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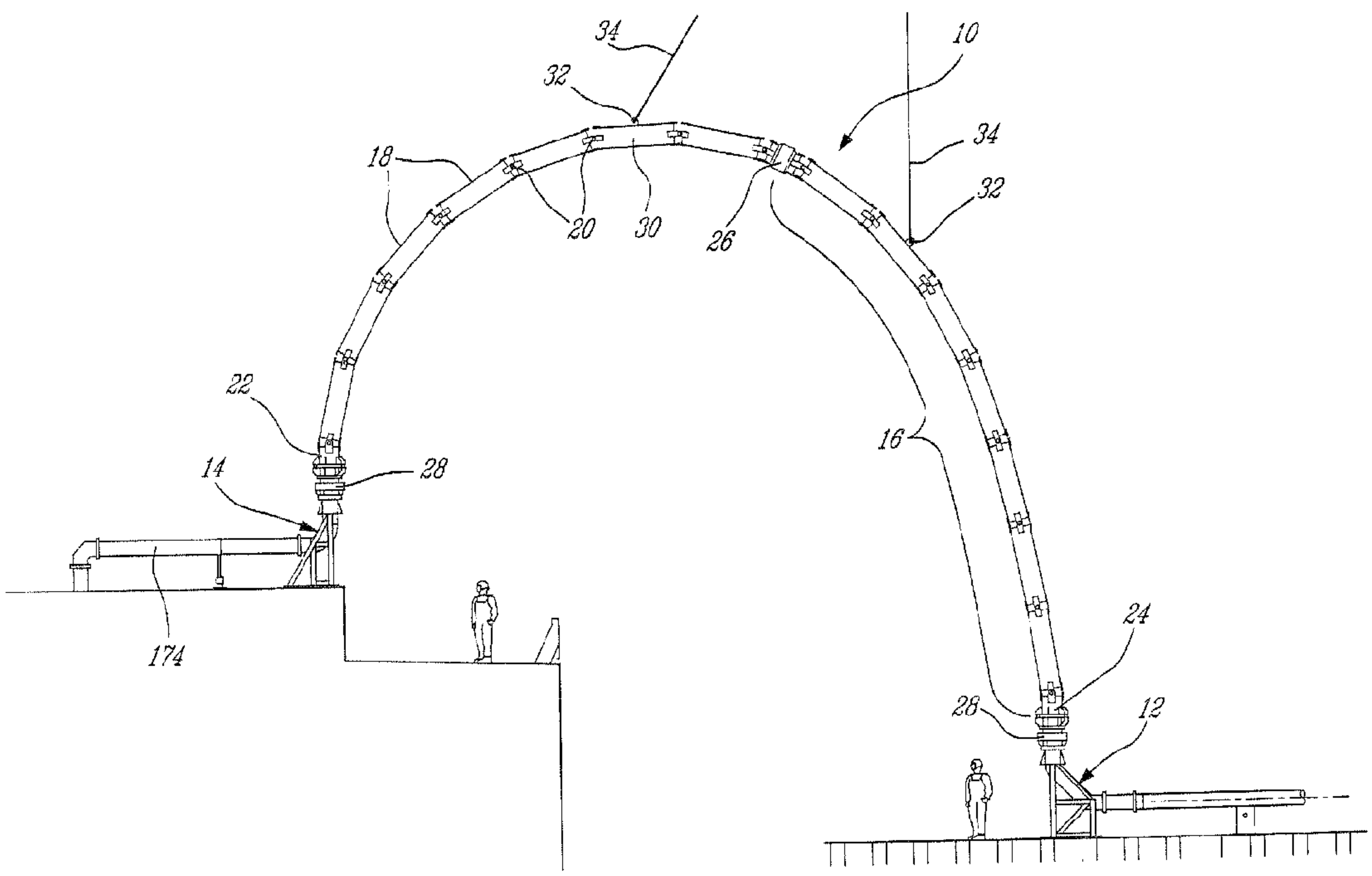
(54) Titre : BRAS FLEXIBLE AUTOPORTEUR DE CHARGEMENT DE NAVIRE POUR LE TRANSFERT PNEUMATIQUE DE SOLIDES
(54) Title: SELF-SUPPORTING FLEXIBLE SHIP-LOADING ARM FOR PNEUMATIC TRANSFER OF SOLIDS



(57) Abrégé/Abstract:
The present invention provides a loading arm and apparatus far pneumatically conveying particulate matter. The loading arm is comprised of a flexible hose with a substantially rigid outer casing surrounding said flexible hose and a plurality of hinge mechanisms. The outer casing includes a plurality of elongate casing segments disposed end to end and one of the hinge mechanisms interconnects adjacent casing segments allowing the adjacent segments to pivot relative to one another around an axis of rotation normal to a surface of the outer casing. The hinge mechanisms also limit rotation about the axis of rotation to within a predetermined range and the axis of rotation are parallel to one another. The loading arm can also include one or two swivel assemblies attached to the charging and discharging ends of the flexible hose and also to the outer casing. These swivel assemblies allow the charging and discharging ends to rotate around an axis which is substantially perpendicular to the ground.

ABSTRACT OF THE DISCLOSURE

The present invention provides a loading arm and apparatus for pneumatically conveying particulate matter. The loading arm is comprised of a flexible hose with a substantially rigid outer casing surrounding said flexible hose and a plurality of hinge mechanisms. The outer casing includes a plurality of elongate casing segments disposed end to end and one of the hinge mechanisms interconnects adjacent casing segments allowing the adjacent segments to pivot relative to one another around an axis of rotation normal to a surface of the outer casing. The hinge mechanisms also limit rotation about the axis of rotation to within a predetermined range and the axis of rotation are parallel to one another. The loading arm can also include one or two swivel assemblies attached to the charging and discharging ends of the flexible hose and also to the outer casing. These swivel assemblies allow the charging and discharging ends to rotate around an axis which is substantially perpendicular to the ground.

TITLE OF THE INVENTION

SELF-SUPPORTING FLEXIBLE SHIP-LOADING ARM FOR PNEUMATIC TRANSFER OF SOLIDS

FIELD OF THE INVENTION

The present invention relates to an apparatus for loading materials into a ship's hold. In particular the present invention relates to an apparatus for pneumatic transfer of solid particulate matter into a ship's hold.

BACKGROUND OF THE INVENTION

The use of compressed gas such as air and a flexible material handling hose to move particulate matter is well known in the art and is used extensively to load and unload transport trailers, train cars and ship holds of a variety of bulk materials including flour, cement and minerals amongst many others. The use of compressed air and flexible hoses has many benefits over more conventional methods of loading bulk goods. In particular, the use of compressed air and hoses limits the exposure of the bulk materials to the outside environment, thereby on one hand protecting the bulk materials from conditions, such as moisture, which may affect the bulk materials, and on the other hand reducing the impact on the environment by reducing the possibility that more noxious bulk materials are uncontrollably released into the environment.

As will be appreciated by one of ordinary skill in the art, in marine applications the distance between the storage container and a ship's hold varies constantly in accordance with the level of the seas and the current weather conditions. Additionally, as the ships hold is filled or emptied the ships draft will increase or decrease accordingly. The combination of these factors can mean that the material handling hose interconnecting the storage container and the ships hold is flexed in a number of directions and in some cases quite abruptly, especially when seas are high and the ship's holds are relatively empty.

In order to compensate for changes in distance and height between ship and shore a variety of assemblies have been proposed. These typically combine telescoping sections of tubing with either rotating elements or flexible portions. One problem with these prior art assemblies is that, given the large number of tubing sections, special attention must be paid to the seals between sections in order to insure proper operation when using compressed air. Another drawback is that such prior art assemblies are typically very limited in the amount that they can move once attached between ship and shore.

In order to overcome these drawbacks, it has been proposed to suspend a flexible material handling hose between ship and shore, using an overhead crane. The crane hoists the material handling hose which is then attached at each end to supports and the particulate matter pumped through the hose using a pneumatic conveying system. However, the material handling hose continually shakes as pulses of concentrate race through the hose and, in addition, winds can cause the hose to sway.

One drawback, therefore, of this prior art assembly is that the crane operator must remain vigilant to maintain constant tension on the material handling hose. Too much tension can cause the hose to tear under static strain. Too little tension can cause the hose to shake violently and tear under dynamic shock load. In order to help the crane operator assess the amount of tension on the hose a sophisticated hook tension indicator is in some cases provided. Where such an indicator is not available, a second person located below and to one side of the material handling hose is typically required to aid the crane operator during operation of the system.

SUMMARY OF THE INVENTION

More specifically, in accordance with the present invention, there is provided a loading arm for conveying particulate matter under gas pressure. The loading arm is comprised of a flexible hose with a substantially rigid outer casing surrounding the flexible hose and a plurality of hinge mechanisms. The outer casing includes a plurality of elongate casing segments disposed end to end and one of the hinge mechanisms interconnects adjacent casing segments allowing the adjacent segments to pivot relative to one another around an axis of rotation normal to a surface of the outer casing. The hinge mechanisms also limit rotation about the axis of rotation to within a predetermined range and the axis of rotation are parallel to one another.

Additionally, the loading arm can be further comprised of a first swivel assembly attached to a charging end of the flexible hose and also to the outer casing. The first swivel assembly allows the charging end to rotate around an axis which is substantially perpendicular to the ground.

Furthermore, the loading arm can also be comprised of a second swivel assembly in addition to the first swivel assembly. The second swivel assembly is attached to a discharging end of the flexible house and also to the outer casing. The second swivel allows the discharging end to also rotate around an axis which is substantially perpendicular to the ground.

There is also provided an apparatus for pneumatically conveying particulate matter held in a first storage chamber into a second storage chamber. The apparatus comprises a source of compressed air, a mixer having an output for combining the compressed air with the particulate matter held in the first storage chamber, a flexible hose having a charging end and a discharging end, the charging end attached to the output, a substantially rigid outer casing surrounding the flexible hose, the outer casing including a plurality of elongate casing segments disposed end to end, and a plurality of hinge mechanisms, one of the hinge mechanisms interconnecting adjacent casing segments to allow the adjacent segments to pivot relative to one another around an axis of rotation normal to a surface of the outer casing. The hinge mechanisms also limit the rotation about the axis of rotation to within a predetermined range and the axis of rotation are parallel to one another. The particulate matter is conveyed along the flexible hose by the compressed air and discharged therefrom at the discharging end into the second storage chamber.

Other objects, advantages and features of the present invention will become more apparent upon reading of the following non-restrictive description of specific embodiments thereof, given by way of example only with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the appended drawings:

Figure 1a is a side view of a flexible ship-loading arm according to an illustrative embodiment of the present invention;

Figure 1b is a side view of an alternative embodiment of a flexible ship-loading arm according to an illustrative embodiment of the present invention;

Figure 2a is a side view of two segments of a flexible ship-loading arm according to an illustrative embodiment of the present invention;

Figure 2b is a top view of the two segments in Figure 2a;

Figure 3 is a side view of a material handling hose according to an illustrative embodiment of the present invention;

Figure 4 is a side view of a mid-link and two segments according to an illustrative embodiment of the present invention;

Figure 5 is a cross-sectional view along 5-5 in Figure 4;

Figure 6a is detailed assembled view of a swivel assembly according to an illustrative embodiment of the present invention; and

Figure 6b is an exploded view of the swivel assembly of Figure 6a.

DESCRIPTION OF THE ILLUSTRATIVE EMBODIMENTS

Referring now to Figure 1a there will now be described a first illustrative embodiment of the present invention.

More precisely, the embodiment provides a flexible ship-loading arm assembly, generally referred to using the numeral 10, flange bolted at either end between a rigid ground-end support assembly 12 and a rigid ship-end support assembly 14. The loading arm assembly 10 includes one or more subsections 16 comprised of a series of segments as in 18 interconnected by a series of hinge mechanisms 20 and terminated at each end by a pair of terminating segments as in 22, 24 or, alternatively, a mid-link assembly 26. The hinge mechanisms 20 are arranged such that the axis around which the interconnected segments 18 rotate is essentially parallel to the ground and normal to the outer surface of the segments 18. The hinge mechanisms 20 allow the displacement between the ground-end support assembly 12 and the ship-end support assembly 14 to vary in terms of relative height and distance apart. The series of interconnected segments 18, terminating segments 22, 24 and, if present, mid-link assembly 26 surround and support a standard material handling hose 30 which is typically fabricated from a reinforced flexible rubber pipe.

The terminating segments as in 22 are attached to the support assemblies 12, 14 by a pair of swivel assemblies as in 28. As the support assemblies 12, 14 are both rigidly mounted to their respective supporting infrastructures, the swivel assemblies 28 allow the terminating segments 22 to rotate relative to the support assemblies 12, 14 around an axis which is substantially perpendicular to the ground. Lifting lugs 32 are provided for on at least a pair of segments 18 for allowing the attachment of wire cable 34 thereby allowing the loading arm assembly 10 to be hoisted into position by a crane (not shown).

In an alternative embodiment a similar loading arm assembly 10 is disclosed wherein, instead of being attached to a ship-end support assembly 14, the ship end of the loading arm assembly 10 is equipped with a discharge chute 35 attached to the terminating segment 24 and allowed to swing free, as disclosed Figure 1b. The loading arm assembly 10 is held up primarily by a crane (not shown) attached to the loading arm assembly 10 via the wire cables 34 and lifting lugs 32. In this alternative embodiment particulate matter being conveyed though the loading arm assembly 10 is discharged directly into the ship's hold (no shown). It will also be apparent to one of ordinary skill in the art that the swivel assembly 28 interposed between the ground-end support assembly 12 and the loading arm assembly 10 may in some implementations also not be necessary, with the terminating segment 22 being attached directly to the ground-end support assembly 12.

Referring now to Figure 2a, each segment 18 includes a steel cylinder 36 fabricated from, for example, CSA G40.21-M grade 300W steel having a nominal diameter of approximately eighteen (18) inches and a wall thickness of about 0.562 inches. A pair of outer hinge support brackets 38 and a pair of inner hinge support brackets 40 fabricated from, for example, 300W steel are lap welded to the outside and towards the ends of each steel cylinder 36. Referring now to Figure 2b in addition to Figure 2a, a hole as in 42 is machined in both hinge support brackets 38, 40 and successive segments are interconnected by inserting a suitable galvanised or stainless steel nut and bolt assembly as in 44. A slotted hexagonal nut/spring pin assembly is used to secure the nut and bolt assemblies 44 in a manner well known in the art while at the same allowing the hinge support brackets 38,40 to freely pivot relative to one another.

Note that although steel has been used in the illustrative embodiment for fabricating a number of the components of the present invention, it will apparent to one of ordinary skill in the art that other materials, for example aluminum, fibreglass or plastic may in some cases be suitable or even preferable.

Referring back to Figure 2a, segment 18a is able to rotate through a predetermined angle relative to adjacent segment 18b. The angle through which adjacent segments can rotate is limited by pairs of upper stopper blocks as in 46 and lower stopper blocks as in 48 which extend into the space between adjacent segments 18 and butt together when the extent of the predetermined angles are reached. The stopper blocks 46, 48 are fabricated from, for example, rectangles of 300W steel and are lap welded to the outside of the steel cylinder 36, typically at a location which is centred on the steel cylinder 36 substantially between the pairs of hinge support brackets 38 or 40.

In an illustrative embodiment the upper stopper blocks 46 extend into the space between adjacent segments 18 such that adjacent segments 18 are aligned along their longitudinal when the upper stopper blocks 46 of adjacent segments 18 abut. The abutting faces 50 of the upper stopper blocks 46 are machined flat such that the abutting faces 50 of adjacent upper stopper blocks 46 are in full contact when abutting.

In an illustrative embodiment the lower stopper blocks 48 extend into the space between adjacent segments 18 such that adjacent segments 18 are able to rotate through a predetermined angle. In the illustrative embodiment an angle of five (5) degrees between adjacent segments 18 has been found to be sufficient for the purposes of the present implementation, although it will be understood to persons of ordinary skill in the art that in other implementations other maximum angles of deflection may be preferred. It will also be understood to one of ordinary skill in the art that that the degree of deflection allowable between adjacent segments 18 will depend on a number of factors including the overall length of the segments 18, the width of the material handling hose 30, the number of segments 18 of which the loading arm assembly 10 is comprised, etc.. The abutting faces 52 of the lower stopper blocks 48 are machined at an angle to match the maximum angle of deflection such that the abutting faces 52 of adjacent lower stopper blocks 48 are in full contact when abutting.

As can be readily seen from Figure 2a and 2b, the material handling hose 30 is substantially encased by the steel cylinder 36 although the hose 30 is partially exposed as it traverses the gaps between adjacent segments 18. As will be understood by one of ordinary skill in the art, the stopper blocks 46, 48 also serve to limit the degree of articulation between adjacent segments 18 such that the portion of the material handling hose 30 which traverses the gap between segments 18 is not pinched or otherwise too severely deformed by this pivoting action. This in turn reduces the stresses placed on the material handling hose 30 thereby improving its reliability.

Referring now to Figure 3, in an illustrative embodiment the material handling hose 30 is fabricated from lengths of ¼" rubber tubing as in 54 having a 12" internal diameter and wrapped in a high tensile cord with a wire helix and a longitudinal Mylar stripe. The hose/wire assembly is encased in a corrugated outer housing. An example of such a material handling hose is GoodFlex™ S1242 material handling hose manufactured by Goodal.

Still referring to Figure 3, rubber lined steel nipple/flange assemblies 56 are inserted into each end of the reinforced rubber tubing 54 and securely attached thereto by vulcanising the ends of the rubber tubing 54 or applying a suitable adhesive. Each nipple/flange assembly 56 is equipped with a flange 58. As is known in the art, a series of bolt holes as in 60 are machined in the faces of the flanges at regular spacing around the circumference thereof. The flanges 58 of successive sections 18 of hose 30 can be attached together simply by bolting the flanges 58 together using nut and bolt fasteners as in 62. In order to ensure good sealing between successive sections 18 of the material handling hose 30, a suitable gasket 64 can be interposed between the flanges 58.

Referring back to Figure 1, as stated above, in order to attach successive sections 16 together a mid-link assembly 26 is provided for. Referring now to Figure 4, each mid-link assembly 26 is comprised of a generally cylindrical shaped outer casing 66 fabricated from, for example, 300W steel. The outer casing is larger towards the middle in order to provide extra spacing for the flanges 58 of the material handling hose 30. The mid-link assembly 26 is provided with two pairs of hinge support brackets 38 which mate with hinge support brackets 40 mounted on adjacent segments 18. Similar to the segments 18, the mid-link assembly 26 also includes upper stopper blocks 46 and lower stopper blocks 48 which extend into the space between the mid-link 26 and each of the adjacent segments 18. Referring now to Figure 5 in addition to Figure 4 the outer casing 66 of the mid-link assembly 26 is fabricated from two separable half-pieces 68, 70 which are fastened together along pairs of matching raised ribs as in 72, 74. A series of holes as in 76 are machined in each rib 72, 74 through which nut and bolt assemblies as in 78 can be inserted. Alternatively, a portion of each hole 76 can be machined with a suitable thread as is known in the art thereby allowing the half-pieces 68, 70 to be secured together using a series of suitably threaded bolts. At this point it will clear to one of ordinary skill in the art that the separable nature of the half-pieces 68, 70 allows the material handling hoses 30 of successive subsections 16 to be joined together while at the same time providing support for the material handling hose 30 in the region of this join.

Referring to Figure 6a, the loading arm assembly 10 is terminated at each end by terminating assemblies 22, 24. Each terminating assembly 22, 24 is fabricated from a hollow cylinder 78 of, for example, 300W steel to which is welded at a first end a lower stopper block 46 and an upper stopper block 48 which oppose the lower stopper block 46 and upper stopper block 48 of the adjacent segment 18. At the opposite of the hollow cylinder 78 a steel flange 80 is attached, typically by means of a weld. A series of steel braces as in 82 are disbursed around the perimeter of the hollow cylinder 78 and securely welded to both the hollow cylinder 78 and the flange 80 in order to provide additional strength to the terminating assembly 22, 24 which at times is supporting a great portion of the weight of the loading arm assembly 10.

Still referring to Figure 6a, the terminating assembly 22, 24 is in turn mounted to a swivel assembly 28 by means of a series of fastening assemblies as in 84, typically twelve (12), evenly distributed around the circumference of the flange 80. Each fastening assembly 84 is typically comprised of a threaded galvanised or stainless steel nut 86 and bolt 88 and a pair of galvanised or stainless steel washers as in 90. Additionally, a galvanised or stainless steel spacer 92 is included in each assembly 84, thereby spacing the terminating assemblies 22, 24 from the swivel assembly 28. The flange 58 of the material handling hose 30 is also mounted to the swivel assembly 28 by means of a series of galvanised or stainless steel nut and bolt fastening assemblies 94, typically twelve (12), evenly distributed around the circumference of the flange 58. In order to ensure proper sealing of the material handling hose 30 with the swivel assembly 28 a gasket 96 manufactured from a suitable material such as Biltrite™ Style 26 Chute Lining/Skirtboard.

The swivel assemblies 28, of which one is located at each end of the loading arm assembly, is interposed between the loading arm assembly 10 and either the ground-end support assembly 12 and the ship-end support assembly 14. The swivel arm assembly allows the ends of the loading arm assembly 10 to rotate relative to the ground-end support assembly 12 and the ship-end support assembly 14 which are fixed securely either to the ground (the ground-end support assembly 12) or to the deck of a ship (the ship-end support assembly 14). This in turn allows a ship located dockside to move laterally relative to the loading arm assembly 10 without tearing or other wise damaging the material handling hose 30. it also allows the loading arm assembly 10, once disconnected from the ship-end support assembly 14 to be swung away from the ship while still attached to the ground-end support assembly 12.

Referring now to Figure 6b, using an exploded view, an illustrative embodiment of the swivel assembly 28 will be described in more detail. Each swivel assembly 28 is comprised of a lower fixed portion 98 and an upper rotating portion 100 which sits upon the lower fixed portion 98. The lower fixed portion 98 includes a lower flange 102, manufactured for example from 300W steel, for attaching the swivel assembly 28, depending on the location of the swivel assembly 28, to either the ground-end support assembly 12 or the ship-end support assembly 14. The lower fixed portion 98 also includes a hollow cylinder 104, also manufactured from 300W steel, which is securely attached to the lower flange 102, typically by means of a weld. Additionally, support braces as in 106 are welded between the lower flange 102, the hollow cylinder 104 and a bushing seat 108 in order to improve strength and rigidity of the lower fixed portion 98. The hollow cylinder 104 is illustratively lined with a liner 110 which is resistant to the abrasive effects of particulate matter passing through the hollow cylinder 104. An example of a suitable material for the liner 110 would be REMA™ Line 70.

Still referring to Figure 6b, a series of packing rings 112 are sandwiched between pairs of bushings as in 114 manufactured from a low friction self lubricating material such as Ultra-High Molecular Weight Poly-Ethylene (UHMW-PE). The packing rings 112 and bushings 114 are placed onto the hollow cylinder 104 and held in place by a retaining ring 116 which is fabricated from, for example, 300W steel. A series of threaded bolts 118, typically twelve (12) and manufactured for example from galvanized or stainless steel, are inserted through a series of complementary holes (not shown) machined in and distributed evenly around the retaining ring 116. These holes are aligned with matching holes machined in the packing rings 112, bushings 114 (not shown) and the bushing seat 108. The threaded bolts 118 are retained in place by a complementary set of nuts 120 into which the bolts 118 are threaded.

Still referring to Figure 6b, the upper rotating portion 100 includes a hollow cylinder 122 which depends downwards from an upper flange 124 and a intersects a stop ring 126, all fabricated from, for example, 300W steel. The upper flange 124 is securely mounted on the end of the hollow cylinder 122, typically by means of a weld with addition braces as in 128 typically welded in between the upper flange and the hollow cylinder 122 to improve the strength and rigidity of the assembly. A similar set of braces as in 130 are typically welded between the stop ring 126 and the hollow cylinder 122. The upper rotating portion 100 is inserted over the packing rings 112, bushings 114 and retaining ring 116. Once the upper rotating portion 100 is in position the threaded bolts 118 can be further tightened thereby compressing the packing rings 112 and bushings 114 between the retaining ring 116 and the bushing seat 108. This in turn causes the packing rings 112 to bulge slightly, thereby bringing the packing rings 112 into closer contact with the outside of the hollow cylinder 104 and the inside of the hollow cylinder 122 and effectively sealing the arrangement.

Once the upper rotating portion 100 is in position over the lower fixed portion 98, a retaining collar comprised of two collar halves as in 130 is placed around the assembly and attached together using a pair of fastening assemblies (comprised in this illustrative embodiment of a pair of galvanised or stainless steel nut 132 and bolt 134 pairs inserted through pairs of opposed bosses as in 136). Each collar half 130 includes a casing portion 140 and counter plate portion 142 manufactured, for example, from 300W steel. A series of bolt holes, typically twelve (12), as in 144 are machined in the casing portions 140 and distributed evenly around the circumference thereof.

Once assembled, the retaining collar halves 130 are fastened to a fastening collar 146 manufactured, for example, from 300W steel and welded to an upper face of the bushing seat 108. In an illustrative embodiment the retaining collar halves 130 are removeably attached to the fastening collar 146 by means of a series of galvanised or stainless steel bolts as in 148 which are inserted through the holes 144 in the casing portions 140 into corresponding holes 150 machined in the fastening collar 146 the insides of which have been machined with a suitable matching thread. Alternatively, the bolts 148 can be inserted and tightened against a series of corresponding nuts as in 152 retained on the inner surface of the fastening collar 146.

The retaining collar halves 130 are such that when assembled the counter plate portions 142 form an annulus closely encircling but not touching the hollow cylinder 122 and resting slightly above the stop ring 126 of the upper rotating portion 100. Once assembled, any movement of the upper rotating portion 100 away from the lower fixed portion 98 along the longitudinal axis of the assembly will bring the upper surface of the stop ring 126 into contact with the lower surface of the annulus formed by the counter plate portions 142. In this manner the upper rotating portion 100 is retained in assembly with the lower fixed portion 98 while at the same time allow the upper rotating portion 100 to rotate relative to the lower fixed portion 98.

In order to correctly mate the rotating assemblies 28 to the terminating assemblies 22 an adapter 154 is provided. The adapter 154 includes a hollow frustum 156 sandwiched between a lower adapter flange 158 and an upper adapter flange 160, all fabricated for example from 300W steel. Typically, the lower adapter flange 158 and the upper adapter flange 160 are fastened to the hollow frustum 156 by means of welds with the assembly being further reinforced by the provision of a series of braces as in 162 for increased strength and rigidity. The adapter 154 is attached to the upper rotating portion 100 typically by a series of fasteners, in the illustrative embodiment twelve (12), each comprised of a galvanised or stainless steel nut as in 164 and bolt as in 166. The bolts 166 are inserted through a series of holes (not shown) machined in the lower adapter flange 158 and evenly distributed around the circumference thereof and through a corresponding set of holes machined in the upper flange 124. Prior to assembly a gasket 168 is typically inserted between the lower adapter flange 158 and the upper flange 124 in order to hermetically seal the assembly. Similar to the hollow cylinder 104, the hollow frustum is provided with a liner 170, with again an example of a suitable material for the liner 170 being REMA™ Line 70.

Referring back to Figure 1, once assembled the loading arm assembly 10 is typically hoisted by a crane (not shown) attached to the loading arm assembly 10 by means of two or more lifting lugs 32 and the wire cable 34. The loading arm assembly 10 is then secured at one end to the ground-end support assembly 12 by means of a swivel assembly 28. When a ship puts into port the other end of the loading arm assembly 10 can be lowered by the crane and attached to the ship-end support assembly 14 by means of a second swivel assembly 28.

Once the loading arm assembly 10 is securely in place between the ground-end support assembly and the ship-end support assembly 14 the tension on the wire cable can be released and the loading arm assembly 10 will stand alone supported only by the swivel assemblies 28 and support assemblies 12, 14 located at each end. It will be apparent to one of ordinary skill in the art that the support assemblies 12, 14 must be constructed from materials and in a manner such that they are at least capable of supporting the weight of the loading arm assembly 10, the swivel assemblies 28 and any material which is being pumped through the loading arm assembly 10 at any one time.

As the ship rises or sinks due to wave action, tides or change in the amount of ballast, the end of the loading arm assembly 10 attached to the ship-end support assembly 14 will adjust itself accordingly without action on behalf of the crane operator. Similarly, if the lateral distance between the support assemblies 12, 14 increases or decreases, the loading arm assembly 10 will compensate accordingly. Finally, if the ship moves at right angles to the loading arm assembly 10 the ends of the loading arm assembly 10 will rotate relative to the support assemblies 12, 14 by means of the swivel assemblies 28. It will be apparent to one of ordinary skill in the art that although the loading arm assembly 10 may move considerably during loading or unloading of materials, the stresses brought to bear on the material handling hose 30 are minimised.

As disclosed, the loading arm assembly is suitable for moving particulate matter, such as dry abrasive nickel concentrate powder, with a bulk density of between 80 pcf (aerated) to 120 pcf (packed). The temperatures of the materials is typically within the range of -25°C to +25°C. In the illustrative embodiment the particulate matter (not shown) is fed into the conveying line 174 from a dense-phase pneumatic conveying system with a maximum pressure of about 65 psi. Note, however, that the loading arm assembly 10 and swivel assemblies 28 as described could also function within a dilute-phase pneumatic conveying system. However, the present trend is to convey pneumatically in dense phase since as this has the advantage not only of making it possible to work with lower rates of air flow, but also of keeping down the wear of the conveyor ducts over time while conserving better quality in the conveyed substance, compared with conveying in dilute phase.

Although the present invention has been described hereinabove by way of an illustrative embodiment thereof, this embodiment can be modified at will, within the scope of the present invention, without departing from the spirit and nature of the subject of the present invention.

WHAT IS CLAIMED IS:

1. A loading arm for conveying particulate matter under pressure comprising:

a flexible hose;

a rigid outer casing surrounding said flexible hose, said outer casing including a plurality of elongate casing segments disposed end to end; and

a plurality of hinge mechanisms having parallel axis of rotation, one of said hinge mechanisms interconnecting adjacent casing segments to allow said adjacent segments to pivot relative to one another around said axis of rotation, said hinge mechanisms limiting rotation about said axis of rotation to within a predetermined range.

2. The loading arm of claim 1, wherein said elongate casing segments are tubular.

3. The loading arm of claim 1, wherein each of said hinge mechanisms includes a pair of upper stopper blocks and a pair lower stopper blocks, one of each pair of stopper blocks being rigidly mounted on adjacent casing segments such that:

when said adjacent segments are pivoted about said axis through a predetermined upper angle said pair of upper stopper blocks come into contact; and

when said adjacent segments are pivoted about said axis through a predetermined lower angle said pair of lower stopper blocks come into contact;

whereby said upper stopper blocks and said lower stopper blocks limit rotation about said axis of rotation to within a predetermined range.

4. The loading arm of claim 3, wherein said predetermined range is about 5 degrees.

5. The loading arm of claim 4, wherein said predetermined upper angle is about 0 degrees and said predetermined lower angle is about 5 degrees.

6. The loading arm of claim 1, wherein said flexible hose has a charging end and further comprising a first swivel assembly attached to said charging end and said outer casing, said first swivel assembly allowing said charging end to rotate around an axis which is perpendicular to the ground.

7. The loading arm of claim 6, wherein said flexible hose has a discharging end and further comprising a second swivel assembly attached to said discharging end and said outer casing, said second swivel assembly allowing said discharging end to rotate around an axis which is perpendicular to the ground.

8. An apparatus for pneumatically conveying particulate matter held in a first storage chamber into a second storage chamber comprising:

a source of compressed air;

a mixer having an output for combining said compressed air with the particulate matter held in the first storage chamber;

a flexible hose having a charging end and a discharging end, said charging end attached to said output;

a rigid outer casing surrounding said flexible hose, said outer casing comprising a plurality of elongate casing segments disposed end to end; and

a plurality of hinge mechanisms having parallel axis of rotation, one of said hinge mechanisms interconnecting adjacent casing segments to allow said adjacent segments to pivot relative to one another, said hinge mechanisms limiting rotation about said axis of rotation to within a predetermined range;

wherein the particulate matter is conveyed along said flexible hose by said compressed air and discharged therefrom at said discharging end into the second storage chamber.

9. The apparatus of claim 8, further comprising a crane for moving said discharging end.

10. The apparatus of claim 8, further comprising a first swivel assembly between said output and charging end, said first swivel assembly allowing said charging end to rotate around an axis which is perpendicular to the ground.

11. The apparatus of claim 10, further comprising a second swivel assembly interposed between and rigidly mounted to said discharging end and the second storage chamber, said second swivel assembly allowing said discharging end to rotate around an axis which is perpendicular to the ground.

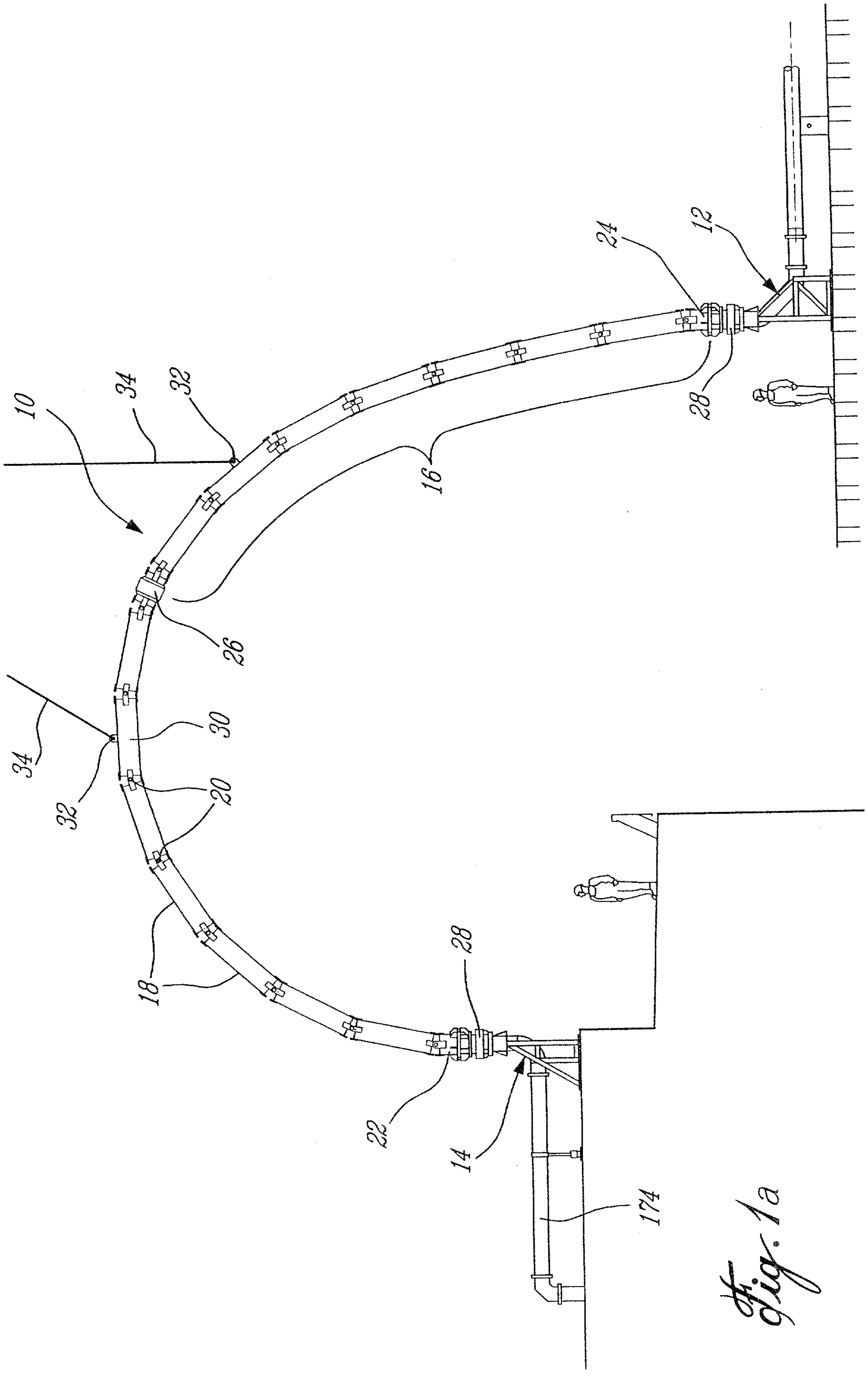


Fig. 1a

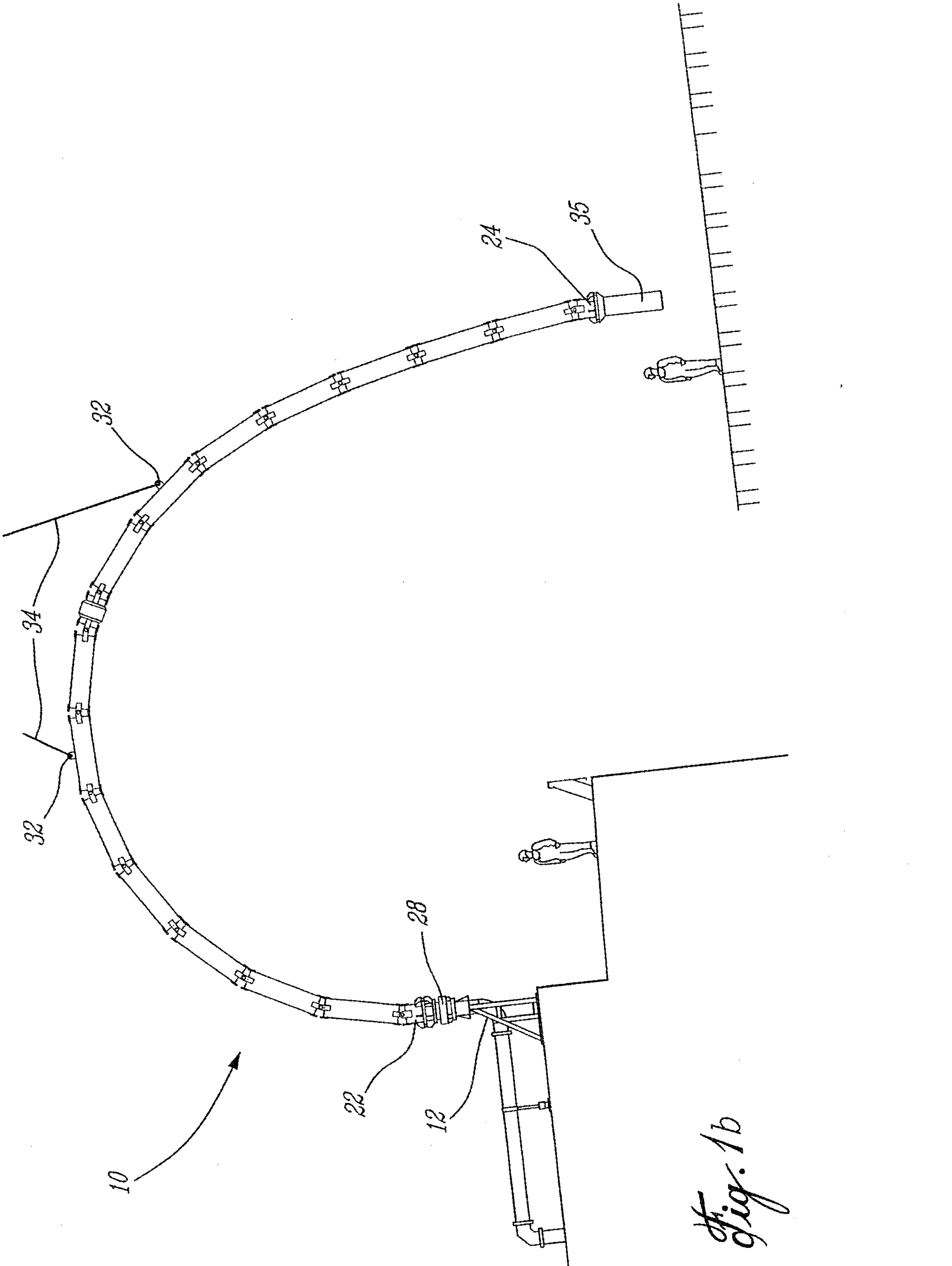


Fig. 1b

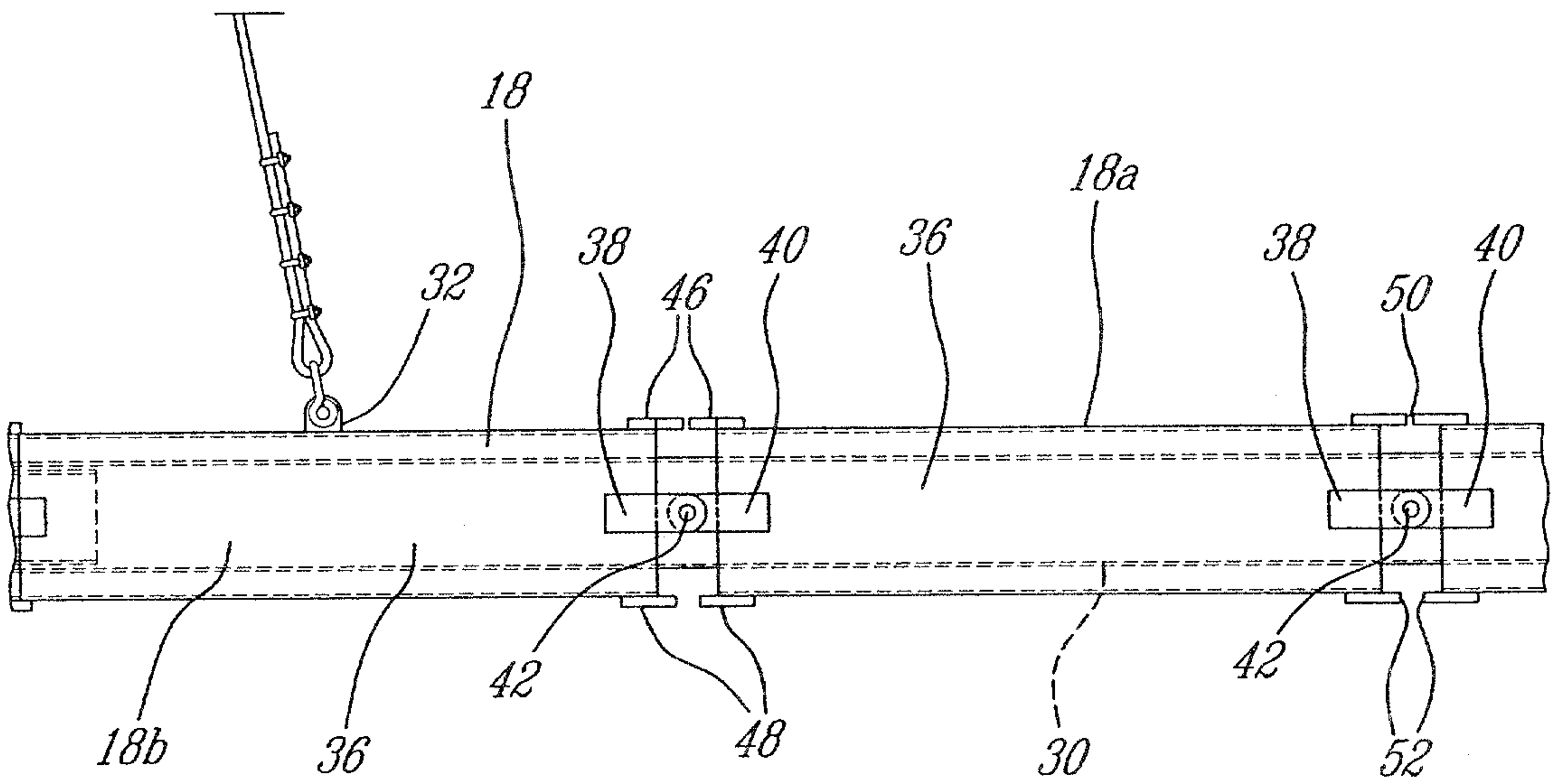


Fig. 2a

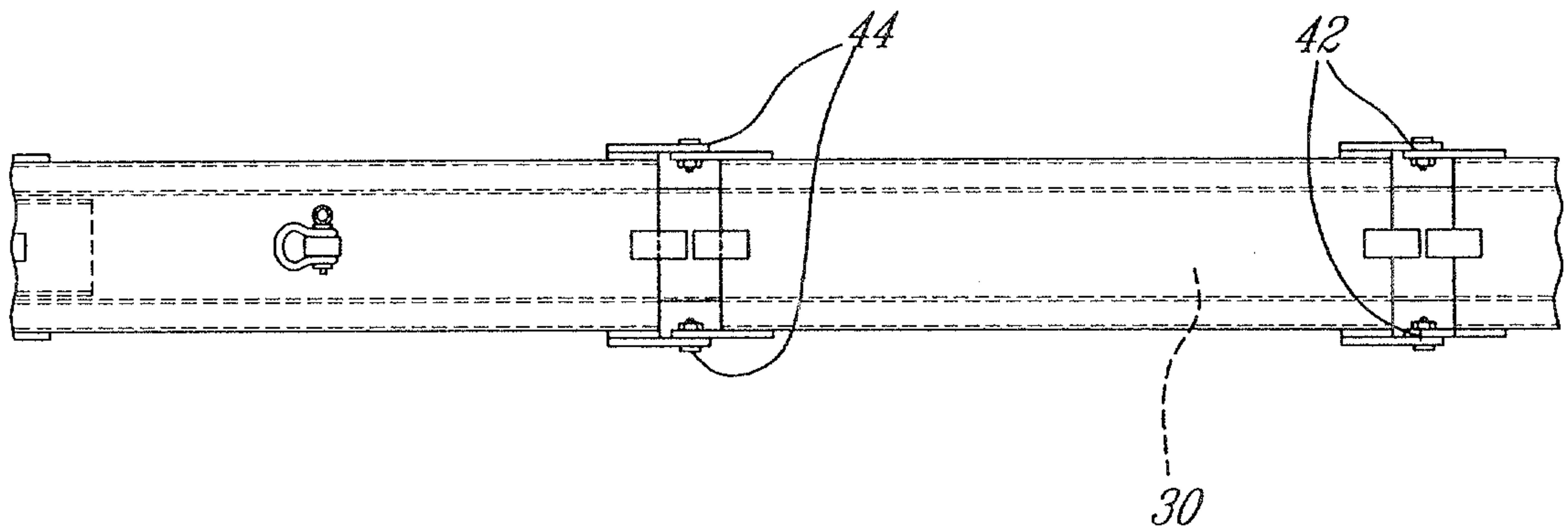


Fig. 2b

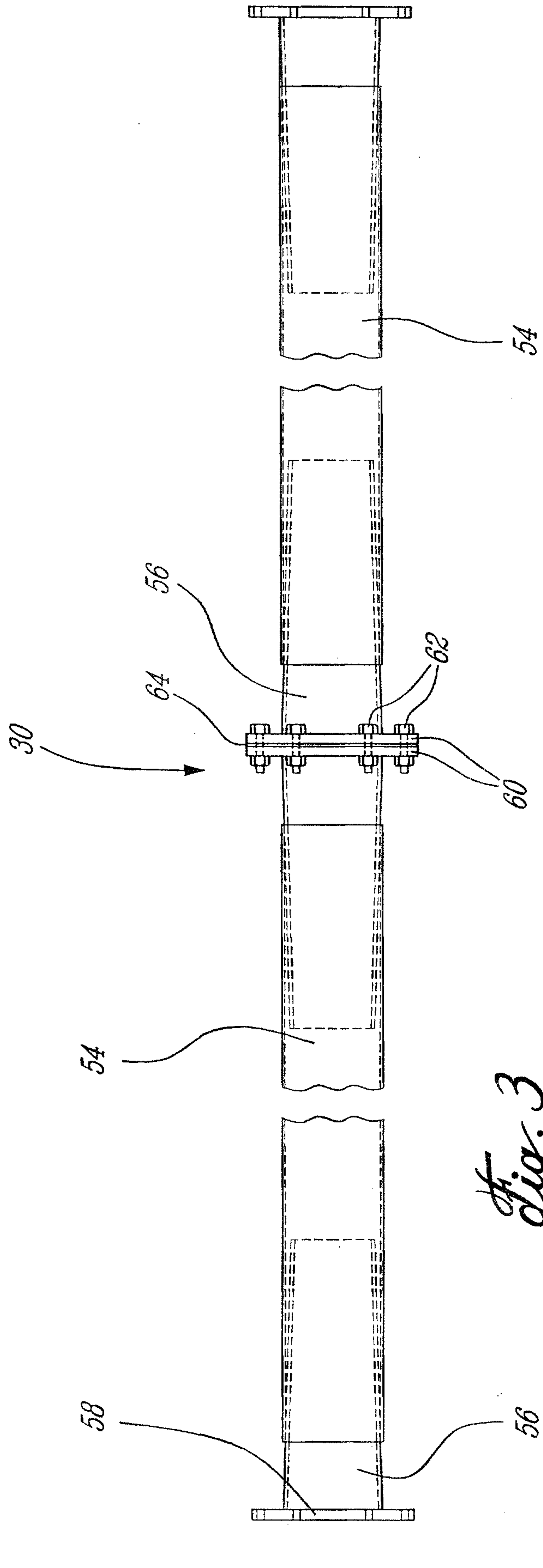


Fig. 3

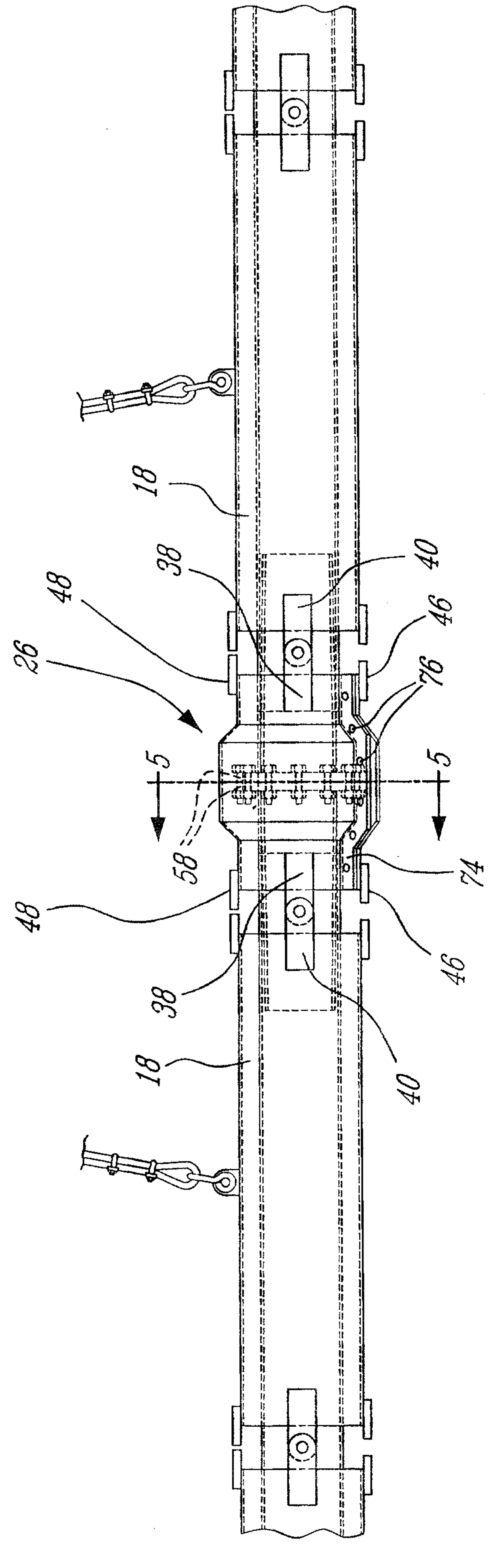


Fig. 4

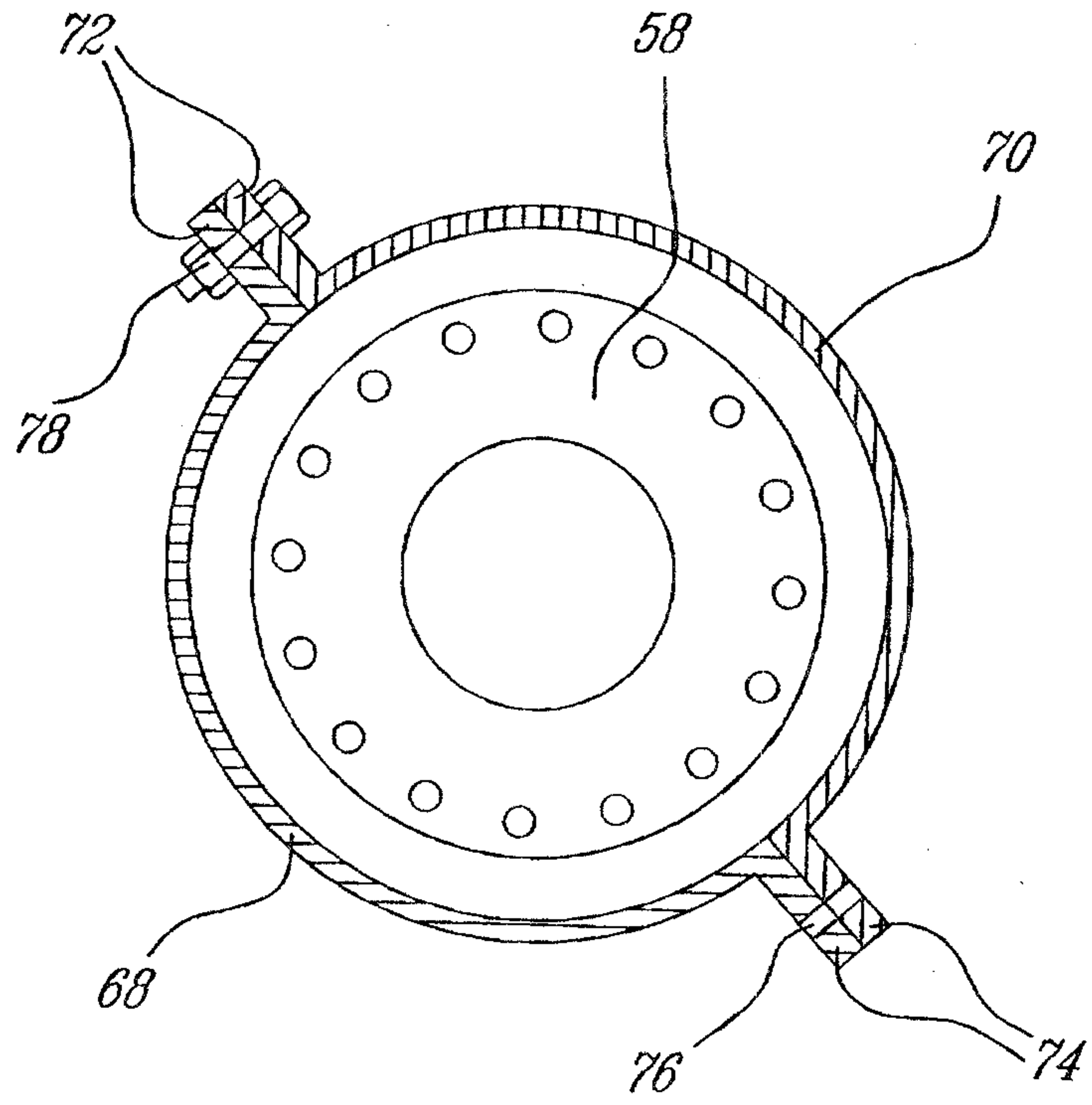


Fig. 5

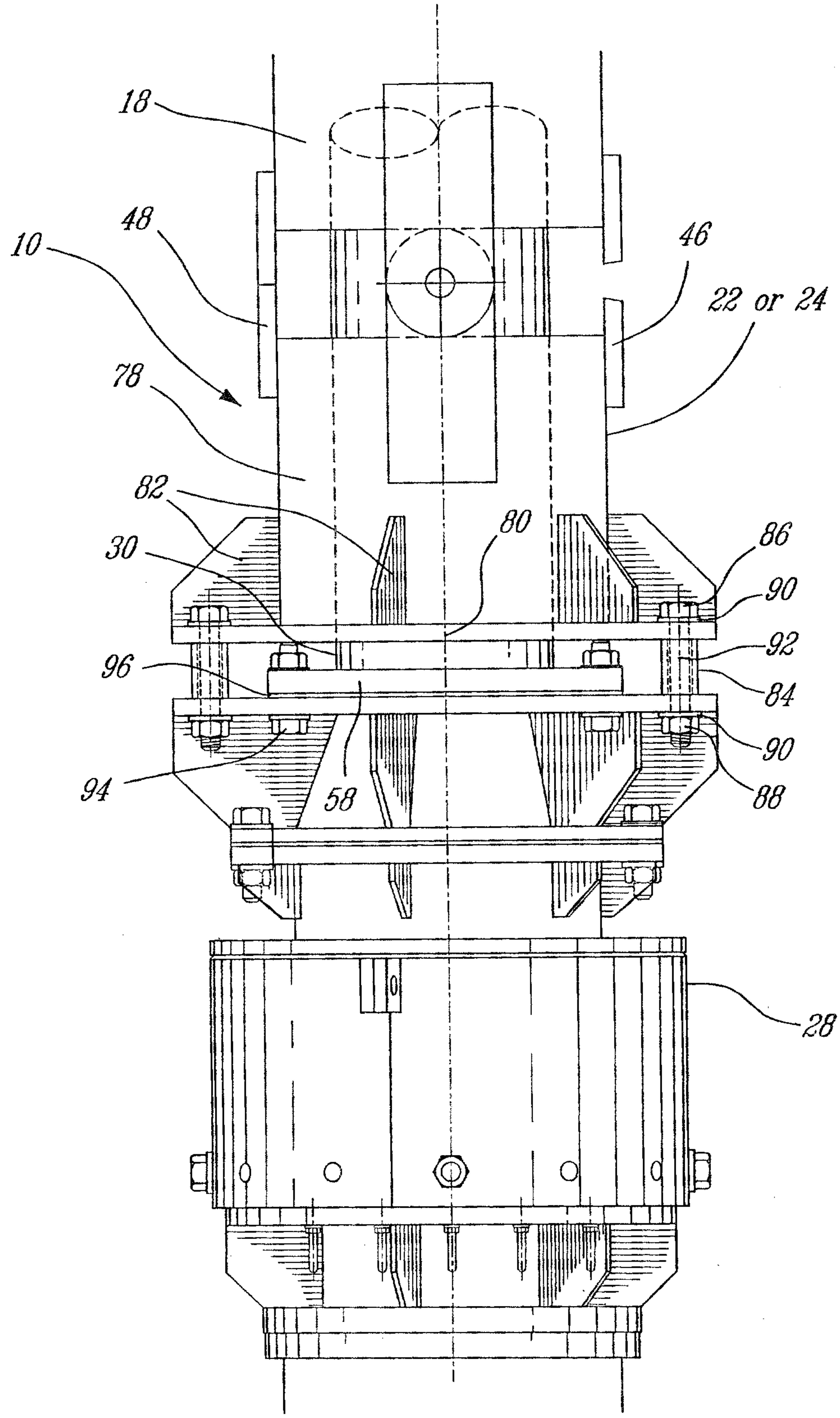


Fig. 6a

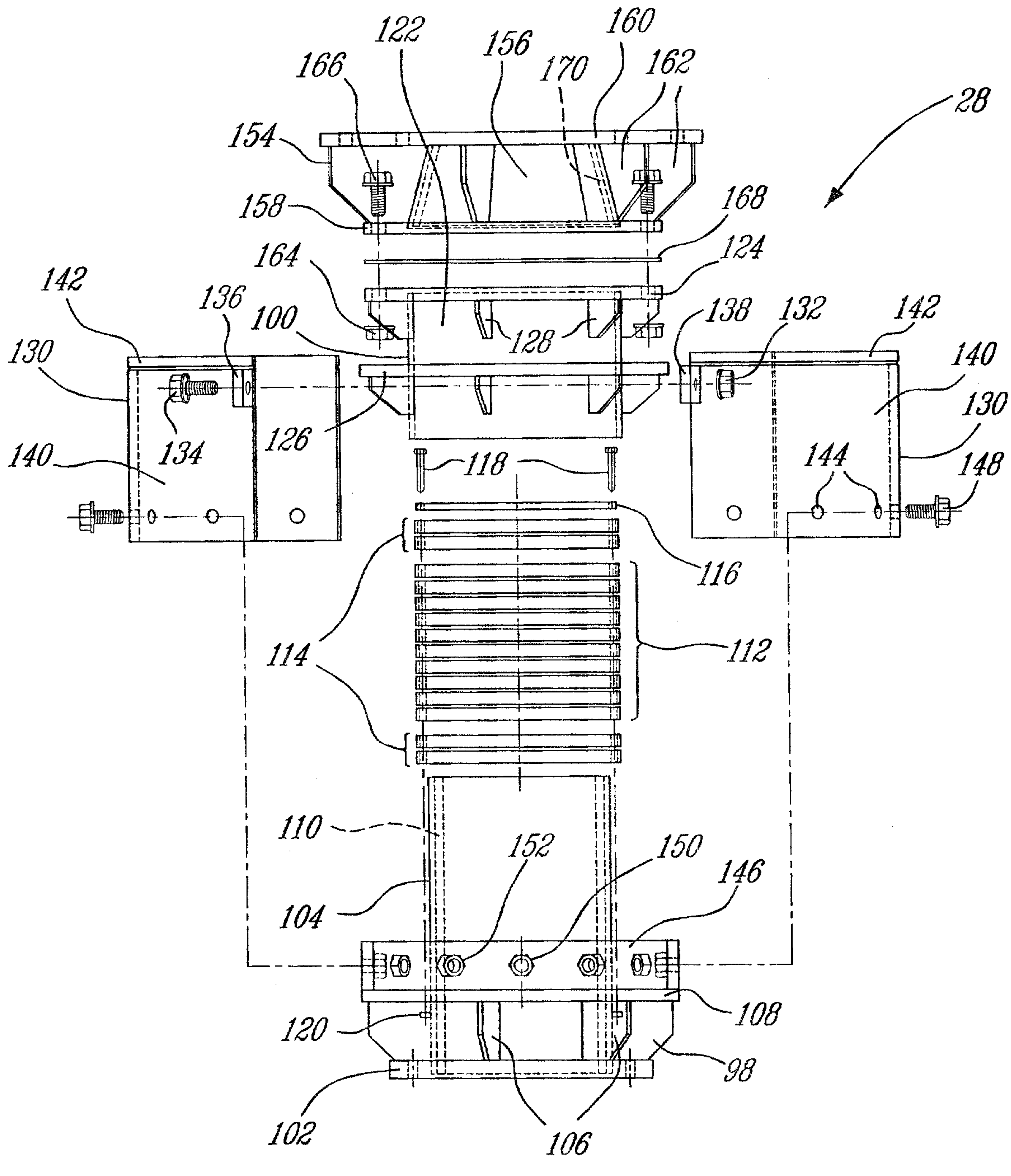

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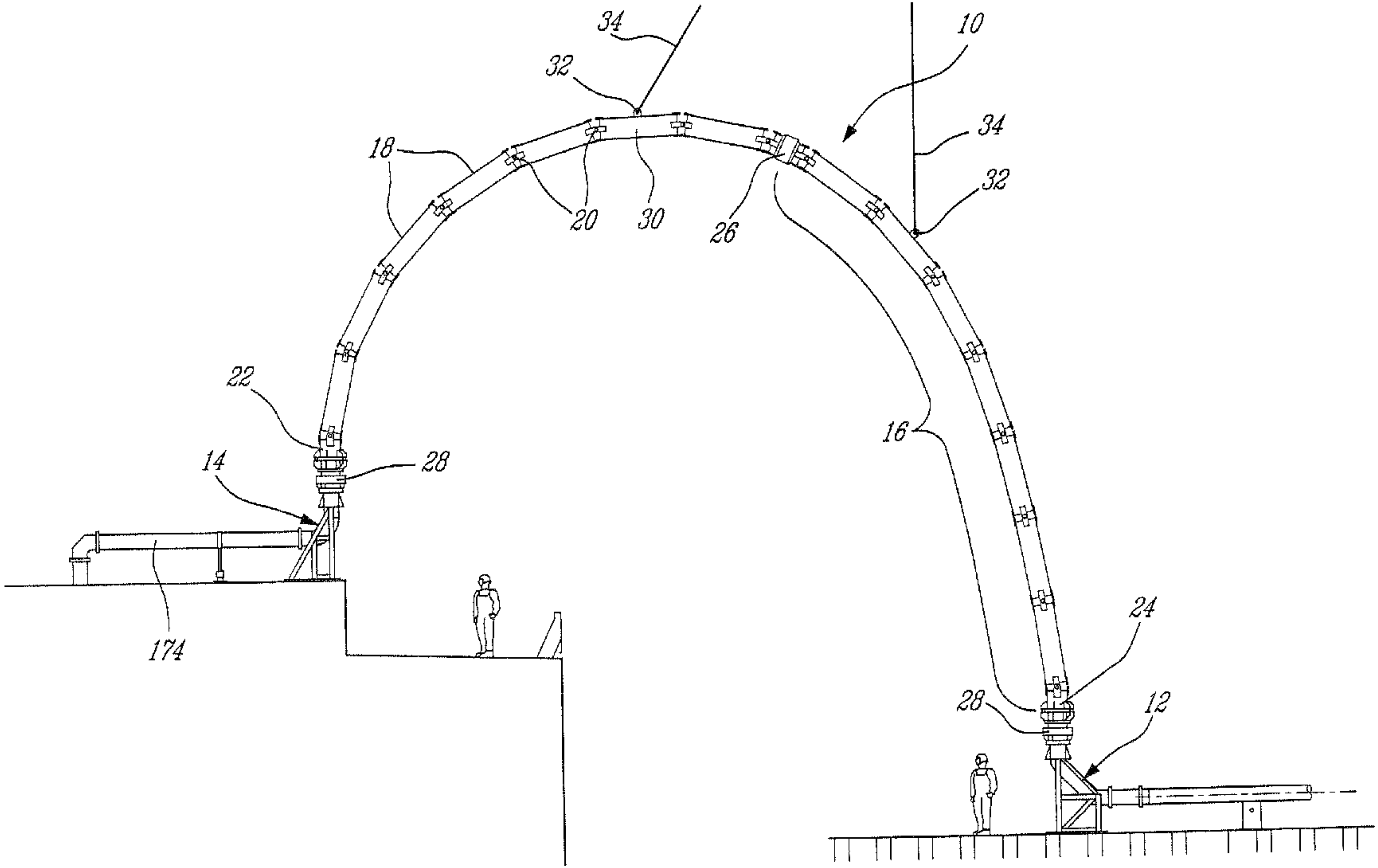
Fig. 6b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