool connector system forms an integral part of the subsea intervention system for the deployment of the wireline tools, and the connection provides an electro/mechanical junction between various elements of a

wireline tool string, which facilitates multiple connect/disconnect operations.

The connection tool 25 has a lower section 68 which
5 comprises a number of circumferentially arranged collet fingers 70, which define an aperture in which is located a moveable, electrical connection ram 72. This part is referred to as the "male part" of the tool 25. Referring to Figure 9a, the top part of the tool 50a has a female
10 receptacle 74 which has an interior profile generally indicated by reference numeral 76, which opens via a recess 77 to an electrical connector 78. In the positions shown in Figure 9a the two parts are shown separated.

In Figure 9b the connection tool 44 is lowered so
15 that the collet fingers 72 are inserted into and engage with the receptacle 74; the collet fingers being slightly spring-loaded, so that they deform inwardly and then engage with the profile 76, as best seen in Figure 9b. In this position the electrical connector ram 72 is still
20 retained within the envelope of the collet fingers, and in this position the connector 25 can simply be retrieved back into the lubricator unit 24. The electrical connection ram 72 is driven into the recess 77 within tool 50a, to achieve the necessary electrical continuity
25 connector 78. When this item is fully forward as shown in Figure 9c, the wider portion 80 of the electrical connector abuts the inner surfaces 82 of the collet fingers, and locks the collet fingers 70 into the profile 76 of the female receptacle 74, and prevents the
30 connection tool 25 from retracting and disengaging from the wireline tool 50a. In this position the tool 50a is fully locked to the connection tool 25 and the clamps 52a

can be released as described above, and the tool 50a deployed into the well for intervention.

Following make up, the electrical continuity and a
5 simple overpull test is applied via the wireline prior to the release of the tool string into the wellbore, to ensure that the connection is electrically and mechanically secure.

The disconnection process is the reverse of the make
10 up sequence, with additional checks being made to ensure that the desired operations have occurred before proceeding. Thus the electrical connection unit is fully retracted using a linear actuation mechanism so that that arrangement as shown in Figure 9b is repeated, but in
15 reverse. Electrical continuity is then checked across the junction to ensure that the electrical connection item has retracted.

The wireline 21 is actuated so that a force to the wireline is effected to 'snap' the collet fingers 70 out
20 of the female receptacle 74, so that the connection unit 25 is separated from the tool 50a, as shown in Figure 9b, and the two parts are then separated, and the tool 50a can be returned to the storage position and the subsequent tools can then be deployed in the manner as
25 described above.

It will be understood that various modifications may be made to the embodiment hereinbefore described without departing from the scope of the invention. For example, it will be understood that the jaws of each clamp could
30 be activated using electrical motors and screw threads on the fixed part of the clamp to provide the lateral motion of the jaws. Furthermore, a different number of tools can be disposed around the periphery of the tool storage

unit. Furthermore, clamps could be moved between the tool centre line and the storage position using an electric motor or screw arrangement, or a mechanical lead screw.

5 Advantages of the new system include: less complexity than equivalent tool selection systems since the tool is moved in only one dimension for make-up, and that dimension is radial. The lateral extent of the radial movement can be easily and readily controlled by
10 limiters and confirmed by simple positional instrumentation.

Make-up certainty is increased as the lateral position (i.e. tool centre-line coincides with well bore centre-line) is controlled as above, and the tool is held
15 vertically in the clamps.

The system is compact and of (relatively low weight) - there are attractive attributes when deploying such a system from a floating vessel.

Tool configurations held in the system can be easily
20 varied for each type of tree or well operation, as can the number of tools "loaded" into the system.

CLAIMS

1. A well intervention system for storage and deployment of wireline tooling, the system comprising:
 - a tool storage chamber having a plurality of tool storage clamping means disposed about the periphery of the chamber, each tool storage clamping means being capable of retaining a tool in a storage position, and being moveable from the storage position to a deployment position where the tool may be coupled and decoupled to a connection tool from above, said tool storage means having a storage clamp at its free end, said clamp being moveable between a closed position for retaining tool in said stored position and for holding the tool as it is moved between the deployment position and the storage position, and an open position when the tool is in the deployment position to allow the tool to be coupled and uncoupled to said connection.
2. A system as claimed in claim 1 wherein the storage clamp has a fully closed position and a partially closed position, the clamp being moveable to the partially closed position when retrieving the tool from the well source to locate the tool in the correct position for full recovery.
3. A system as claimed in claim 1 or claim 2 wherein the storage chamber is cylindrical, said plurality of tool storage clamp means are disposed around the circumference of a cylindrical storage chamber and the clamping means are moveable radially.

4. A system as claimed in any one of claims 1 to 3 wherein eight tool storage and clamping means are disposed around the periphery of the storage chamber.

5. A system as claimed in any one of claims 1 to 3 wherein any number of tools up to twelve are stored in the chamber.

6. A system as claimed in any one of claims 1 to 4 wherein each clamp has two jaws which are moveable open and closed or partially closed positions, the jaws being hydraulically or electrically actuatable.

7. A system as claimed in claim 6 wherein each clamp includes a fixed portion and a moveable portion, the moveable portion comprising a pair of jaws which are moveable towards each other to clamp the tool, and away from each other to release the tool, said clamp actuating means being located within the fixed portion.

8. A method of deploying a tool from a well intervention system according to any one of claims 1 to 7, said method comprising:

20 storing a plurality of oil intervention tools within the tool storage chamber, each tool being retained by a respective tool storage clamping means so that the tools are substantially vertically aligned within said chamber when in said storage position;

25 selecting a tool for deployment;

moving said tool storage clamping means with the selected tool transversely to a tool deployment position, said tool deployment position being substantially coaxial

with said subsea well;

coupling a connection tool from above to the top of the selected tool; and

releasing the selected tool from the tool storage
5 clamping means and deploying the selected too in said well.

9. A method as claimed in claim 8 wherein the method includes arranging the centre line of the storage chamber to be coaxial with the subsea well, and radially moving the tools between the storage position and the deployment
10 position in said centre line.

10. A method as claimed in claim 8 including returning the deployed tool to a first position within the tool storage chamber, said first position being substantially the same as said deployment position;

15 engaging the deployed tool in a second position, said second position still being coaxial with said subsea well;

clamping said tool in the second position using the respective tool storage clamp means; and

decoupling the tool from a wireline connection system
20 and moving the clamped tool from the deployed position to said tool storage position.

11. A method as claimed in claim 10 wherein the method includes arranging the centre line of the storage chamber to be coaxial with the subsea well, and radially moving the
25 tools between the storage position and the deployment position in said centre line.

12. A tool storage and deployment mechanism for use with a well intervention system according to any one of claims 1

to 7, said tool storage and deployment mechanism comprising:

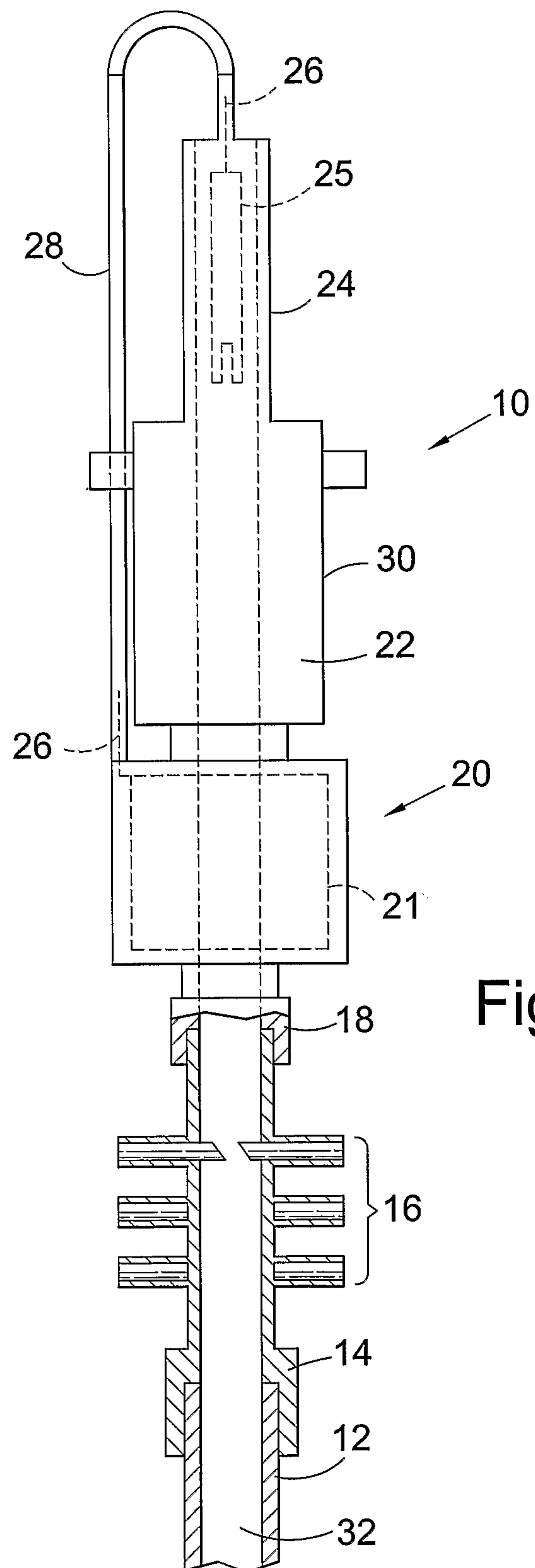
tool storage clamping means being capable of retaining a tool in a storage position, and being moveable from the storage position to a deployment position where the tool may be coupled and decoupled to connection tool from above, said tool storage means having a storage clamp at its free end, said clamp being moveable between a closed position for retaining tool in said stored position and for holding the tool as it is moved between the deployment position and the storage position, and an open position when the tool is in the deployment position to allow the tool to be coupled and uncoupled to said connection tool.

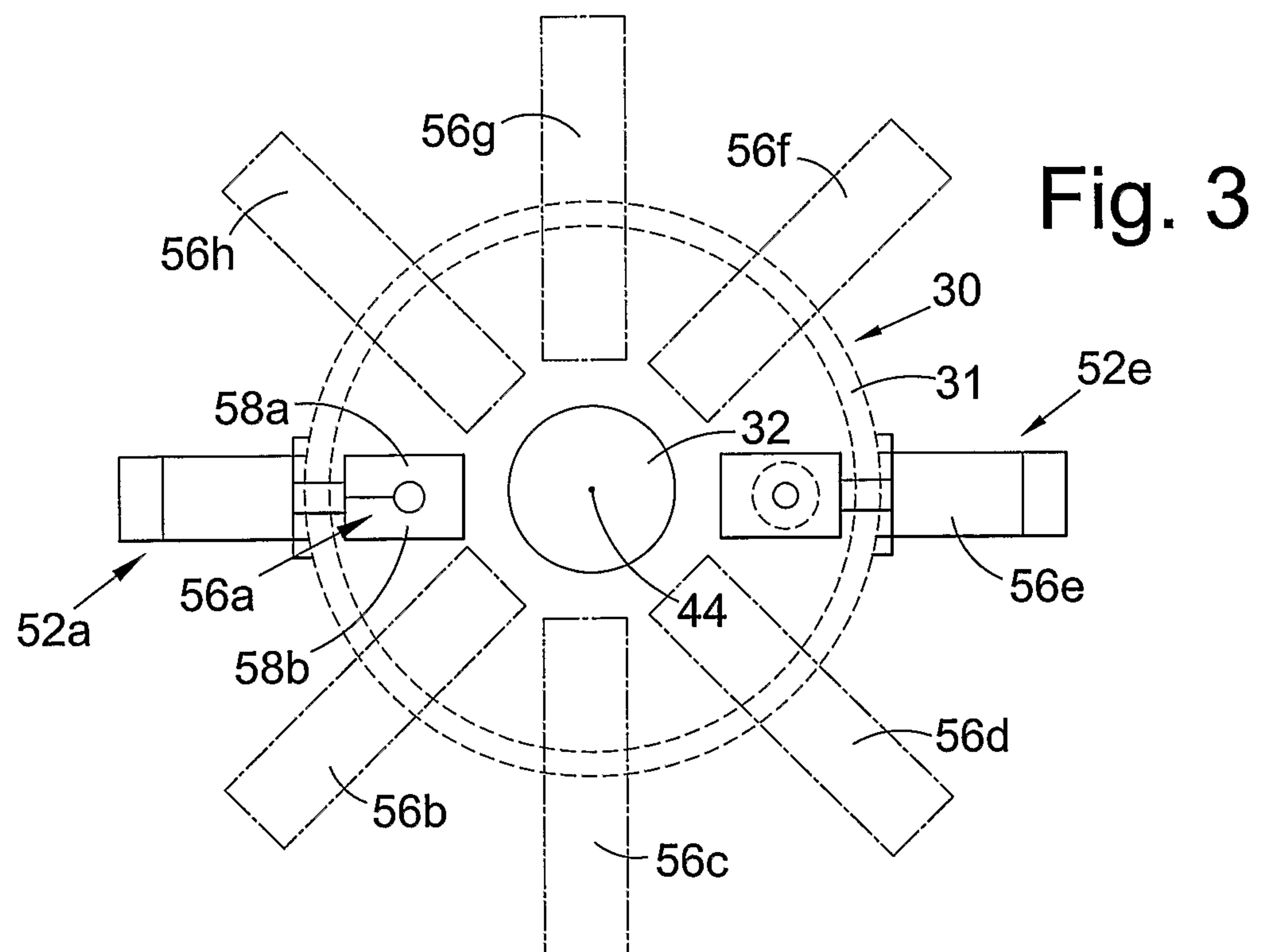
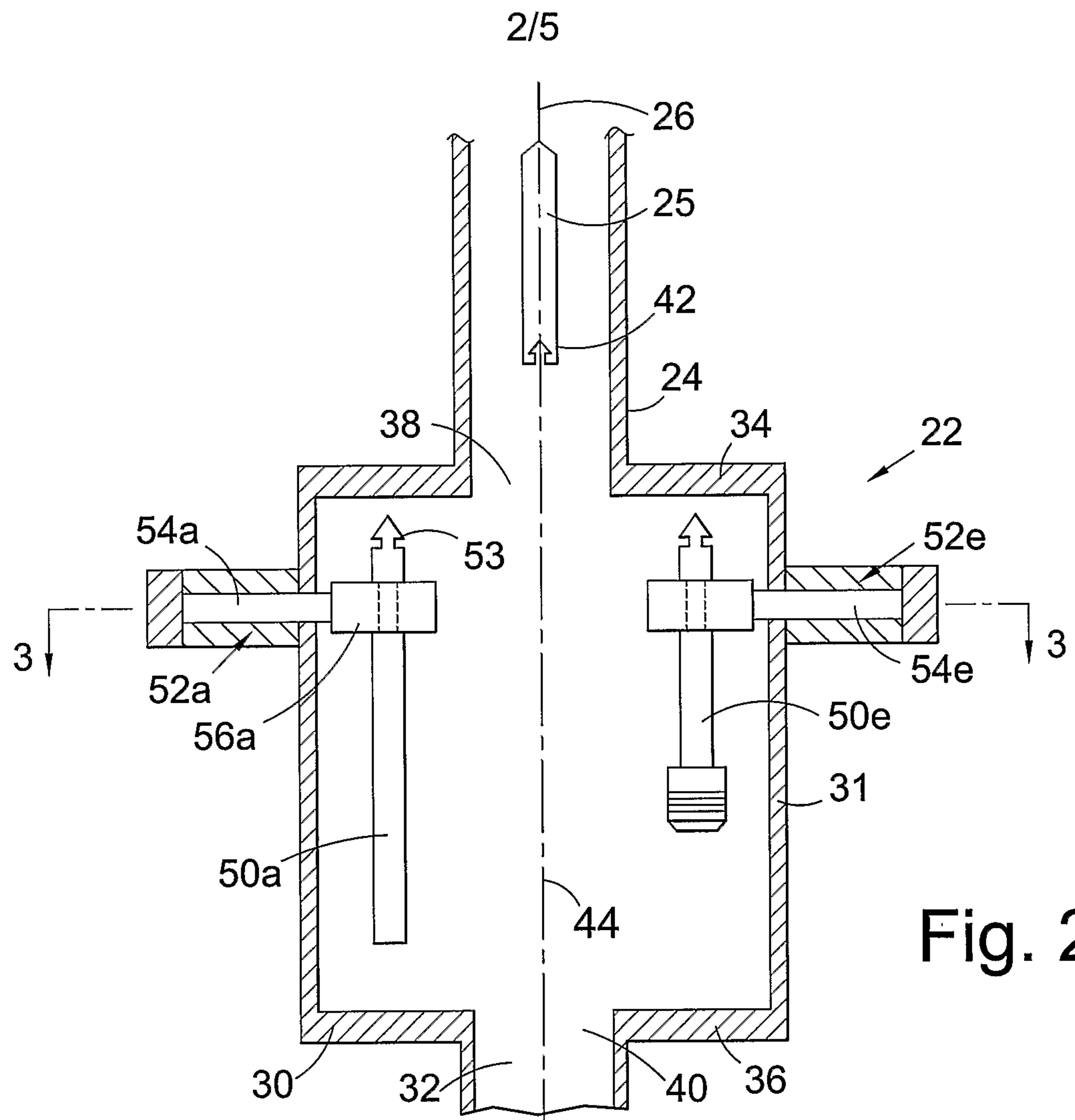
13. A mechanism as claimed in claim 12 wherein the tool storage and deployment mechanism has eight clamping means disposed about the periphery of the tool storage chamber.

14. A mechanism as claimed in claim 12 wherein there are one to twelve clamping means.

15. A mechanism as claimed in claim 13 or 14 wherein each clamp has two jaws and the jaws are electrically or hydraulically actuatable.

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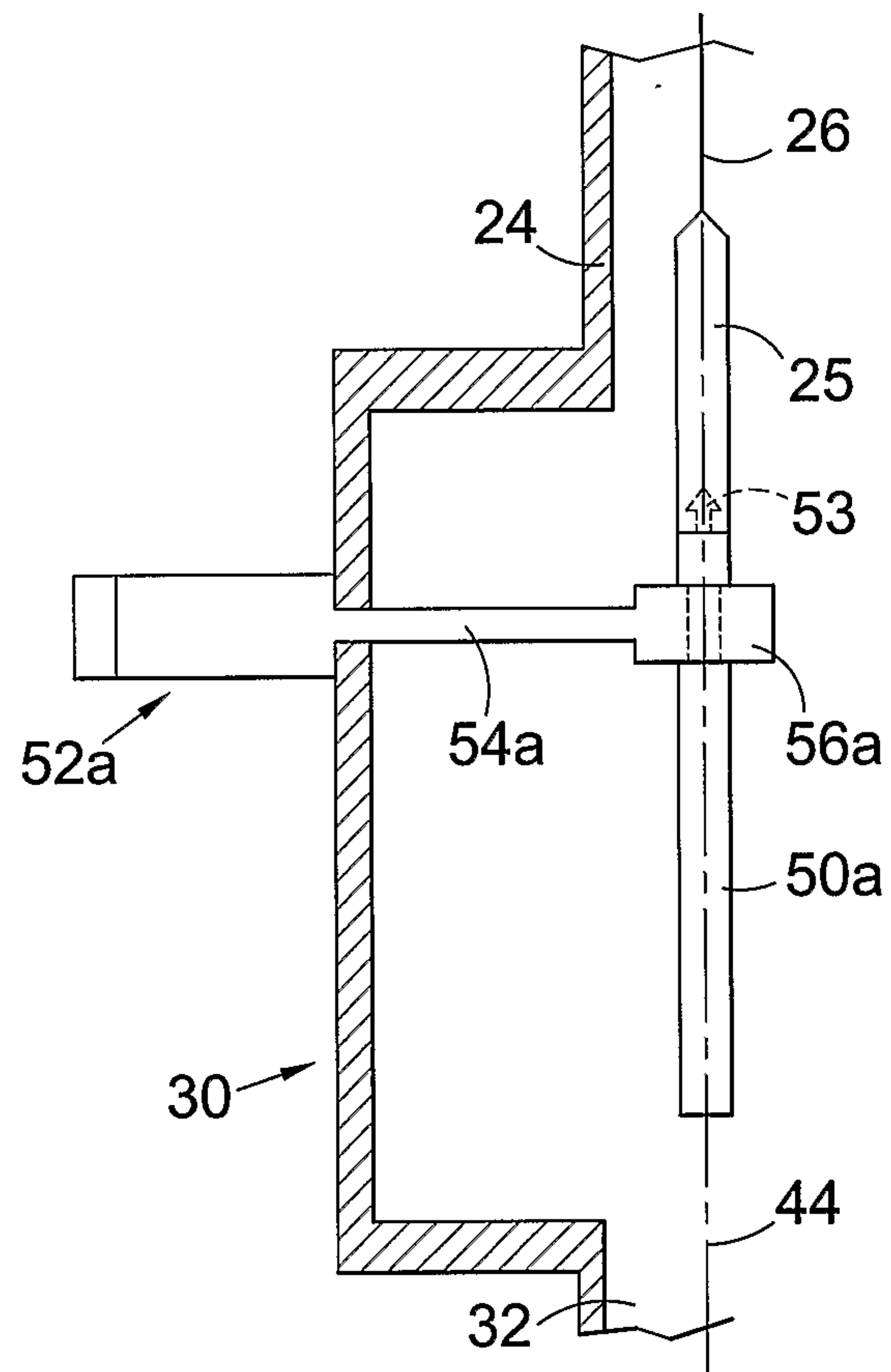


Fig. 4

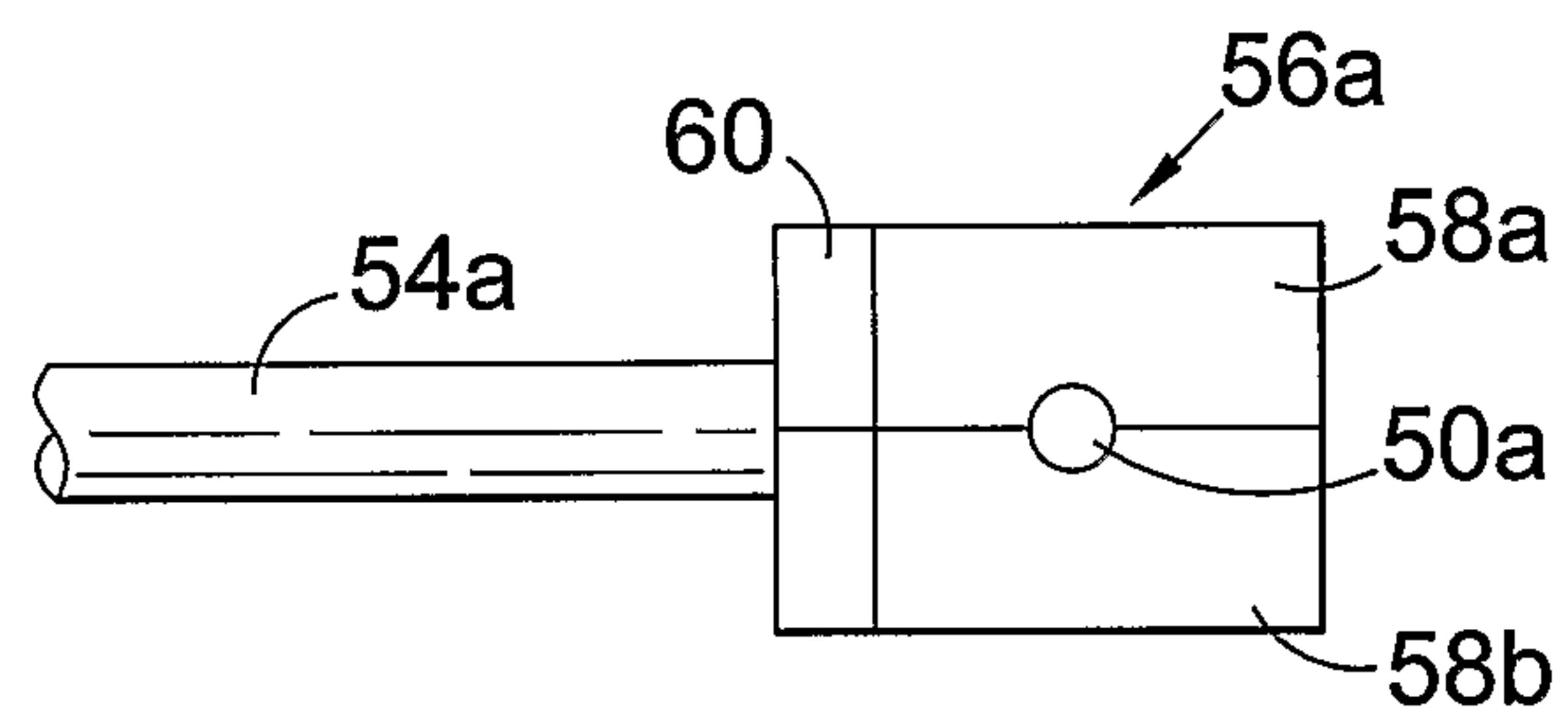


Fig. 5

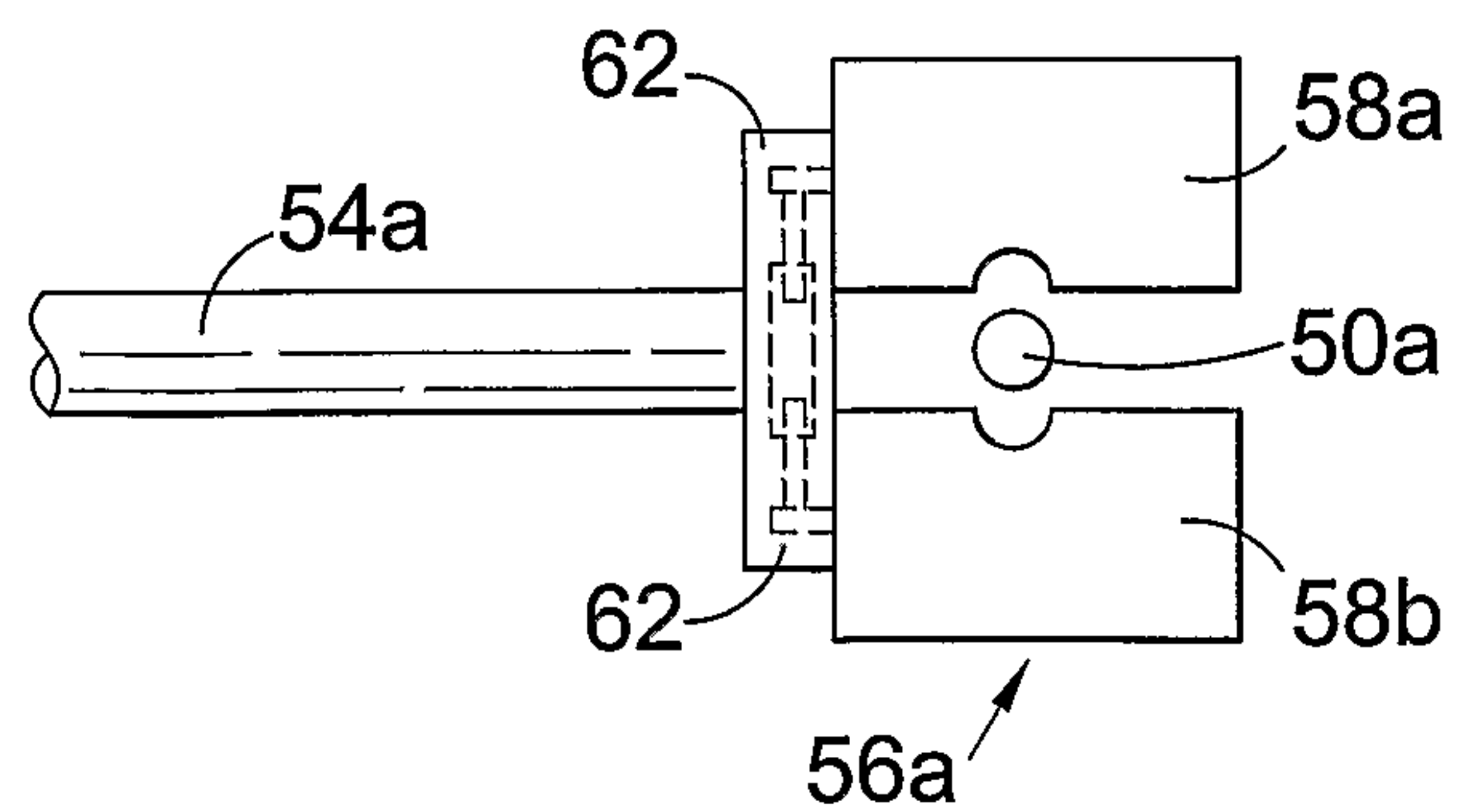


Fig. 6

4/5

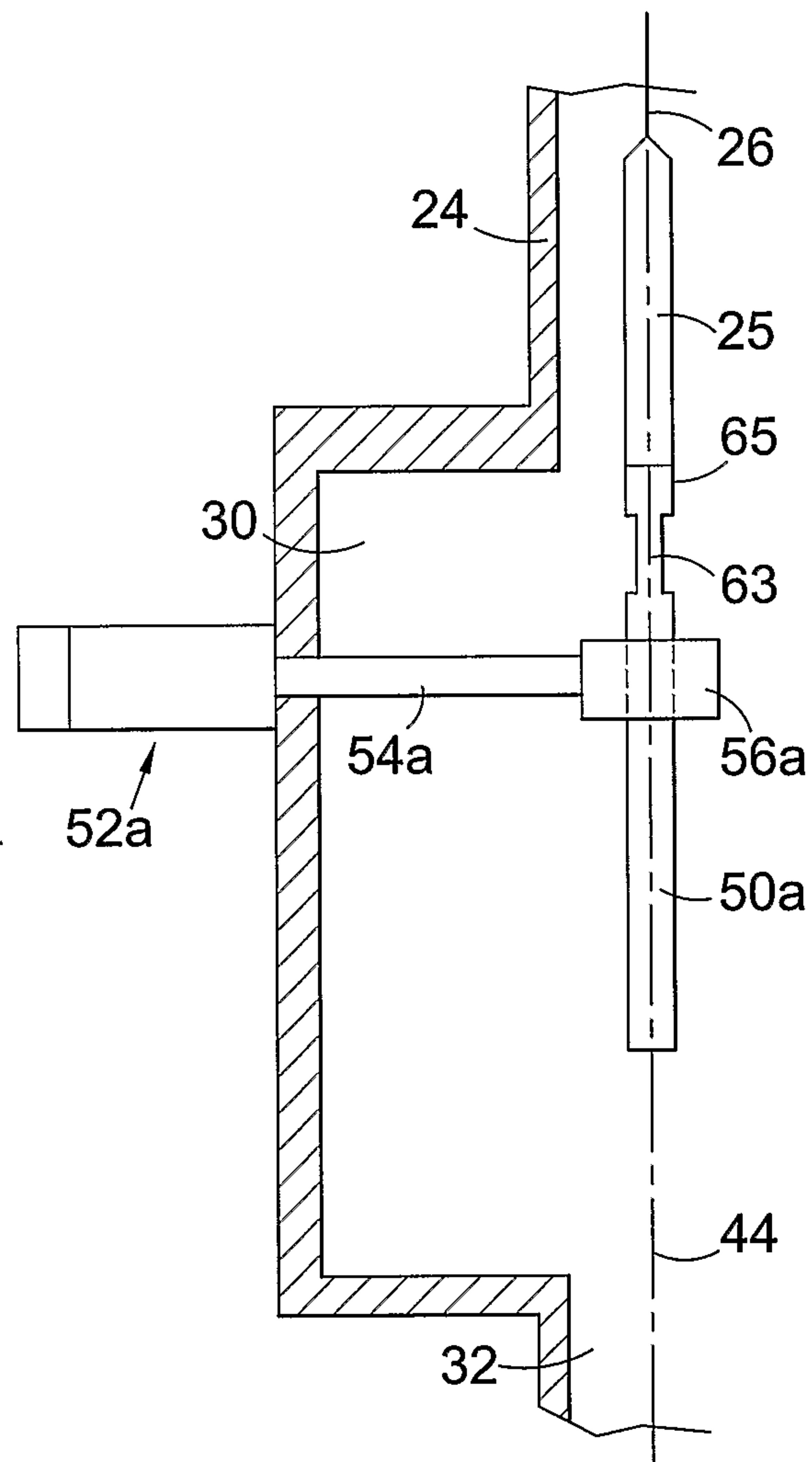


Fig. 7

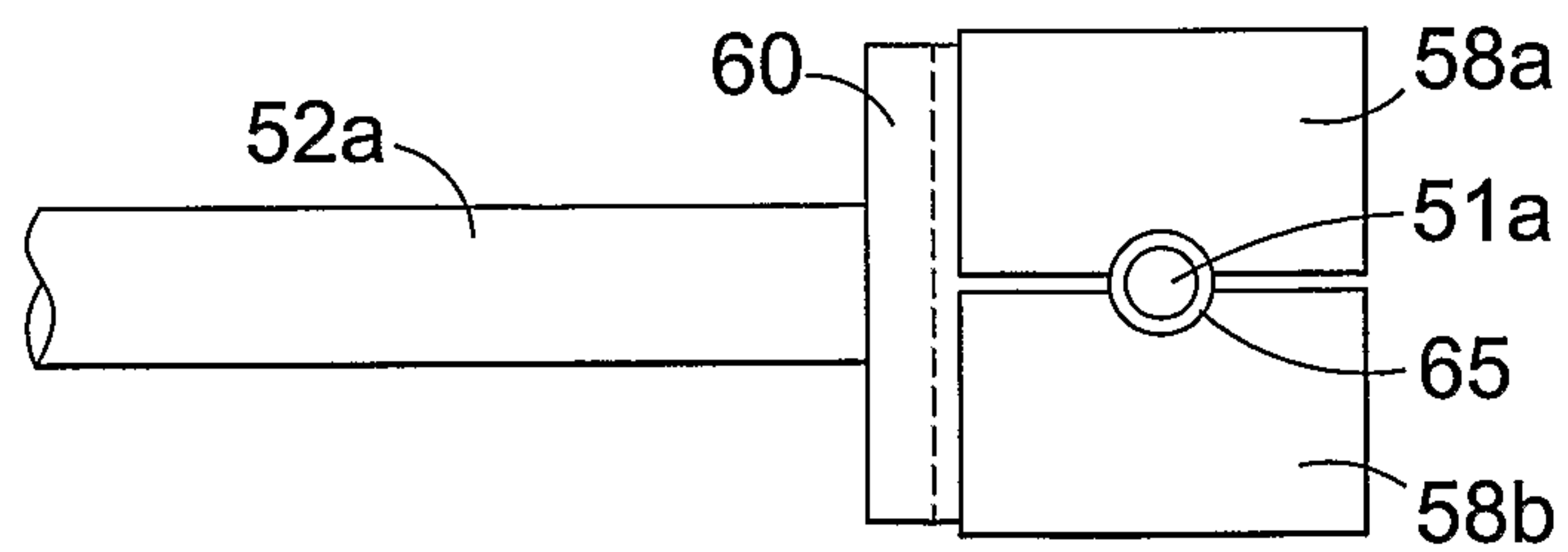


Fig. 8

5/5

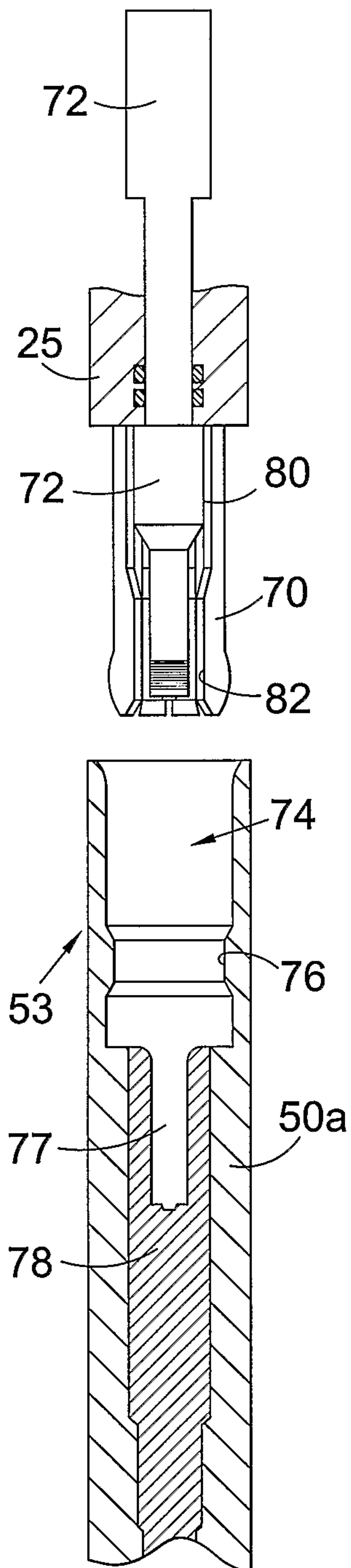


Fig.9a

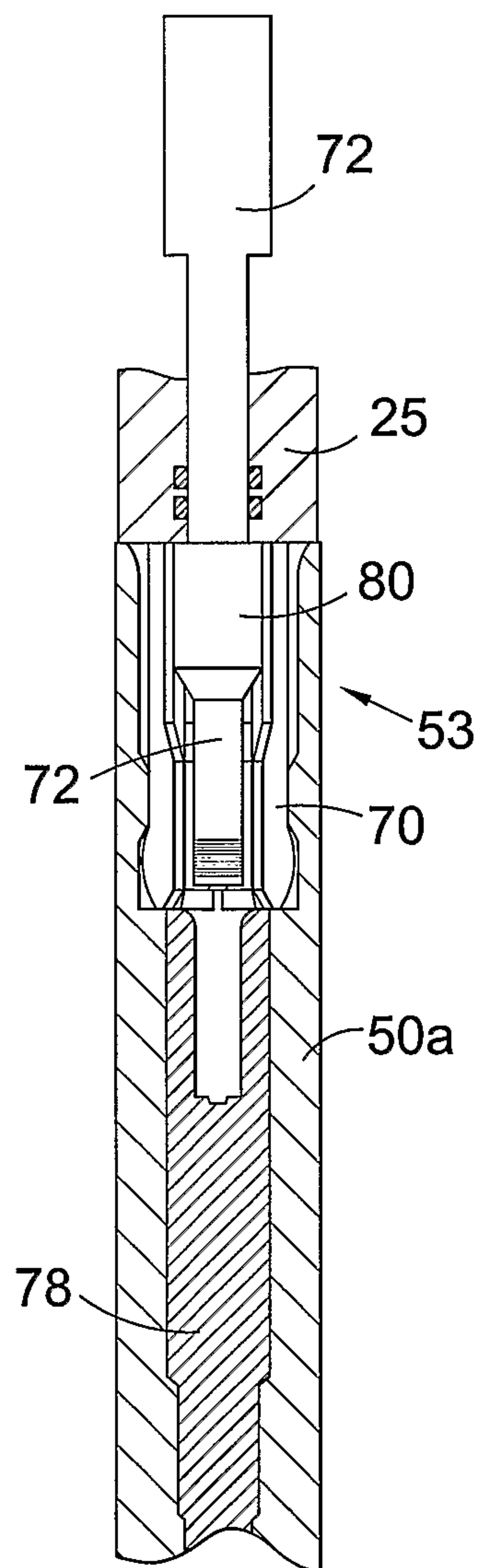


Fig.9b

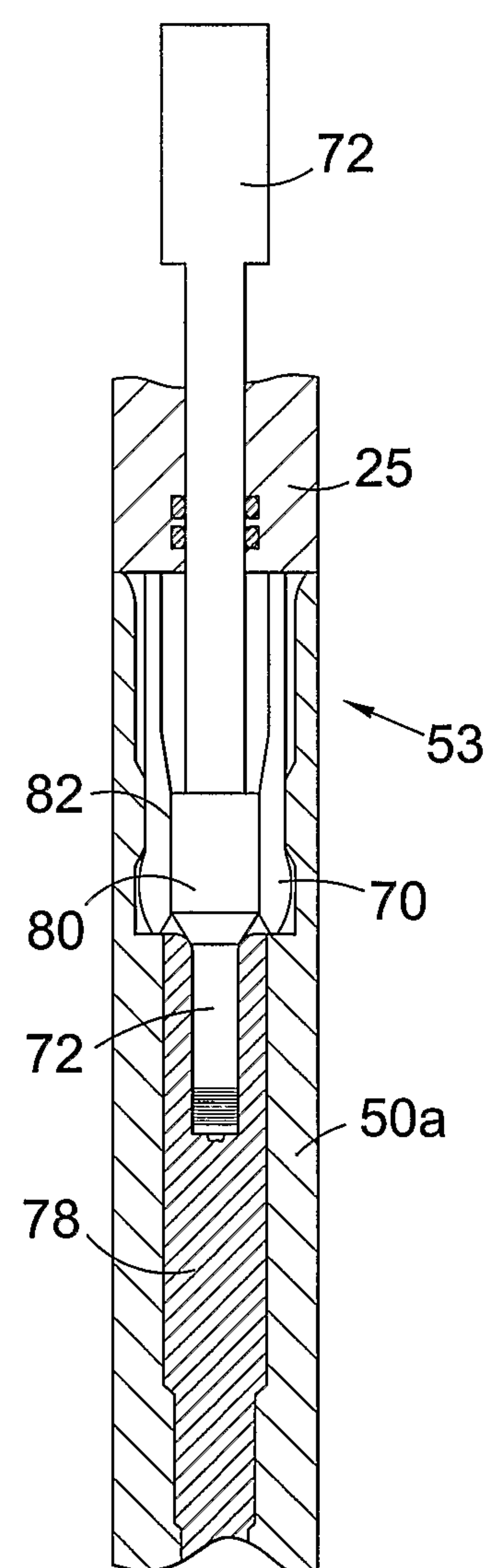


Fig.9c

