(12) UK Patent (19) GB (11) 2568860 (13) B

(45) Date of B Publication 08.04.2020

(54) Title of the Invention: Rope management apparatus

(51) INT CL: ***A62B 35/00*** (2006.01) ***A62B 1/06*** (2006.01) ***A63B 27/00*** (2006.01) ***B61B 12/12*** (2006.01)
B66D 1/60 (2006.01)

(21) Application No: **1716220.7**

(22) Date of Filing: **05.10.2017**

(43) Date of A Publication **05.06.2019**

(56) Documents Cited:
US 20030071252 A1

(58) Field of Search:
As for published application 2568860 A viz:
INT CL **A62B, A63B, A63G, B61B, B66D**
Other: **EPODOC, WPI**
updated as appropriate

Additional Fields
Other: **None**

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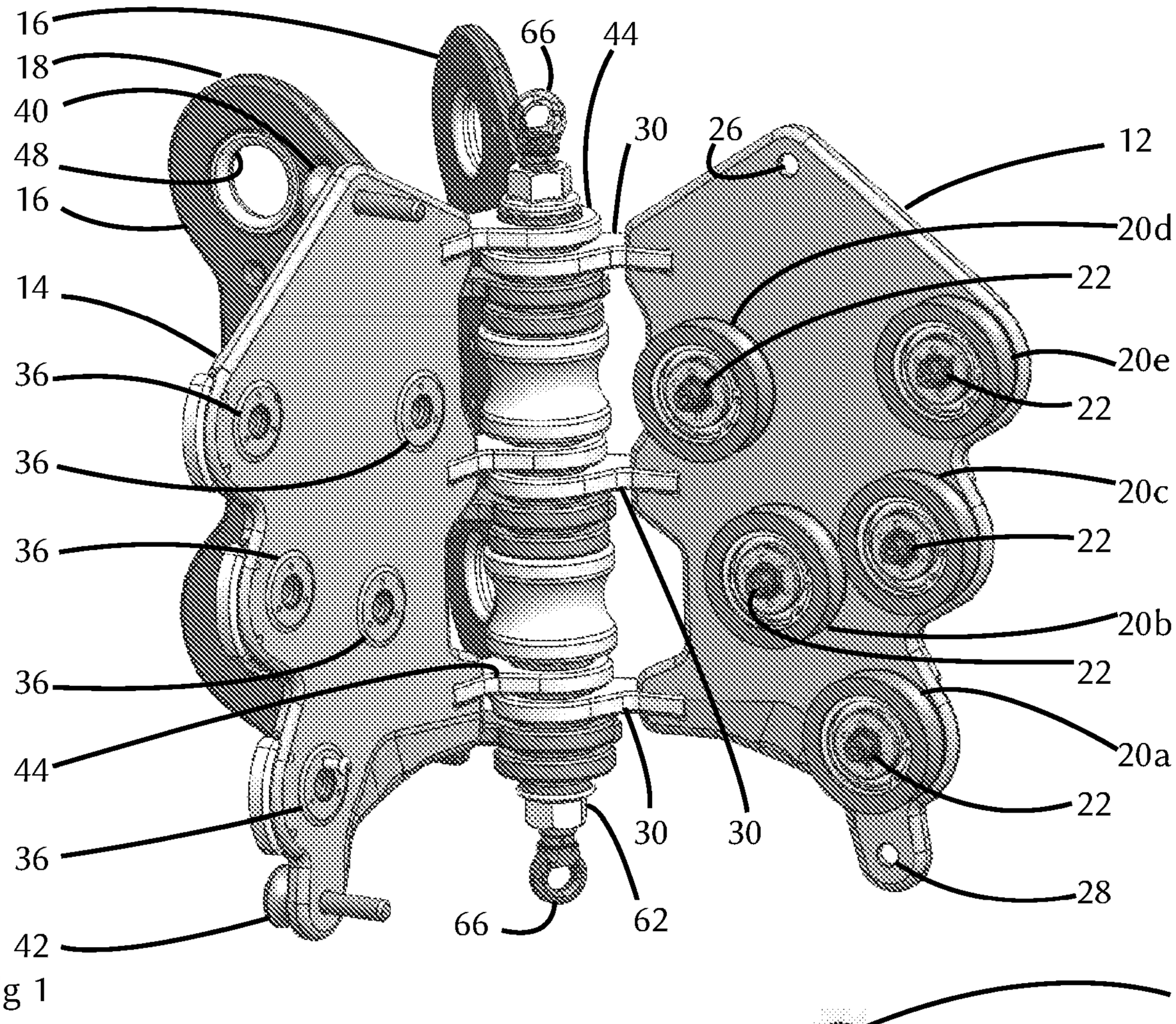
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66
62
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20d
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20a
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28

Fig 1

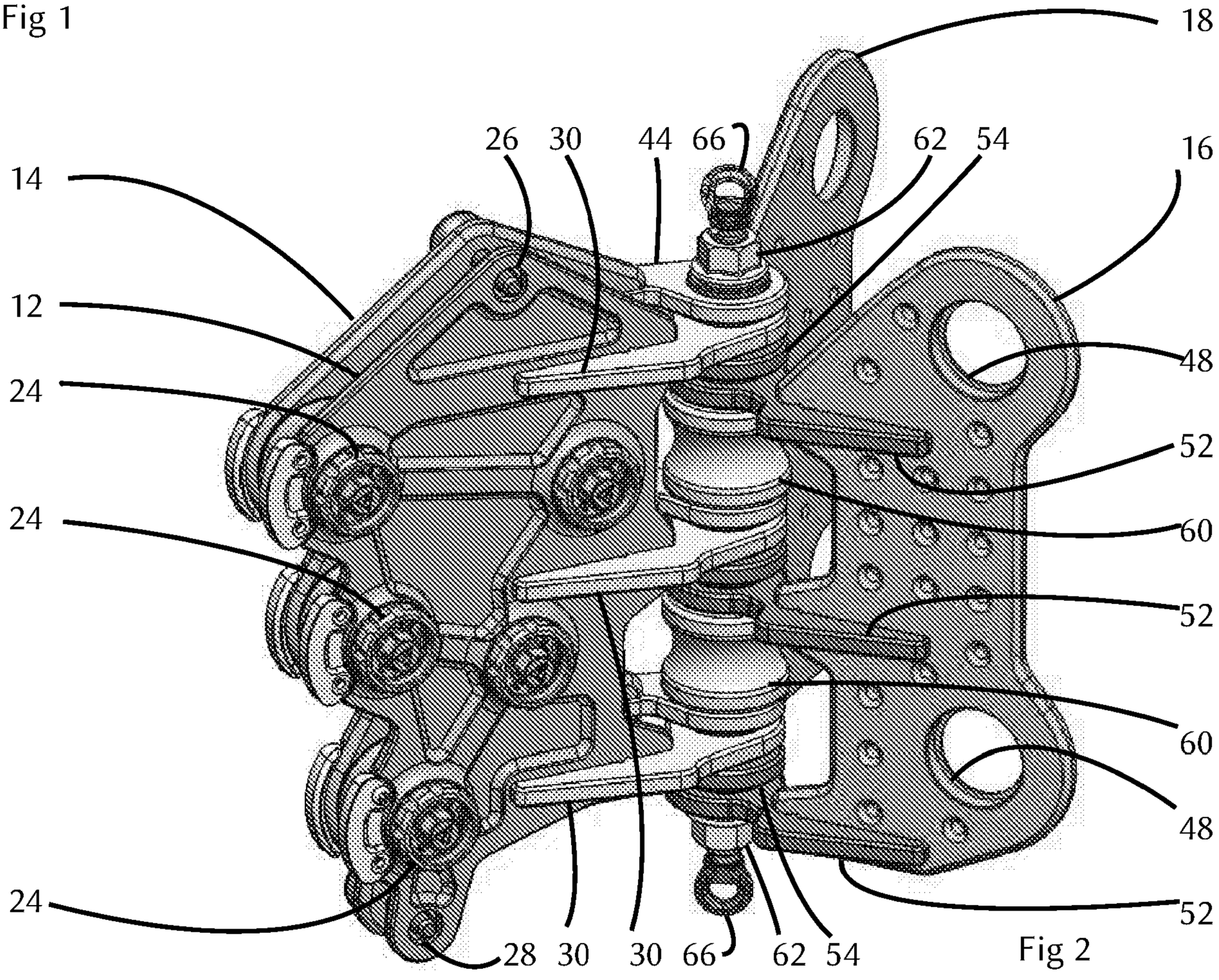
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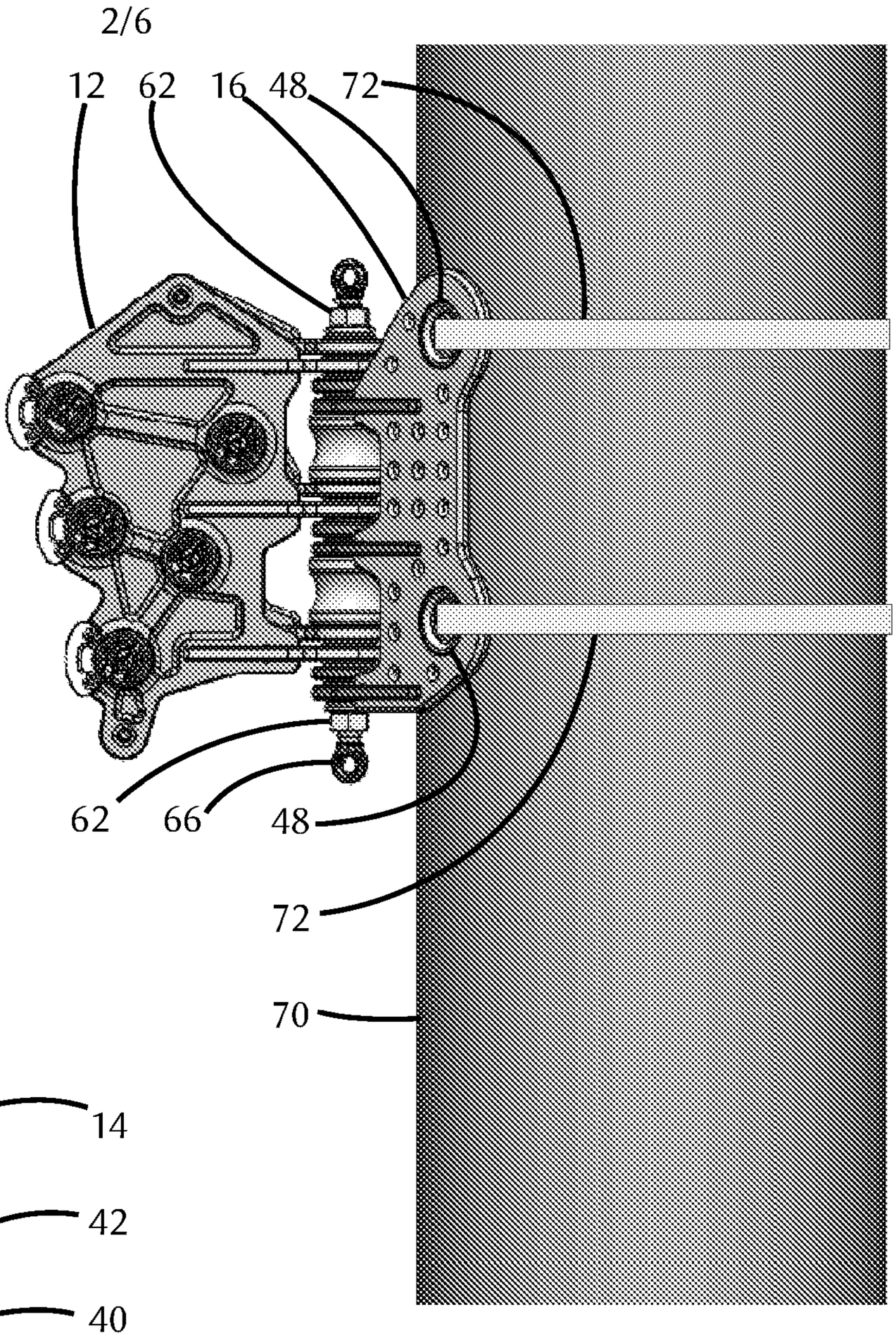
Fig 2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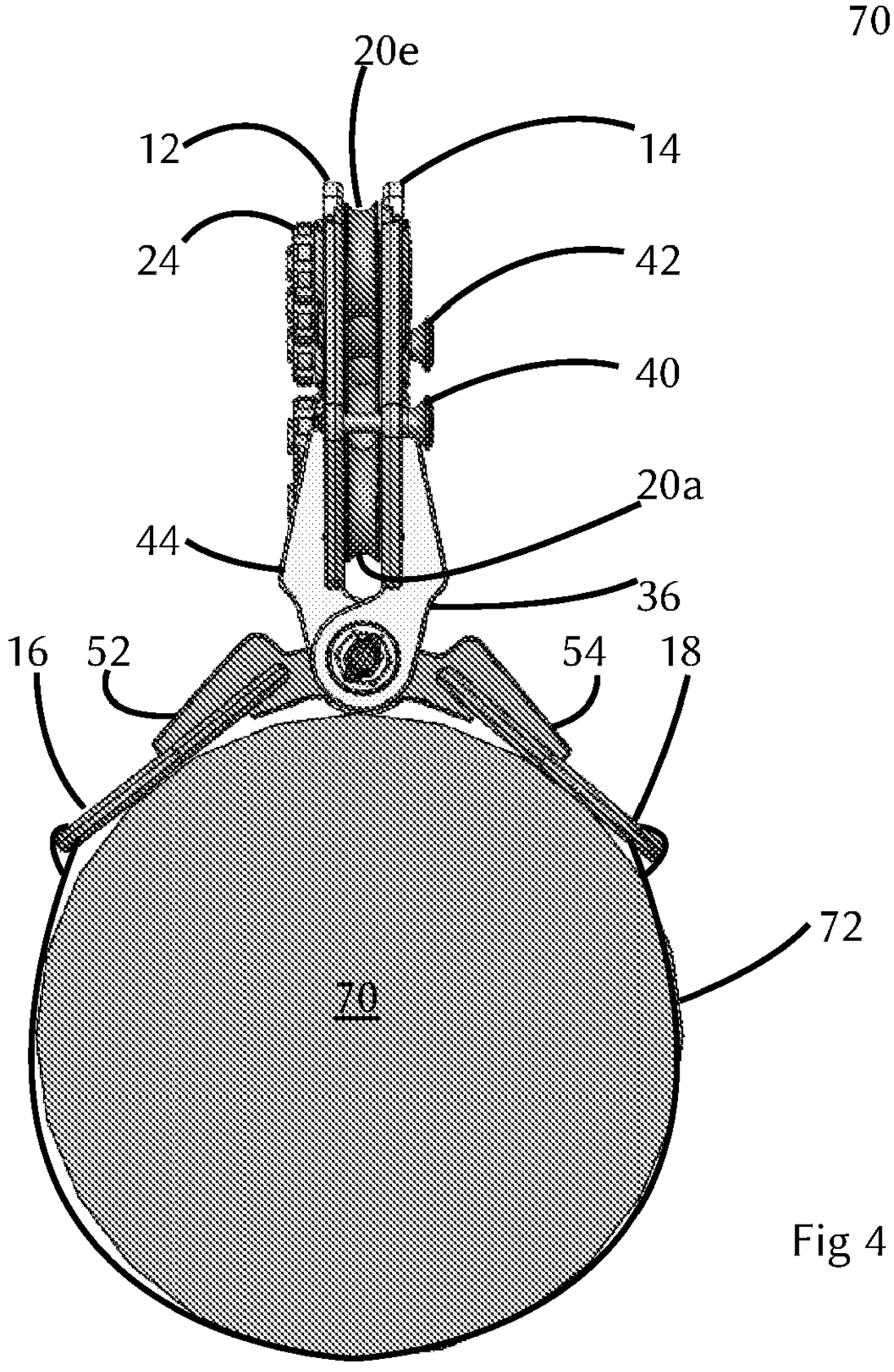
70

Fig 3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12
14
24
42
40
20a
44
36
16
52
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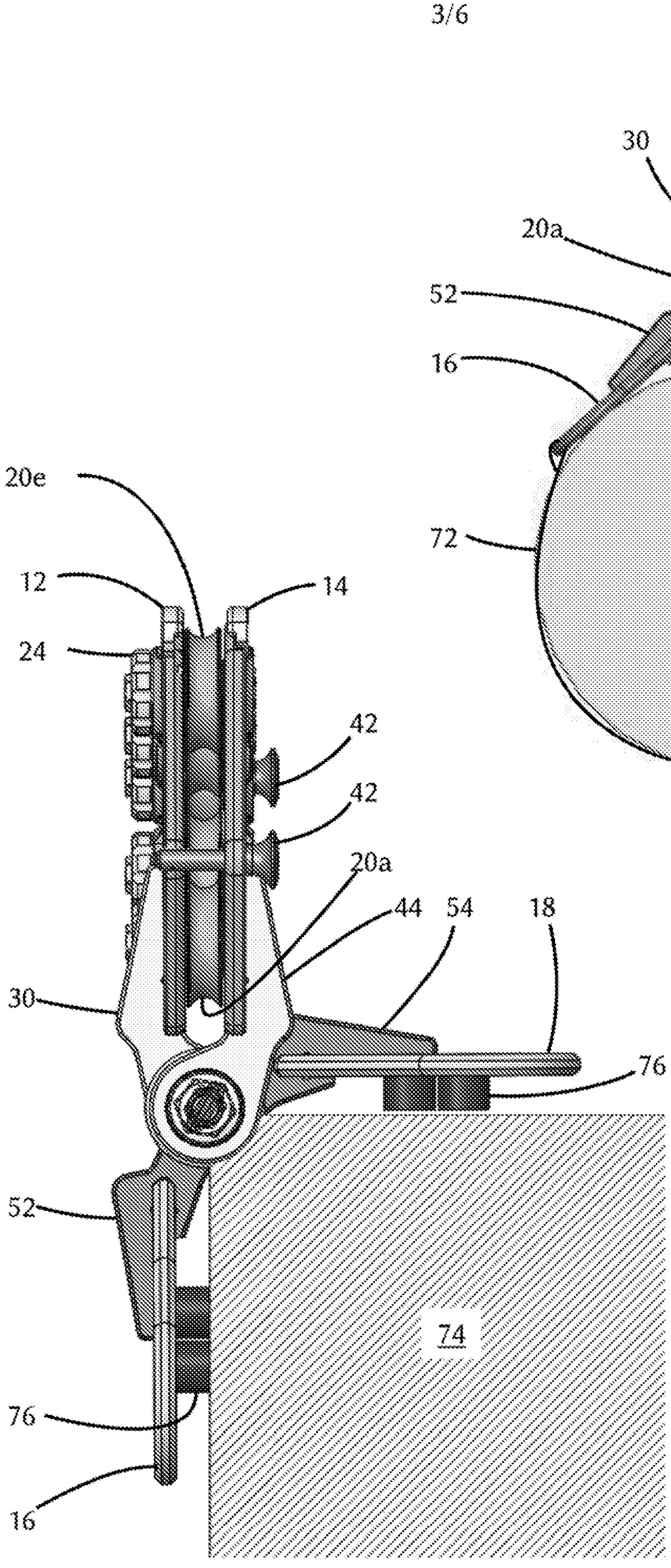
18
72
70

Fig 4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20e
14
30
20a
44
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16
18
72
70
20e
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20a
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54
18
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76
52
74
76
16

Fig 5

Fig 6

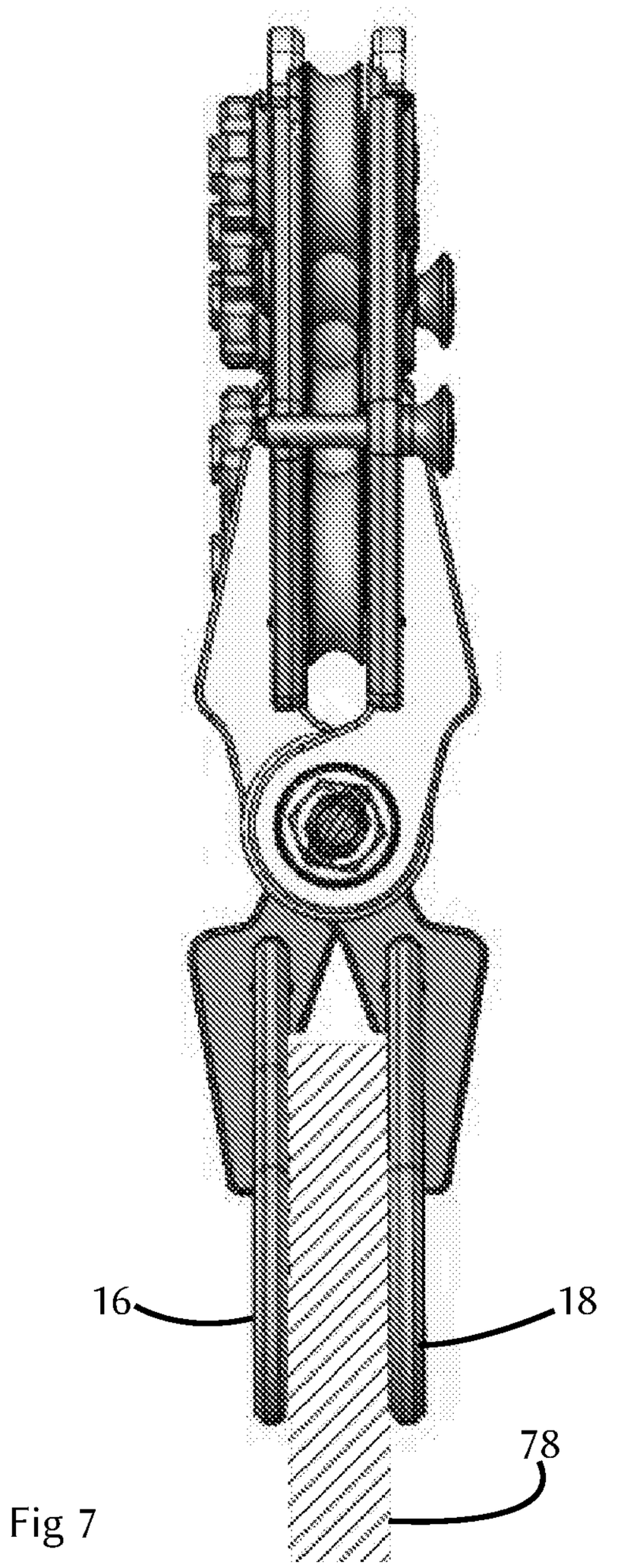

Fig 7

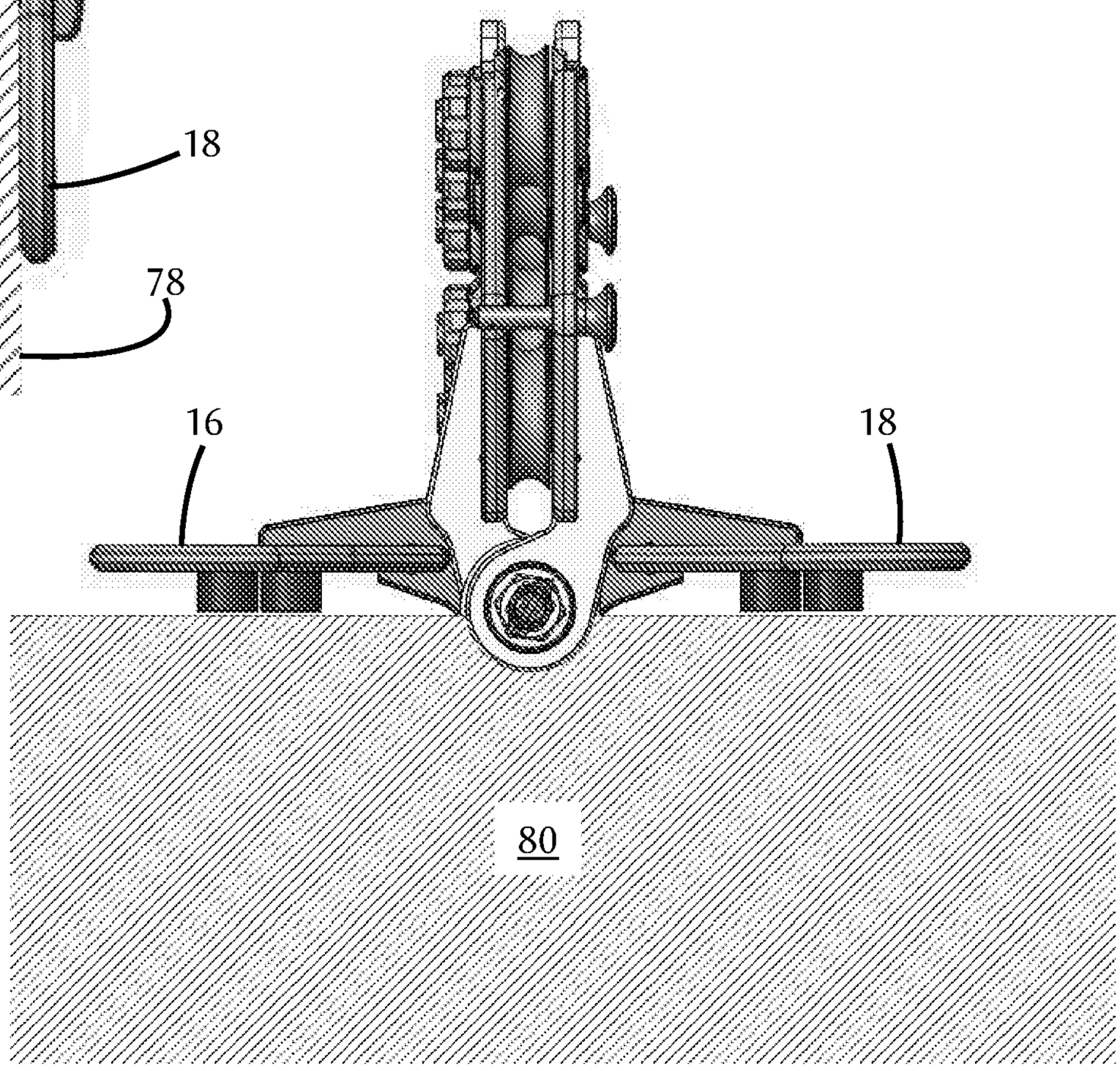

Fig 8

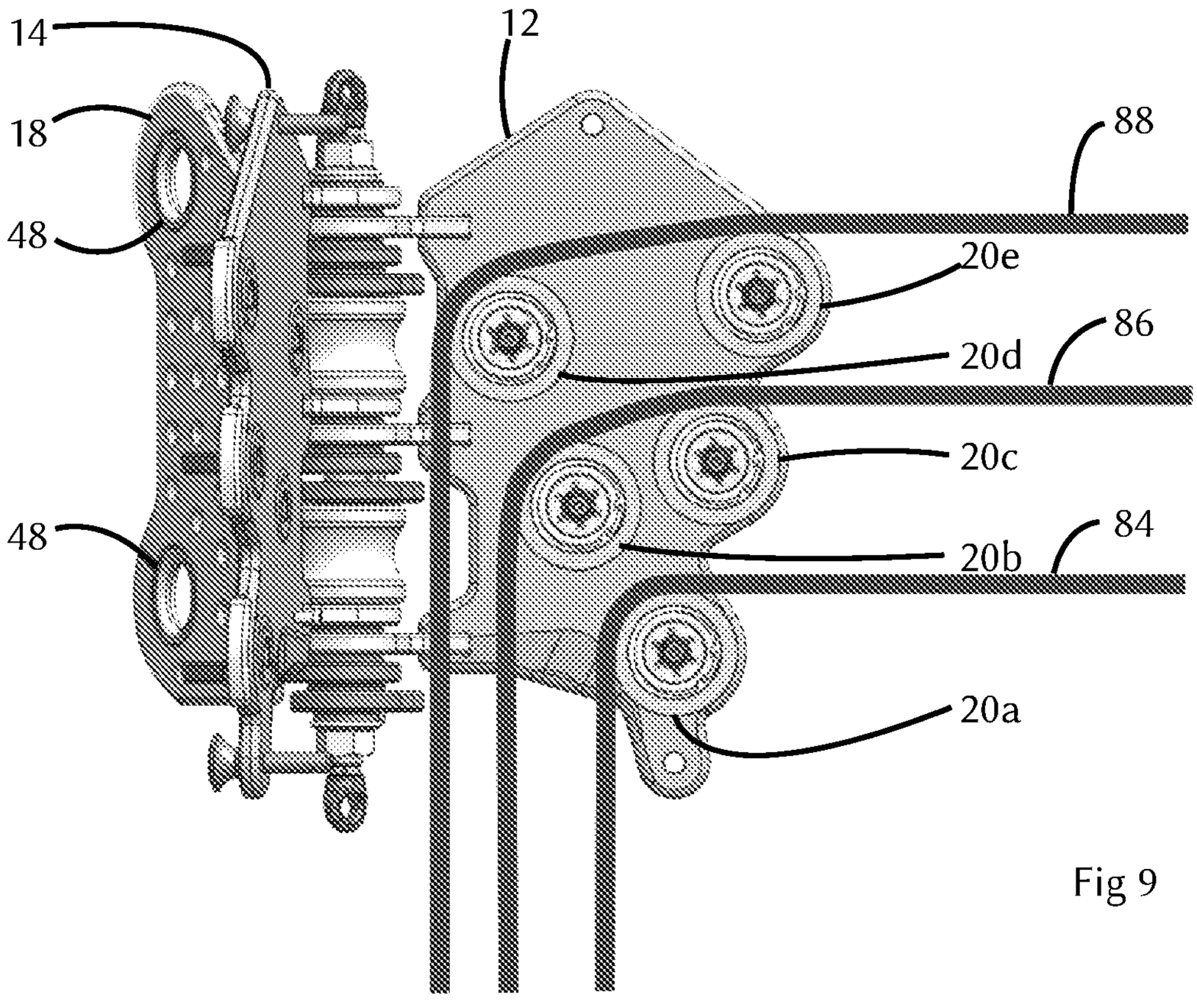
14
18
48
12
88
20e
86
20d
20c
48
84
20b
20a

Fig 9

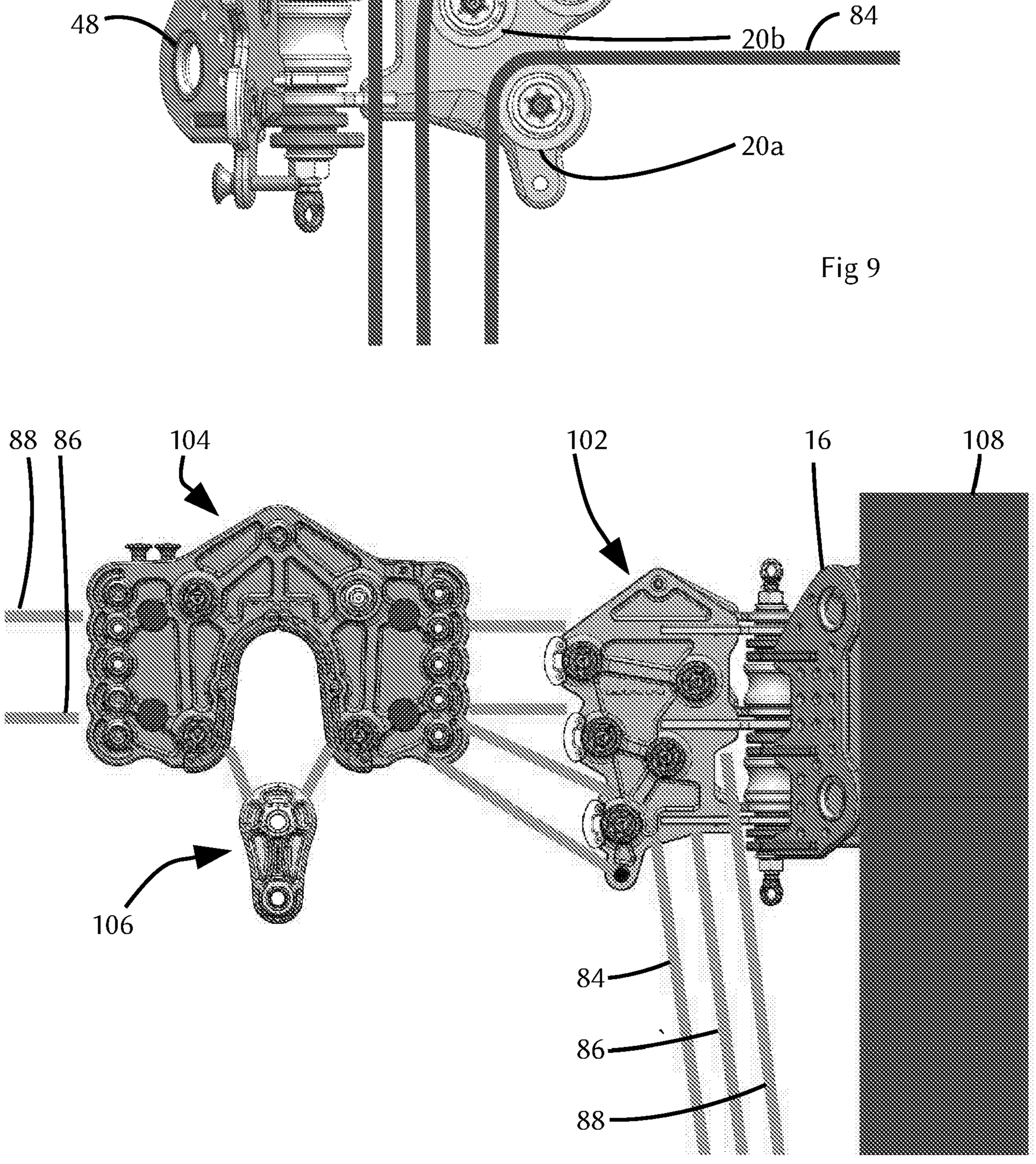
88
86
104
102
16
108
106
84
86
88

Fig 11

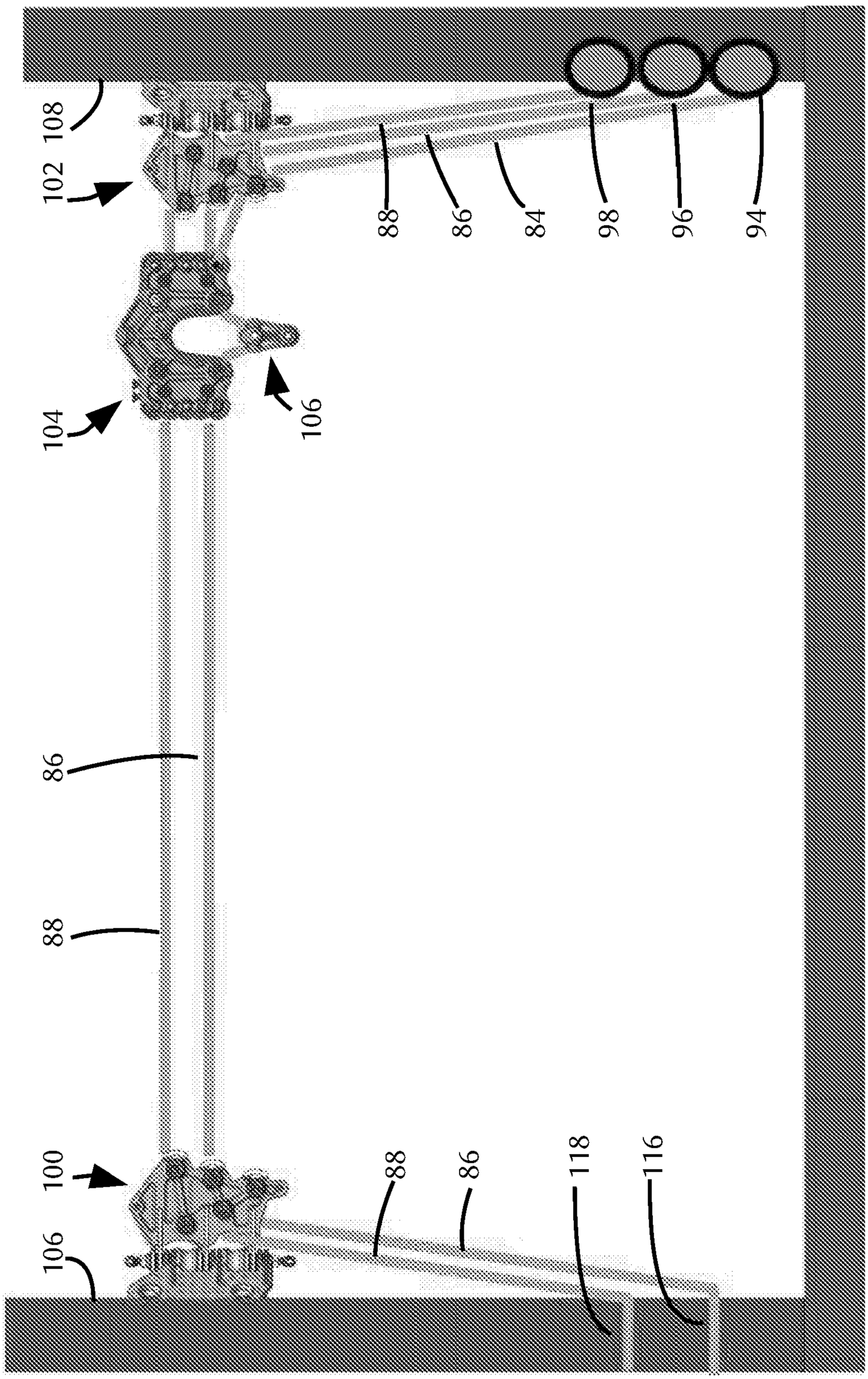

Fig 10

Rope Management Apparatus

This invention relates to rope management apparatus. In particular, it relates to a type of rope handling apparatus commonly known as a "redirect".

In EP-A-3 159 052, the present applicant has disclosed apparatus for moving objects in the manner of a Tyrolean traverse and a number of further configurations that permit a load to be moved. To enable the apparatus to work correctly and efficiently, ropes that it runs along and is controlled by need to be carefully anchored and managed. In known installations, arrangements for anchoring ropes are typically *ad hoc*, involving attaching pulleys to anchorage points (such as tree trunks) using ropes. They are complex to install, time consuming to set up, and are difficult to maintain in correct operation. A key feature of such an installation is that it is typically necessary for different parts of multiple ropes to extend in different directions (e.g., a generally horizontal part that spans a gap and a generally vertical part that extends to an anchorage, winch, etc.). The installation must allow these ropes to move freely and independently of one another with a minimum of resistance.

An aim of this invention is to provide apparatus that enables installation of a rope system, for example for installation of a Tyrolean traverse.

To this end, from a first aspect, the present invention provides redirect apparatus comprising:

a. a sheave assembly comprising a plurality of sheaves disposed for rotation about parallel axes; and

b. a mounting assembly that is suitable for connection to a support

wherein the mounting assembly and the sheave assembly are interconnected such that they can be pivoted with respect to one another about an axis that is generally normal to the axes of rotation of the sheaves , and wherein the sheave assembly comprises two plates disposed axially to opposite sides of the sheaves, the plates being connected to and can pivot around a main axle or main axle assembly.

Such apparatus enables sheaves to be mounted in a position required to achieve rope redirection in a predictable, convenient manner and in such a way that separation is maintained between the ropes; that is, with clearance between adjacent ropes.

In some embodiments, the mounting assembly and the sheave assembly can be pivoted with respect to one another about a plurality of axes.

One or all of the sheaves is secured to one plate for free rotation relative to the plate. One plate can be pivoted between a closed configuration in which it lies adjacent to the sheaves and an open configuration in which it is remote from one or all of the sheaves. This allows ropes to be introduced into the apparatus without the need to free an end of the rope from an anchorage. Most typically, connection components, such as bolts are provided, that are operable to releasably retain the plates in the closed configuration. At least one of the connection components is coaxial with a respective one of the sheaves. This may take the form of an axle bolt that is concentric with one of the sheaves.

The mounting assembly may include two mounting members that can pivot with respect to one another. Typically, the mounting members can pivot with respect to one another about the same axis (or other, substantially parallel axes) as the mounting assembly and the sheave assembly pivot with respect to one another.

One or each mounting member typically includes a plate. One or each mounting member may have a connection formation, such as an eye, that can be used to facilitate connection between the mounting member and a support.

The mounting members may be connected to the main axle.

From a second aspect, the invention provides a rigging installation including a redirect assembly embodying the first aspect of the invention and a plurality of ropes that pass through the redirect assembly.

A typical embodiment includes two redirect assemblies and a plurality of lines, one or more of which pass through both redirect assemblies.

Most advantageously, the lines are maintained in spatial separation within the or each redirect assembly. This allows each line to move independently of the others.

One type of installation further includes a carriage assembly that can be caused to move along on one or more line. The carriage may include a lifting arrangement suitable for connection to a load that can, under the control of one or more lines, be caused to raise or lower with respect to the carriage.

At least one line may pass over a single sheave within a redirect assembly. One or more lines may pass over more than one sheave within a redirect assembly. This arrangement serves to spatially separate the lines as they pass through the redirect assembly, ensuring that clearance is maintained between them. It also has the effect of increasing the bend radius that the line will experience, as compared with a line passing over a single sheave, which is beneficial for the mechanical efficiency of the installation.

An embodiment of the invention will now be described in detail, by way of example, and with reference to the accompanying drawings, in which:

Figure 1 shows redirect apparatus embodying the invention in an open configuration;

Figure 2 shows the apparatus of Figure 1 in a closed configuration;

Figures 3 and 4 show the apparatus of Figure 1 mounted on a cylindrical support;

Figure 5 show the apparatus mounted on a cylindrical support pivoting to align with ropes;

Figure 6 shows the apparatus of Figure 1 mounted on an edge of a block-shaped support;

Figure 7 shows the apparatus of Figure 1 mounted on a thin of a support;

Figure 8 shows the apparatus of Figure 1 mounted on a flat surface of a support;

Figure 9 shows the apparatus of Figure 1 in the open condition with ropes being installed;

Figure 10 shows a Tyrolean traverse installation using two instances of redirect apparatus of the preceding figures; and

Figure 11 is a detail of the installation of Figure 10.

Redirect apparatus embodying the invention is constructed on a centre axle to which components are pivotally connected. The main components of the redirect apparatus are a sheave plate 12, a closure plate 14 and two mounting plates 16, 18. When the apparatus is in use, the centre axle is typically approximately in alignment with the ropes approaching the 'fairlead' of the redirect (for example, approximately vertical), in the orientation in which it is shown in the figures. Therefore, for convenience, "top", "bottom", "upper", "lower" and related terms will be used in this specification with the assumption that the apparatus is in that orientation.

The sheave plate 12 has a smooth flat inner surface. The sheave plate 12 carries five sheaves 20a ... 20e adjacent to the inner surface of the sheave plate 12 and an outer surface that is generally flat, with ribs and lands formed on it as required to provide the sheave plate 12 with sufficient strength. Each sheave 20 is carried on a respective axle bolt 22 that passes through the sheave plate 12. Each sheave 20 can rotate freely upon its axle bolt 22, and the axle bolts 22 can rotate with respect to the sheave plate 12. Each axle bolt 22 has a head 24 located adjacent to an outer surface of the sheave plate 12 and can rotate within the sheave plate 12. An end portion of each axle bolt 22 opposite the head is externally threaded. A respective through hole 26, 28 is formed through the sheave plate 12 in an upward extension and a downwardly projecting lug of the sheave plate 12. Three similar mounting brackets 30 are carried on the sheave plate 12. Each mounting bracket comprises a plate of metal secured to the sheave plate 12 and extending in a plane perpendicular to that of the sheave plate 12. Each mounting bracket 30 has a circular mounting aperture extending through it, the mounting apertures of the three mounting brackets 30 being coaxial.

The closure plate 14 has a smooth flat inner surface and an outer surface that is generally flat, with ribs and lands formed on it as required to provide the closure plate 14 with sufficient

strength. The closure plate 14 has a peripheral shape that approximately coincides with that of the sheave plate 12 when the two plates 12, 14 are placed with their inner faces directed towards one another. The closure plate has five tapped bushes 36, each located within a respective aperture through the closure plate 14. A respective through hole is formed through the closure plate 14 in an upward extension and a downwardly projecting lug of the closure plate 14, a respective locking pin 40, 42 being located in each through hole. Three similar mounting brackets 44 are carried on the closure plate 14. Each mounting bracket 44 comprises a plate of metal secured to the closure plate 14 and extending in a plane perpendicular to that of the closure plate 14. Each mounting bracket 44 has a circular mounting aperture extending through it, the mounting apertures of the three mounting brackets 44 being coaxial.

The two mounting plates 16, 18 are similar. Each mounting plate 16, 18 has a flat inner surface. Two apertures extend through each mounting plate, an eyelet 48 being located within each aperture. Three similar mounting brackets 52, 54 are carried on each mounting plate 16, 18. Each mounting plate 16, 18 comprises a plate of metal secured to the mounting plate 16, 18 and extending in a plane perpendicular to that of the mounting plate 16, 18. Each mounting bracket 52, 54 has a circular mounting aperture extending through it, the mounting apertures of the three mounting brackets 52, 54 being coaxial.

In each case, the mounting apertures of the mounting brackets 30, 44, 52, 54 are provided with bronze bushes, which act as bearings when the apparatus is assembled, as described below.

The apparatus further includes two cylindrical spacing rollers 60, each of which has a concave outer surface and an axial through bore that is provided with a bronze bush.

The apparatus is assembled by passing the main axle through the mounting apertures of the mounting brackets 30, 44, 52, 54 of the sheave plate 12, the closure plate 14 and the mounting plates 16, 18. This allows the plates 12, 14, 16, 18 to pivot with respect to the main axle 10 and with respect to each other, the bushes minimising friction and wear, and also minimising non-pivotal movement. The mounting brackets 30, 44, 52, 54 are arranged upon the main axle 10 in three groups of four, each group containing a mounting bracket 30, 44, 52, 54 from each of the sheave plate 12, the closure plate 14 and the mounting plates 16, 18 in order. Between each group, a respective spacing roller 60 is carried on the main

axle to maintain spacing between the groups. End portions of the main axle 10 are externally threaded, and a nut 62 is applied to each of these to retain all of the components in place on the main axle 10. Washers are also carried on the main axle, to act as thrust bearings to minimise axial movement of components on the main axle 10 while allowing free pivotal movement. Outwardly from the nuts 62, a swivelling lifting eye 66 is carried on each threaded end portions of the main axle 10.

The two main functional configurations of the sheave plate 12 and the closure plate 14 are shown in Figures 1 and 2. In the open configuration, shown in Figure 1, the sheave plate 12 and the closure plate 14 are pivoted to extend from the main axle 10 in different directions, so spacing the plates 12, 14 apart. In the closed configuration, the sheave plate 12 and the closure plate 14 are pivoted to a position in which they are parallel with one another, as shown in Figure 2.

The mounting brackets 30, 44 of the sheave plate 12 and the closure plate 14 are positioned on the plates 12, 14 such that, when the plates are parallel, the following conditions are met:

- the plates 12, 14 are spaced apart by a distance just greater than the axial depth of the sheaves 20 (so the centre of each mounting aperture is offset from the plane of the corresponding plate);

- each of the axle bolts 22 is in alignment with a respective one of the tapped bushes 36; and

- the locking pins 40, 42 are each in alignment with one of the holes 26, 28.

Therefore, in the closed configuration, each axle bolt 22 can be turned using the head 24 to cause its threaded end portion to enter into and be retained within a tapped bush 36 to create a strong and secure shaft on which the corresponding sheave 20 can turn. Each locking pin 40, 42 can also be installed to cause it to engage with the corresponding hole 26, 28 to create a fixed bridge extending between the sheave plate 12 and the closure plate 14.

Examples of installations of the redirect apparatus will now be described.

In Figures 3 to 5, the apparatus is shown on an upright cylindrical support 70, such as a tree trunk. The apparatus is placed with inner surfaces of the mounting plates 16, 18 in contact with the support 70. Flexible fastenings, such as ratchet straps, are passed through the eyelets 48 of the mounting plates 16, 18 and around the support 70 and are tightened to clamp the mounting plates 16, 18 tightly against the support. In this configuration, the axes of the sheaves 20 are horizontal. Comparison between Figures 4 and 5 show that the closed sheave plate 12 and closure plate 14 can pivot together on the main axle so that the sheaves can move into a suitable alignment without requiring any movement of the mounting plates 16, 18 on the support 70.

Alternatively, a rope can be installed into the redirect apparatus by threading the rope between the closed sheave plate 12 and closure plate 14.

Figure 6 shows an arrangement for mounting on an edge of a horizontal and vertical surface of a block 74. In this arrangement, screws may be passed through the eyelets 48 of the mounting plates 16, 18, and spacers 76 may be located between the mounting plates and the block 74. Figures 7 and 8 show a similar arrangement for mounting the apparatus on a slim support 78 or a flat surface 80. In each case, the mounting plates 16, 18 are pivoted on the main axle to accommodate the support on which the apparatus is to be mounted.

Once the apparatus has been installed as described above, ropes can be installed. This embodiment allows three ropes to be redirected between a generally vertical alignment and a generally horizontal alignment.

The spacing rollers 60 have an outside diameter that is greater than the other elements carried on the main axle, so they are the first part of the assembly to come in to contact with a support structure that the redirect apparatus is attached to (wall, tree, etc). Therefore, even if the rollers are unable to rotate due to contact with the structure, the plates 12, 14, 16, 18 are still free to swing.

To install the ropes, the axle bolts 22 and the locking pins 40, 42 are all loosened to allow the sheave plate 12 and the closure plate 14 to be moved to the open configuration, as shown in Figure 9.

A first rope 84 (a control line, in this example) is passed over a first sheave 20a, which is lowermost in the installed apparatus. A second rope 86 (a lifting line, in this example) passes over second and third sheaves 20b, 20c, both of which are above the first sheave 20a, and respectively closer to and further from the main axle 10 than the first sheave 20a. A third rope 88 (a main line, in this example) passes over fourth and fifth sheaves 20d, 20e, which are above the second and third sheaves 20b, 20c, and respectively closer to and further from the main axle 10 than the second and third sheaves 20b, 20c. Once the ropes are in place, the closure plate 14 is pivoted to the closed configuration, and the axle bolts 22 and the locking pins 40, 42 are all secured.

It will be seen that the sheaves 20 are arranged within the apparatus such that they maintain separation between the ropes 84, 86, 88 so allowing the each rope to move freely and independently of the others. In addition, the ropes are subject to redirection over a comparatively large diameter to minimise frictional losses. The control line is subject to redirection over a single sheave, so as not to unnecessarily increase the size and weight of the apparatus.

With reference to Figures 10 and 11, an installation for performing a Tyrolean traverse includes two redirect apparatus 100, 102 as described above and a carriage 104, being an embodiment of the invention of EP-A-3 159 052.

Each redirect apparatus 100, 102 is located at one end of a spaced to be crossed and is secured by its mounting plates 16, 18 to a support 106, 108, as described above. One redirect apparatus 100 is located at what will be referred to as the “anchor end”, and the other at the “drive end”.

The three ropes 84, 86, 88 described above are installed as follows.

The main line 88 extends from a winch 98 at the drive end, through the second redirect apparatus 102, to the first redirect apparatus 100 and then to a fixed anchor 118. The main line 88 passes through the carriage 104, upper sheaves of the carriage 104 being carried on the main line 88, which serves as the principal load-bearing line for the installation. The lifting line 86 extends from a winch 96 at the drive end, through the second redirect apparatus 102, to the first redirect apparatus and then to a fixed anchor 118. The lifting line 86 passes through the carriage 104, where it is supported on lower sheaves of the carriage

104 and where it supports a pulley 106 of the carriage 104. The control line 84 extends from a winch 94 through the second redirect apparatus 102 where it is looped round a lower sheave and returns to a fixed point on the second redirect apparatus 102. As the main line 88 is tensioned, the sheave plate 12 and the closure plate 14 pivot to ensure that the sheaves 20 are properly aligned with the ropes.

Following installation, the main line 88 may remain fixed, which the lifting line 86 and the control line 84 are shortened or lengthened by the winches 96, 94 to operate the Tyrolean traverse as disclosed in EP-A-3 159 052 and as known to those skilled in the technical field. This can cause the carriage 104 to move along the main line 88 and can cause the pulley 106 to be raised or lowered with or without a load being attached.

Typically, each of the redirect apparatus 100, 102 is located above the anchors 116, 118 or winches 94, 96, 98, so act to redirect the direction of force applied to the ropes between a generally vertical direction to a generally horizontal direction.

All examples below show the redirect apparatus set up in a vertical orientation, but all examples shown could be implemented in a horizontal and other orientations as well.

A redirect embodying the invention does not only have application as part of a Tyrolean traverse; it can be combined with any traditional rigging and hauling system to provide an end-of-line anchoring system.

The redirects can be used with any rope-based rigging system that would benefit from a pulley with the ability to redirect a line and/or track a load because the efficiency of the system remains the same, even though alignment has changed. Examples include:

- a winching installation using one rope (single or doubled back to a pin) where the winched load moves from-side-to-side whilst being manoeuvred;

- a winching or lifting installation incorporating two lines where, for example, the lines are attached to both ends of a load (such as a log). This allows the orientation of the load to be altered by changing the relative lengths of the two ropes to manipulate the load around an obstacle; or

- any lifting installation which requires the use of a lifting line and a control line. Although the example uses a carriage as disclosed in EP-A-3 159 052, embodiments of this invention may be used, for example, with the prior art arrangements disclosed in that application.

Claims

1. A redirect apparatus comprising:

    a. a sheave assembly comprising a plurality of sheaves disposed for rotation about parallel axes; and

    b. a mounting assembly that is suitable for connection to a support

    wherein the mounting assembly and the sheave assembly are interconnected such that they can be pivoted with respect to one another about one or more axis that is generally normal to the axes of rotation of the sheaves, and

    wherein the sheave assembly comprises two plates disposed axially to opposite sides of the sheaves, the plates being connected to and can pivot around a main axle or main axle assembly.

2. A redirect according to claim 1 in which one or all of the sheaves is secured to one plate for free rotation relative to the plate.

3. A redirect according to claim 1 or claim 2 in which one plate can be pivoted between a closed configuration in which it lies adjacent to the sheaves and an open configuration in which it is remote from one or all of the sheaves.

4. A redirect according to claim 3 comprising connection components that are operable to releasably retain the plates in the closed configuration.

5. A redirect according to claim 4 in which at least one of the connection components is coaxial with a respective one of the sheaves.

6. A redirect according to claim 4 in which at least one of the connection components is an axial bolt that is concentric with a sheave.

7. A redirect according to any preceding claim in which the mounting assembly includes two mounting members that can pivot with respect to one another.

8. A redirect according to claim 7 in which the mounting members can pivot with respect to one another about the same axis as the mounting assembly and the sheave assembly pivot with respect to one another.

9. A redirect according to claim 7 or claim 8 in which one or each mounting member includes a plate.

10. A redirect according to any one of claims 7 to 9 in which one or each mounting member has a connection formation that can be used to facilitate connection between the mounting member and a support.

11. A redirect according to any one of claims 7 to 10 as dependent from claim 6 in which the mounting members are connected to the main axle or assembly of axles.

12. A rigging installation including a redirect assembly according to any preceding claim and a plurality of lines that pass through the redirect assembly.

13. A rigging installation according to claim 12 that includes two redirect assemblies according to any one of claims 1 to 11 and a plurality of lines, one or more of which pass through both redirect assemblies.

14. A rigging installation according to claim 12 or claim 13 in which the lines are maintained in spatial separation within the or each redirect assembly.

15. A rigging installation according to any one of claims 12 to 14 further including a carriage assembly that can be caused to move along on one or more line.

16. A rigging installation according to claim 15 including a lifting arrangement suitable for connection to a load that can, under the control of one or more line, be caused to rise or to lower with respect to the carriage.

17. A rigging installation according to any one of claims 12 to 16 in which at least one line passes over a single sheave within a redirect assembly.

18. A rigging installation according to any one of claims 12 to 17 in which at least one line passes over more than one single sheave within a redirect assembly.