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# DESCRIPTION

Description

## Field of the invention

**[0001]** The present invention relates to a support rib of an excavation and a method for producing a support structure inside an excavation.

**[0002]** The invention has been developed with particular regard, though in a non-limiting manner, to a rib which is provided with a connection element between adjacent ribs for producing a support structure and reinforcing an excavation, for example, for producing a road or rail tunnel.

## Technological background

**[0003]** It is known to reinforce excavations, for example, for tunnels, by using support arches which are called ribs. In particular, a rib usually comprises a plurality of structural elements which are shaped from steel and which are mutually connected so as to form an arch. Such elements are constituted by open or closed profiles with a cross-section of various types, for example, C-shaped, H-shaped, T-shaped or circular. Normally, the profiles are shaped with structural workshop and are then connected to each other to form a rib at the construction site of the excavation to be reinforced. After being assembled, each rib is connected to the adjacent ones via suitable connection elements. The space between two consecutive ribs and the wall of the excavation is then reinforced usually using sprayed concrete (shotcrete) .

**[0004]** A method for installing a support structure and for reinforcing an excavation is known from the document EP 2354447, which describes a reinforcement structure for an excavation in which a plurality of ribs are connected to each other by using chains. Each connection chain engages at a first end with a first connection ring which is welded to a first rib, and at a second end with a second connection ring which is welded to a second rib.

**[0005]** This system has been found to be effective, but has a number of disadvantages: the chains have to be engaged manually with the connection rings and the operation is complex. If, once the rib is installed, it should be found that a chain has not been engaged correctly, it is possible for it to be necessary to reposition the rib in order to repeat the engagement operations.

**[0006]** The document EP 3152400 describes a connection system between ribs which provides for rods which slide inside a rib which is intended to be fixed and which are inserted with snap-fitting in the head of the fixing rods of the adjacent rib which is already fixed. This connection system has been found to be effective but it requires a given precision during alignment between successive rods, which is not always easy to comply with.

**[0007]** Document CN 106522998 A discloses a longitudinal positioning and connecting device for an underground support arch frame, comprising a connecting rod with a head which can be inserted into a hollow receptacle where it engages a bearing clip.

### **Statement of invention**

**[0008]** An object of the present invention is to overcome the disadvantages of the prior art and to provide a rib which is provided with a connection element which is even more rapid and easy to put in position and which has a reduced risk of accidental disengagement.

**[0009]** Furthermore, it is intended to provide a rib of any cross-section, open or closed, including a hollow cross-section filled (for example, with concrete) with a rapid, easy and quick connection element. Another object is to provide a rib which is economical, reliable during use and secure.

**[0010]** Another object of the present invention is to provide a method for installing in a simple manner a structure which is constituted by a plurality of ribs and which is stable and reliable.

**[0011]** According to a first aspect, there is described a rib for supporting an excavation which may comprise at least one structural element and at least one connection element or connection assembly for the structural element of the rib with respect to a structural element of an adjacent rib. The connection assembly may comprise a male engagement member or element and a female engagement member or element. The male engagement element of a rib may thereby readily and rapidly be engaged with the male member of the adjacent rib, producing a stable connection.

**[0012]** The male engagement element may comprise a head and a neck. The female engagement element may comprise a retention element or member. The head of the male engagement element may be capable of being inserted in the female engagement element of the connection assembly of the adjacent rib. The retention element of the female engagement element of the adjacent rib may thereby retain the neck.

**[0013]** According to another aspect, the retention member of the female engagement element may be a resiliently deformable retention member. For example, it may be a washer or an escutcheon. More specifically, it may be a disc spring washer. In particular, it is a slotted disc spring washer, that is to say, a disc spring washer which is provided with tabs or plates.

**[0014]** According to another aspect, the disc spring washer can be received inside a bowl-like member.

**[0015]** According to another aspect, the disc spring washer may comprise tabs which are inclined at an angle greater than  $0^\circ$  with respect to a plane which is defined by an external edge of the disc spring washer. Preferably, the tabs can be inclined towards the inner side of the bowl-like member. This formation of the female engagement element allows the male engagement element to be inserted therein without it necessarily being in the same axis as the female one. Thus, it is possible to insert it at an angle of  $10^\circ$ . Naturally, this great flexibility allows the connection operations between a plurality of ribs to be facilitated.

**[0016]** According to another aspect, the female engagement element may comprise a cap which is capable of retaining the disc spring washer inside the bowl-like member. The cap may have a flared opening. The flared opening may be inclined at an angle which is equal to the inclination angles of the tabs. In this manner, when two ribs are positioned and connected, any traction forces which tend to draw apart the two ribs are supported mainly by the cap and not only by the tabs of the disc spring washer. There is thereby obtained a far greater resistance. Furthermore, the risk of accidental disengagement is generally eliminated. In fact, the tabs which are supported against the inclined opening of the cap cannot become deformed sufficiently to allow the passage of the head of the male engagement element.

**[0017]** According to another aspect, the connection assembly may further comprise a rod and one of the male engagement element and the female engagement element may be provided at a first end of the rod, preferably the male engagement element. A second end of a rod may be selectively able to be secured to the at least one structural element of the rib. Preferably, it can be screwed to a threaded coupling which is fixed to the at least one structural element of the rib. Preferably, the threaded coupling is welded to the at least one structural element of the rib.

**[0018]** According to another aspect, one of the male engagement element and the female engagement element, preferably the female engagement element, is fixed in a stable manner to the at least one structural element of the rib, preferably by welding. Preferably, the bowl-like member of the female engagement element may be fixed in a stable manner to the at least one structural element of the rib.

**[0019]** According to another aspect, there is described a method for producing a support structure of an excavation comprising at least a first rib and a second rib with some or all of the features set out above. The method may comprise the step of positioning the first and the second rib in the excavation at a predetermined distance from each other. It may comprise the step of inserting the male engagement element of the connection assembly of the second rib in the female engagement element of the first rib.

**[0020]** There is further described a connection system between a first rib and a second rib, which is adjacent to the first rib. The connection system may comprise a male engagement

element which is provided on the first rib and a female engagement element which is provided on the second rib. The male engagement element may comprise a head and a neck having a transverse dimension which is less than a corresponding transverse dimension of the head. The female engagement element of the second rib may comprise a retention member. The head of the male engagement element of the first rib is capable of being inserted in the female engagement element of the second rib in such a manner that the retention member of the female engagement element of the second rib retains the neck of the male engagement element of the first rib. The housing for the retention member comprises an abutment surface, against which the retention member moves into abutment following a traction which tends to move the first rib away from the second rib. The abutment surface prevents the release of the head of the male engagement element of the first rib.

### **Brief description of the drawings**

**[0021]** Additional features and advantages will be appreciated from the following detailed description of a preferred embodiment of the invention with reference to the appended drawings, which are provided purely by way of non-limiting example and in which:

- Figure 1 illustrates a section of a rib with a connection assembly between ribs as a partial cross-section;
- Figure 2 shows a general view of a support structure of an excavation which is produced with a plurality of ribs;
- Figure 3 shows the engagement step of a connection assembly of a rib with respect to the connection assembly of an adjacent rib;
- Figure 4 shows the detail of the connection assembly of a rib which is engaged with the connection assembly of the adjacent rib.

### **Detailed description**

**[0022]** With reference to Figure 1, a rib 10 for supporting an excavation comprises at least one structural element 12. In the exemplary case illustrated, the structural element has a circular cross-section, is hollow and may be filled with concrete. As known in the sector, a single rib may comprise a plurality of structural elements to be connected to each other in order to produce a general arch-like structure.

**[0023]** The rib further comprises a connection assembly 14 which connects the structural element 12 to a structural element of an adjacent rib. The term "adjacent" is intended to be understood to mean a rib which is positioned before or after the rib under consideration and which is spaced apart by a predetermined distance.

**[0024]** The connection assembly 14 comprises a rod 16 which is connected at a first end 17 to the structural element 12. The connection is preferably produced by means of a threaded coupling 18 which is fixed in a stable manner to the connection assembly 12, into which the first end 17 which is threaded for the purpose is screwed. The Figure shows a weld bead 20 which fixes the coupling 18 to the structural element 12.

**[0025]** A second end 22 of the rod has a neck 24 and a head 26. The head is preferably spherical and the diameter thereof is greater than the diameter of the neck. It may be noted that the rod, the neck and the head have a circular cross-section in the embodiment depicted. However, cross-sections which are also completely different are not excluded provided that the head 26 has a transverse dimension which is greater than the neck. In other words, there has to be an undercut 28 between the head and the neck.

**[0026]** The head and the neck together constitute a male engagement element 30 which is capable of being engaged with a corresponding female engagement element 32 of an adjacent rib.

**[0027]** The female engagement element 32 comprises a bowl-like member 34 which is welded with a bead 36 to the structural element 12 at a side opposite the threaded coupling 18.

**[0028]** A retention member 40 is positioned on the opening 38 of the bowl-like member 34. The retention member is a disc spring washer 40 which is slotted. Therefore, it is an annular object with a frustoconical inclined wall 42, a central hole 44 and an external edge 46; the inclined wall is subdivided into a plurality of tabs 48 which are arranged in a circular manner. The spring is preferably of spring steel so that each tab 48 can be resiliently deformed. At rest, the tabs 48 are inclined towards the inner side of the bowl-like member 34 at an angle A which is greater than  $0^\circ$  with respect to a plane which is defined by the external edge 46 of the disc spring washer.

**[0029]** A cap 50 retains the disc spring washer against the opening 38 of the bowl-like member 34. The cap is preferably screwed to the bowl-like member and even more preferably welded thereto, for example, with a bead 52, for a maximum retention property. The cap 50 has a base 54 which is of frustoconical form with a central hole 56, which may be circular or of another shape. In other words, it has a flared opening. The hole 56 has a dimension greater than the transverse dimension of the head 26. The internal face or surface 58 is preferably inclined towards the interior at an angle B. The angle B is identical or in any case similar to the inclination angle A of the tabs 48 of the disc spring washer. The term "similar" is intended to be understood to be having a difference of a maximum of  $15^\circ$ .

**[0030]** The disc spring washer has such dimensions as to receive and retain the head 26. The diameter of the hole 44 thereof is therefore smaller than the diameter of the head 26 and greater than or equal to the diameter of the neck 24.

**[0031]** A plurality of ribs as described above may be used to produce a support structure 1 of

an excavation, as shown in Figure 2.

**[0032]** In a first step, if a first rib 10" is composed of two structural elements 12", they are connected to each other. The rib 10" is therefore positioned inside the excavation. A second rib 10 is then mounted and positioned at a predetermined distance from the first one. The connection assembly 14, in particular the rod 16, is fixed to the second rib 10 and screwed in the threaded coupling 18. The male engagement element 30 of the second rib 10 is inserted in the female engagement element 32" of the first rib, as can better be seen in the detailed view of Figure 3. In particular, the head 26 of the connection assembly 14 of the second rib 10 is inserted in the hole 56" of the cap 50" and in the hole 44" of the disc spring washer 40", pressing on the tabs 48", which become resiliently deformed. The insertion can also be carried out by maintaining the rod 16 inclined with respect to the axis of the female engagement element 32". Therefore, complete alignment during assembly is not necessary.

**[0033]** When the head 26 of the connection assembly 14 of the second rib 10 is inserted in the disc spring washer 40" of the first rib 10", the tabs 48" return to the original position thereof, retaining the head 26 by the neck 24.

**[0034]** Therefore, it is possible to improve the positioning of the second rib 10, if necessary. Once the ribs are connected and correctly positioned, a stress which tends to move the two ribs 10", 10 away from each other will be supported, as can be seen in the detailed view of Figure 4, by the cap 50" and in particular by the frustoconical base 54" thereof. In fact, as a result of the frustoconical base with an internal face or surface 58" having an inclination which is similar to that of the tabs 48" of the disc spring washer 40" (that is to say, since the angle A is similar to the angle B), they are supported against the internal surface of the frustoconical base of the cap which prevents them from becoming deformed and therefore the head 26 of the male engagement element 30 of the second rib 10 from being released. As mentioned above, the hole 56 has suitable dimensions so that it allows the passage of the head 26 and at the same time is sufficiently small to prevent the inverse deformation of the tabs and therefore the release of the head 26. The hole 56 therefore has such dimensions as to allow the insertion with play of the head 26.

**[0035]** The strength of the connection between two adjacent ribs 10", 10 is therefore given by the resistance of the joints between the various components and not by that of the disc spring washer 40", which is usually less. It may further be noted that the configuration described above in fact eliminates the risk of accidental disengagement because the head 26, once it is retained by the disc spring washer 40", cannot be released. Therefore, an irreversible connection is involved.

**[0036]** Once the second rib 10 is correctly positioned, it is possible to carry out the positioning in the same manner of a third rib 10' and so on, until ribs are positioned over the entire portion of excavation which is intended to be reinforced, thereby producing a support structure 1 of an excavation.

**[0037]** It may be understood that the configuration which comprises a bowl-like member and a cap and which is illustrated in the drawings is intended to be considered to be an example of a housing for the retention member 40 which comprises an abutment surface 58 for the retention member 40. The retention member 40 rests on the abutment surface 58 when a traction which tends to move apart two ribs which are connected to each other is applied, that is to say, when the head of the male engagement element 30 of the second rib is drawn towards the outer side of the female engagement element, pressing against the retention member 40. The abutment surface 58 is configured so as to prevent the release of the head 26 of the male engagement element 30 of the second rib following a traction which tends to move apart two ribs which are connected to each other. In greater detail, the abutment surface 58 ensures that the dimensions of the central hole 44 of the retention member remain less than the transverse dimensions of the head 26, preventing or limiting the deformation of the retention member.

**[0038]** For example, the abutment surface 58 and the opening 56 thereof can have such dimensions that, during use, a main portion of the retention member 40 moves into abutment with the abutment surface 58. If the retention member is a disc spring washer, the abutment surface 58 has such dimensions that, during use, at least a portion of the tabs 48 rests thereon. For optimum operation, the abutment surface 58 has an inclination which is similar to that of the tabs 48 of the disc spring washer 40.

**[0039]** The Figures illustrate the retention member in the form of a slotted disc spring washer, with tabs which have an angle  $A$  which is greater than zero. However, the angle  $A$  may be equal to  $0^\circ$ . More generally, the retention member may therefore be a resilient washer or escutcheon, that is to say, an annular object with a hole 44, which is typically produced from metal and in particular spring steel and which has internal tothing. The retention member is such that it is able to become deformed following pressure by the head of the male component in order to allow the passage thereof through the hole 44 and therefore to allow the connection between the ribs. It may also be indicated using the term circular fixing member.

**[0040]** A retention member with an angle  $A$  which is greater than  $0^\circ$ , that is to say, a slotted disc spring washer, is therefore preferable because, as a result of the conical formation, the retention member is capable of supporting a greater stress depending on whether the head 26 presses more in one direction than in the other. Consequently, it is possible to orientate the retention member 40 in such a manner that, as in the Figures, the concavity is directed outwardly, in order to become deformed with a relative capacity for receiving the head 26 of the male engagement element 30 at the time of the connection between two ribs, and to instead provide greater resistance to the disengagement. It will be understood that the abutment surface 58, with an inclination angle  $B$  similar to the inclination angle  $A$ , prevents the deformation of the retention member 40 in the presence of a traction which is directed towards disengaging the ribs and it therefore constitutes the element which most contributes to preventing the disengagement between the ribs.

**[0041]** Another advantage of a retention member with an angle  $A$  greater than  $0^\circ$  is given by the fact that the abutment surface 58 may constitute, as in the drawings, a surface of a

frustoconical wall (the base 54 of the cap 50) which externally constitutes a flared opening which facilitates the insertion of a head 26 and therefore facilitates the connection process between ribs.

[0042] Naturally, the principle of the invention remaining the same, the embodiments and construction details may vary widely with respect to what has been described and illustrated, without thereby departing from the scope of the invention, which is defined by the appended claims.

## REFERENCES CITED IN THE DESCRIPTION

### Cited references

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

### Patent documents cited in the description

- [EP2354447A \[0004\]](#)
- [EP3152400A \[0006\]](#)
- [CN106522998A \[0007\]](#)

**Patentkrav**

1. Ribbe (10") til at støtte en udgravning, som omfatter mindst et konstruktionselement (12") og mindst en forbindelseskonstruktion (14") til at  
5 forbinde ribbens konstruktionselement med et konstruktionselement (12) af en lignende tilstødende ribbe (10), hvor forbindelseskonstruktionen (14") omfatter et hanindgrebselement (30") og et hunindgrebselement (32"), hvor hanindgrebselementet omfatter et hoved (26") og en hals (24") med en tværgående dimension, som er mindre end en tilsvarende tværgående dimension  
10 af hovedet (26"), og hvor hunindgrebselementet omfatter et fastholdelseelement (40"), som er anbragt i et hus (34", 50"), idet hunindgrebselementet (32") er i stand til at modtage hovedet (26) af hanindgrebselementet af forbindelseskonstruktionen (14) af den tilsvarende tilstødende ribbe (10) på en sådan måde, at fastholdelseelementet (40") af hunindgrebselementet (32") af  
15 ribben (10") fastholder halsen (24) af hanindgrebselementet (30) af den tilsvarende tilstødende ribbe (10), hvor huset (34", 50") til fastholdelseelementet (40") omfatter en anlægsflade (58"), mod hvilken fastholdelseelementet (40") bevæger sig til anlæg efter en trækraft, der har tendens til at bevæge ribben (10") væk fra den tilstødende ribbe (10), hvilket forhindrer frigivelsen af hovedet  
20 (26) af hanindgrebselementet (30) af den tilstødende ribbe (10), **kendetegnet ved, at** fastholdelseelementet (40) af hunindgrebselementet (32) er en skivefjderspændeskive med slidser, som omfatter flige (48), som er skråtstillet i en vinkel (A) større end  $0^\circ$  i forhold til et plan, som er defineret af en ekstern ringformet kant (46) af skivefjderspændeskiven (40), og hvor anlægsfladen (58) er skråtstillet i en vinkel (B), og forskellen mellem vinklen (B) af anlægsfladen (58) og hældningsvinklen (A) af fligene er maksimalt  $15^\circ$ .

2. Ribbe ifølge det foregående krav, hvor fastholdelseelementet (40) hviler over en hoveddel deraf på anlægsfladen (58).

30

3. Ribbe ifølge et hvilket som helst af de foregående krav, hvor fastholdelseelementet (40) af hunindgrebselementet (32) er elastisk deformerbart.

**4.** Ribbe ifølge det foregående krav, hvor fastholdelselementet (40) af hunindgrebselementet (32) er en spændeskive.

**5.** Ribbe ifølge krav 1, hvor skivefjederspændeskiven (40) modtages inde i et skållignende element (34) og fastholdes af en hætte (50).

**6.** Ribbe ifølge et hvilket som helst af de foregående krav, hvor anlægsfladen (58) har en central åbning (56) med en dimension større end den tværgående dimension af hovedet (26), og fastholdelselementet har en åbning (44), som er mindre end dimensionerne af hovedet (26) og større end eller lig med dimensionerne af halsen (24).

**7.** Ribbe ifølge et hvilket som helst af de foregående krav, hvor forbindelseskonstruktionen (14) yderligere omfatter en stang (16), hvor et af hanindgrebselementet (30) og hunindgrebselementet (32) er tilvejebragt ved en første ende (22) af stangen.

**8.** Ribbe ifølge krav 7, hvor en anden ende (17) af en stang (16) selektivt er i stand til at blive fastgjort til det mindst ene konstruktionselement (12) af ribben.

**9.** Ribbe ifølge et hvilket som helst af de foregående krav, hvor et af hanindgrebselementet (30) og hunindgrebselementet (32) er fastgjort på en stabil måde til det mindst ene konstruktionselement (12) af ribben.

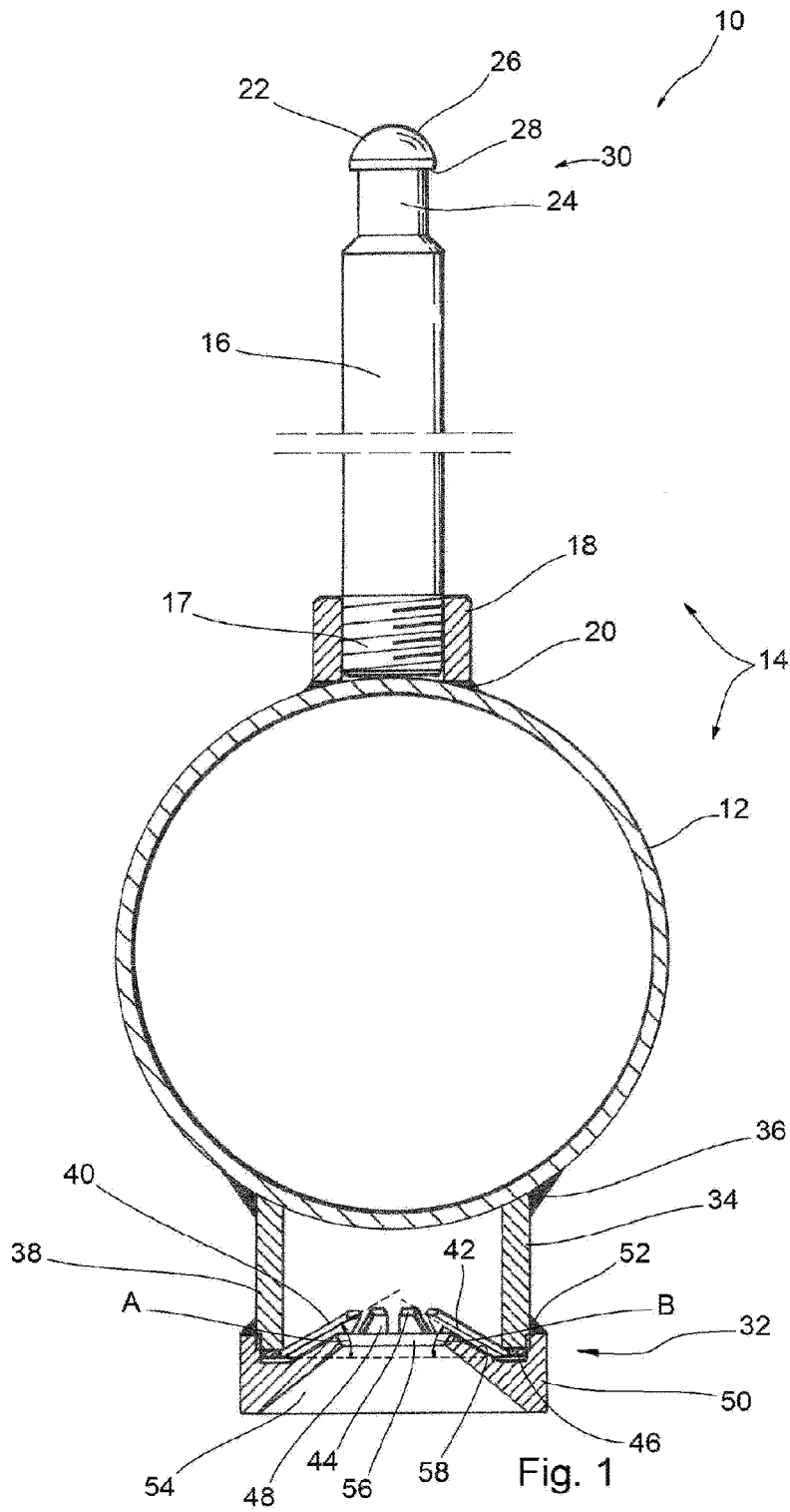
**10.** Ribbe ifølge krav 9, hvor det skållignende element (34) er fastgjort på en stabil måde til det mindst ene konstruktionselement (12) af ribben (10).

**11.** Fremgangsmåde til fremstilling af en støttestruktur af en udgravning omfattende mindst en første ribbe (10") og en anden ribbe (10) ifølge kravene 1 til 10, hvor fremgangsmåden omfatter trinnene:

- placering af den første og den anden ribbe (10", 10) i udgravningen i en forudbestemt afstand fra hinanden,
- indsættelse af hanindgrebselementet (30) af forbindelseskonstruktionen (14) af den anden ribbe (10) i hunindgrebselementet (32") af den første ribbe (10").

# DRAWINGS

Drawing





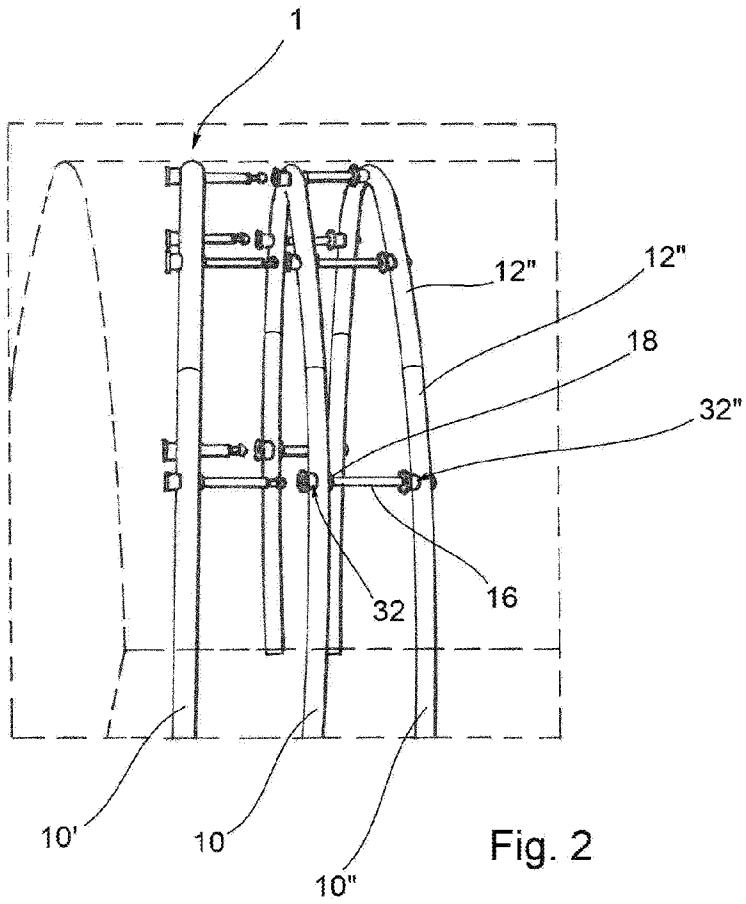


Fig. 2

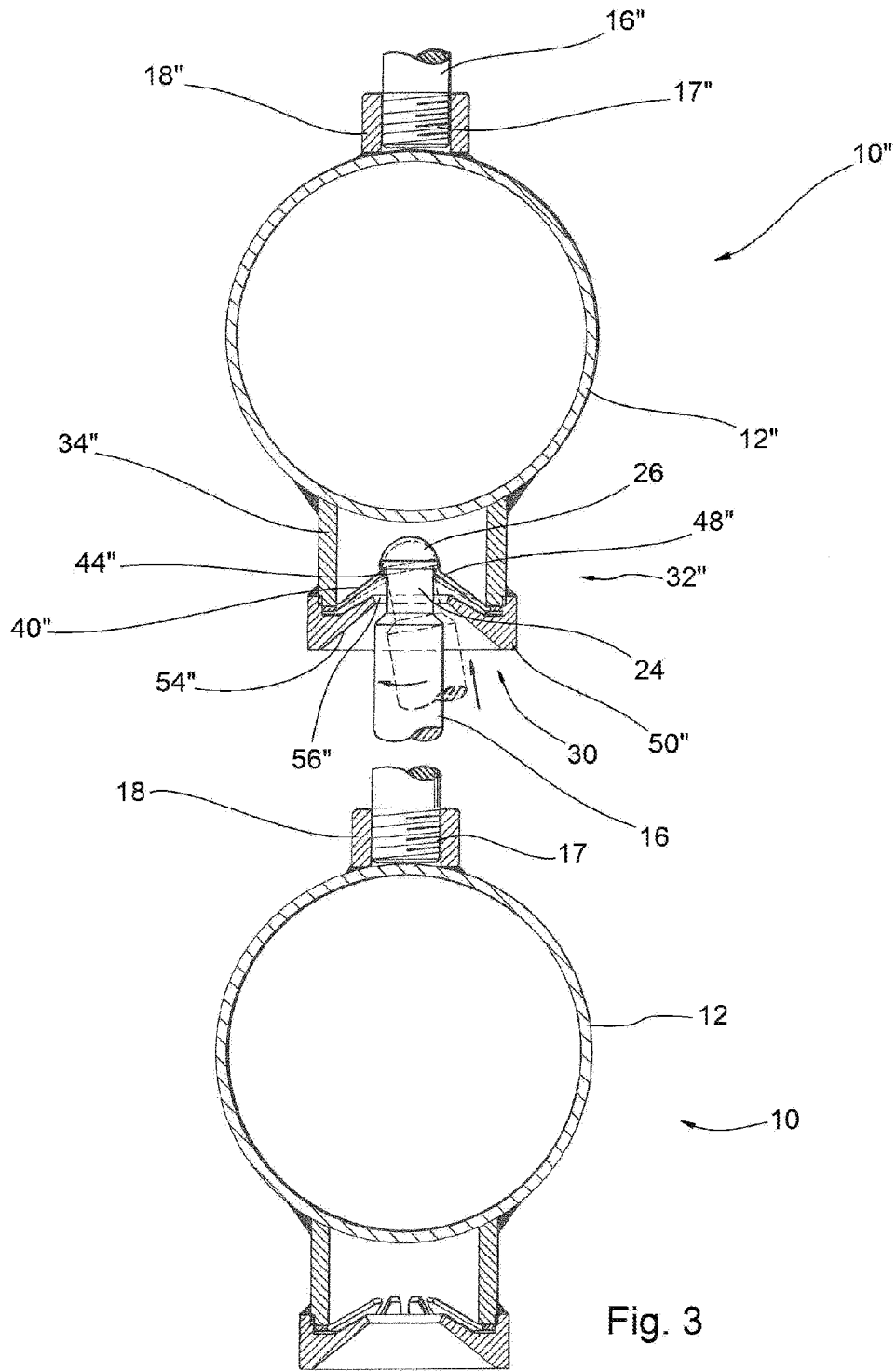


Fig. 3

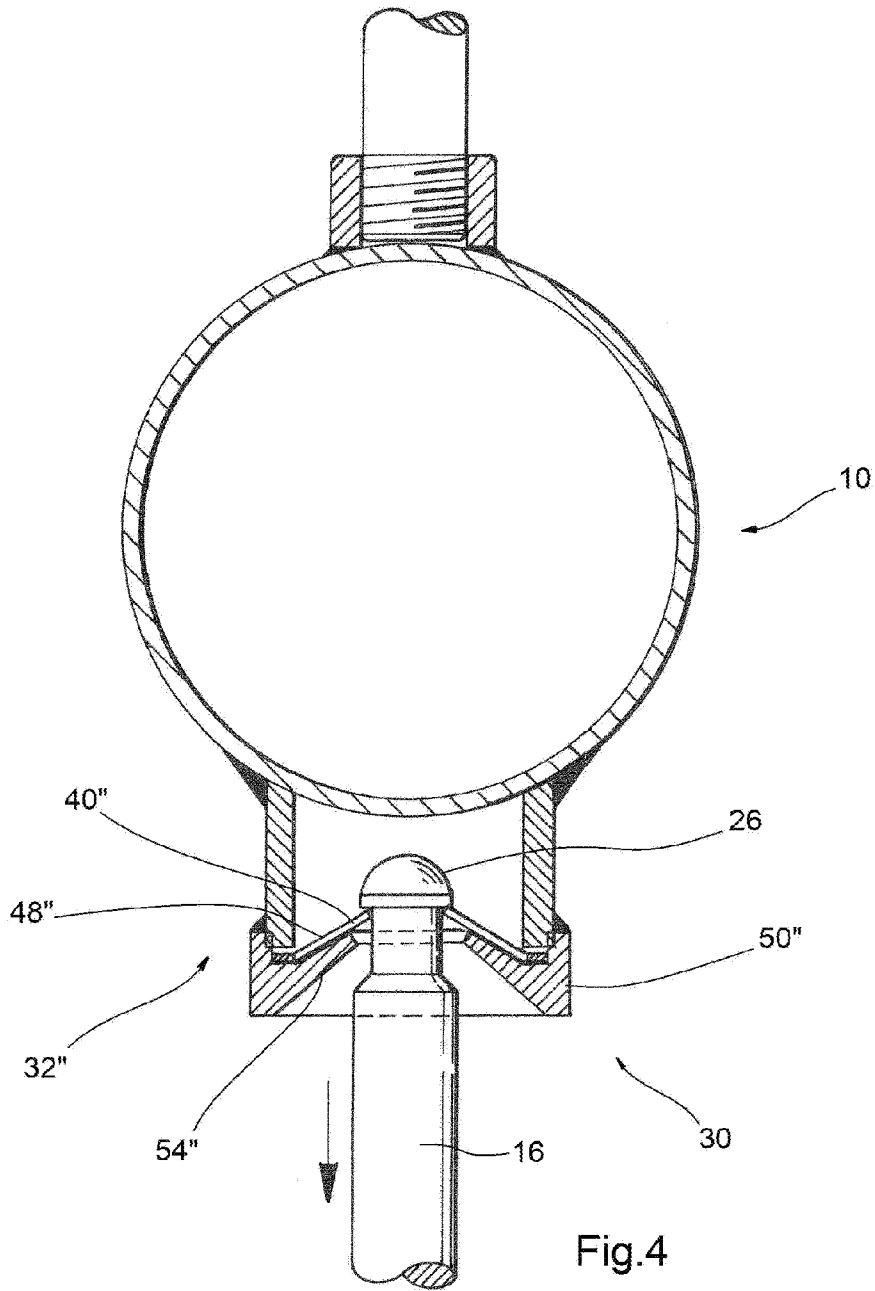


Fig.4