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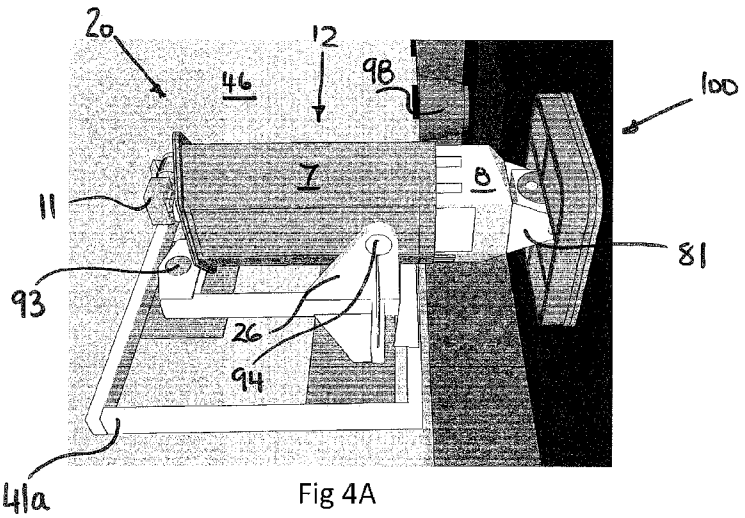


Fig 4A

(57) Abstract: A automated mooring device for mooring a first structure to a second structure, the device comprising: a vacuum engagement member for releasably engaging the first structure; a dampener having a first portion movably connected to a second portion, the first portion being connected to the engagement member and the second portion being connected to the second structure, wherein the dampener is configured to damp load transfer between the first and second portions of the dampener and thereby damp relative motion between the first and second structures.

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AUTOMATED MOORING DEVICE

TECHNICAL FIELD

This invention relates to the field of automated mooring systems and more particularly to apparatus for automatically accommodating movements between a vessel and a dock. The invention is directed to automated mooring systems for both permanent docks and temporary docking structures. The invention further relates to apparatus for the docking of vessels moored to each other at sea or moored to a fixed or floating berth. The invention further relates to a modular mooring system configurable to moor different sizes of vessel.

BACKGROUND

Port berths vary in both their construction and the use of their attached fender systems. Furthermore, there can be substantial design variations between individual berths with a single port.

A mooring system needs to be flexible enough in its design to cope with these differences and variations as port authorities prefer a mooring system with common characteristics over a series of different designs to cater for the variations. A common mooring system not only allows for standard components and the cost savings that ensue from bulk orders but ease of maintenance and training of personnel.

Typical mooring equipment mountings on the front of a quay require considerable space to operate, which can result in substantial costs to modify berths or replace fenders to fit the available space.

Automated mooring devices on the market to date have been hydraulic systems. These hydraulic systems are not without their problems, for example, the salt water environment and risk of oil leaks and spillage is not a good environment for hydraulic systems and similar types of equipment.

Hydraulic systems also require specialised, regular servicing and maintenance, otherwise, the risk of failure rises substantially. These failures have the ability to lead to catastrophic mooring system failure and which may impact the safety of personnel, and the risk of losing vessels and berth structure.

The term “Sea State” is understood herein to refer to the Beaufort Sea State Code. The code spans from a Sea State 0 where the sea is mirror like and wind speed is less than 1 knot to Sea State 6 where the sea has large waves, white foam crests and spray being subject to wind speeds of 22 – 27 knots. Sea State “0” has no waives, in contrast to Sea State “6” which exhibits waves of up to 3m.

The term “Sea State 2” as used herein refers to a sea condition with the occurrence of small wavelets on the surface of the sea, having no visible whitecaps or crests to the waves. The wind speeds for Sea State 2 vary from 4 to 6 knots.

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. Although any methods and materials similar or equivalent to those described herein can also be used in the practice or testing of the present invention, a limited number of the exemplary methods and materials are described herein.

The term “vessel” is understood herein to refer to ships, boats, submarines, barges, tugs, carriers and any other manner of sea-faring craft.

The term “dock” as used herein is intended to include within its scope all of the various types of berth, pile, wharf, mooring, pontoon and other locations at which a vessel can be moored

SUMMARY

In accordance with the present invention there is provided a mooring device for mooring a first structure to a second structure, the device comprising: an engagement member for releasably engaging the first structure; a dampener having a first portion movably connected to a second portion, the first portion being connected to the engagement

member and the second portion being operably connected to the second structure, wherein the dampener is configured to damp load transfer between the first and second portions of the dampener and thereby damp relative motion between the first and second structures.

The dampener may include a damping mechanism configured to move the first portion of the dampener relative to the second portion of the dampener.

The damping mechanism may further comprise a tensioner, the tensioner being in resilient communication with opposing ends of the first portion of the dampener such that movement of the tensioner urges the first portion of the dampener to move relative to the second portion of the dampener

A first end of the first portion of the dampener may be operably engaged with the tensioner via a first resilient member and a second end of the first portion of the dampener is operably engaged with the tensioner via a second resilient member.

The damping mechanism may further comprise a drive mechanism, the drive mechanism configured to drive the tensioner toward or away from the second portion of the dampener.

Motion of the tensioner within the first portion of the dampener, in a first direction, may push on the first end of the first portion of the dampener via the first resilient member, thereby moving the first portion of the dampener toward the second structure.

The first portion of the dampener may be telescopically movable within the second portion.

The tensioner may include opposing faces acting as surfaces against which the first and second resilient members are respectively supported.

The operating mechanism may include a worm drive directly engaged with the tensioner.

The first and second resilient members may comprise at least one of the following: a resilient member, a spring, a series of springs, an air bellow, a plurality of rubber balls or an air cylinder.

The damping mechanism may be sealingly housed within the first portion of the dampener.

Each of the first and second resilient members may comprise a plurality of rubber balls housed within a conduit, wherein the rubber balls are compressible within the conduit of each resilient member. The first portion of the dampener may comprise a first internal projection at a first end thereof and a second internal projection at a second end thereof, the first and second internal projections being partially disposed within the conduits of the first and second resilient members, respectively, wherein movement of the tensioner toward the first projection will drive the first projection into the conduit of the first resilient member, compressing the plurality of rubber balls therein and thereby moving the first portion of the dampener relative to the second portion of the dampener.

The mooring units comprise an electro-mechanical drive that is less susceptible to the sea and salt water environment of a shipyard or dock, than that of a hydraulic system.

The mooring unit provides a temporary restraint for restraining the vessel to the dock, whilst allowing the necessary flexibility and articulation to damp the oscillating motion of the vessel on the water. Where a mount is secured to a vessel too rigidly, the buffeting of the sea and thus the vessel against the mooring can lead to damage of the vessel hull. This is not only expensive but can cause hazards around a dock, to both machinery and personnel. Alternatively, if a vessel is moored to loosely to a dock, the resulting relative movement of the vessel can cause the vessel to break free of the mooring device severing connection with the dock. In the worst case scenario control of the vessel can be lost entirely.

The mooring units provide flexibility, in a number of directions, to control and damp the movement of a vessel relative to the dock. The mooring units damp the vessel without using direct force that may otherwise damage the hull of the vessel.

The mooring units provide for flexible tensioning of both the vessel and the dock, independently, as the mooring unit tensions internal components of the dampener in both directions, simultaneously.

Use of an electrical drive method over a hydraulic drive is faster. The electric drive further provides greater control, takes up less physical space and uses about a quarter of the energy requirements of comparable hydraulic system.

In accordance with the present invention there is further provided a method of engaging an engagement member on a mooring device to a vessel, comprising: storing a negative pressure in a vacuum storage cavity in the engagement member, wherein the negative pressure is generated before the engagement member contacts a vessel; contacting a vacuum pad of the engagement member with the vessel so to create a suction cavity; and transferring air from the suction cavity into the vacuum storage cavity to create a vacuum pressure in the suction cavity thereby holding the engagement member to the vessel. The engagement member may be driven into contact with the vessel by an electro-mechanical mechanism.

In accordance with the present invention there is still further provided a vacuum engagement member for engaging a vessel to a mooring device, comprising a vacuum pad supported by a frame and a perimeter seal extending around the vacuum pad on the frame; the engagement member including a vacuum storage cavity in communication with the vacuum pad so that when the vacuum pad contacts a vessel a suction pressure is created through air transferring from between the vacuum pad and vessel into the vacuum storage cavity.

The vacuum engagement member may further comprise one or more valves, wherein the one or more valves allow the communication between the storage cavity and the suction cavity.

The storage cavity may store the negative pressure when the one or more valves are in a closed position, and wherein the vacuum storage unit is in communication with the suction cavity when the one or more valves are in an open position.

The one or more valves may be moveable from the closed position to the open position upon attachment of the pad to the hull. The one or more valves may be moveable from the open position to the closed position upon detachment of the pad from the hull.

The engagement member may further comprise a vacuum unit, wherein the vacuum unit is in communication with the storage cavity, and wherein the negative pressure in the storage cavity is provided by the vacuum unit.

The vacuum pressure may be maintainable by the vacuum unit.

The engagement member may further comprise a heat source within at least one of the storage cavity and the suction cavity.

The engagement member may further comprise an articulated yoke. The yoke may include a self-adjusting mechanism to centre the engagement member on the yoke.

The engagement member may further comprise a continuous peripheral seal, the seal configured to retain vacuum pressure within the suction cavity.

The engagement member may further comprise a spacer disposed within the suction cavity of the engagement member. The spacer is made from an elastomeric or rubber material.

In accordance with the present invention there is further provided an adjustable mooring unit for mooring a vessel to a dock, the adjustable mooring unit comprising: a mooring device having an engagement member for releasably engaging a vessel; a guide on which the mooring device is mounted; and an adjustment system for moving the mooring device along the guide.

The engagement member may be a vacuum pad. The mooring device may further comprise a dampener having a first portion movably connected to a second portion, the first portion being connected to the engagement member and the second portion being connected to the dock, wherein the dampener is configured to damp load transfer between

the first and second portions of the dampener and thereby damp relative motion between the vessel and the dock.

A pile mooring system allows for placement of a vacuum or claw type mooring unit on a pile, placed to suit an ideal attachment area on a vessel where it is not always practical to mount berth designs and does not need a berth for mounting.

In accordance with the present invention there is further provided a mooring unit comprising: a mooring device as described above; and a support, wherein the second portion of the dampener is mounted to the support, the support being connected to the second structure. The second portion of the dampener may be pivotally connected to the support such that the dampener can pivot relative to the second structure in at least one direction.

The mooring unit may further comprise a secondary drive mechanism for adjusting the second portion of the dampener relative to the support. The support may be operably engaged with a guide on the second structure, the guide being any one of a rail, a system of rails, a cable, a series of cables, a cable and winch assembly, a fixed pile, a floating pile or any combination of thereof. The mooring unit may further comprise a tertiary drive mechanism, wherein the tertiary drive mechanism moves the support along the guide.

The second portion of the dampener may be mounted to the support by a secondary pivotal connection such that the dampener is rotatable relative to the second structure in at least a two rotational directions.

The mooring unit may further comprises a second engagement member, pivotally mounted to a first end of a second dampener, the second dampener having a second end operably connected to the support, such that the engagement member and the second engagement member move independently of one another. The second engagement member may be mounted in substantially the same direction as the first engagement member.

In accordance with the present invention there is still further provided an apparatus for mooring a vessel to a structure, the apparatus comprising: a body comprising a float by which the apparatus remains buoyant in water; and an attachment system supported by the body for attaching the vessel and structure to the apparatus.

The float may be inflatable and deflatable. The float may be selectively buoyant.

The attachment system may comprise a vacuum engagement member. The attachment system may comprise a pair of engagement members. The second engagement member may be mounted in a direction substantially opposing the first engagement member.

The apparatus may further comprise a propulsion unit coupled to the body to drive the apparatus in water.

The apparatus may further comprise a services conduit, the services conduit configured to provide services to the device from a remote location. The services cable may provide at least one of the following; power, air, compressed air, a vacuum, a tow line.

When two vessels need to transfer goods or fuel or personnel therebetween, the vessels require flexible restraints, as the two vessels will be oscillating relative to the sea and to each other. This situation gives rise to difficulties relating to both the safety and the success of such transferences.

This invention ameliorates some of the problems associated with securing a vessel alongside another vessel either in a port, open water, stationary, or under way, allowing vessels the ability to refuel, transfer material or vehicles.

The device is used to cushion the hulls of vessels from each other or a berth or both and can also attach to the hulls and or berth with vacuum pads to moor or fasten together.

The need for mooring ropes is eliminated and the operation can be achieved by a single operator using a radio control device. This reduces some safety hazards from the mooring task and significantly reduces the required manpower for setting up a fender and mooring operation.

The fender mooring units are interconnected between the two vessels to be moored and the unit damps the oscillations from at least one of the two vessels to reduce relative motion between the two vessels.

The float may comprise a plurality of flotation members. The plurality of flotation members may be interconnected. The plurality of flotation members may be interconnected by one or more flexible cable linkages. At least one flotation member may be inflatable and deflatable independently of the inflation or deflation of the other flotation member(s). The float may form a fender to inhibit the vessel from coming into contact with the structure. An inflation pressure of the float may be adjustable to change compressibility of the float when inflated.

The attachment system may comprise one or more vacuum pads. Fluid may be drawn from the one or more vacuum pads into the float to inflate the float.

The apparatus may further comprise a controllable positioning system attached to the body for controlling a position of the apparatus, when in water, independently from the vessel or structure. The controllable positioning system may comprise a motor for driving the apparatus is a desired direction. The controllable positioning system may be operable by remote control.

The apparatus may further comprise one or more solar panels for generating power for operation of the controllable positioning system. The apparatus may further comprise a power supply for providing power for operation of the controllable position system.

In accordance with the present invention there is still further provided an apparatus for mooring a vessel to a structure, the apparatus comprising: a body comprising a float by which the apparatus remains buoyant in water; and an attachment system comprising at least one vacuum member, the at least one vacuum member comprising: a vacuum storage member; a vacuum pad for attaching the vessel or object to the body; and a valve for fluidly connecting and disconnecting the vacuum storage member and vacuum pad, wherein a pressure in the vacuum storage member is reducible to lower than an ambient pressure prior to the vacuum pad contacting the vessel or structure and when the vacuum pad contacts the vessel or structure the valve fluidly connects the vacuum pad and vacuum storage member to draw fluid from the vacuum pad into the vacuum storage member thereby lowering a pressure in the vacuum pad to lower than ambient pressure.

The at least one vacuum member may comprise a frame and the vacuum storage member forms part of the frame. The vacuum storage member may forms an internal volume of the frame.

In accordance with the present invention there is still further provided an apparatus for mooring a vessel to an object, the apparatus comprising: a body comprising a float by which the apparatus remains buoyant in water; and an attachment system for attaching the vessel and object to the body, wherein the float is inflatable and deflatable and is smaller in size when deflated.

The object may be a vessel or a dock. The vessel may be a floating vessel or a submarine. The dock may be a pile, berth, wharf or similar, and may include a target area designed to be attached to the attachment member. The float may comprise a plurality of flotation members.

The attachment system may comprise at least two attachment members and inflation of the float causes the two attachment members to move apart. Two of the at least two attachment members may be spaced on respectively opposite sides of the float. One of the two attachment members may be for attachment to the vessel and the other of the two attachment members may be for attachment to the object. The vessel and object may be attachable to the apparatus on opposite sides of the apparatus.

The float may form a fender to inhibit the vessel from coming into contact with the object.

An inflation pressure of the float may be adjustable to change compressibility of the float when inflated. In other words, the pressure within the float may be adjustable. The

higher the inflation pressure the less compressible the float. Thus for higher inflation pressures the float will have a higher spring constant.

The inflation pressure of the float may also be adjustable to change the buoyancy of the apparatus. By adjusting the buoyancy of the apparatus the attachment system can be changed. In may therefore be possible for the attachment system to attach to the vessel or object at various heights below the waterline, at the waterline, or above the waterline.

The attachment system may comprise one or more vacuum pads. Fluid (e.g. air) may be drawn from the one or more vacuum pads into the float to assist with inflation of the float.

The present disclosure also provides an apparatus comprising: a body comprising a float by which the apparatus remains buoyant in water; an attachment system for attaching the vessel and object to the body; and a controllable positioning system attached to the body for controlling a position of the apparatus, when in water, independently from the vessel or object.

The controllable positioning system may be self-guided. Self-guiding may be achieved by sensing a position of the vessel or object and manoeuvring the apparatus to attach to a desired position on the vessel or object. Self-guiding may also be achieved using GPS (global positioning system) tracking of the apparatus and the vessel or object, and manoeuvring the apparatus to meet the vessel or object at specific coordinates for attachment to the vessel or object.

The present disclosure still further provides an apparatus for mooring a vessel to an object, the apparatus comprising: a body comprising a float by which the apparatus remains buoyant in water; and an attachment system comprising at least one vacuum member, the at least one vacuum member comprising: a vacuum storage member; a vacuum pad for attaching the vessel or object to the body; and a valve for fluidly connecting and disconnecting the vacuum storage member and vacuum pad, wherein a pressure in the vacuum storage member is reducible to lower than an ambient pressure prior to the vacuum pad contacting the vessel or object and when the vacuum pad contacts the vessel or object the valve fluidly connects the vacuum pad and vacuum storage member to draw fluid from the vacuum pad into the vacuum storage member thereby lowering a pressure in the vacuum pad to lower than ambient pressure.

In some embodiments, where the float is inflatable and deflatable, deflation of the float reduces the size of the apparatus for storage and to facilitate manoeuvring of the apparatus over the deck of a vessel or dock. Conversely, in some embodiments inflation of the float increases its buoyancy and compressibility. The buoyancy of the float can therefore be adjusted as desired to change the height of the attachment system relative to the vessel. Similarly the compressibility changes the restorative force (i.e. the force applied for the float to return from a compressed condition to an at rest, or uncompressed, condition) that the float applies to the vessel and object when acting as a fender.

In some embodiments, where the apparatus comprises a controllable positioning system, the apparatus is positionable as desired near the waterline of the vessel or object. When compared with apparatuses tether to the vessel or object, an apparatus with a controllable positioning system can be positioned at a point on the vessel or object that best facilitates relative positioning between the vessel and object. Similarly, where multiple apparatuses are used concurrently, they can be independently positioned along the vessel or object as desired.

In accordance with the present invention there is still further provided a ship mounted mooring unit, for mooring a ship to a structure, the mooring unit comprising: a mooring device having an engagement member for releasably engaging the structure; and a support for mounting the mooring unit within a cavity of the ship, wherein the mooring device selectively moves between an operative condition, where the engagement member is oriented to engage the structure, and a stowage condition, where the engagement member is retracted to be stowed within the cavity.

The support may comprise a dampener having a first portion movably connected to a second portion, the first portion being connected to the engagement member and the second portion being connected to the ship, wherein the dampener is configured to damp load transfer between the first and second portions of the dampener and thereby damp relative motion between the ship and the structure.

The invention addresses the shortcomings of previous ship mounted mooring devices in the following description.

Existing mooring devices with vertically mounted vacuum pads parallel with the hull take up substantial hull area which also requires a watertight door operation of larger area than the vacuum pad area to be closed when the vessel is at sea.

The operation of the water tight doors and extension of vacuum pads from a mounting requires substantial space which in most vessels is not available. The mooring unit is located between the main deck beam structures on the underside of a deck.

Stowing the mooring unit is achieved by rotating the vacuum pads to lie flat against the supports, which means a significantly smaller "slot" in the hull for the vacuum pads to pass through. Because the mooring units are mounted between the main beam structures there is no loss of space in the workspace areas below them.

In accordance with the present invention there is still further provided a … portable mooring device for mooring a vessel to a structure, the device comprising; a guide configured to detachably engage with a structure; an engagement assembly movably mounted to the guide such that the engagement assembly can be moved to a predetermined position along the guide, wherein the engagement assembly releasably engages the vessel to moor the vessel to the structure;

The engagement assembly may comprise an engagement member and a dampener connected to the engagement member.

In accordance with the present invention there is still further provided a modular mooring system comprising: a portable mooring device and a rail permanently attached to a berth, the rail defining a plurality of predetermined docking stations therein, wherein the rail is configured to detachably engage with the portable mooring device at any one of the predetermined docking stations, to operably install the mooring device in the berth.

This invention is a more cost effective option than stationary permanently installed mooring units while improving vessel quayside flexibility. Mobility of the mooring units provides additional advantages of locating mooring units where ever needed along a berth to cater for ever changing vessel placement as well as adding additional units for extreme weather conditions.

When not in use, the mooring units can be stored and maintained out of the weather. When required a bespoke system of mooring units is configured to receive and restrain a given size and weight of ship in the berth.

Because the units are all electric, there is no increased HAZMAT risk of hydraulic oil leakage or spillage into the marine environment.

Mooring units can be placed on a common berth mounted track with horizontal drives for positioning and vessel movement.

Various features, aspects, and advantages of the invention will become more apparent from the following description of embodiments of the invention, along with the accompanying drawings in which like numerals represent like components.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention are illustrated by way of example, and not by way of limitation, with reference to the accompanying drawings, of which:

Figure 1 is a perspective view of a vacuum pad illustrating a perimeter seal and an outer lip to seal uneven attachment surfaces, according to one embodiment of the invention;

Figure 1A is a perspective view of a hollow frame of the vacuum pad of Figure 1;

Figure 2 is an end views of the vacuum pad of Figure 1, located immediately adjacent a section of hull;

Figure 3 is an end view of the vacuum pad of Figure 1 and the hull attached together, further illustrating a location of heating elements within the perimeter of the vacuum pad;

Figure 3A is a schematic view of the vacuum pad of Figure 1, illustrating a fluid flow through the vacuum pad from a vacuum pump;

Figure 4 is a perspective view of an automated mooring unit, illustrating a mechanically adjustable vacuum attachment;

Figure 4A is a perspective view of an automated mooring unit, pivotally mounted to compensate for relative movement between the unit and the vessel;

Figure 4B is a perspective view of an automated mooring unit providing centering mechanisms for the vacuum pad in three degrees of freedom;

Figure 4C is a top view of the automated mooring unit of Figure 4B, illustrating the centering mechanism in a direction that extends along the dock;

Figure 4D is a side perspective view of the automated mooring unit of Figures 4B and 4C, illustrating a centering mechanism acting in a direction vertical to the dock;

Figure 4E is a perspective view of a vacuum pad frame mounted on a two-way gimbal;

Figure 4F is a side view of the vacuum pad pivoting relative to the mooring unit about two rotational axes;

Figure 4G is a top view of the vacuum pad, illustrating the movement of the gimbal about the two rotational axes;

Figure 5 is a perspective view of a damper unit, cut away to illustrate the internal componentry therein and alternative compressible elements;

Figure 5A is a perspective view of the three dampener units, configured to damp motion of a vessel in four directions (two degrees of freedom);

Figure 5B is an exploded view of the components of the damper unit of Figure 5;

Figure 6 is a transparent perspective view of an alternative drive mechanism, illustrating the stack–up of the internal components therein;

Figure 7 is a perspective view of a berth automated mooring unit seated on rails to facilitate movement of the vacuum pads of the mooring unit;

Figure 8 is a perspective view of the underside of the mooring unit of Figure 7, illustrating a drive unit and braking system attached thereto;

Figure 9 illustrated a dockside installation of a plurality of mooring units according to the unit of Figure 7, attaching a vessel to the dock;

Figure 10 illustrated perspective views of a number of alternative mountings for the vacuum pad of Figure 1, according to various embodiments of the invention;

Figure 11 is a perspective view of a mooring pile unit, illustrating the vacuum pad of Figure 1 operably mounted to a pile;

Figure 12 is a perspective view of a housing of the mooring pile unit of Figure 11 and a winch system for varying the height of the housing relative to the pile;

Figure 12A is a top perspective view of the housing of Figure 12, illustrating an orientation of the winch system;

Figure 13 is a perspective view of the housing and a cabling system operably engaged with the winch system;

Figure 14 is a transparent perspective view of the housing and winch system, illustrating the position of a damper unit operably connected to the vacuum pad via a pivoting yoke;

Figure 15 is a perspective view of an alternative mooring pile unit, illustrating the vacuum pad of Figure 1 operably mounted to an alternative pile;

Figure 16 is a perspective view of a pair of mooring fender units approaching a vessel for attaching thereto;

Figure 17 is a perspective view of both mooring fender units attached attach to the hull of the vessel;

Figure 18 is a perspective view of the first and second vessel secured to each other, the first and secondary mooring fender units and attached vacuum pads compressed between the two vessels;

Figure 19 is a perspective view of a vessel secured to a pontoon via a pair of mooring fender units;

Figure 20 is an enlarged view of the pair of mooring fender units from Figure 19;

Figure 21 is a perspective view of a plurality of vessels secured to a pontoon via a plurality of mooring fenders units configured to provide mutable attachments;

Figure 22 is a perspective view of a mooring fender unit, illustrating an inflatable floatation module, extended body section and plurality of vacuum pads mounted thereto;

Figure 23 illustrated an alternative embodiment of a mooring fender unit, illustrating the plurality of vacuum pads pivotally mounted to the extended body section;

Figure 24 is a perspective view of a mooring fender unit adapted for ship-to-ship mooring, illustrating the flotation module prior to inflation positioned alongside a vessel;

Figure 25 is a perspective view of a pair of ship-to-ship mooring fender units, fully inflated and restrained by a plurality of operating cables;

Figure 26 illustrates a frontal view of a hull of a vessel, illustrating a water tight door disposed about a rubbing strake;

Figure 27 is a perspective view of the hull of Figure 30, the water tight door open and a pair of mooring units in their fully retracted, stowable configuration;

Figure 28 illustrates a first stowable mooring unit of Figure 31 partially extending from the hull of the vessel;

Figure 29 is a perspective view of the first stowable mooring unit from Figure 32, illustrating a fully extended configuration from the hull of the vessel, wherein the vacuum pad is rotated to a vertical operable configuration;

Figure 30 is a perspective view of the vacuum pad, partially retracted with the vacuum pad in operable configuration ready for attachment to a berth fixture;

Figure 31 is a perspective view inside the vessel looking upwards at a housing of each of the mooring units;

Figure 31A is a perspective view of an alternate arrangement of a stowable mooring unit having a damping unit configured to centre the vacuum pad once attached to a vessel;

Figure 32 is a perspective view of the vacuum pad mounted to a housing, the housing having a chain driven mechanism that can be used in the mooring units of Figures 11 to 15;

Figure 32A is a side view of the housing of Figure 32, illustrating the chain drive mechanism in more detail;

Figure 33 is a perspective view of a portable mooring system, illustrating a portable mooring unit connected to a mounting frame, operably connected to a customised vehicle;

Figure 34 is a perspective view of the vehicle supporting the mooring unit parked at right angles to an installation location along a berth, wherein an extension mechanism of the customised vehicle slides the mooring unit and attached frame into the installation location;

Figure 35 is a perspective view of the vehicle aligning the installation location with the portable mooring unit;

Figure 36 is a perspective view of the extension mechanism, pivoting, to position the mooring unit and attached frame into the installation location, the mooring unit rotated into a vertical position;

Figure 37 is a perspective view of the mooring unit being lowered into position into the fixed formwork of the dock;

Figure 38 is a perspective view of the vehicle preparing to reverse away from the dock, to position the mooring unit for attachment to the fixed formwork;

Figure 39 is a perspective view of the mooring unit lowered into position, such that a top mount of the unit locks into the fixed formwork along a top face of the berth and the bottom locking section of the frame locked into a braced beam of the fixed formwork, ready for connection to a power source;

Figure 40 is a perspective view of the mooring unit in place, detached from the vehicle, such that the housing can translatable on the mounting frame to vertically adjust the position of the vacuum pads;

Figure 41 is a transparent, perspective view of a housing of the portable mooring unit of Figures 33 to 40, illustrating the internal damping mechanism of the housing, the chain drive of the housing, a gimbal mount of the vacuum pad and a centering mechanism of the gimbal;

Figures 42A to 42C are perspective views of a centering mechanism incorporated into a yoke of a vacuum pad;

Figure 43 is a perspective view of a pivoting yoke of a vacuum pad, I one rotational degree of freedom; and

Figure 44 is a perspective view of a compressible component of the centering mechanism of Figures 42 and 43.

DESCRIPTION OF EMBODIMENTS

The invention will now be described more fully hereinafter with reference to the accompanying drawings, in which various embodiments, although not the only possible embodiments, of the invention are shown. The invention may be embodied in many different forms and should not be construed as being limited to the embodiments described below.

Whist a mooring device is described herein in relation to the automated mooring of ships and sea vessels, it is contemplated that the mooring device is applicable to other waterborne craft such as pontoon, temporary docks, floating cranes and barges and the like.

With reference to Figure 1, there is illustrated a vacuum pad 100. The vacuum pad 100 comprises backing plate 1, a perimeter seal 2 an outer, peripheral lip 3, a frame 5 and a spacer 4. The perimeter seal 2 and lip 3 facilitate the formation of a vacuum seal, when the vacuum pad 100 is placed against a relatively planar surface, such as the hull 6 of a vessel. As pressure is applied to the backing plate 1, air is trapped between the inner spacer 4 and the backing plate 1 by the perimeter seal 2. As further pressure is applied to the backing plate 1, the trapped air is forced out through the seal 2, and the lip 3 prevents further air from being drawn in through the seal 2. This action creates a suction or negative pressure between the vacuum pad 100 and the hull 6. The suction created temporarily engages the hull 6 and the vacuum pad 100, holding the two in a fixed relationship with one another.

The automated mooring unit 20 provides a mechanical attachment between a vessel hull 6 and a dock 46 where the mooring unit 20 lowers the vacuum pad 100 into a matching recess on a vessel hull 6 or rubbing strake 67 or alternative predetermined mounting point and the vacuum pad 100 attaches to the hull 6 locking the vacuum pad 100 in place thereon.

The vacuum pad 100 provides a small, compact and simplified attachment device for automated mooring systems.

The perimeter seal 2 is constructed of a rubber compound either poured into a mould, or extruded to give flexible enough characteristics to seal the vacuum pad 100 to a vessel hull 6.

A vacuum pump 24, illustrated in Figures 42 to 43 can be used in conjunction with the vacuum pad 100, to increase the negative pressure, or suction, thus increasing the strength of the connection between the vacuum pad 100 and the hull 6.

Figures 1A and 2 illustrate the hollow perimeter frame 5 of the vacuum plate 1, in which the negative pressure can be increased by the use of a vacuum pump 24. The suction created by the pump 24 is pulls air through a cavity 5a in the hollow frame 5 of the perimeter which increases the vacuum force between the hull 6 and the vacuum pad 100. The frame 5 can be made from rolled steel sections, tubes, or extruded metal to provide the necessary hollow sections for fluid communication therethrough.

Figure 3A is a schematic view of the vacuum pad of Figure 1, illustrating a fluid flow through the vacuum pad 100 from the vacuum pump 24. The system utilises a series of valves to control the flow of fluid through the pad 100. A non-return valve is located between

the vacuum pump 24 and the vacuum pad 100 to prevent the vacuum being drawn into the pump 24 and potentially damaging the pump 24.

A valve “A” is located between the non-return valve and the vacuum storage cavity 5a to control the flow of fluid into the storage cavity 5a. A valve “B” is located between the vacuum pad 100 and the storage cavity 5a, to control the release of the fluid from the storage cavity 5a into the vacuum pad 100. In this manner the vacuum pressure can be accumulated within the cavity 5a in preparation for engagement between the pad 100 and the vessel’s hull 6.

There is further provided a release valve, valve “C” for releasing the fluid from the vacuum pad 100 and thereby the suction between the vacuum pad 100 and the hull 6. Opening valve “C” will allow the vacuum pad 100 to disengage from the hull 6.

In the centre of the pad 100 there is provided the spacer 4. The spacer 4 is made from a resilient material like a rubber or an elastomer and enhances the friction between the pad 100 and the hull 6. The spacer 4, as a resilient material also provides a compressible member between the vessel’s hull 6 and the back plate 1 of the vacuum pad 100. If the vacuum generated between the pad 100 and the hull 6 is too great the plate 1 or the hull 6 can be deformed and brought into contact with each other. This could cause damage to the vacuum pad 100 and more importantly damage to the hull 6. The spacer 4 can provide grip for the pad 100 but also a further safety advantage to prevent hull damage.

The spacer 4 further comprises a plurality of through-apertures 4a of any shape, that allow air to be removed by the vacuum pump 24 from the cavity between the pad 100 and the hull 6. In this manner the placement of the spacer 4 on the plate 1 of the pad 100 does not impair function of the pad 100.

The spacer 4 is evenly spread across the plate 1 of the vacuum pad 100 and thus provides a uniform coverage and uniform protection to the hull 6. A more localised spacer 4 can result in high point loads being applied to the hull 6. This is not ideal and can lead to localised hull 6 deformation or damage.

The shape and size of the apertures 4a in the spacer 4 allow for the even support of the hull 6 and vacuum plate 1 without distortion. An alternative to the apertures 4a is the use of a characteristic material that would be sufficiently porous to allow vacuum to be created within the outer seal 2 having sufficient strength to maintain its shape under pressure.

The spacer 4 provides increased grip between vacuum pad 100 and hull 6 to counter horizontal/ vertical forces created by the movement of the vessel relative to the dock 46.

The additional grip provided by the spacer 4 also provides a buffer between the pad 100 and the hull 6 ensuring that no metal-to-metal connection is made that can scrape and otherwise damage the hull 6 of the vessel. Ideally the pad 100 and the hull are planar surfaces and contact is avoided; however, both the pad 100 and the hull 6 can be subject to surface variations, whether as designed or due to damage. While most vessels have a thick outer hull 6, the painted coating on the hull 6 is more susceptible to scrapes and scratches. This can exposed the underlying material of the hull to salt and water and wind, which alone or in combination will have an erosion effect on the underlying substrate of the hull 6.

When the pad 100 is placed near to a structural support beam 60 of a hull 6 the pad 100 will not create sufficient suction to deform the hull 6. However, the further the pad 100 is positioned from a beam 60, the greater the risk of deforming a panel of the hull 6. This risk increases with the roughness of the sea (the higher the Sea State) as the full momentum of the moving vessel can be forced against the pad 100. Figure 2 further illustrates a secondary structural beam 60’ perpendicularly to the first beam 60. This configuration of beams 60, 60’ is a particularly rigid location on the hull 6 for attachment of a pad 100.

As the suction is increased, whether by pressure of the use of a vacuum pump 24, the pad 100 is pulled into tight engagement with the hull 6, as illustrated in Figure 3. The arrow of Figure 3 illustrating the direction of load upon the backing plate 1 of the pad 100.

Within the hollow frame 5 of the perimeter of the pad 100, heating elements 27 can be located. These heating elements 27 are contemplated for use in colder regions, where the heating element 27 is fitted within the seal 2 or the vacuum cavity 5a within the vacuum pad framework to counter the effects of cold and ice which can affect the flexibility of the seal 2.

When the vacuum pad 100 is mounted to the hull 6 of a vessel, the pad 100 will move with the vessel. This means that any structure affixed to the pad 100 must either be moveable or provide the necessary flexibility to account or compensate for this movement, whilst maintaining connection between the pad 100 and the vessel hull 6.

In Figure 4 the pad 100 is illustrated to mount to a damping unit 12 by means of a pair of pivot points 52 that allow the pad 100 to rotate about a first axis. However, the motion of a ship on water will try to translate and rotate in a number of different directions.

A co-ordinate system is constructed to comprise:

a positive and negative **y-direction**, where positive y-direction extends along the dock 46;

a positive and negative **x-direction**, where positive x-direction extends from the dock 46, perpendicularly from the y-direction; and

a positive and negative **z-direction**, where positive z-direction extends upwards from the dock 46, perpendicularly to both the x and the y directions.

Rotations about each of the above axes have specific terms. These are: pitch which occurs around the x-axis, roll which occurs about the y-axis and yaw which occurs about the z-axis.

Figure 4A illustrates a dampener 12 having a vacuum pad 100 that rotates about two rotation axes; z-axis and y-axis.

Figures 4E to 4G illustrate the two-way gimbal of a yoke 81 mounted to the frame 5 of the pad 100. The yoke 81 comprises a central mount 91 having two perpendicular axles posted therethrough, first axle 85 and second axle 96. In Figure 4E the second axle 96 is divided into two equal sized axles 96, 96', this provides packaging space for the first axle 95 to extend through the central mount 90. The yoke 81 can then allow the vacuum pad 100 to be permanently affixed to a dampener 12 and still allow rotation about the z-axis and the y-axis. In Figure 4G the pad 100 is free to rotate in the z-axis by about ± 023 degrees. The shape and configuration of the dampener 12 can be varied to accommodate a greater or lesser swept angle. In Figure 4F an extended portion 8 of the dampener 12 has been chamfered to accommodate the rotation of the pad 100 about the y-axis

In one embodiment, illustrated in Figures 42A-42C, there is provided a self-centering yoke 81. The yoke 81 provides pivot mounts 54 on the back plate 1, the pivot mounts 54 being located on opposing sides of the back plate 1 and are interconnected by a spring dampener 92.

The spring dampener 92 comprises a central mount 90 that mounts the vacuum pad 100 to an armature or the dampener 12. The central mount includes two rotating arms 90a, and 90b that are co-axially aligned with the pivot mounts 54. The first arm 90a extends to the right of the central mount 90 and the second arm 90b extends to the left of the central mount 90. The two arms 90a, 90b are slidably mounted within the central mount 90.

Further attached to the sliding mount 90 is a detent 91, centrally positioned thereon. The detent 91 is illustrated in Figures 42A-C as a flat plate disposed upon the sliding mount and extending perpendicular thereto. Opposing sides of the detent 91 are placed in contact with a pair of compressible pins 88 (two pins 88 on the left and two pins 88 on the right of the detent 91. Each of the compressible pins 88 comprising a resilient portion 89 and a rigid body 88a (illustrated in Figure 44).

As an attached vessel pulls in the y-axis the vacuum pad 100 is also pulled in that direction, see Figure 42C. The movement of the pad 100 pushes detent 91 into the pins 88 on the left side of the pad 100, thereby compressing the resilient portion 89 of the pins 88 and sliding rotating arm 90a into the central mount 90. The pins 88 act as springs, where the compressed portion 90 of the pins 88 on the left of the central mount 90 apply load to the

detent 91 to urge the central mount 90 back to an equilibrium position between the four pins 88, thereby centering the vacuum pad 100 to the central mount 90.

The pivoting action of the vacuum pad 100 is illustrated further in Figure 43. The perspective view of Figure 43, more clearly illustrates the central mount 90 as a triangular prism, where the base of the prism provides a planar mounting surface for the yoke 81 of the pad 100. The remaining two surfaces of the prism each have an ear protruding perpendicularly therefrom, the two ears forming the detent 91 against which the compressible pins 88 can act against.

Where a vessel is moored to a fixed berth or to a second vessel, there will be relative displacement between the two structures: if relative displacement in not catered for the vessel can be damaged, the berth or other vessel damaged or the connection lost. In all scenarios damaging the hull 6 of the vessel(s) or berth, or losing the mooring of the vessel, will have commercial repercussions and can present a safety risk. To minimise the chance of losing a mooring the vacuum pad 100 can be increase in suction with the use of vacuum pumps 24 but increasing the attraction forces between the two structure in high sea or inclement weather conditions, will increase the possibilities of hull damage if the vessel is retained. Providing a mounting unit 20 for the vacuum pad 100 that allows for relative movement between the two interconnected structures will reduce the opportunity for hull 6 to be damaged, whilst retaining the mooring of the vessel. Illustrated in Figure 4A is the vacuum pad 100 mounted to a dampener 12.

The use of vacuum pads 100 on the hull 6 of a vessel using hydraulic pressure has the potential to damage the hull 6 if the control of the hydraulic pressure is faulty in any way. For example, if a sensor controlling the amount of pressure becomes faulty, damage can occur from the uncontrolled force applied to the hull 6 or structure. The same applies to a vessel once attached to the mooring device 20 where hydraulic pressure restricts the movement of the vessel in such a way as to damage the hull 6, mooring unit 20 or berth 46.

The relative motion of the vessel and dock is compensated for by a dampener 12, which comprises a first portion, inner portion 8, which is extendable and retractable in relation to a second outer portion 7. Turning now to Figure 5, the outer portion 7 has a closed end 7a for supporting an electrically driven motor 11 or similar drive mechanism. The outer portion 7 further provides an open end 7b for receiving the inner portion 8 of the dampener 12. The inner portion 8 has both ends closed. A first closed end 8b is configured for mounting the pad 100 and can come into contact with water. This closed end will reduce the opportunity for water to enter the dampener 12. The second end 8a of the inner portion 8 is housed within the outer portion 7, and is also closed, to provide a reaction surface for the resilient components of the dampener 12 to work against.

The vacuum pad 100 is mounted to the first end 8b of the extendible inner portion 8, with a means of articulating the pad 100 relative to the inner portion 8. In Figure 4E, the articulation is illustrated as a mount 54. The mounting provides a pivot mount 54, allowing the pad 100 to rotate in a first degree of freedom relative to the dampener 12.

The outer portion 7 is mounted to a frame 41a which is slidably mounted to a guide, illustrated as rail 23 in Figure 4. The rail 23 is fixed to a top portion of the dock 46 and extends horizontally along a portion of the dock 46. This mounting arrangement allows the pad 100 to be laterally positioned proximal to a predetermined mooring location on the hull 6. The rail 23 and housing 41a can be mounted on rollers, or castors or a bogey comprising a plurality of wheels, or a linear bearing set (not illustrated in Figure 4).

Returning to Figure 4A, there is illustrated a frame 41a to which the mooring unit 20 is attached. The frame 41a provides a rectangular framework. The dampener 12 is supported upon the framework 41a so as to provide two rotational degrees of framework between the dampener 12 and the framework 41a. At the rear of the frame 41a, farthest from the vacuum pad 100 is a rotational axis 93 which allows a portion of the frame 41a to rotate in the z-axis to maintain contact between the pad 100 and the hull 6 when the vessel is yawing. In combination with the z-rotation of the yoke 81 supporting the pad 100 on the

dampener 12, this allows the vessel and mounting unit 20 to remain connected, effectively providing the dampener 12 with a z-rotational axis at opposing ends thereof.

A portion of the frame 41a is raised above the dock 46, and illustrated in Figure 4A as a pair of braces 26 (only one of which is visible). At an upper portion of the braces 26 there is a second rotational axis 94 that supports the dampener 12 and allows rotation of the dampener 12 about the y-axis. As the vessel moves up and down with the tide, relative to the dock 46, the rotation about axis 94 in combination with the y-axis rotation of the yoke 81, allows the vessel and mounting unit 20 to remain connected effectively providing the dampener 12 with a y-rotational axis at opposing ends thereof.

Figures 4B – 4D illustrate the automated mooring unit 20 having centering mechanisms for the vacuum pad 100 in three degrees of freedom. The dampener 12 biases the vacuum pad 100 to hold the vessel in the neutral position in the x-direction.

A pair of springs 13b,13c is coaxially aligned on either side of the mooring unit 20, along the y-direction, that is along the length of the dock. As the mooring unit 20 is configured to pivot about a rotational axis 93, one of the pair of springs 13b,13c is loaded depending on which way the vessel translates relative to the vacuum pad 100. The loaded spring, in compression, acts in concert with the non-loaded spring, in tension, to bias the mooring unit 20, bringing the vessel back toward the neutral position, as illustrated in Figure 4C.

A further pairing of springs 13d, 13e and springs 13f, 13g can be mounted to the rear of the dampener 12, as illustrated in Figure 4D. Similar to the action described above in relation to movement in the y-direction, the springs 13d-g are coaxially aligned in Figure 4D and are configured to act in the z-direction, that is perpendicularly upwards, away from the dock 46. In this embodiment, the springs 13d,e and 13f,g are mounted in pairs, in series, on either side of the mooring unit 20. These springs 13d-g are configured to bias the rotational movement of the mooring unit 20 about the second rotational axis 94. The rear of the dampener 12 is attached to all four springs 13d-g, with two springs 13e,f extending downwardly in the z-direction and fixedly mounted to the base 41a of the housing 41, and two springs 13d,g extending upwardly in the z-direction. In this manner, movement of the mooring unit 20 about the second rotational axis 94 places two of the springs 13d-g in tension and two of the springs 13d-g in compression. The four springs 13d-g acting in concert, bias the mooring unit 20 about the rotational axis 94, bringing the vessel back toward the neutral position.

Figures 4B-4D are illustrated to use coil springs 13b-g, however, it is contemplated that compression coil springs, leaf springs and dampeners, and alternative resilient members can also be used.

A damping mechanism 71 is provided for varying the damping, or tension, of the mooring device 20. This allows the device 20 to be adjusted for different sizes of vessels to be received. If the device 20 is not stiff enough, the vessel will be subject to excessive movement and may break free of the mooring device 20. Alternatively, if the mooring device 20 is too stiff, the hull of the vessel can be damaged by the mooring device 20.

The damping mechanism 71, illustrated in Figure 5, within dampener 12 is configured to damp forces (or dissipate energy) between the inner portion 8 and the outer portion 7. By mounting the mechanism 71 within the dampener 12 there are fewer external projections on the dampener 12. This reduces the opportunity for catching or snagging other dockyard machines or personnel. Furthermore, as each dampener12 has a dedicated damping mechanism therein, the replacement and maintenance of the dampener12 is simplified, as the entire damping mechanism 71 can be quickly removed and replaced and any necessary repairs done undercover of a workshop and not exposed to the elements. A further benefit of having the damping mechanism 71 housed within the dampener 12 is the reduction in exposure to sea water, salt and hostile weather conditions, all of which impair the longevity of mechanical or hydraulic componentry.

A first embodiment of dampener 12 is shown Figure 5 which illustrates an electrically driven and mechanical operating system of the damping mechanism 71

specifically designed for the extension, attachment, retraction, damping and maintenance of a vessels position by vacuum pads 100 to a vessel hull 6.

The dampener 12 is rectangular in configuration and the inner portion 8 and outer portion 7 of the dampener12 are dissimilar in size to allow the inner portion 8 to telescopically slide in and out of the open end 7b of the outer portion 7. Inner and outer portions 7 and 8 provide a sealed housing in which to install operable components of the damping mechanism 71 providing a shield from the environment of the dock 46. The interface between inner portion 8 and outer portion 7 can be further enhanced by providing a seal between the two components (not illustrated).

A first end of the dampener 12 is mounted to the vacuum pad 100. At a second opposing end of dampener 12 there is mounted a geared motor 11, operably connected to a worm drive 10. The worm drive 10 extends through the dampener 12 and is driven by the motor 11 to extend the inner portion 8 of the dampener 12 relative to the outer portion 7. The worm drive 10 is connected to a moving pedestal or tensioner 9, the tensioner 9 being configured to move backwards or forwards relative to outer portion 7, depending on the rotation of the worn drive 10, but also is capable of shifting or sliding within inner portion 8 in order to control and adjust the pre-tension within the dampener and to adjust after pad 100 connection depending whether the mooring device 20 requires a stiffer or softer damping effect as a consequence of vessel size and sea state conditions.

The tensioner 9 is located within the dampener 12. Held between the tensioner 9 and the front face 8b of inner portion 8 is a single resilient member, illustrated in Figure 5 as a spring 13. On the opposing side of the tensioner 9, compressed between a rear face 8a of the inner portion 8 and the tensioner 9 is a series of resilient members, illustrated in Figure 5 as three springs 13a, arranged in parallel. Springs 13a are held under compression between the back face 8a of the inner portion 8 and the tensioner 9.

Spring 13 is attached to the tensioner 9 only, and as such can push the front face 8b of the inner portion 8 outwardly away from the dock 46. The drive motor 11 turns the worm drive 10 and extends the tensioner 9 outwards thereby pushing the spring 13 against the front face 8b of the inner portion 8 which then extends away from the outer portion 7, until the vacuum pad 100 at the first end of the dampener 12 is extended in preparation for engaging the hull 6 of a vessel.

Springs 13a are attached at their opposite ends to the rear face 8a and the tensioner 9. Accordingly, when the mooring device is extended the springs 13a pull the inner portion away from the dock 46, and when the mooring device is retracted from its engaged position with the hull, the tensioner 9 bears against the springs 13a and pushes them against the rear end 8a of the inner portion 8 to retract the inner portion 8 back towards the dock 46.

Once vacuum pad 100 is located on the hull ready for attachment the vacuum pad 100 is retracted marginally, and in retracting the inner portion 8, the resilient component, springs 13a are compressed to a measured distance suitable, thereby pre-tensioning the dampener 12 for vacuum pad 100 in preparation for attachment. The vacuum or negative pressure generated in the vacuum pump 24 is then used to attach the vacuum pad 100 to the hull 6. Motion of the vessel towards the dock 46 is absorbed by a fender unit 98, illustrated in Figure 4A.

Once the connection has been established between the hull 6 and the vacuum pad 100, the drive motor 11 reverses and the tensioner 9 pushes against the rear series of flexible components 13a which load the rear face 8a of the inner portion 8, in turn retracting the inner portion 8 into outer portion 7 and thereby retracting the pad 100, to bring the vessel closer to the dock 46 in a controlled manner. In this manner the vessel is brought to a neutral position, that is, a predetermined position relative to the dock 46 suitable for loading and unloading the vessel.

Furthermore, when the vessel is at the fender line and cannot move any closer to the dock, further shifting of tensioner 9 a short distance toward rear wall 8a of inner portion 8, compresses springs 13a to thereby increase the stiffness of the mooring device.

With the vessel moored in position, the damping mechanism 71 passively maintains the dampener 12 in equilibrium, by resiling the forces of the vessel pulling away from the dock 46. The vessel cannot move towards the dock 46 as a fender system will be present to absorb any collision between the vessel hull 6 and the dock 46. When wind or waves urge the vessel away from the dock 46, control of the vessel is maintained by the amount of tension in the resilient components 13a the stronger (stiffer) of the two spring sets 13, 13a. If the vessel moves away from the dock 46 beyond the acceptable moored position (neutral position), the damping mechanism 71 will passively resile the tension within the springs 13a to bring the dampener 12 back into equilibrium.

Essentially, the springs 13 and 13a on either side of the tensioner 9 will always be drawn to equilibrium within the inner portion 8 of the dampener 12. As such, driving the tensioner 9 toward the vacuum pad 100 will urge the inner portion 8 forward, and driving the tensioner 9 away from the vacuum pad 100 will retract the inner portion 8 of the dampener 12 until such point as the vessel contact the fender line. Any load imparted into the vacuum pad 100 by the vessel will be damped by the motion of the springs 13, 13a on either side of the tensioner 9 until the damping mechanism 71 returns to equilibrium within the inner portion 8.

The series of three springs 13a in parallel are compressed between the tensioner 9 and an end face 8a of the inner portion 8. The stiffness of these springs 13a provides a variable damping force to damp the movement of the vessel away from the dock 46. By activating the motor 11 and adjusting tensioner 9 relative to the end face 8a of inner portion 8, the damping capability of the series of springs 13a is adjustable. This occurs especially when the vessel is against the fender line so that inner portion 8 cannot move back into the outer portion 7 (because of the vacuum pad being attached to the hull) as the tensioner 9 is drawn by the worm drive 10 back toward end face 8a.

A sensor can be mounted to the springs 13, 13a to monitor the tension therein. For example, a load cell or similar measurement device. The signal from the sensor can be remotely communicated to a controller for monitoring and assessment, or even to a computer that can be set to activate the motor and thus move the tensioner 9 in response to the tension in the springs 13, 13a. If the loads within the springs 13, 13a become excessive the tensioner 9 is activated to draw the vessel closer to the dock 46 and thereby exercise more control over the motion of the vessel. This action will enable the vessel to be constrained at or closer to the neutral position (ideal loading positions) to allow efficient loading and unloading of the vessel.

The term “damping” as used herein refers to an influence upon a system that reduces, restricts or prevents oscillations by dissipating energy from within the system before the energy can be transferred to other parts of the system or interconnected systems.

Once the pad 100 is attached to a vessel, at sea, the vessel will oscillate with the wave motions of the sea. These oscillations will supply a force input to the dampener 12 and thus the damping mechanism 71 therein. The series of spring 13a will be subjected to the force input from the vessel and the stiffness of the springs 13a will absorb and dissipate the force input by compressing the springs 13a. In this manner the force input from the vessel is not directly transferred to the second structure.

The resilient members within the damping mechanism 71 need not be a springs 13, or a series of springs 13a. Alternative resilient members can be an air bellow 14, shaped rubber sections 15 or an air cylinder 16.

The damping mechanism 71, as described above, can be used in a mooring system for both horizontal and lateral damping, as illustrated in Figure 41.

Figure 5A is a perspective view of the dampener 12 described above, co-located with two additional dampeners 12’ and 12’’. The dampeners 12’, 12’’ are located on opposing sides of the first dampener 12, to control motion in a positive and negative, perpendicular direction to that of the original dampener 12. While the original dampener 12 attached to the vacuum pad 100 damps motion of the ship away from the dock 46 (x-direction), the two dampeners 12’, 12’’ passively damp motion along the face of the dock 46

(positive and negative y-direction). The upwards and downwards motion of a vessel is rarely damped, as this horizontal motion, caused by the wave motion of the sea, is too great to counteract; attempting this form of control over a vessel's motion is likely to damage the hull 6 of the vessel.

Figure 5B, illustrates an exploded view of the damping mechanism 71 of Figure 5, for ease of viewing. The yoke 81 is also illustrated to have a two-way gimbal allowing for rotation of the vacuum pad 100 in two rotational directions relative to the dampener 12. In this embodiment of the dampener 12 a hexagonal shaped section has been used for the dampener 12. A cut-out 12a in the sidewall of the outer portion 7 of the dampener 12 provides access to the springs 13a and any sensors or measurement devices within the body of the dampener 12. The front face 8b of the inner portion 8 has been chamfered to provide clearance for the articulation of the vacuum pad 100 relative to the dampener 12.

The damping mechanism 71 as described above, also provide the movement mechanism for the dampener 12 and thus the movement of the vacuum pad 100 attached thereto. As the movement is controlled by an electric motor 11 (running the worm drive 10) the mooring unit 20 is very responsive. The dampener 12 can be activated and extended quickly into position ready to engage a vessel's hull 6. This control method is to be contrasted with hydraulic units, which are comparatively less responsive and not able to react with the same efficiency and speed as an electric motor. A hydraulic unit relies on fluid power and the time the fluid takes to react will vary depending on the size of the unit, the volume of the fluid to influence and the viscosity of the fluid. In contrast and electric motor and instantaneously be activated to activate the worm drive 10 and alter the position of the tensioner 9.

Once the damping mechanism 71 has guided the vessel to the neutral position for loading and unloading the ship, the motor 11 is turned off. The damping mechanism 71 then passively resiles the forces within the damping mechanism 71 to bias the vessel motion back towards the neutral position. If the tension in the damping mechanism 71 is being monitored a predetermined trigger condition can set, at which time the motor 11 is reactivated, immediately activating the worm drive 10 and thereby adjusting the tensioner 9. Once tension is reduced below the predetermined level the damping mechanism 71 returns to a passive operating mode.

An alternative dampener 12 is illustrated in Figure 6. In this damping mechanism 71, the dampener 12 is of a cylindrical construction comprising an inner portion 8 and an outer portion 7. The damping mechanism 71 is configured to operate as described in relation to the embodiment illustrated in Figure 5. However, the springs 13, 13a have been substituted for tubes 70, each tube containing a plurality of rubber balls 15. As the worm drive 10 urges the tensioner 9 away from the outer portion 7, the rubber balls 15 push against a series of aligned cylindrical members 17 forcing the inner portion 8 of the dampener 12 to extend.

As the worm drive 10 moves the tensioner 9 towards the outer portion 7, the rubber balls 15 apply pressure to the cylindrical members 18 attached to the rear face 8a of the inner portion 8, retracting the inner portion 8 back into the outer portion 7.

This alternative damping mechanism 71 provides the damping, or energy dissipation within the dampener 12 to compensate or damp the input force from the vessel once attached to the pad 100.

The worm drive 10 is operably connected to the tensioner 9, and driven by the motor 11. Accordingly, the motor 11 controls the position of the tensioner 9 within the dampener 12 and the amount of damping provided by varying the compression on the rubber balls 15 within the tubes 70.

A load cell or alternative form of sensor can be located within the tubes 70 to measure the force (tension) within the rubber balls 15. This force can be relayed to a controller for monitoring or a computer. By this method, the tensioner 9 can be adjusted to reduce the tension in the rubber balls 15 and thereby increase the damping of the dampener

12 depending on weather conditions and how much the vessel is moving relative to the dock 46.

With reference to the Figure 7, the components of a mooring device 20 are illustrated in accordance with one embodiment of the invention.

The mooring unit 20 uses two vacuum pads 100 to overcome tide and draught displacement by a control system recognising a change in tide distance. In response to the change the mooring unit 20 deactivates a first vacuum pad 100, raises or lowers the first vacuum pad 100 by either mechanical or pneumatic cylinders 22, and reattaches the first vacuum pad 100 in a new position on the hull 6. Once reattached, a second vacuum pad 100' is detached and raised or lowered and then the second vacuum pad 100' is reattached to the vessel hull 6.

The mooring device 20 is configured for mooring a first structure such as a vessel to a second structure such as a dock 6. The device 20 comprises an engagement member for releasably engaging the first structure, illustrated in Figure 1 as vacuum pad 100. The vacuum pad 100 is attached to the dampener 12, wherein the dampener 12 comprises a first inner portion 8, and a second outer portion 7. The inner portion 8 is articulately mounted to the vacuum pad 100 while the outer portion 7 of the dampener 12 is operably connected to the second structure or dock 46. The mooring unit 20 further comprises a damping mechanism 71 associated with the dampener 12 to dampen load transfer between the first and second portions of the dampener 12 and thereby damp the relative movement between the first and second structures.

The mooring device 20 includes a housing 41 having two vacuum pads 100 respectively attached to two supports 12 therein. The supports 12 are independent units and can articulate independently of one another. This allows the vacuum pads 100 to be moved independently of one another. In situations where a vessel mooring requires adjustment, the first vacuum pad 100 can be maintained in contact with the vessel hull 6 while a second vacuum pad 100' is disconnected from the vessel hull 6 and either replaced or repositioned. This action is then repeated, with the second vacuum pad 100' remaining in contact with the vessel hull 6 such that the first vacuum pad 100 can be adjusted and reconnected.

The housing 41 couples the two vacuum pads 100, 100' together and provides an environment for the mechanical systems of the mooring unit 20 sheltered from the dock 46 environment. As illustrated in Figure 7, the housing 41 is mounted on a guide, illustrated as a pair of rails 23. These rails 23 provide means for adjusting the horizontal location of the mooring unit 20 relative to the vessel along the length of the dock 46. The housing 41 includes a base 41a, the base 41a associated with a secondary drive means to propel the mooring unit 20 along the dock 46 on the rails 23.

The secondary drive means comprises a plurality of roller bogeys 19 having a plurality of wheels or castors or bearings upon which to slidably translate the base 41a and housing 41. Furthermore, the secondary drive means comprises a secondary geared motor 59 to propel the housing 41 and a brake 25 for slowing and arresting the housing 41 upon the rails 23. It is contemplated that other methods of propelling the mooring unit 20 along the length of the dock 46 other than a protruding rail system can be employed such as an inset track system, an independently driven unit or vehicle or modular carriage type system where the mooring units 20 can be independently positioned and thus providing further degrees of freedom in positioning the unit 20 not constrained by a track 23.

The brakes 25 can be a number of sprung loaded disc brakes as illustrated in Figure 7; however, it is contemplated that other braking means can be employed to arrest the mooring units 20 when moving them on the rails 23. The brakes 25 further provide a method of locking the mooring units 20 in place on the rail 23 to ensure that once connected to a vessel hull 6, the mooring unit 20 is not easily pulled around or otherwise adjusted by the vessel motion.

Each dampener 12 is rotatably mounted to the housing 41. This allows each dampener 12 to pivot from braces 26 which form the base 41a and structural components of

the housing 41. The drive motor 11 for varying the damping of each dampener 12 is mounted to a back face of the outer arm 7, allowing the dampener 12 to pivot relative to the housing 41 while maintain operably connections with the motor 11.

A pair of pneumatic cylinders 22 is mounted between the housing 41 and the back face 7a of each dampener 12, to provide a mechanism for pivoting the supports 12. The pneumatic cylinders 22 can be free to move in response to the movement of the vessel hull 6 when attached via the pads 100. Alternatively, the pneumatic cylinders can be actuated to manoeuvre the dampener 12 to a predetermined vertical height to receive a vessel hull 6.

Figure 8 illustrates the mooring unit 20 of Figure 7 viewed from below the unit 20 and rails 23. The secondary drive motor 59 can be seen centrally positioned within the housing 41 operably engaged with a set of driving wheels 21 to transfer the output from the motor 59 to the rails 23. It is contemplated that the driving wheels 21 can be configured to contact both of the pair of rails 23 thereby evening the weight distribution of the mooring unit 20 upon the rails 23.

A plurality of roller bogeys 19 can be seen distributed about the base 41a of the housing 41. The number of roller bogeys 19 will be varied depending on a number of factors e.g. the size of the housing 41 and the weight of the housing 41. From the illustration in Figure 8, a number of truss beams or braces 26 can be seen forming the base 41a of the housing 41. These are contemplated to be rolled steel sections for supporting the weight of the mooring units 20. Other materials with sufficient structural rigidity can be used in place of steel.

Located on the backing plate 1 of each vacuum pad 100, there is a vacuum pump 24. The vacuum pumps 24 provide the additional vacuum for increasing the retention capacity of each vacuum pad 100. The pumps 24 are preferably sealed to the vacuum pad 100 to provide efficient operation and a shield from the harsh dock side environment of salt, water and wind, which can compromise the working of the pump 24 and associated seals.

Turning now to Figures 9 which illustrates a pair of mooring units 20, mounted to a single rail system 23 that extends the length of a berth on the dock 46. The units 20 can be positioned in a predetermined location, appropriate to the vessel hull 6 to be restrained. Furthermore, the mooring units 20 can be adjusted to provide the appropriate damping for the size and weight of vessel to be restrained. A mirroring pair of mooring units 20 (not illustrated) can be positioned on the opposing side of the vessel, depending on the size and weight of the vessel.

An added advantage of the flexible mooring system described above is that units 20 attached to a vessel can assist with positioning a vessel into a dock 46.

Figure 10 illustrates a variety of embodiments of the invention configured for specific berths and dock 46 variations as encountered at shipyards; a pile mooring 30 mounted on a pile 40 to the sea bed or 36 berth mounted; a horizontally translatable berth mooring 31; a fixed berth mooring 32 (which provides a variation of mooring unit 20 from Figures 7 and 8) where a simplified unit 20 is fixed to a berth 46 or mounted to a vehicle to be portably installed or "plugged in" at a predetermined berth location; a vertically translatable berth mooring 33, this provides a portable unit 20 within its own operating frame which can be fixed or transported by vehicle and mounted in a preselected mooring position; a ship mounted claw mooring unit 34; a cable mooring 35, which provides a mooring unit of narrow profile that can operate using vertical tensioned cables; an alternative fixed berth mount 37; and a ship mounted vacuum mooring unit 38.

The individual components of the above embodiments will be described in more detail in relation to Figures 11 to 36. The embodiments described hereunder provide various aspects that can incorporate the mooring device 20 described above into different devices that are directed to solving problems against different backdrops, which are explained in more detail below.

Pile Mounting Automated Mooring System

Automated mooring systems to date have not catered for situations where pile berths are used, which have no deck space upon which to fit mooring units or where a mooring unit needs to be placed, and there is no suitable structure to receive the units. In relation to non-pile berths, it is not uncommon for berths to have recessed areas or areas of lightweight structure unsuitable for mounting mooring units.

Figure 11 illustrates a mooring system described herein. The vacuum pads 100 are mounted to the housing 41 in the same manner as described above in relation to Figures 1 to 6; however, the housing is configured to mount to a pile 40. The housing 41 includes an inner portion 8 and outer portion 7 to articulately mount a vacuum pad 100 facing outwards away from the pile 40.

This embodiment of the invention is intended for use when a dock 46 has limited space for mounting mooring equipment.

A pile mooring unit 30 comprises a pile 40 of any shape or appropriate size constructed of steel or other material, embedded in the sea bed in a suitable location ideal to moor vessels for loading, unloading operations onto a berth 46.

The pile 40 comprises a counterweight 45 disposed within the pile 40. Alternatively the counterweight 45 could be mounted from an adjacent structure where it is not viable to have it inside the pile 40.

The counterweight 45 is used to counter balance the weight of the housing 41 located towards a top end of the pile. The counterweight 45 is moved to locate closer to the water/sea at the lower end of the pile 40 as the housing 41 is adjusted away from the water. Alternately, the counter weight 45 moved away from the water as the housing 41 is lowered down the pile 40 towards the water.

An alternative to the counterweight method could be vertical chains 87 or ropes attached to the pile 40 and running through a winch 52 or geared drive sprockets 82, and idler sprockets 83 mounted to the housing 41 of the mooring unit 20 for height positioning.

Illustrated in Figure 32, the housing 41 is configured to be translatable up and down the pile 40 to align to the predetermined mooring point of a vessel hull 6. The translation of the housing 41 is achieved by attaching the housing 41 to a set of cables 51 or ropes operably engaged to a series of pulleys, or a chain drive 84, or a winch 52, and a secondary drive motor 59, for example a dog clutch and motor drive. A further alternative would be a winch and rope drum in the housing 41 supporting the mooring unit 30.

The ropes or chains 87 suspended over the pulleys or chain drives 84 in the housing 41 supports the mooring unit 30 disposed about the outside periphery of the pile 40 and can be coupled to a counterweight 45 inside the pile 40.

A more detailed illustration of the components within the housing 41 is shown in Figure 32. The housing 41 is mounted to a vertical guide track or pile 40, the housing 41 being transparent to better illustrated the components therein. It is contemplated that the housing 41 and chain drive illustrated in Figure 32 can be equally configured to run along a horizontal or vertical guide track for altering the location of the vacuum pad 100 in relation to a vessel hull 6.

The backing plate 1 of vacuum pad 100 in Figure 32 is shown to be pivotally mounted to a yoke 81. In turn, the yoke 81 is mounted to the inner portion 8 of the dampener 12. The internal components of the dampener 12 are illustrated in shadow in Figure 32, but are more clearly illustrated in Figure 5.

Towards each end of the housing 41 is a chain guide 84, through which a cable of chain 87 can be fed. The chain 87 is further attached to the counterweight 45, and the pile 40, to lower and raise the housing 41 relative to the pile 40. A top mount 86 of the mooring unit 30 sits atop the pile 40. Within the top mount 86 there is housed a pulley for securing the chain 87 and counterweight 45 to the pile 40 (not illustrated).

The housing 41 includes a first geared drive motor 11 for driving the worm gear 10 within the support 13, to extend the inner portion 8 of the dampener 12 relative to the outer portion 7. A secondary motor 59 is also provided for driving the chain 87 to raise and lower

the housing 41. The chain 87 is engaged with a distanced pair of idler sprockets 83 and a drive sprocket 82. The secondary motor 59 drives the drive sprocket 82 while the pair of idler sprockets 83 maintains tension in the chain 87. When the motor 59 is activated the drive chain sprocket 82 rotates such that the housing 41 is hoisted upwards away from the water as the counterweight 43 is lowered towards the water or the housing 41 is lowered towards the water, while the counterweight is hoisted away from the water.

Within the housing 41 there is further provided a vacuum pump 24 to create the necessary suction to activate the vacuum pad 100 and retain a vessel hull 6 thereto. Figure 32A illustrates the chain 87 wound around the drive sprocket 82 and idler sprockets 83. This chain 87 arrangement can be disposed on the outside of the housing 41, but is more preferably positioned within the housing 41 to provide protection from snagging and the salt-water environment around a dock 46.

The pile 40 is further supported in some embodiments by a pair of flexible support members 42. The support members 42 can be attached to the top of the dock 46, a side wall of the dock or an alternative rigid structure nearby to the pile 40.

At the bottom end of the travel of the mooring unit 30 on the pile 40 is a collar 43 supported back to the nearest structure. The collar 43 can be supported by a strut of fixed length member, or a chain, that constrains a lower portion of the pile 40 to the dock 46.

In some embodiments, the collar 43 is configured to acts as the counterweight 45 mounted as the external collar 43 on the pile 40 or separately mounted from an adjacent structure.

The entire housing 41 can be suspended upon the pile 40 by a plurality of chains 87. The chains 87 are driven around a winch 52, or wound about the winch 52 within the top mount 86 of the pile mooring unit 30, illustrated in Figures 12 and 12A. In this embodiment, a pair of vacuum pads 100 is incorporated into the mooring unit 30, each pad 100 operatively engaged to a dampener 12 and configured to independently damp the motion of each pad 100 relative to the housing 41. In situations where the vessel's motion relative to the pile 4 cannot be fully accommodated by the yoke 81 of the pad 100, the pair of vacuum pads 100 can be independently released from the hull 6 and reattached, to reposition the vessel relative to the pile 40. While a first of the two pads 100 remains attached to the vessel, the second pad 100 is repositioned. Then the first pad is repositioned retaining control over the vessel at all times.

Figure 13 is a perspective view of the housing 41 supporting a pair of pads 100 mounted to cylindrical dampeners 12 (in accordance with that illustrated in Figure 6). The centre of the housing 41 provides a circular aperture therethrough to accommodate the pile 40. The cable system from which the housing 41 is supported is driven by a winch 52 or pair of winches housed within the top mount 86.

Figure 14 is a transparent perspective view of the housing and winch system. Within the housing 41 the damping mechanism 71 is visible, illustrating the worm drive 10 which drives the tensioner 9 to extend the inner portion 8 of the dampener 12 relative to the outer portion 7. The yoke 81 of the vacuum pad 100 further provides a two-way gimbal to rotationally adjust about two separate rotational axes about mounting points 54, 54'.

Figure 15 illustrates an alternative embodiment of a pile mooring unit 36, the housing 41 mounted on the pile 40 of sufficient length to cover the operational range of the berth/dock 46. The pile 40 is permanently affixed to the dock 46 and supported by high tensile, rigid support structures 47. The rigid supports 47 of Figure 15 are of tubular construction; however, it is contemplated that the rigid supports 47 can be made from steel bar, I-beams, square or rectangular sections or the like. Alternatively materials other than steel can be used to manufacture the housing 41 and pile 40 and supports 47, providing the material has sufficient tensile strength to support the mooring unit 36 when attached to a vessel.

Inside of the housing 41 a similar chain driven drive can be configured as described above in relation to Figure 32.

The pile 40 can be constructed in several connectable sections to allow predetermined sections to be quickly removed from a section secured to the dock 46 or sea bed. This provides for ease of repair or maintenance of the mooring unit 36.

For ease of installation and servicing, the alternative pile mooring 36, including the housing 41, mooring unit 20 and counterweight 45 can be preassembled and attached to a crane for positioning, installing and removing for maintenance from the dock 46.

Because the mooring unit 20 and the counterweight 45 are balanced, the alternative pile mooring 36 requires only a small motor gearbox 11 and dog clutch with brake 25 in the housing 41 to position the vacuum pads 100 for attachment to the hull 6 of a vessel and once the vacuum pads 100 are attached, the mooring unit 20 is free to move vertically with the movement of the vessel.

When the dampener 12 is in a fully retracted position, the mooring unit 20 and vacuum pads 100 will be within the maximum impact distance of dock 46 fender systems to minimise the opportunity of a vessel or the mooring equipment being damaged in a high impact, mooring situation.

Alternative automated mooring units are discussed in co-pending PCT application no. , entitled "Mooring Apparatus" and filed by the Applicant on 25 March 2015, the disclosure of which is incorporated herein by reference in its entirety.

Ship-to-ship Automated Mooring System

In sheltered ports vessels are often tethered together to avoid the need to providing a berth for each vessel. Tethering between vessels is typically achieved using ropes and fenders. The mooring of vessels together in sheltered port conditions is done conventionally with mooring ropes and floating fenders.

As the sea state changes – e.g. wave size increases/decreases – it can be necessary to change the tension in the ropes, the number of ropes or the number of fenders. Similarly, when repositioning vessels it is necessary to untie ropes and remove fenders.

The positioning and tying of the ropes and floating fenders require considerable manpower. Making changes to ropes and fenders can be time consuming and potentially dangerous, particularly in conditions where waves are increasing in size.

If the Sea State increases beyond Sea State "2" (small wavelets), this fender method and rope mooring becomes increasingly unstable, substantially increasing the risk of hull damage and lack of vessel control and increasing the risk of safety to personnel that may be required to increase the number of fenders, ropes or removal thereof, to reposition vessels.

Furthermore, for ships at sea, it is very difficult to carry out a ship-to-ship hull connection of any sort and with vessels under way, it is virtually impossible without inflicting hull damage.

If the Sea State is higher than "2", vessels are advised to stand-off from each other and use either a boom or cable device to transfer supplies therebetween.

When a vessel is travelling at sea it can also be necessary for other vessels to pull alongside, for example, to refuel or transfer supplies. In these cases connecting hulls of vessels together (e.g. by tethering with ropes) can be highly dangerous and can result in damage to the hulls of both vessels. For these reasons travelling vessels typically stand off from each other and use a boom or cable device to transfer supplies.

Described herein is a buoyant mooring system 29 for securing two vessels to one another at sea.

Figures 16 to 25 illustrate mooring fender units 29, 29' manoeuvring into position for securing two vessels together by radio control. Each mooring fender unit 29 comprises a propulsion unit 62 that propels the mooring fender unit 29 across the water and against a vessel hull 6 such that the vacuum pads 100 of the fender unit 29 can attach to the vessel hull 6. Any number of mooring fender units 29 can be used depending on the size of the vessels to be secured together.

Once the mooring fender units 29 are in position, along the hull 6 of the first vessel, a second vessel manoeuvres into position alongside the first vessel. This then places the plurality of mooring fender units 29, 29' between the opposing hulls 6, 6' of the two vessels. As the second vessel approaches the mooring fender units 29 and makes contact with the vacuum pads 100, the mooring fender units 29, 29' begin to compress urging the vacuum pads 100 to attach to the second vessel. In the above manner, the two vessels become temporarily secured together at sea.

A similar attachment process can be achieved between a vessel and a pontoon 46 with extended target areas for fastening, or a mutable attachment, as illustrated in Figures 19 to 21.

Figure 20 illustrates an enlarged view of the pair of mooring fender units 29 from Figure 19. Each fender unit 29 has an elongate body, illustrated as housing 41, disposed below the sea level 39. The top mount 86 of the fender unit 29 is buoyant and illustrated as an elongate flotation member preventing the fender unit 29 from sinking.

Depending on the vacuum source used on a given fender unit 29, the buoyancy of the top mount 86 can be adjusted to vary the depth at which the fender unit 29 is positioned relative to the sea level 39. Each fender unit 29 comprises at least two vacuum pads 100, each mounted on opposing sides of the fender unit 29 to receive two structures either side thereof. The two structures can be two vessel hulls 6, 6', or a single vessel hull 6 and a permanent dock 46 or floating pontoon or the like.

The propulsion unit 62 is mounted to the housing 41 disposed at least partially below the water level, to efficiently propel the fender unit 29 while in the water. In some embodiments a 360 degree propulsion unit 62 is attached to provide a high degree of manoeuvrability of the unit 29.

The propulsion unit 62 may be self-guided. Self-guidance can be achieved by sensing a position of the vessel or object and manoeuvring the apparatus to attach to a desired position on the vessel or object. Self-guiding can also be achieved using GPS (global positioning system) tracking of the mooring fender unit 29 and the vessel or object, and manoeuvring the fender unit 29 to meet the vessel or object at specific coordinates for attachment to the vessel or object.

Where the fender unit 29 comprises a controllable propulsion system 62, the fender unit 29 is positionable as desired near the waterline of the vessel or object. When compared with fender units 29 that tether to the vessel or object, a fender unit 29 with a controllable propulsion system 62 can be positioned at a point on the vessel or object that best facilitates relative positioning between the vessel and object. Similarly, where multiple fender units 29 are used concurrently, they can be independently positioned along the vessel or object as desired.

The vacuum pads 100 are articulately mounted to a dampener 12. Figures 22 and 23 illustrate the articulating mechanism as pivot mounts 54. In Figure 20 a large four-lobed yoke 81 is mounted to the inner portion 8 of the support. As with previous aspects of the invention, the pad 100 is supported by a dampener 12. The inner portion 8 is slidably engaged with an outer portion 7 of the dampener 12. The inner portion 8 can slide relative to the outer portion 7, in which it is partially housed. The inner portion 8 and outer portion 7 are operably connected to one another via resilient members 13, such that forces inputted to the vacuum pads 100 are damped within the dampener 12 and not transmitted into the housing 41.

The dampener 12 is configured to have a damping mechanism 71 that works to passively resile forces within the damping mechanism 71 in two opposing directions, as described above in relation to Figures 5 and 6. In Figure 22, an embodiment of the damping mechanism 71 is configured such that the two dampeners 12 on either side of the unit 29 share the outer portion 7. The dampener 12 has a central outer portion 7 which partially houses to inner portions 8 on either side supporting a pair of vacuum pads 100 facing in substantially opposing directions. The loads transmitted into each of the pads 100 are

damped within the dampener 12 to maintain connection between the two vessels while each is subject to wind and wave motion.

Figure 23 illustrates an embodiment of the mooring fender unit 29, wherein the vacuum pads 100 are pivotally mounted to the inner portions 8 of the dampeners 12. Each of the four vacuum pads 100 of Figure 23 are configured to pivot independently of one another in response to the oscillatory motion of the two vessels relative to one another while at sea. Furthermore, the dampeners 12 are mounted directly to the body 41 of the unit 29 by two pairs of pivoting arms 48.

Figure 23 further illustrates the mooring fender unit 29, wherein the dampeners 12 are disposed between each pair of vacuum pads 100, and articulately mounted to the housing 41 by the plurality of pivoting arms 48. This set-up of the vacuum pads 100 allows articulation of each pad 100 relative to the dampener 12 and to the housing 41 giving the fender unit 29 more articulation that that of the fender unit 29 in Figures 16 to 22. The propulsion unit 62 is mounted to the lowest portion of the housing 41, to ensure it is submerged in the sea water and thus operating in an efficient manner. As this embodiment mounts the vacuum pads 100 from pivoting arms 48, the housing 41 is substantially smaller than that of alternative embodiments. This provides both cost and weight saving for the manufacture of the fender unit 29.

The fender units 29 are compact in design and as such can be stowed on boat a vessel, ready for deployment at sea when required. In combination with the propulsion units 62, guide ropes of tow ropes can also be employed to influence the fender unit 29 position in the sea.

It is contemplated that the hosing 41, or buoyant top mount 86 can contain a vacuum pump 24 and the required motor 11 to make the fender unit 29 self-sufficient. However, it is alternatively contemplated that the fender unit 29 can be fed, power, compressed air, suction/vacuum, from the vessel via a service conduit 64 (illustrated in Figures 24 and 25).

An alternative mooring fender unit 29 is illustrated in Figure 24. The unit 29 does not have a propulsion mechanism, and is guided into position via a tow line or service conduit 64. The conduit 64 further provides the essential services to the fender unit 29 to function as a mooring device.

In Figure 24 the deflated or partially inflated fender unit 29 is lowered into the sea from the first vessel and positioned alongside by use of guide lines of service conduit 64. The vacuum pads 100 are located on two opposing sides of the fender unit 29. The pads 100 are attached to a dampener 12, which comprises a plurality of inflatable modules 61, making the dampener 12 both buoyant and compressible. The inflatable modules 61 support the fender unit 29 on the sea, around the fender line of a vessel and also provide a damping function when the vacuum pads 100 on opposing sides of the fender unit 29 are loaded simultaneously.

The dampener 12 comprises a plurality of inflatable modules 61. In the embodiment shown in Figure 24, the inflatable modules 61 forms a 2-by-3 array – in other words, 2 rows of inflatable modules 61, with each row having 3 inflatable modules 61. It will be appreciated that any number of flotation members may be used, in any desired arrangement, as appropriate to achieve the necessary buoyancy.

The inflatable modules 61 are articulately linked together via a series of flexible linkages 63 and a cable 63a. The cable 63a passes through the linkages 63 on the inflatable modules 61. Both ends of each flotation member are provided with linkages 63. Using flexible linkages 63 maintains the ends of the inflatable modules 63 in desired relative positions. This stabilises the shape of the fender mooring unit 29 when in use. To provide further stability, additional securement members (e.g. straps 124) may be provided to secure the inflatable modules 61 together between their ends.

These linkages 63 allow the body of the dampener 12 to flex and adjust the orientation of the vacuum pads 100 attached thereto. Any number of inflatable modules 61 can be used to form the dampener 12. The modules 61 are fastened together, each end or

each module 61 having a flexible cable linkage 63 to articulately tie the modules 61 into form the dampener 12. Vacuum pads 100 of any size and number are attached on both sides of the inflatable modules 61 of the mooring fender unit 29.

Once in the water, the services conduit 64 can be used to provide air, compressed air or alternative fluid to inflate the inflatable modules 61 of the dampener 12. The amount of air or fluid pumped into the inflatable modules 61 will vary the stiffness of the dampener 12 between the two vessels and thereby vary the amount of damping provided as forces are inputted via the vacuum pads 100.

Figure 25 illustrates a pair of fully inflated mooring fender units 29 positioned in between a pair of vessels to be secured to each other at sea. The service conduit 64 is used to restrain the fender unit 29 against the hull 6 of the first vessel. Once the mooring fender units 29 are inflated, both vessels can come together, which impacts on the mooring fender unit 29 compressing them between the two vessels as the second vessel manoeuvres into position alongside the first.

The vacuum pads 100 on both sides of the fender unit 29 are activated from a vacuum hose connected to the service conduit 64 from a vacuum source or vacuum pump 24 on the first vessel.

An alternative mechanism is contemplated to supply power to the mooring fender unit 29 by employing a separate module attached with a vacuum pump 24 and compressor (not illustrated).

For submarine fender and mooring methods, the mooring fender units 29 (Figures 20, 21 and 22) must extend downwards, below the water line 39, to allow ideal placement on the curvature of the vessel hulls 6. The 360 degree propulsion unit 62 further facilitates remote positioning around the hull 6 of a submarine.

The mooring fender unit 29 of Figures 24 and 25 is inflatable and deflatable, and is smaller in size when deflated. The mooring fender unit 29 as a whole is therefore smaller when the inflatable modules 61 are deflated. Providing a smaller fender mooring unit 29 facilitates storage of the device.

In some cases, it may be desirable for the vacuum pads 100 to sit lower in the water than in other cases. To achieve this, each of the inflatable modules 61 may be only partially inflated. Alternatively, some of the inflatable modules 61 may not be inflated at all, while other inflatable modules 61 are inflated. In the latter case, at least one of the inflatable modules 61 will need to be inflatable and deflatable independently of the inflation or deflation of the other inflatable module(s) 61.

The inflatable modules 61 are inflatable and deflatable via valves (not illustrated). The valves are located between the vacuum pads 100. The valves may; however, be located at any desired position on the fender unit 29 that will be accessible for inflation/deflation when needed.

In some embodiments, there may be only one valve provided for each row of inflatable modules 61. In this case, each of the inflatable modules 61 in a respective row are fluidly connected (e.g. form a single internal volume) so that supplying compressed air through a respective valve results in inflation of all of the inflatable modules 61 in the respective row.

The attachment system comprises four vacuum pads 100. The vacuum pads 100 are disposed in pairs being disposed on respectively on opposite sides of the fender mooring unit 29. Inflation of the inflatable modules 61 thus causes the pairs of vacuum pads 100 to move apart.

The distance between the pairs of vacuum pads 100 can therefore be adjusted by changing the volume of the inflatable modules 61. Typically, the volume will change depending on the inflation pressure. The lower the inflation pressure or volume, the lesser the distance between the pairs of vacuum pads 100. Conversely, the greater the inflation pressure (or volume) of the inflatable modules 61 the greater the distance between the pairs of vacuum pads 100.

While the inflatable modules 61 as presently described is useful insofar as it maintains the buoyancy of the fender mooring unit 29, the inflatable modules 61 is further advantageous as it acts as a fender between the vessels. After engagement of the vacuum pads 100 should both vessels subsequently approach each other, they will compress the inflatable modules 61 which will act as a fender/dampener for inhibiting contact between the vessels. The higher the internal pressure in the inflatable modules 61, the higher the resistance of the inflatable modules 61 to further compression.

Just as the inflation pressure can be used to change the buoyancy of the inflatable modules 61, it can similarly be used to adjust the compressibility of the inflatable modules 61. The higher the inflation pressure, the higher the internal pressure in the inflatable modules 61 and the greater the resistance of the inflatable modules 61 to compression.

The vacuum pads 100 must have a vacuum in order to attach to the hull of a vessel. Air will usually be drawn from the pads 100 after contact between the pads 100 and vessel. Air removed from the vacuum pads 100 may be conveyed into the inflatable modules 61. In this way the energy required to maintain the vacuum in the vacuum pads 100 may serve the dual purpose of topping up air in the inflatable modules 61.

The fender mooring unit 29 is stored on the vessel and is lowered into the water for use. The services conduit 64 or ropes are then shortened as needed until the vacuum pads 100 contact the hull of the vessel 104. The vacuum pads 100 then attach to the hull 6 to hold the fender mooring unit 29 in position against the hull 6.

A distance between the vessels is then reduced to bring the vacuum pads 100 against the hull of the second vessel. The vacuum pads 100 may attach to the second vessel either by actively powering the vacuum pads 100 (e.g. using an air compressor to actively remove air from the pads 100) or by the pressure from vessels bearing against the pads 100 driving the air from the pads 100.

Ship Mounted Automated Mooring System

Ship mounted, automated mooring devices to date, tend to take up a substantial area within a ship in areas normally allocated for other machinery, equipment and storage.

Alternative ship mounting mooring devices are discussed in co-pending PCT application no. , entitled "A Mooring Mechanism" and filed by the Applicant on 25 March 2015, the disclosure of which is incorporated herein by reference in its entirety.

A difficulty in finding suitable mounting locations for such devices is the requirement for mooring devices to be mounted in specific locations and heights along the length of a hull for effecting safe and stable attachment to the berth.

Turning now to Figures 26 to 31, there is illustrated a ship mounted mooring system 38 that is installed within the hull 6 of the vessel.

The mooring system 38 is sealed within the hull 6 of the vessel by a water-tight door 66. The door 66 is located on the hull 6 above a buffer, illustrated as rubbing strake 67.

The watertight doors 66 are manually or electronically opened and a single or a pair of two mooring units 20, 20' are retractable from a stowable configuration 69 within the hull 6, illustrated in Figure 26. The mooring unit 20 when in a stowable configuration 69, has the vacuum pad 100 oriented to align with the dampener 12 such that the dimensions of the water-tight door 66 is kept to a minimum size. As the vessel approaches its berth 46, the watertight doors 66 open (Figure 27) and the mooring units 28, 28' driven by motor units 11 within the dampener 12, extend the dampener 12 and the attached pad 100 far enough out from the hull (6) of the vessel to allow clearance to rotate the vacuum pads 100 to a vertical position. This is done by a motorized drive 11 from the mooring unit 38.

Each mooring unit 20 and 20' are independently controllable to enable detachment and reattachment of a single unit while retaining the vessel to the dock 46 with the other of the two mooring units. The extension of a first mooring unit 20 from the hull 6 is illustrated in Figure 28. Each mooring unit 20, 20' comprises a vacuum pad 100 articulately connected to a dampener 12. The dampener 12 comprises an inner portion 8 and an outer portion 7, the

inner and outer portions being slidably connected to one another. A damping mechanism 71 as earlier described is incorporated within the dampener 12, to damp the loads inputted to the vacuum pad 100 and stop them being directly transmitted into the structure of the vessel.

The articulate connection between the vacuum pad 100 and the dampener 12 facilitates the rotation of the vacuum pad 100 when extending the mooring unit 20 from the hull 6 and also to compensate for motion between the vessel and the dock 46 once the vessel is moored. Once the vacuum pad 100 is fully extended from the hull 6, the pad 100 is reoriented to be substantially perpendicular to the dampener 12, this is the operable configuration 86 of the vacuum pad 100, see Figure 29.

Once in the operable configuration, the pad 100 is partially retracted ready to receive a portion of a berth fixture 46 to moor the vessel along the fender line above the rubbing strake 67, illustrated in Figure 30. The partial retraction of the pad 100 back into the vessel hull 5, tensioning the dampener 12.

When the vessel is stationary and in position, the vacuum pads 100 can be extended to attach to either fixed target plates on a floating berth 46 or target plates mounted in a frame with rollers to allow the target plate to maintain the correct height throughout tide change for attachment. This can be done by adding a counterweight 45 and float device to the target plate.

The housing 41 for the ship mounted mooring system 38 is visible from within the vessel, as illustrated in Figure 31. The housing 41 comprises a pair of dampener 12, one for each vacuum pad 100 such that each vacuum pad 100 is independently operable from the other. As described in relation to Figure 5 and 6, the damping mechanism 71 is housed within the dampener 12, such that inner portion 8 and outer portion 7 can extend to engage the pad 100 and retract to provide adjustable levels of damping between the vessel hull 6 and the berth fixture 46.

Within the vessel, the mooring system 38 is securely mounted to a load earing beam or rail 23 mounted to the main beams 60 of the vessel. Multiple ship-mounted mooring systems 38 can be installed on a single vessel depending on the size and weight of the vessel.

Figure 31A illustrates an alternative damping mechanism 71 for the ship mounted mooring system 38. In this embodiment, the dampener 12, as described above, is operatively engaged with the housing 41. The extension of the vacuum pad 100 out of the hull 6 of the vessel is actuated by the damping mechanism 71, driving the inner portion 8 of the dampener 12 away from the housing 41 to engage a mooring structure or the dock 46. Once the vacuum pad 100 is attached to the mooring structure, the dampener 12 and damping mechanism 71 damp the loads exerted by the vessel to bias the vessel towards the neutral position.

Portable Automated Mooring System

Typical automated mooring devices to date have been configured to permanently mount to a dock. This can results in an expensive mooring system as the mooring units have to be spaced along the full length of a dock sufficiently close, to cater for both large and small vessels.

It is against the above backdrop and problems associated therewith that the inventive solutions described herein are provided.

Also described herein is a portable mooring system 33. The system 33 comprises a portable mooring device 20 for mooring a first structure such as a vessel, to a second structure, for example a dock 46. The portable mooring device 20 comprises an engagement assembly: an engagement member, illustrated in Figure 33 as a vacuum pad 100 for releasably engaging a vessel; and a dampener 12 having a first portion 8 and a second portion 7, the first portion 8 being articulately connected to the vacuum pad 100 and the second portion 7 being operably connected to the dock 46 via guide, illustrated in Figure 37 as a mounting frame 72. The dampener 12 and associated vacuum pad 100 are

movably mounted to the frame 72 such that the vacuum pad 100 can be relocated along the frame 72.

The dampener 12 and mounting of the dampener 12 to the vacuum pad 100 can be configured as described herein in reference to Figures 5, 6 and 32 although this part of the portable mooring unit 20 is not visible in Figure 33.

The portable mooring system 33 can comprise one or a plurality of portable mooring devices 20 for use in combination with a fixed formwork 78 mounted to the top or side of the dock 46. The formwork 78 can extend partially or substantially along the length of the dock 46. At predetermined locations along the formwork 78, there are defined docking stations 74, configured to receive the frame 72 of the portable mooring unit 20.

The frame 72 is delivered to the docking station 74 by a specialised vehicle, where the frame 72 and mooring unit 20 are temporarily mounted to the formwork 78 at the docking station 74, and secured thereto. The portable mooring unit 20 illustrated in Figure 33, once attached to the formwork 78 has limited lateral translation. However, the unit 20 is movably mounted to the frame 72 and can vertically travel along the frame 72 to further vary the height of the unit 20 relative to the dock 46 and more importantly any approaching vessel hull 6.

The frame 72 provides a rigid framework for supporting the mounting unit 20. The frame 72 comprises a top mount 86 for securing the unit to the docking station 74 or the dock 46. The bottom of the frame 72 provides locking section 79 for securing the frame 72 in position upon the formwork 78. Finally the frame 72 provides a pair or tracks 85 along which the mooring unit 20 can travel.

In an alternative embodiment, the mooring unit 20 can be mounted to the frame 72 to provide horizontal adjustment within the docking station 74. Any of the features of the frame 72, the top mount 86, the locking section 79 and the tracks 85 can be relocated depending on the dock 46 docking station 74 to be accommodated. For example, the mounting 86 can be centrally located or mounted to the side face of the dock 46. Furthermore a single track 85 can be used and not a pair of tracks 85, thereby providing manoeuvrability of the unit 20 and saving weight in the frame 72.

The portable mooring unit 20 is a mechanical electrical design and can be completely self-contained requiring only a power connection or access to a power connection at the docking station 74. It is contemplated that a generator or other portable power source could be installed into the mooring unit 20.

The mooring units 20 and associated frames 72 can be removed from the dock 46 when not in use and stored out of the weather. This allows for simplified access to the units 20 for maintenance and also an increased working life of the unit 20, as they are not constantly exposed to harsh, corrosive dockside conditions.

A customised vehicle 73 is configured to pick-up a complete unit 20 and frame 72, illustrated in Figure 34. The vehicle 73 delivers the unit 20 to the docking station 74, locates the frame 72 within the formwork 78 and secures the unit 20. The vehicle 73 can repeat the above process to set-up as many units 20 are required to dock a given vessel. In this manner a bespoke mooring layout for an incoming vessel can be configured.

The vehicle 73 provides a base 76 for supporting the unit 20 and frame 72 and a pair of moving supports 75. The supports 75 can travel along the length of the base 76 of the vehicle 73 to thereby extend the frame 72 over the docking station 74, as illustrated in Figure 35. The vehicle 73 parks at right angles to the berth 46 to align with the docking station 74. The mooring unit 20 is contained within its frame 72 which is fastened to the vehicles moveable supports 75.

An alternative to the customised vehicle 73 can use a frame 72 configured such that a common forklift or small crane can pick-up and transport the unit 20 to the docking station 74.

When the supports 75 reach the rear of the vehicle 73, a rotary mechanism 77 is activated, to reorient the frame 72 and mooring unit 20 to be received by the formwork 78, illustrated in Figure 36. In this embodiment the formwork comprises a series of upright

supports, or piles 4 a lower braced beam 80 and an upper mounting beam 80a. The upper mounting beam 80a provides a cross-rail for the piles 40 to be attached to. The upper mount 80a is permanently affixed to the dock 46 at intermediate locations along its length. The lower braced beam 80 provides a retaining member to which the locking section 79 of the frame 72 can attach.

Alternatively to the berth 46 illustrated in Figures 33 to 40 where the open structure requires support beam member 80, a solid berth can be used to mount the system 33. For a solid berth 46, a series of rigid support members 47, for example locating lugs, can be installed along the top of the berth 46 and similar lugs provided along the lower section of the berth 46.

Figure 37 is a perspective view of the vehicle supporting the mooring unit parked at right angles to an installation location along a berth, wherein an extension mechanism of the customised vehicle slides the mooring unit and attached frame into the installation location.

In Figure 35, the locking section 79 of the frame 72 is illustrated as a C-section although an I-beam or similar profile can also be used. As the frame 72 is rotated to be oriented vertically, and lowered down the dock 46 towards the water, the C-section engages the lower braced beam 80 and counterbalances the weight of the mooring unit 20 at the opposing end of the frame 72. The portable mooring unit 20 is primarily supported by the top mount 86, illustrated in Figures 39 and 40, mounted to the dock 46. As additional weight of the unit 20 increases the handling difficulties of this system 33, the top mount can be configured to attach to the dock 46 and not rely solely on weight to maintain its location on the dock 46.

The moving supports 75 are attached to the tracks 85 of the frame 72 such that the supports 75 can lower the mooring unit 20 down the front face of the berth 46 at the installation location 74 and into an aligned position within the fixed formwork 78, as illustrated in Figure 38. The vehicle 73 then reverses so that the mooring unit 20 and frame 72 can be attached to the fixed formwork 78, illustrated in Figure 39.

The top mount 86 locks into the top of the dock 46 and the locking section 79 engages with the lower bean 80, illustrated in Figure 40. The unit 20 can then be translated along the tracks 85 of the frame 72. The mechanism for moving the unit 20 upon the frame 78 is described in detail in relation to Figure 32, using a motor 59 or winch 52 and chains 87 or cables 51a to raise and lower the unit 20 upon the frame 72. Once a vessel hull 6 has been secured to the unit 20 via the vacuum pad 100, the mooring unit 20 is free to move vertically with the movement of the vessel.

The mooring unit 20 is sprung in mid position between the vertical frames 85 to allow for some horizontal movement when attached to a vessel hull 6. The spring mounting employed can be in accordance with any of the embodiments described herein (see Figure 41).

With the mooring unit 20 and frame 72 in place, the vehicle 73 disengages from the unit 20. The unit 20 is then plugged into a power source 65 and activated. Each mooring unit can be operated manually or operated in combination with a plurality of portable mooring units 20 to operate collectively by radio control.

The portable mooring system 33 as described above can further be used in conjunction with the fixed mooring systems 30, 32, 34, 35, 36, 37 and 38 as described herein. In this manner, additional mooring capability can be used to augment a dock 46 to restrain a particular vessel.

Figure 41 is a transparent, perspective view of the housing 41 of the portable mooring unit 20 of Figures 33 to 40. The housing 41 is hoisted along the tracks 85 by virtue of a chain drive, as described in reference to Figures 32 and 32A.

Two dampeners 12 are also illustrated in Figure 41, mounting the vacuum pad 100 to the portable mooring unit 20. These dampeners 12 are configured in accordance to that described in Figure 5, but are not limited to such an arrangement.

The vacuum pad 100, of Figure 41, comprises to separate dampeners 12 supporting a single vacuum pad 100. However, any number of pads 100 and dampeners 12

can be configured to cooperate within a single portable mooring unit 20 as required for the size and type of vessel to be accommodated.

The vacuum pad 100 is mounted about a pivot 54 which allows the pad 100 to rotate about the z-axis accommodating the yawing motion of the vessel in relation to the length of the dock 46. Furthermore, a series of four springs 13 are positioned about either side of the pivot 54 to passively bias the vacuum pad 100 back to a centralised position upon the yoke 81. When attached to the vessel, the vessel will pull on the pad 100 as the tide pulls the vessel along the dock 46. The motion is resisted by the opposing pair of spring 13 to maintain the vessel in the initial docked position suitable for loading and unloading of goods

It will be appreciated by persons skilled in the art that numerous variations and modifications may be made to the above-described embodiments, without departing from the scope of the following claims. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.

Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is not to be taken as an admission that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed before the priority date of each claim of this application.

In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word “comprise” or variations such as “comprises” or “comprising” is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

CLAIMS:

1. A mooring device for mooring a first structure to a second structure, the device comprising:
an engagement member for releasably engaging the first structure;
a dampener having a first portion movably connected to a second portion, the first portion being connected to the engagement member and the second portion being connected to the second structure,
wherein the dampener is configured to damp load transfer between the first and second portions of the dampener and thereby damp relative motion between the first and second structures.

2. The mooring device of claim 1, wherein the dampener includes a damping mechanism configured to move the first portion of the dampener relative to the second portion of the dampener.

3. The device of claim 2, wherein the damping mechanism comprises a tensioner, the tensioner being in resilient communication with opposing ends of the first portion of the dampener such that movement of the tensioner urges the first portion of the dampener to move relative to the second portion of the dampener.

4. The device of claim 3, wherein a first end of the first portion of the dampener is operably engaged with the tensioner via a first resilient member and a second end of the first portion of the dampener is operably engaged with the tensioner via a second resilient member.

5. The device of claim 4, wherein the tensioner includes opposing faces acting as surfaces against which the first and second resilient members are respectively supported.

6. The device of any one of claims 3 to 5, wherein the damping mechanism further comprises a drive mechanism, the drive mechanism configured to drive the tensioner toward or away from the second portion of the dampener.

7. The device of claim 6, wherein the drive mechanism includes a worm drive directly engaged with the tensioner.

8. The device of any one of claims 3 to 7, wherein motion of the tensioner within the first portion of the dampener, in a first direction, pushes on the first end of the first portion of the dampener via the first resilient member, thereby moving the first portion of the dampener toward the second structure.

9. The device of any one of claims 2 to 8, wherein the damping mechanism is sealingly housed within the first portion of the dampener.

10. The device of any one of the preceding claims, wherein the first portion is telescopically movable within the second portion.

11. The device of claim 4, wherein the first and second resilient members comprise at least one of the following: a resilient member, a spring, a series of springs, an air bellow, a plurality of rubber balls or an air cylinder.

12. A method of engaging an engagement member on a mooring device to a vessel, comprising:

storing a negative pressure in a vacuum storage cavity in the engagement member, wherein the negative pressure is generated before the engagement member contacts a vessel;

contacting a vacuum pad of the engagement member with the vessel so to create a suction cavity; and

transferring air from the suction cavity into the vacuum storage cavity to create a vacuum pressure in the suction cavity thereby holding the engagement member to the vessel.

13. The method of claim 12, wherein the engagement member is driven into contact with the vessel by an electro-mechanical mechanism.

14. A vacuum engagement member for engaging a vessel to a mooring device, comprising a vacuum pad supported by a frame and a perimeter seal extending around the vacuum pad on the frame; the engagement member including a vacuum storage cavity in communication with the vacuum pad so that when the vacuum pad contacts a vessel a suction pressure is created through air transferring from between the vacuum pad and vessel into the vacuum storage cavity.

15. A mooring unit comprising:

a mooring device according to any one of claims 1 to 11; and

a support,

wherein the second portion of the dampener is mounted to the support , the support being connected to the second structure.

16. The mooring unit of claim 15, wherein the second portion of the dampener is pivotally connected to the support such that the dampener can pivot relative to the second structure in at least one direction.

17. An adjustable mooring unit for mooring a vessel to a dock, the adjustable mooring unit comprising:

a mooring device having an engagement member for releasably engaging a vessel;

a guide on which the mooring device is mounted; and

an adjustment system for moving the mooring device along the guide.

18. The adjustable mooring unit of claim 17, wherein the engagement member is a vacuum pad.

19. The adjustable mooring unit of claim 17 or claim 18, wherein the mooring device further comprises a dampener having a first portion movably connected to a second portion, the first portion being connected to the engagement member and the second portion being connected to the dock, wherein the dampener is configured to damp load transfer between the first and second portions of the dampener and thereby damp relative motion between the vessel and the dock

20. An apparatus for mooring a vessel to a structure, the apparatus comprising:

a body comprising a float by which the apparatus remains buoyant in water; and

an attachment system supported by the body for attaching the vessel and structure to the apparatus.

21. The apparatus of claim 20, wherein the float is inflatable and deflatable.

22. The apparatus of claim 20 or claim 21, wherein the attachment system comprises a vacuum engagement member.

23. A ship mounted mooring unit, for mooring a ship to a structure, the mooring unit comprising:

a mooring device having an engagement member for releasably engaging the structure; and

a support for mounting the mooring unit within a cavity of the ship,

wherein the mooring device selectively moves between an operative condition, where the engagement member is oriented to engage the structure, and a stowage condition, where the engagement member is retracted to be stowed within the cavity.

24. The ship mounted mooring unit of claim 23, wherein the support comprises a dampener having a first portion movably connected to a second portion, the first portion being connected to the engagement member and the second portion being connected to the ship, wherein the dampener is configured to damp load transfer between the first and second portions of the dampener and thereby damp relative motion between the ship and the structure.

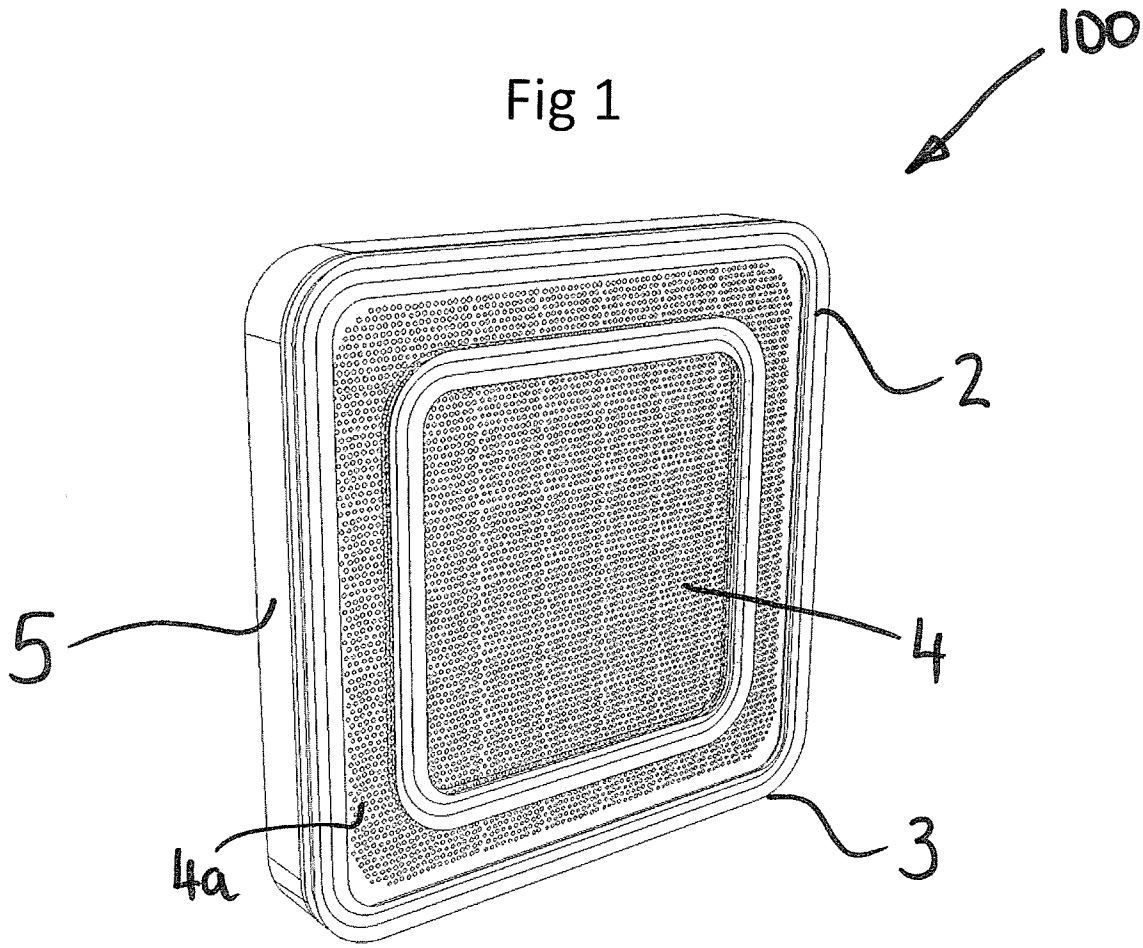
25. A portable mooring device for mooring a vessel to a structure, the device comprising:

a guide configured to detachably engage with a structure; and

an engagement assembly movably mounted to the guide such that the engagement assembly can be moved to a predetermined position along the guide, wherein the engagement assembly releasably engages the vessel to moor the vessel to the structure;

26. The portable mooring device of claim 25, wherein the engagement assembly comprises an engagement member and a dampener connected to the engagement member.

Fig 1



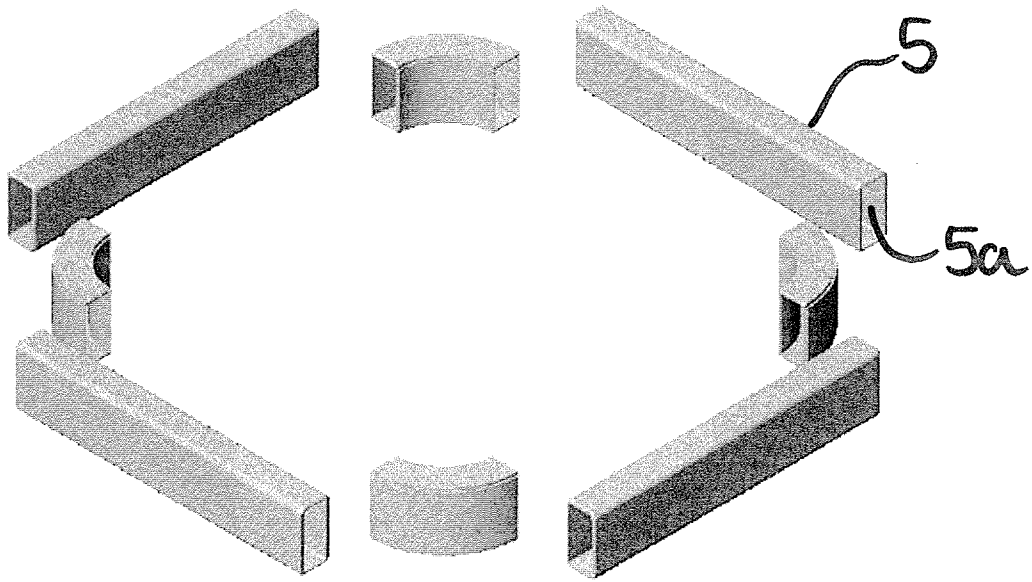
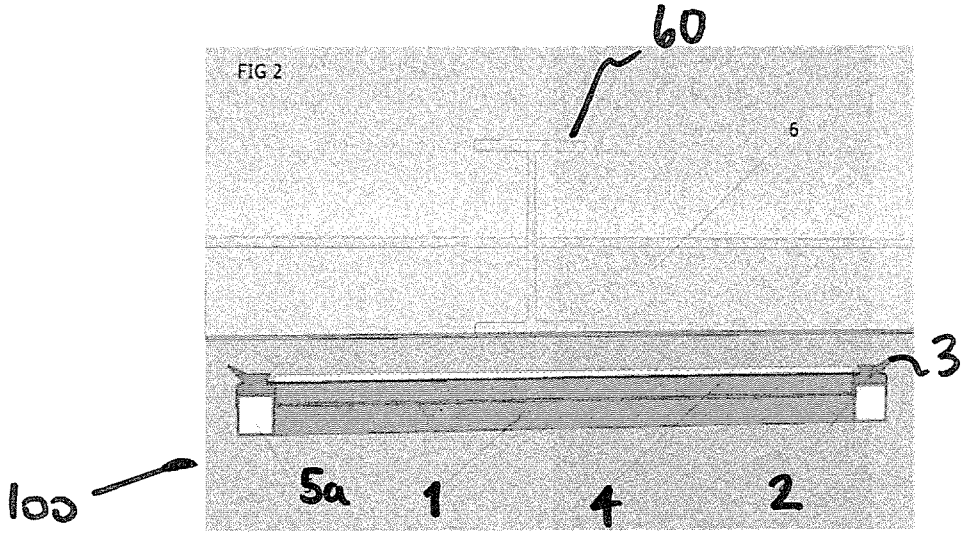


Fig 1A

Fig 2



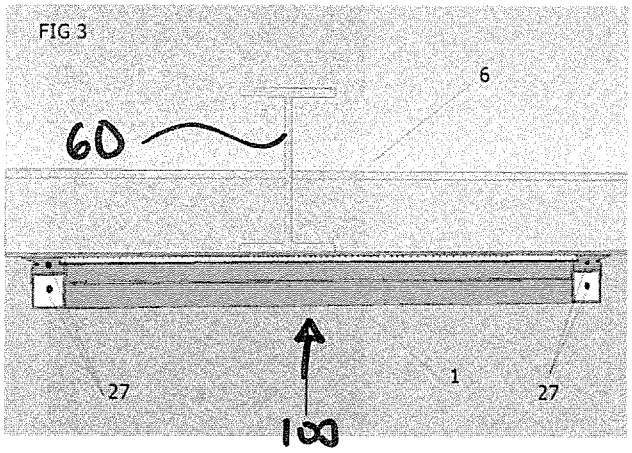


Fig 3

Fig 3A

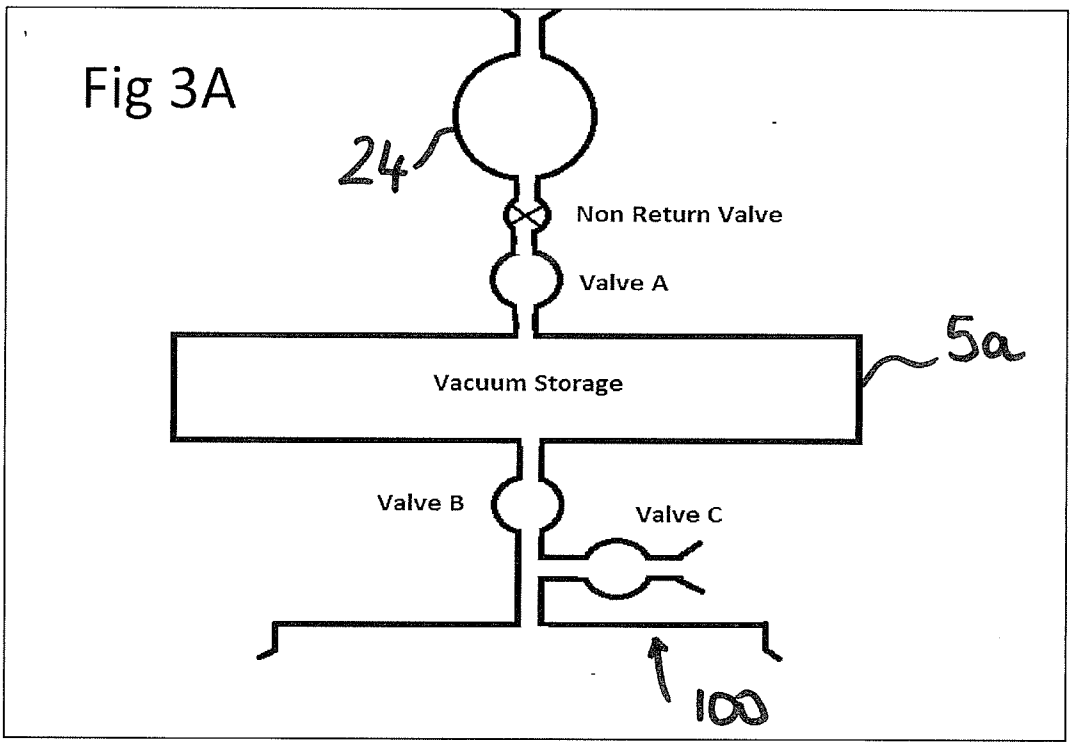
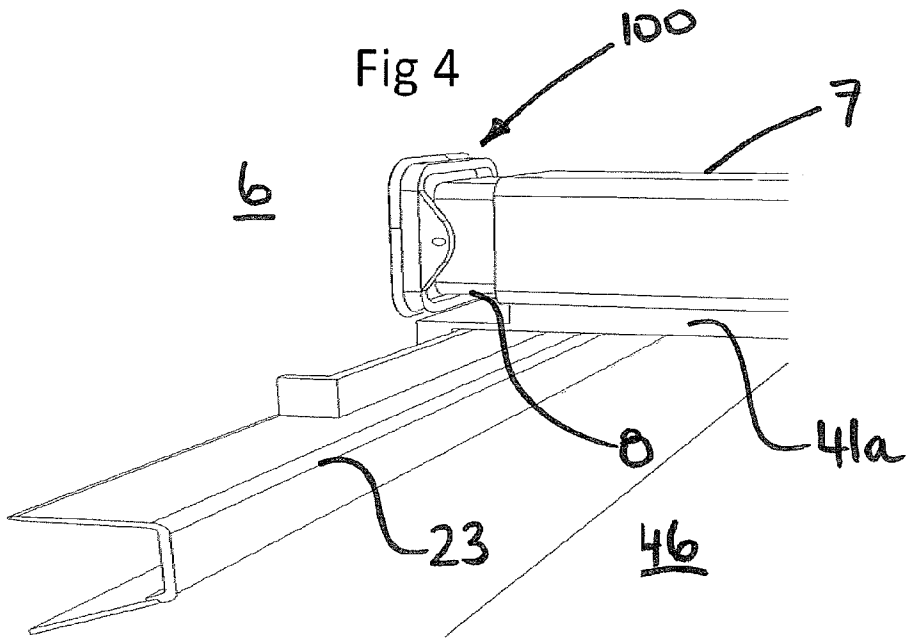


Fig 4



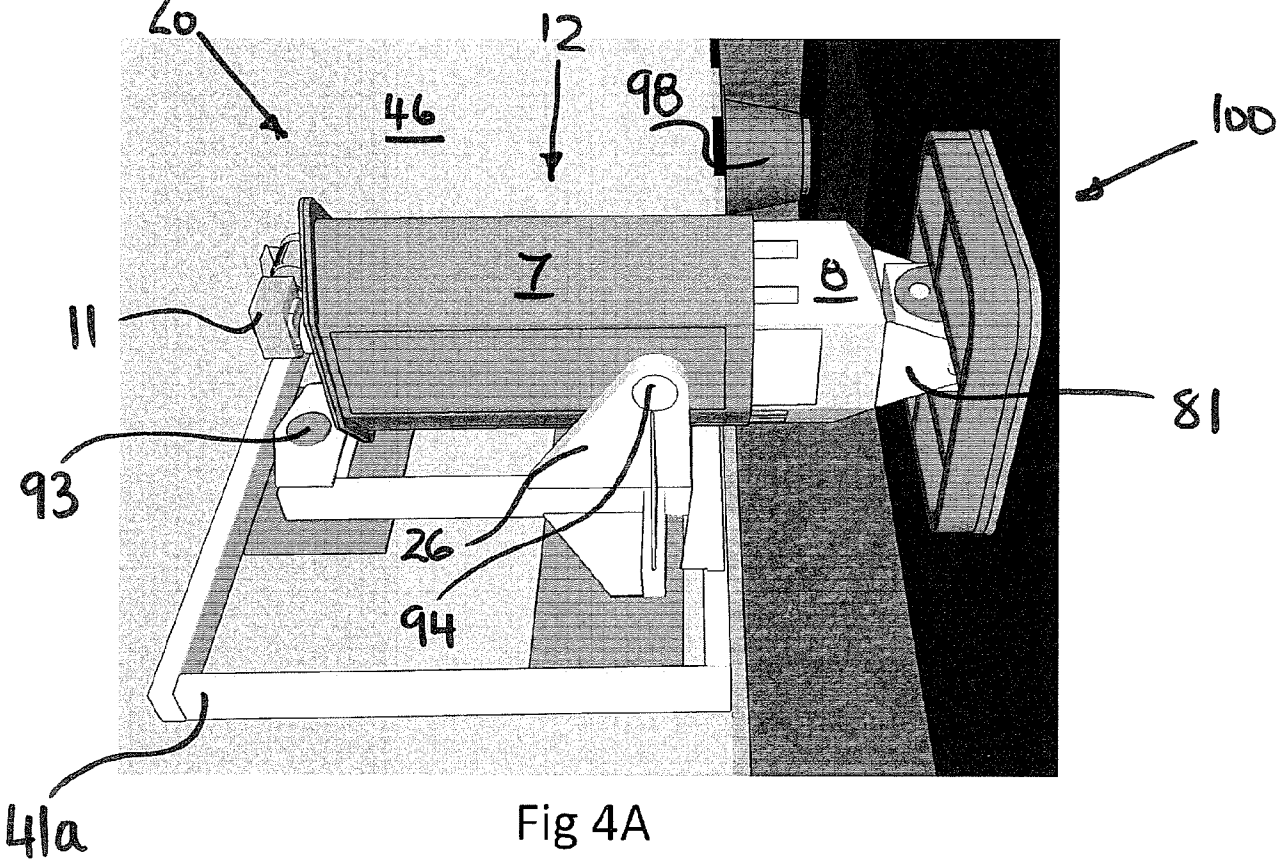


Fig 4A

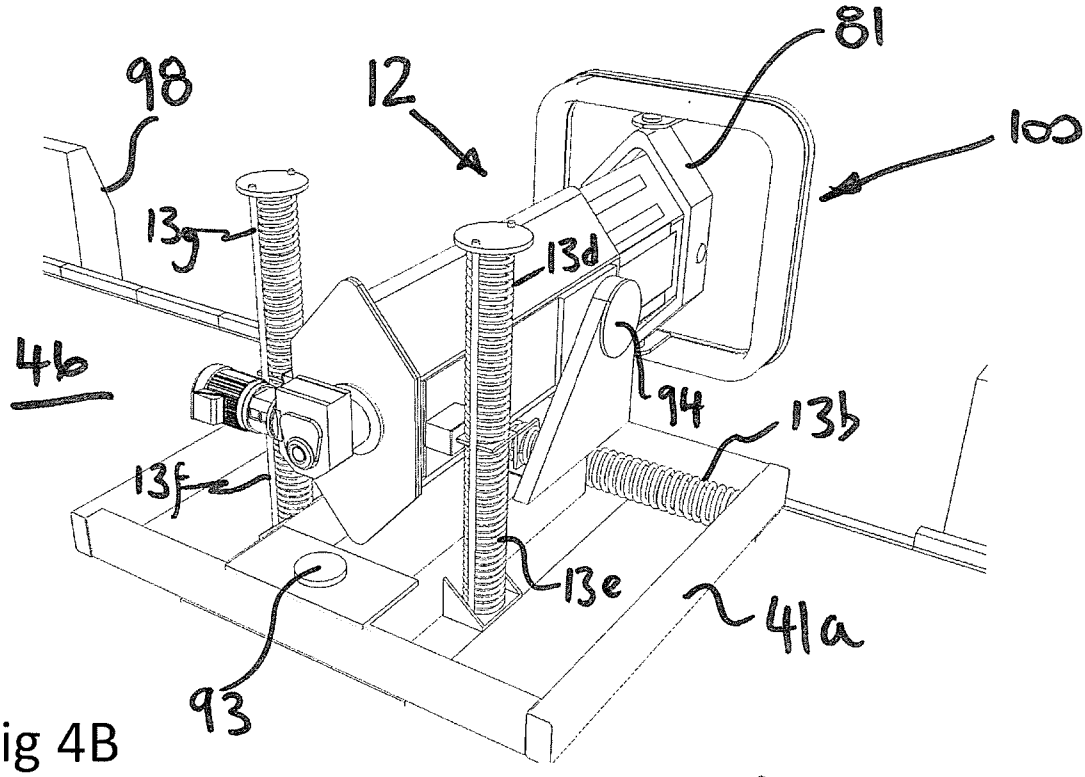

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Fig 4B

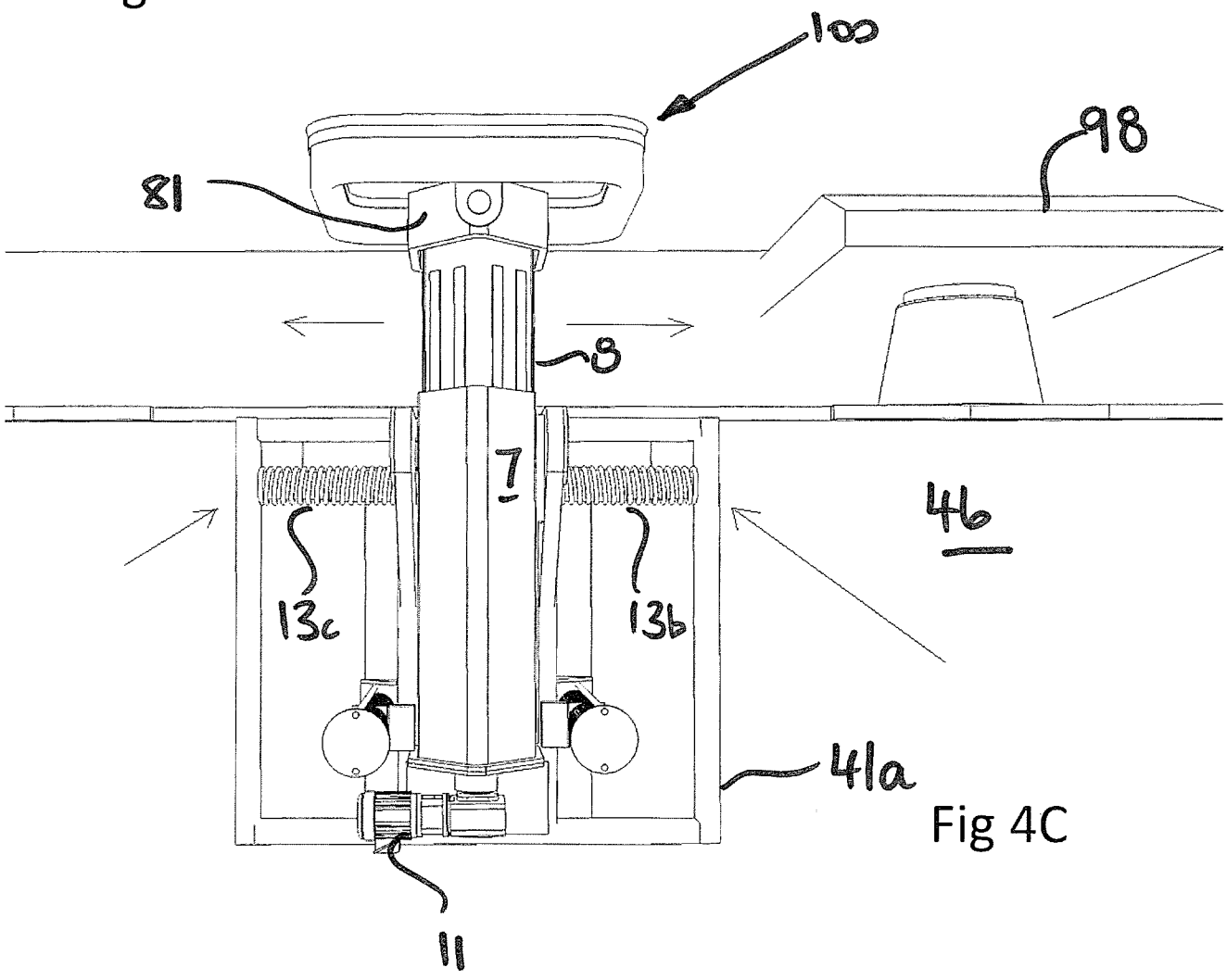

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13c
13b
41a
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Fig 4C

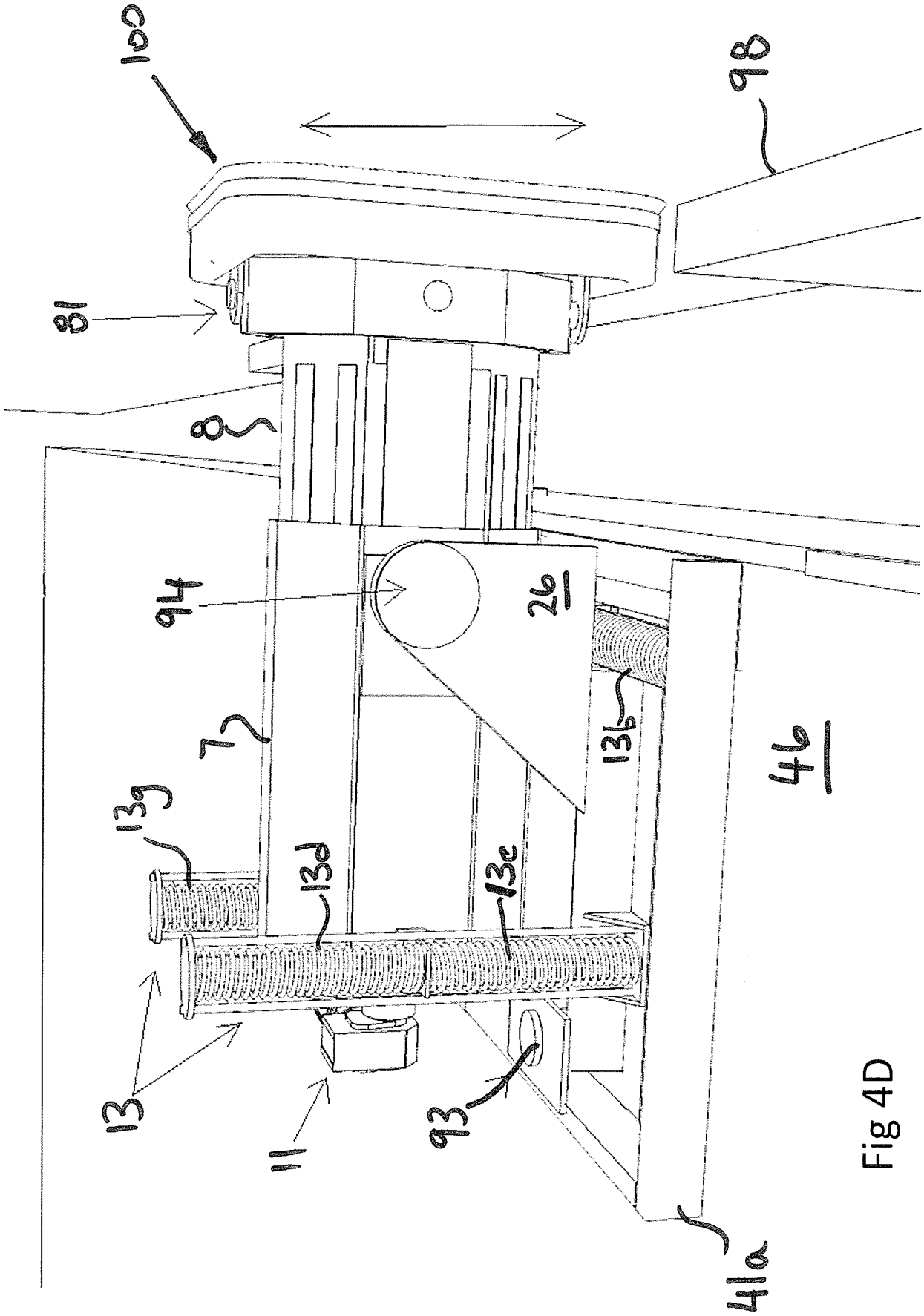


Fig 4D

Fig 4E

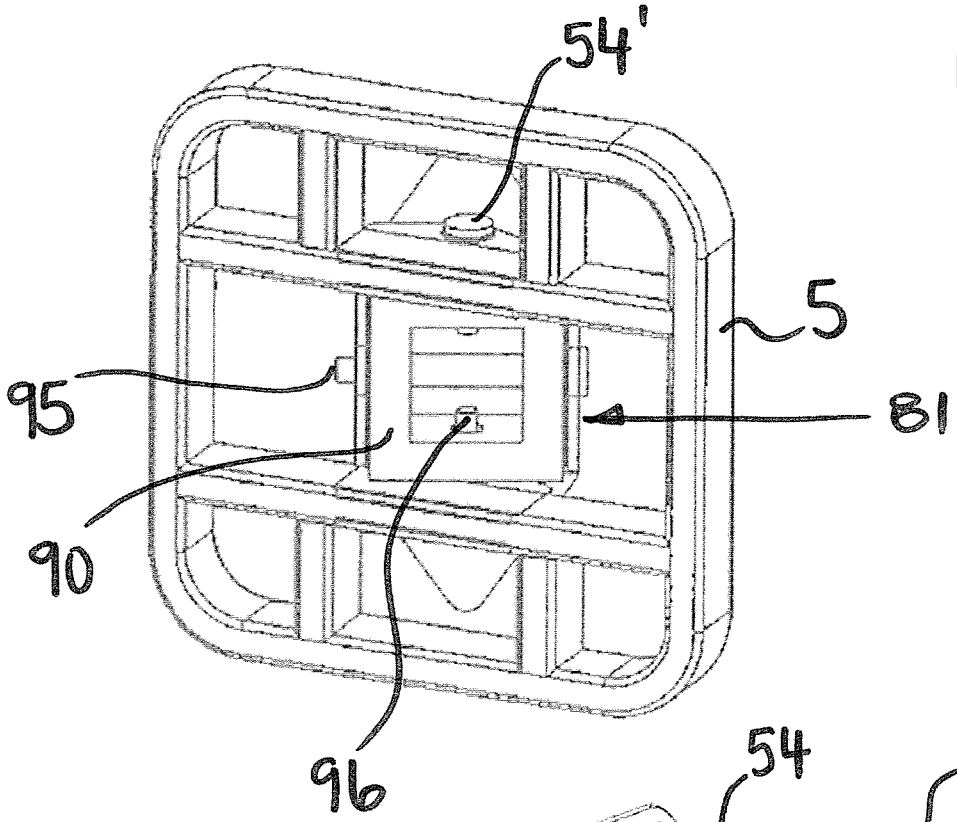


Fig 4F

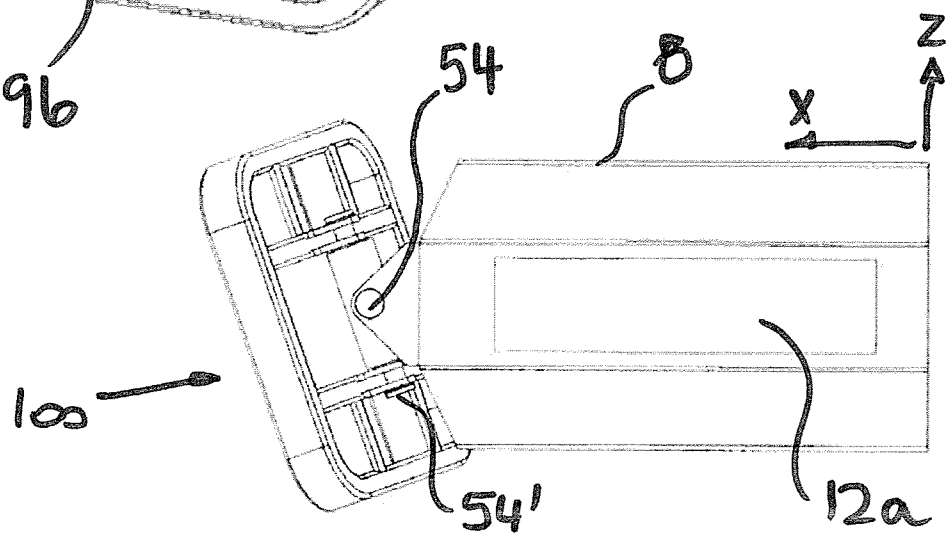


Fig 4G

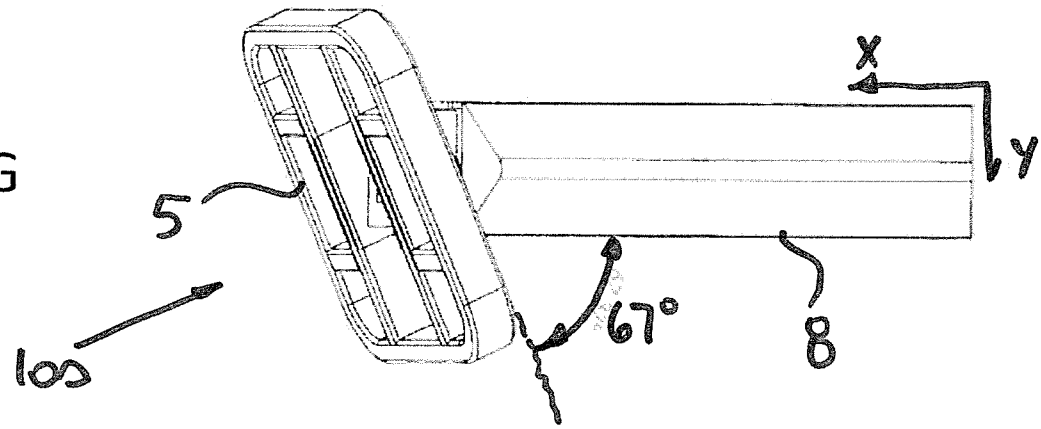


Fig 5

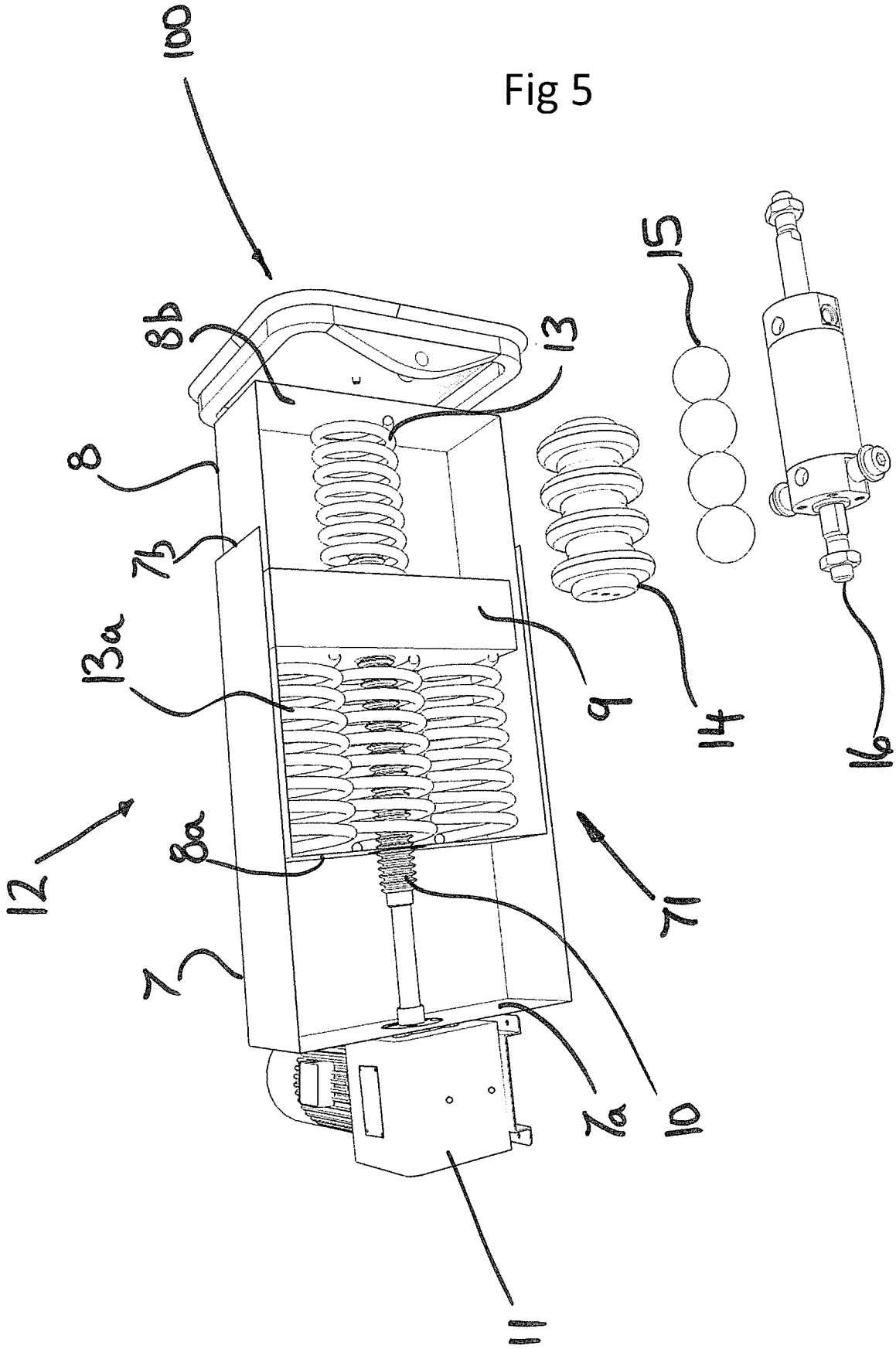
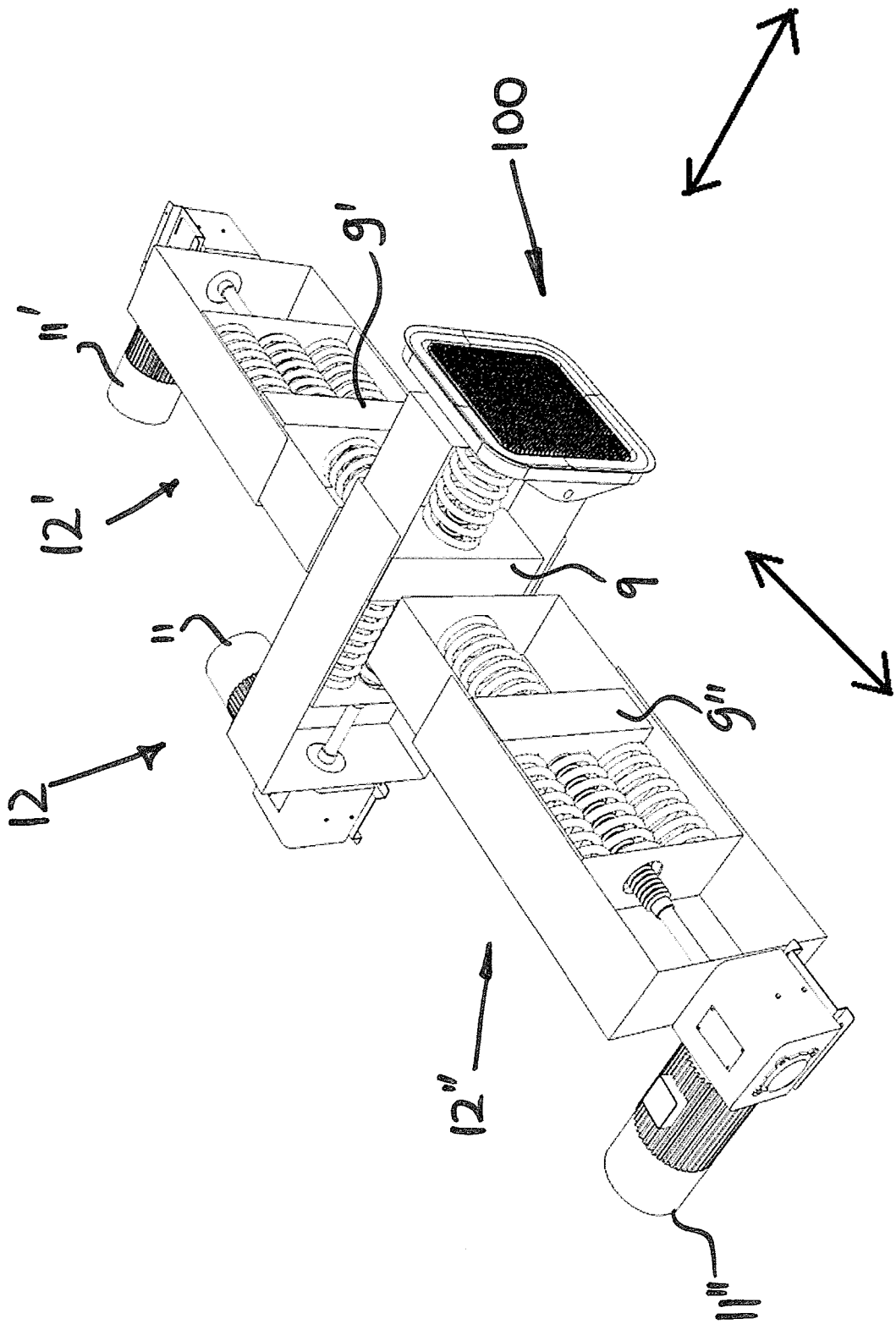


Fig 5A



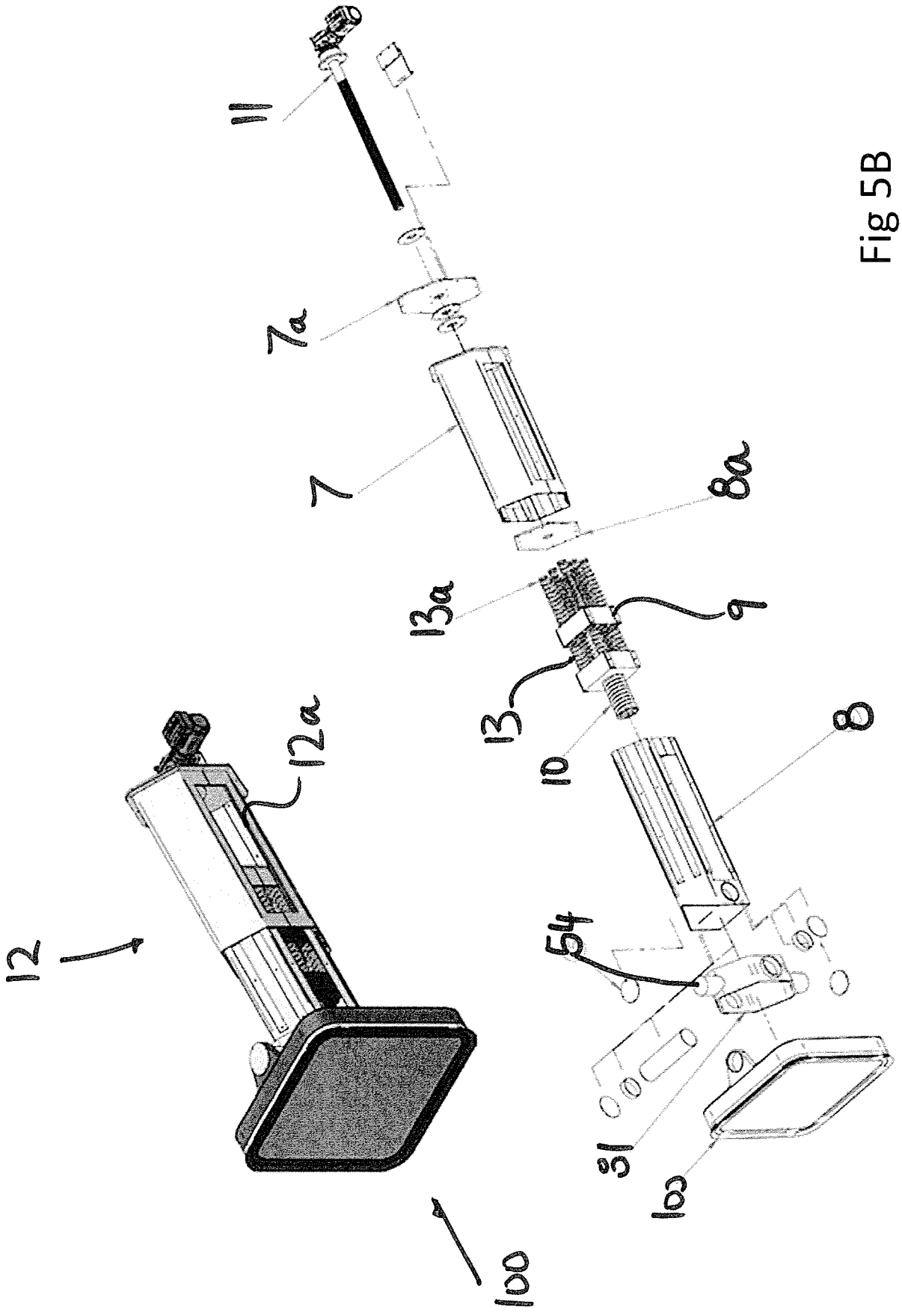
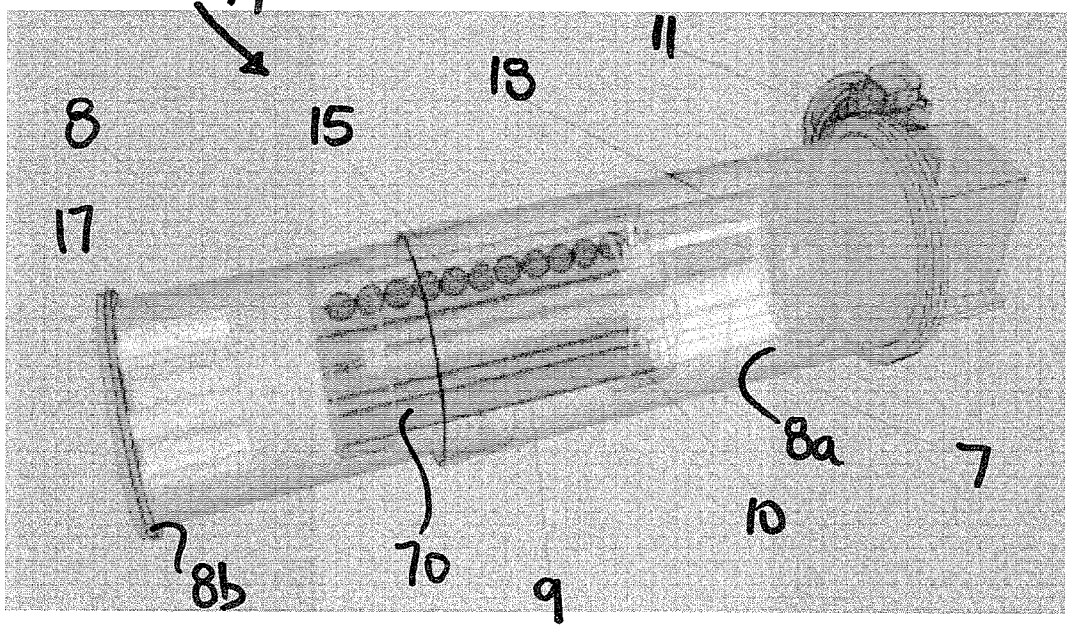


Fig 5B

Fig 6


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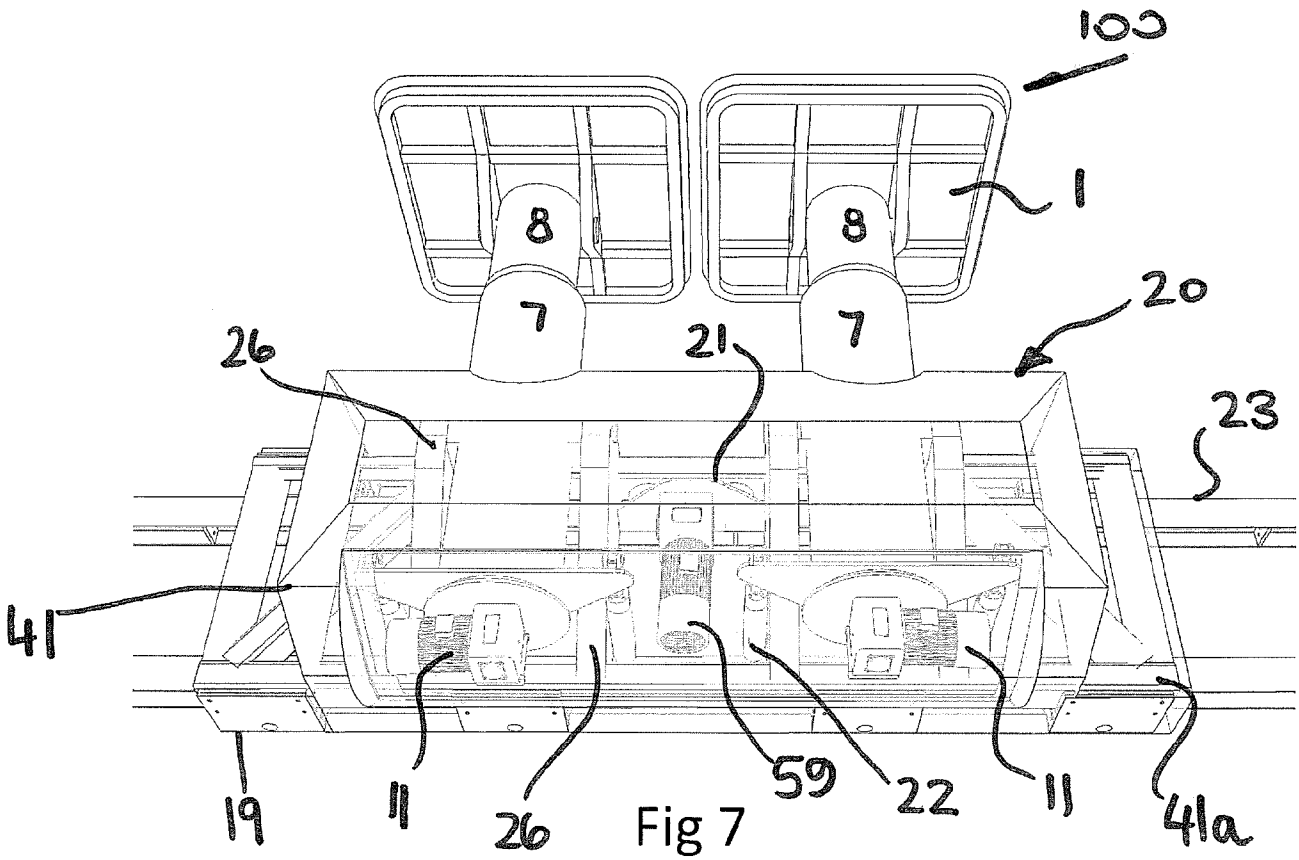
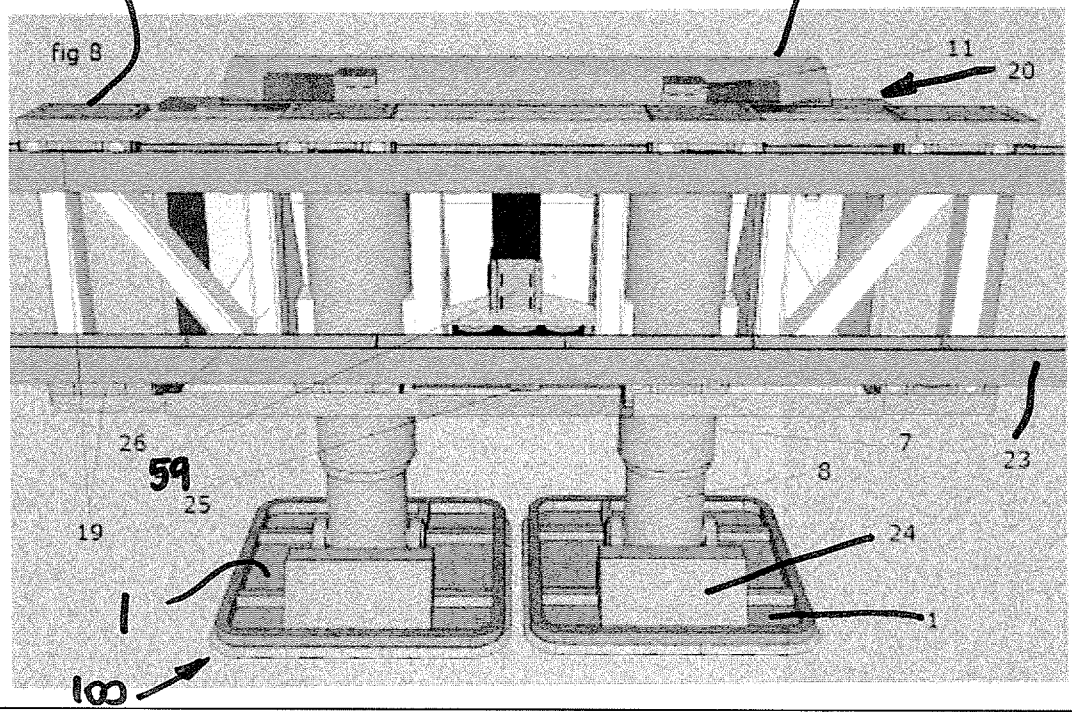

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Fig 7

Fig 8



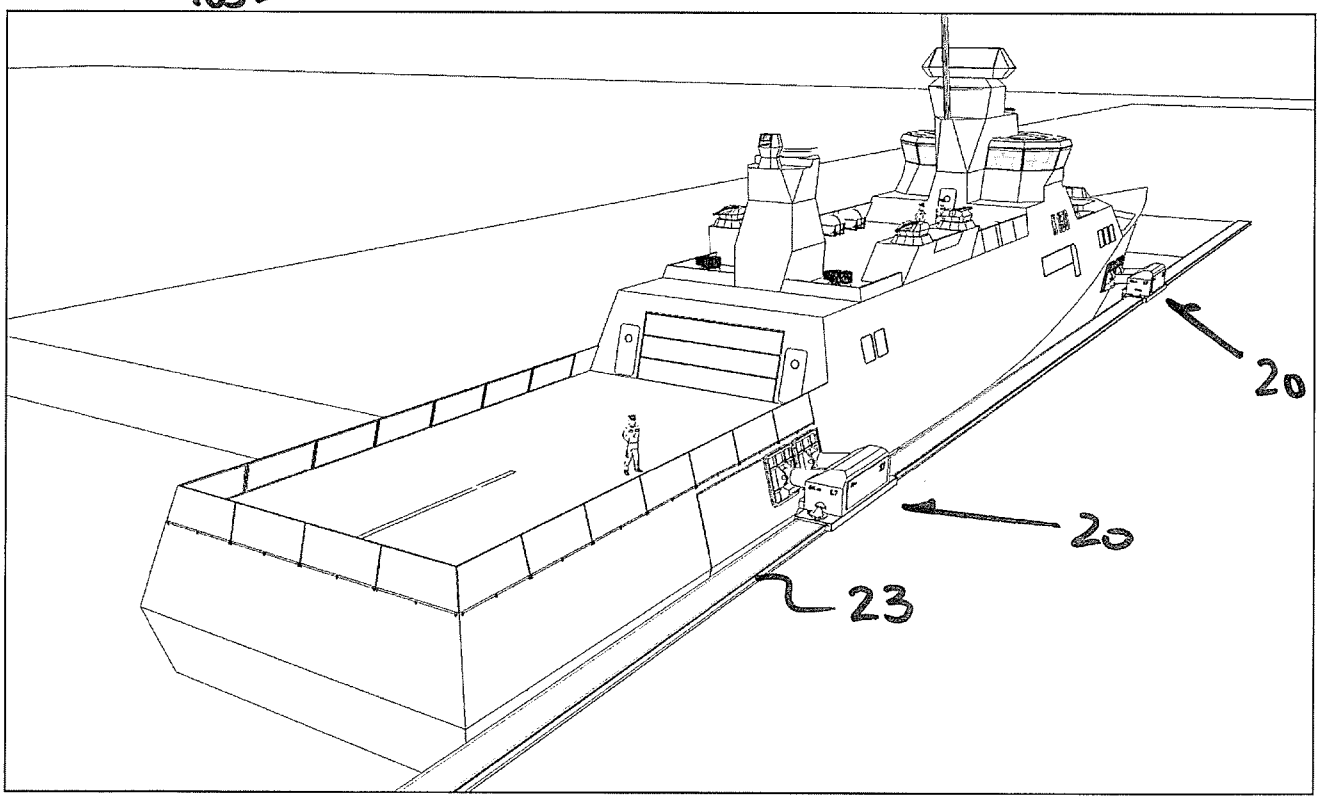


Fig 9

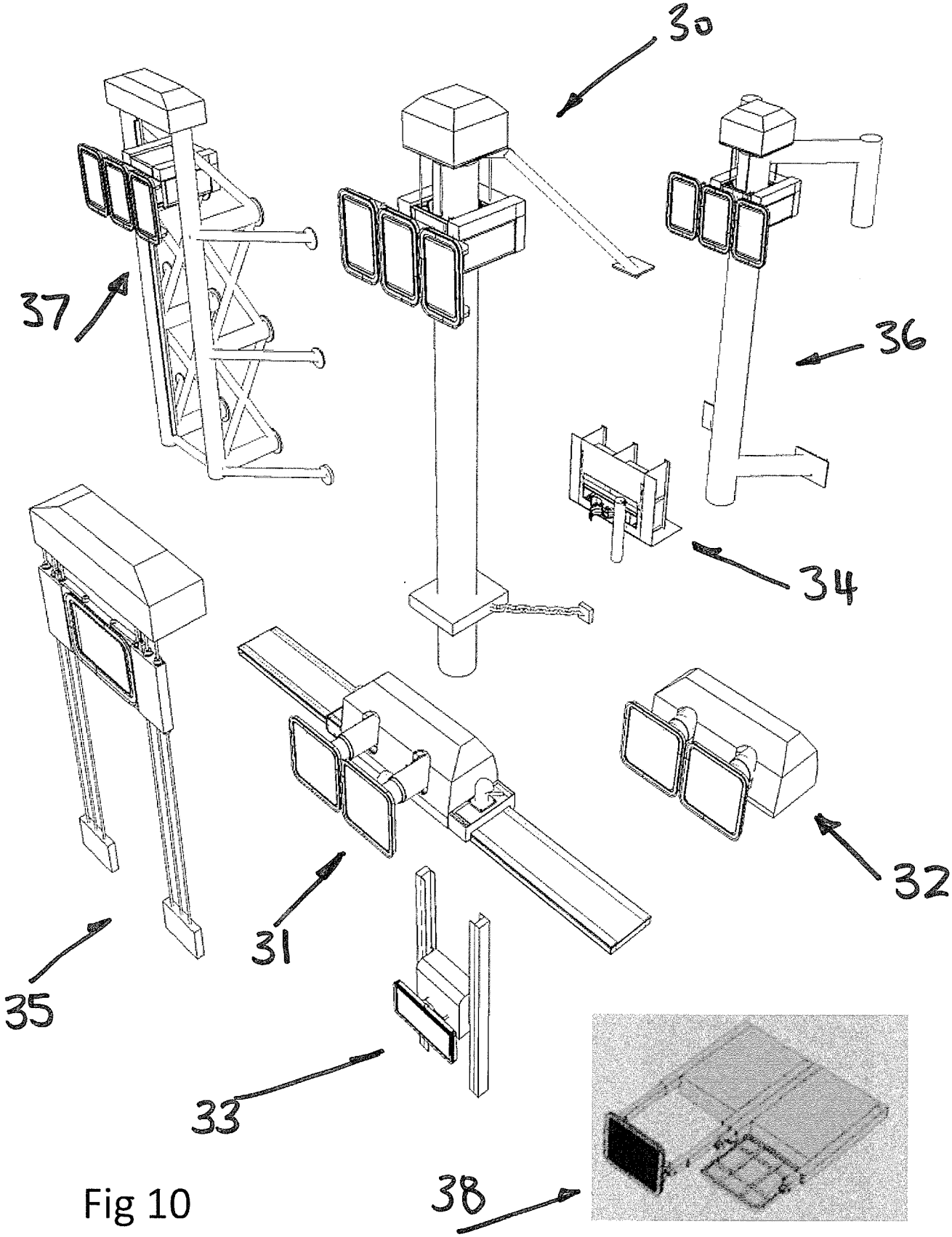


Fig 10

Fig 11

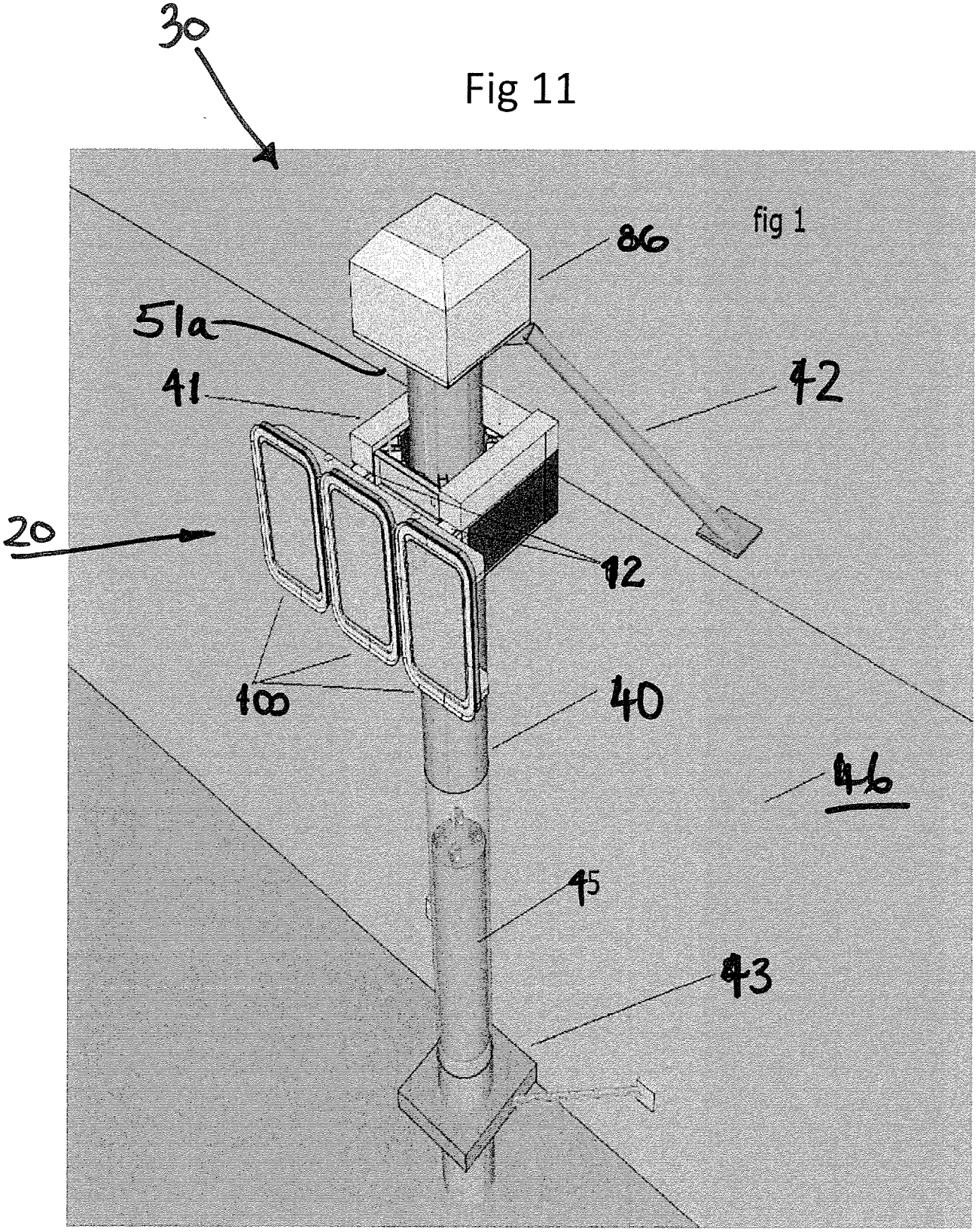
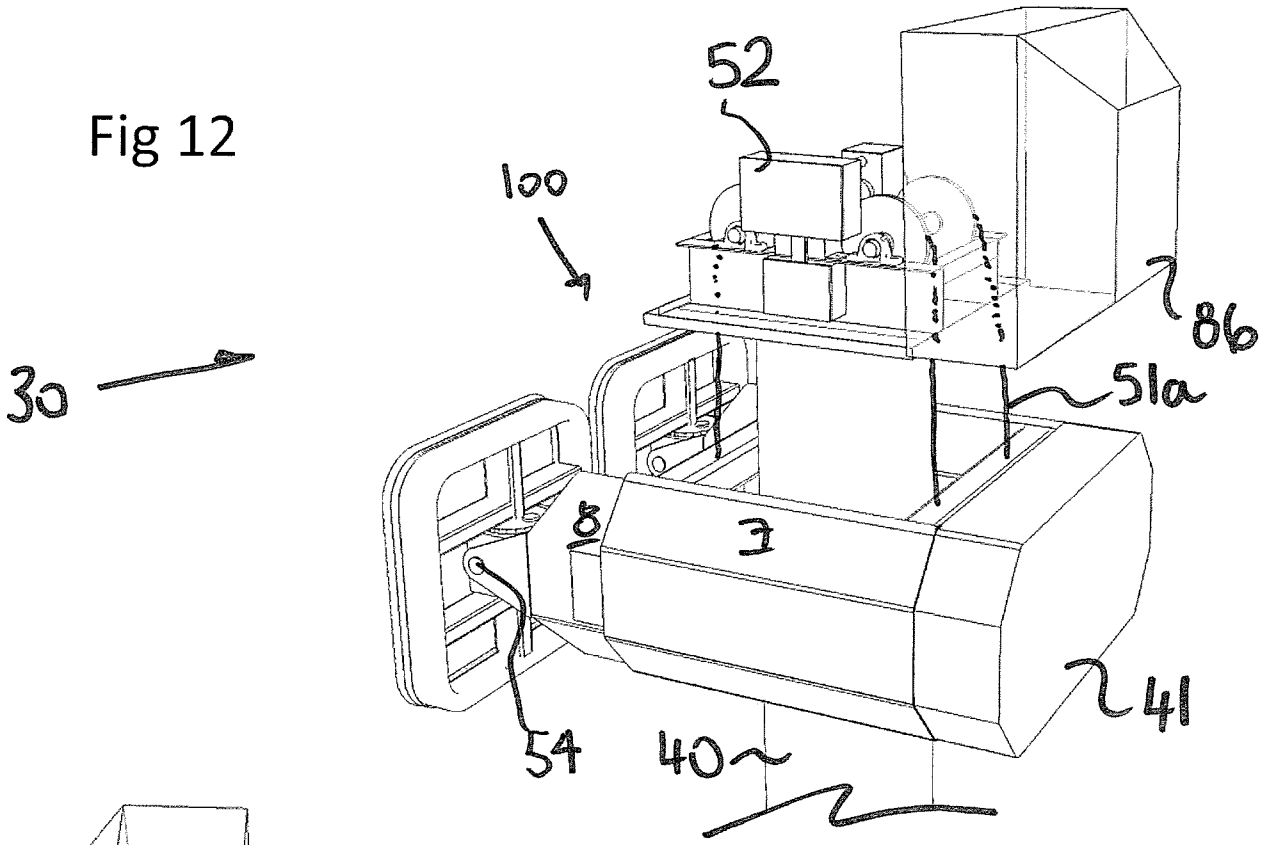


Fig 12



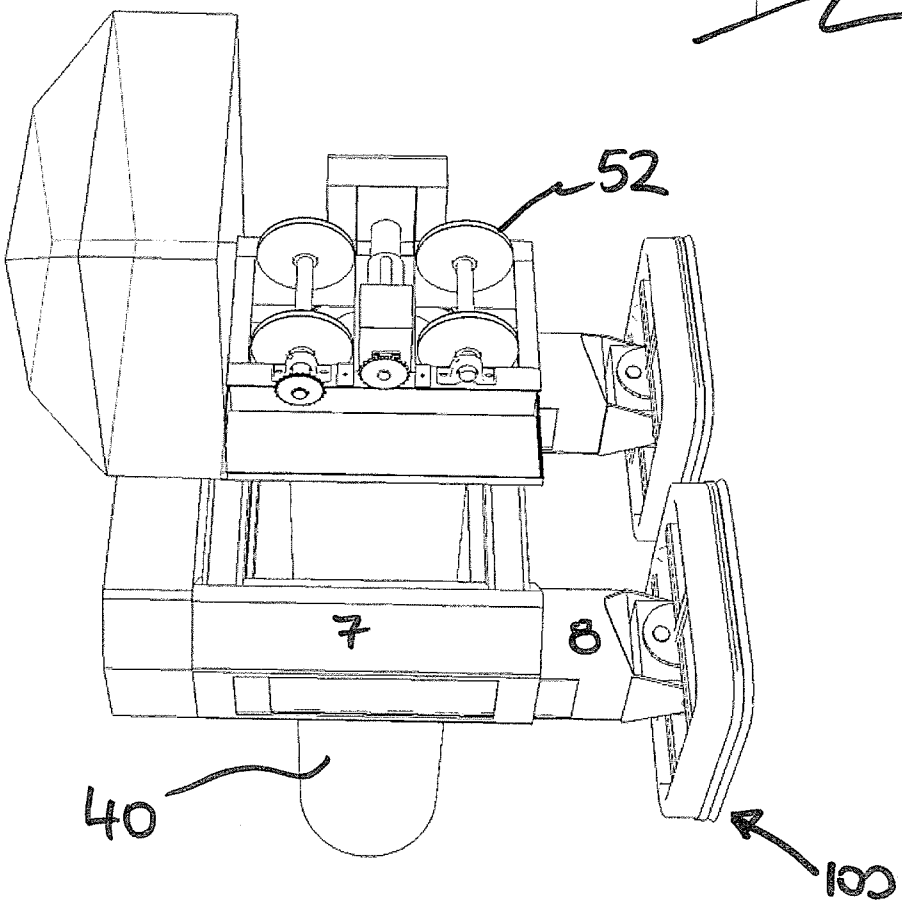
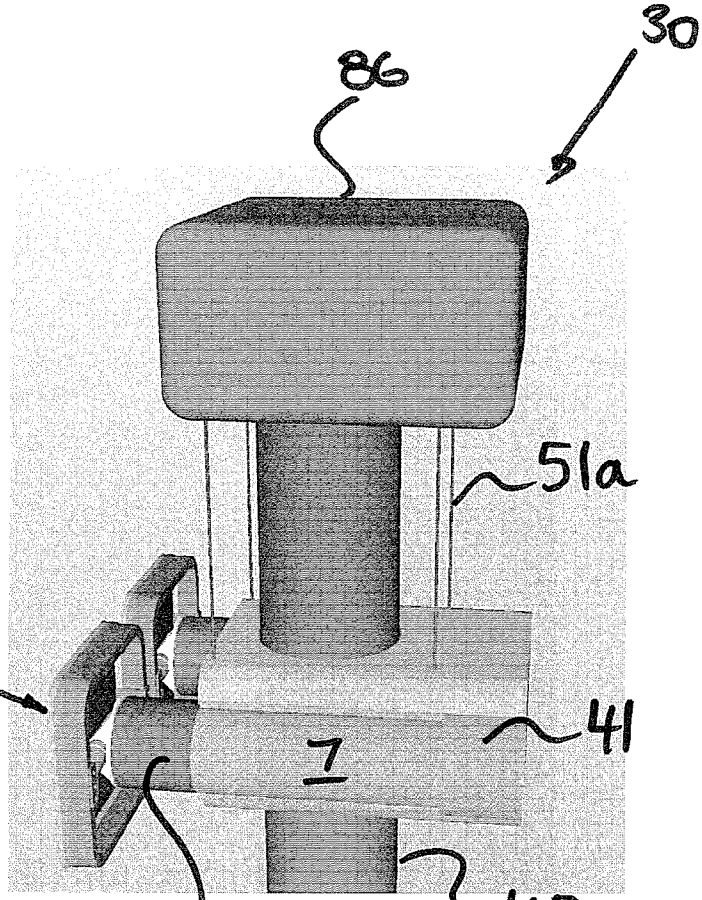


Fig 12A

Fig 13



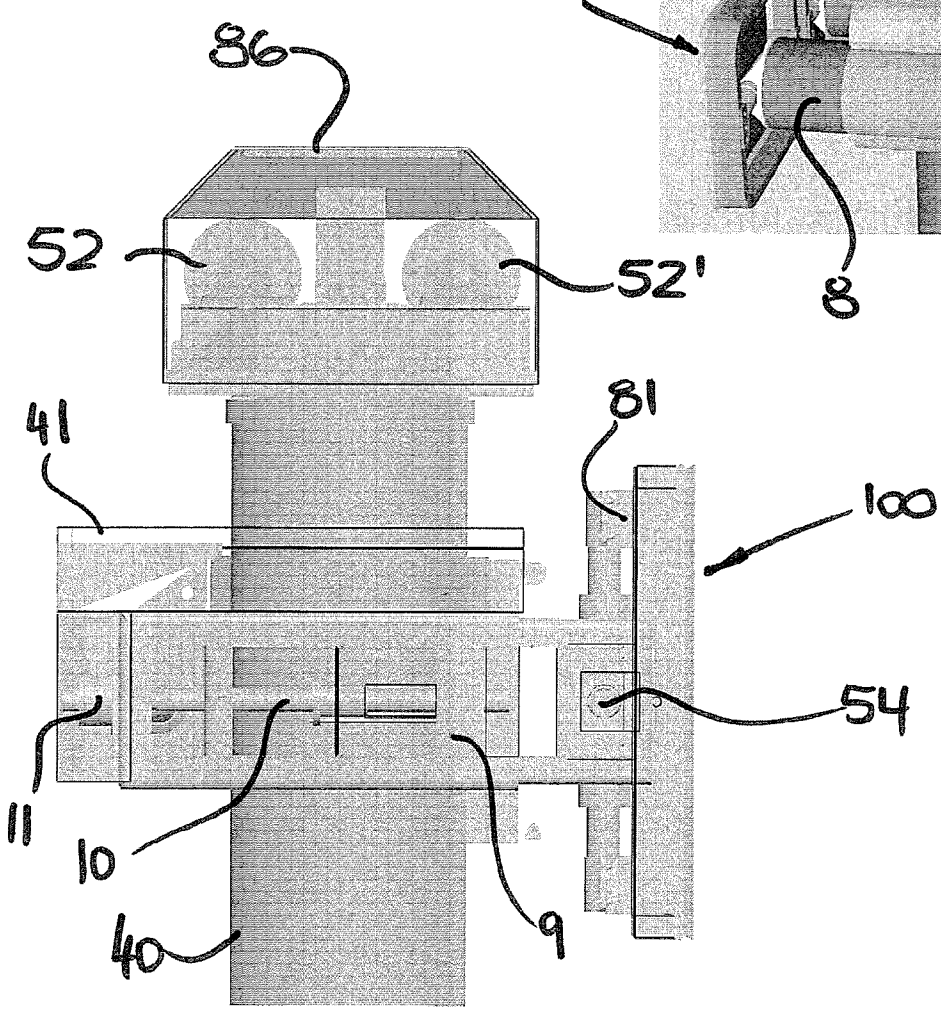


Fig 14

Fig 15

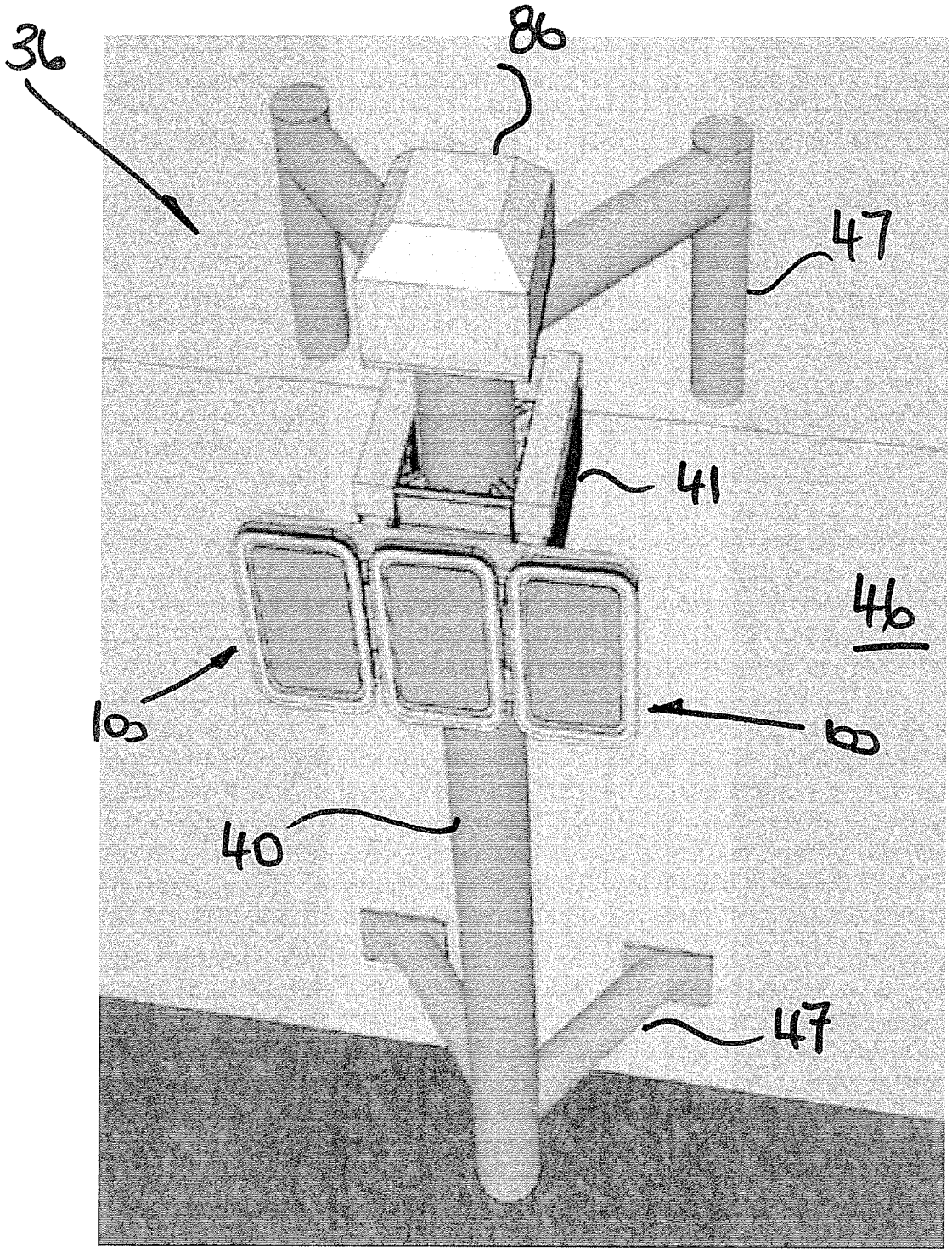


Fig 16

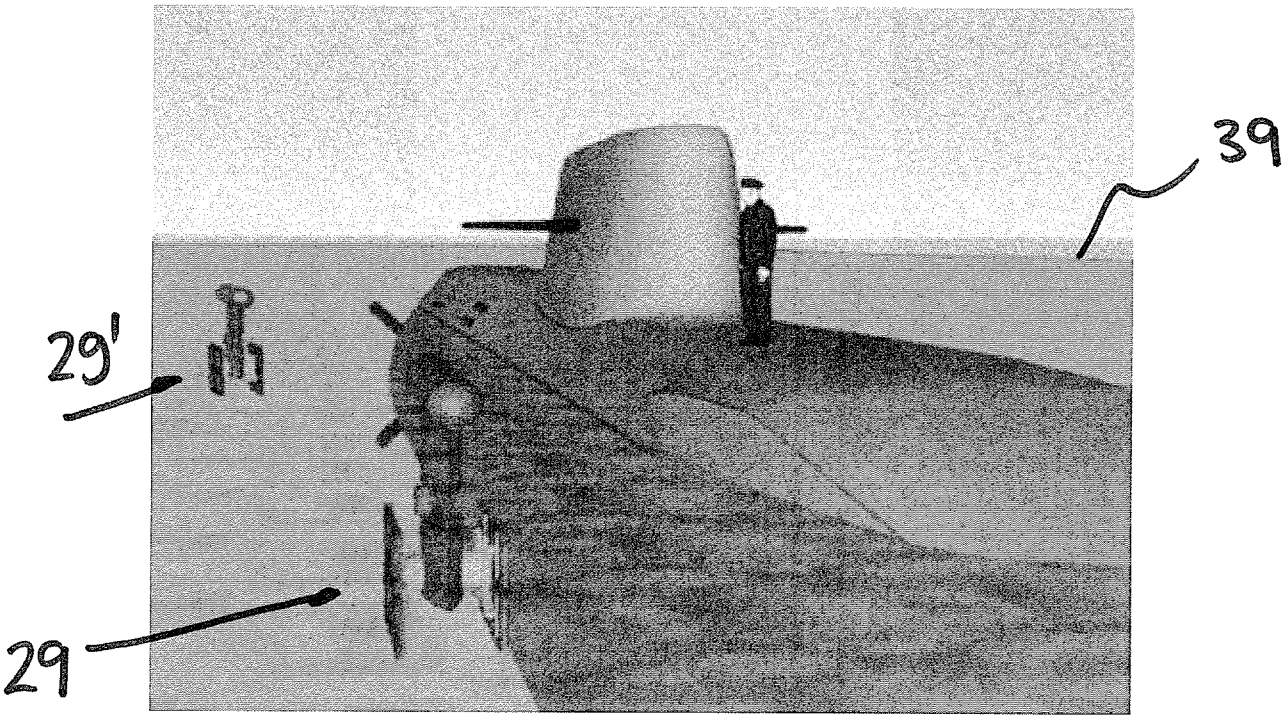


Fig 17

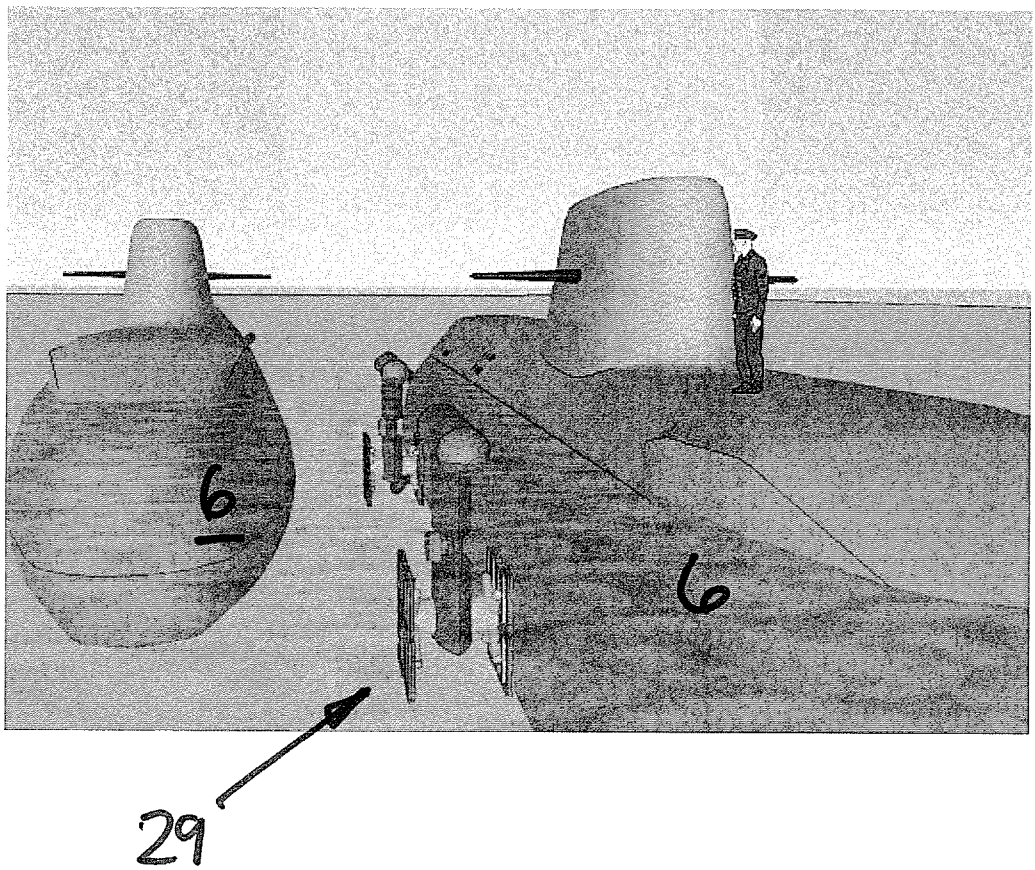


Fig 18

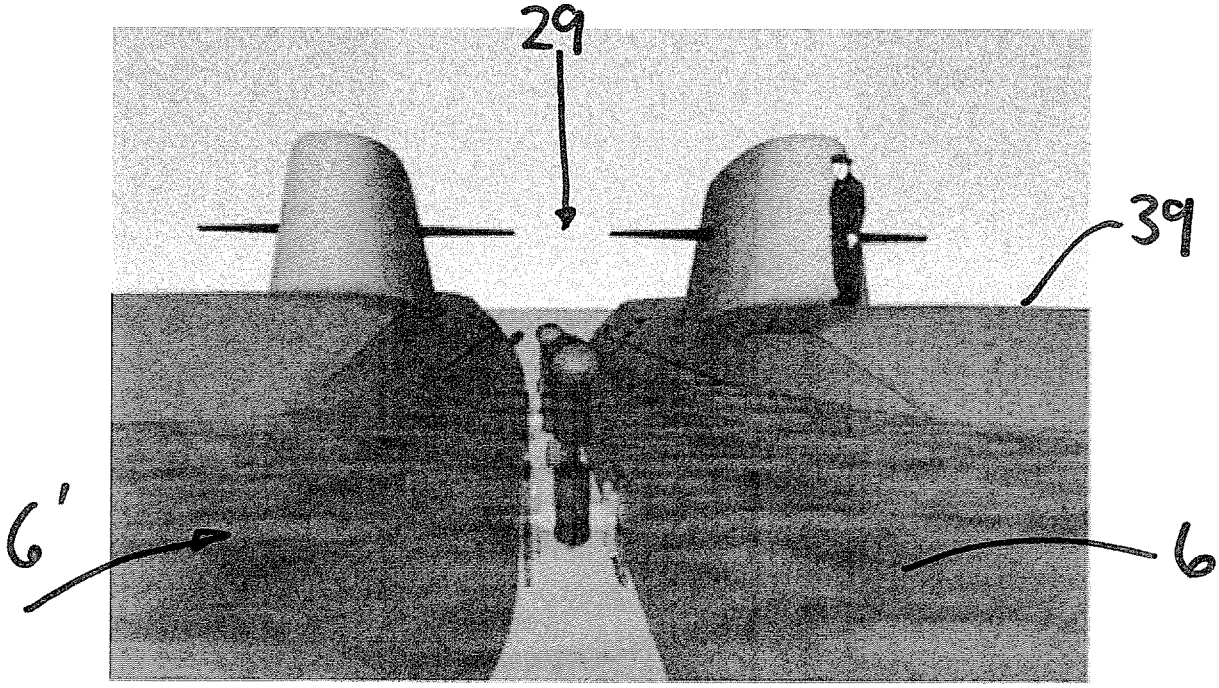


Fig 19

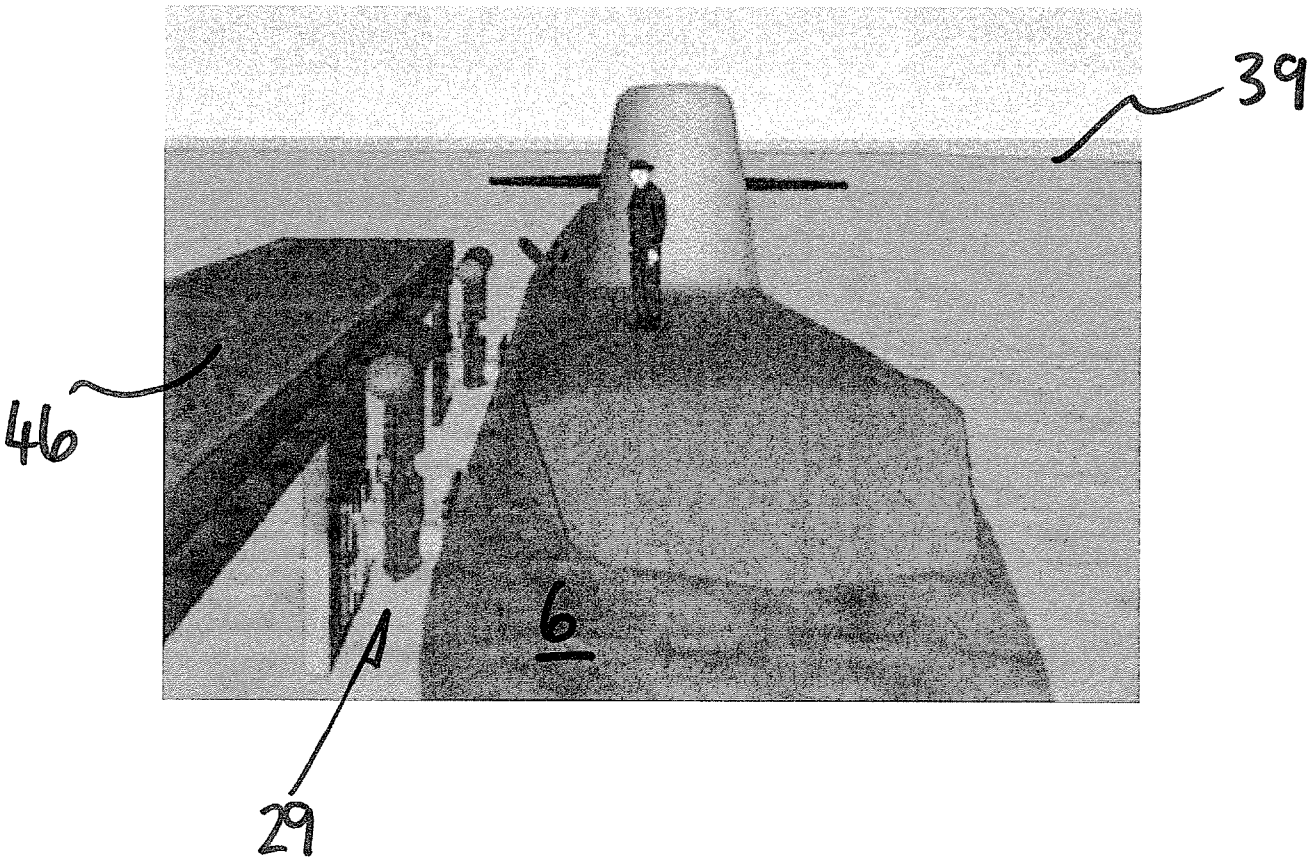


Fig 20

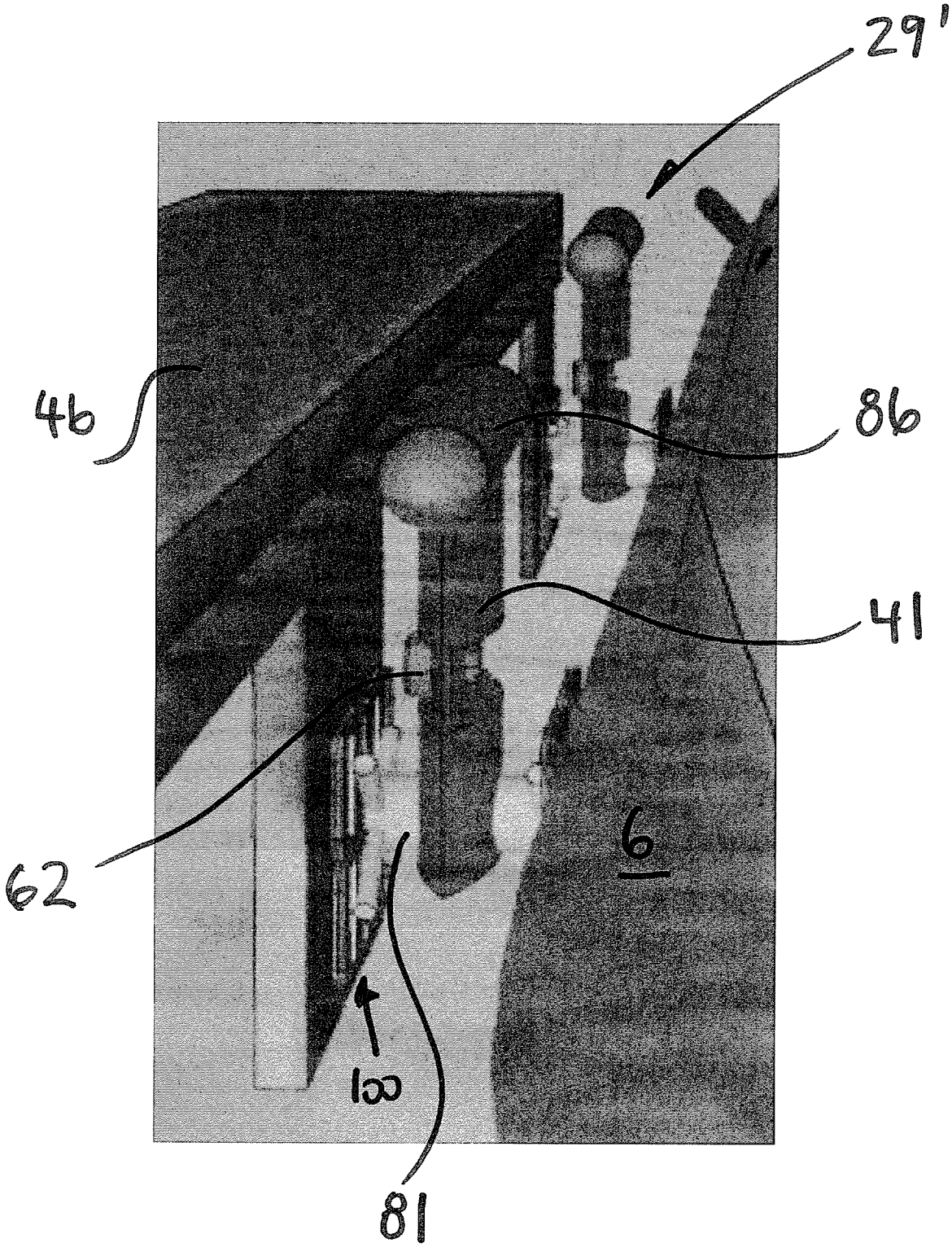


Fig 21

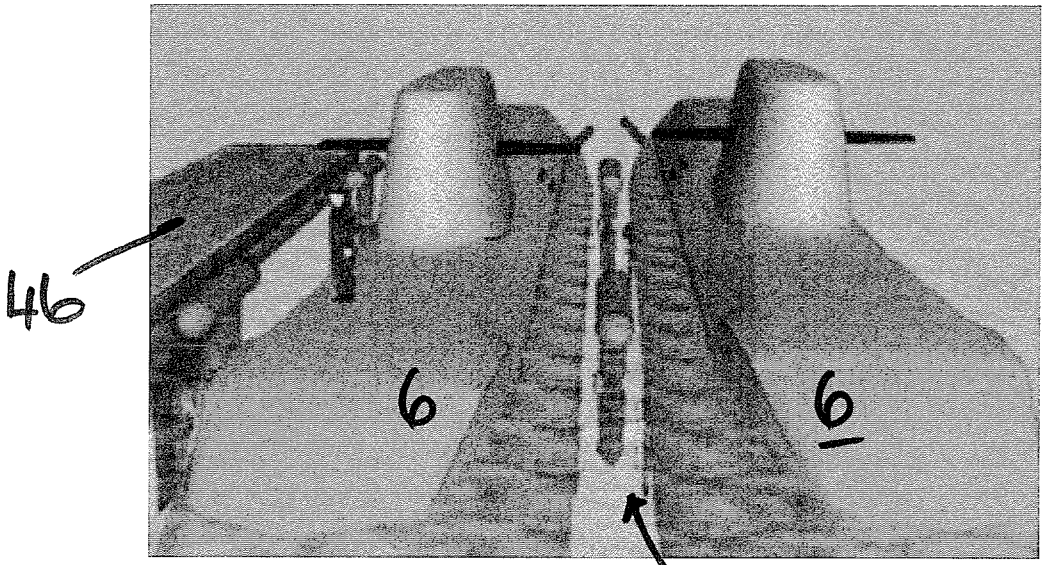


Fig 22

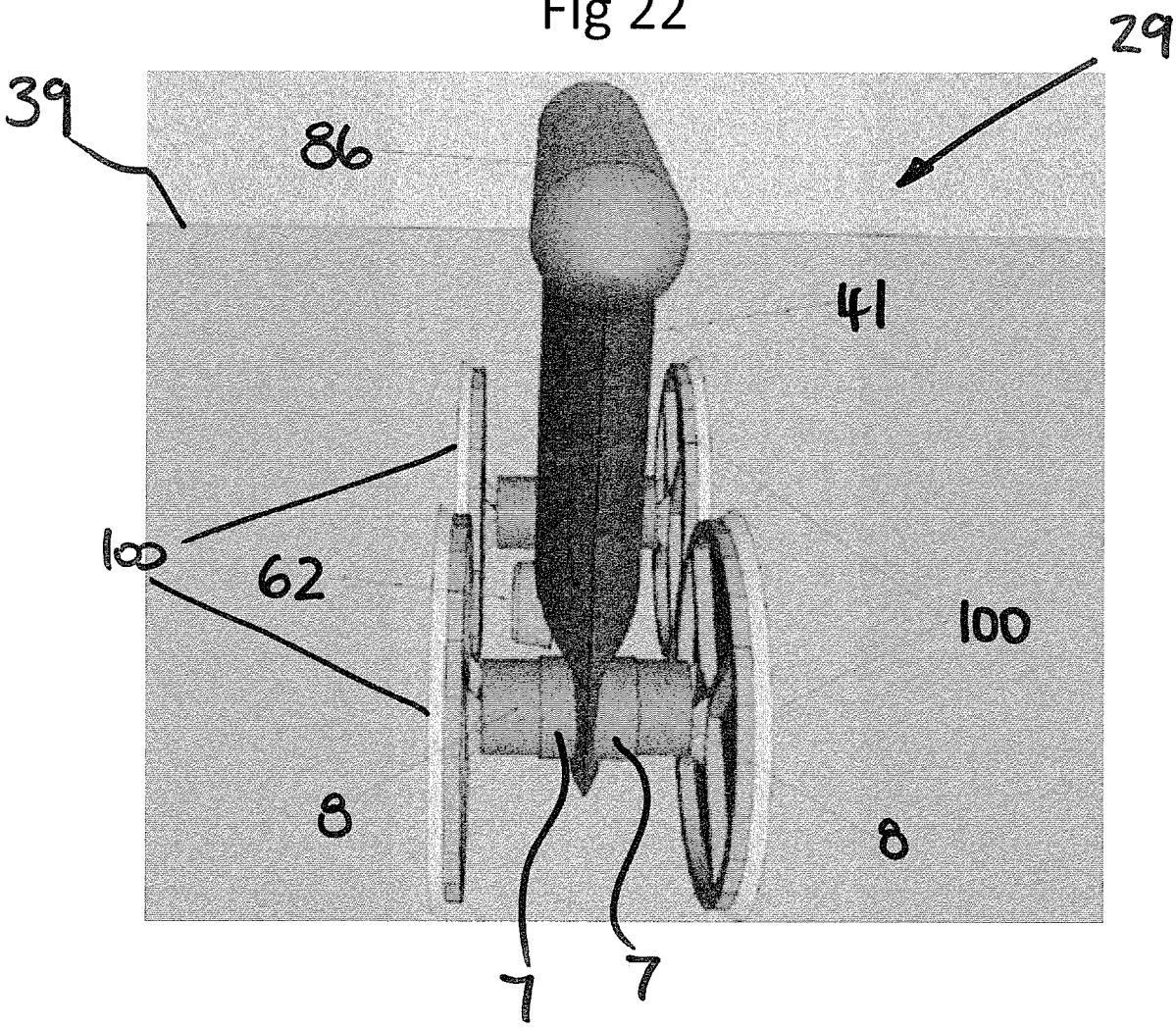


Fig 23

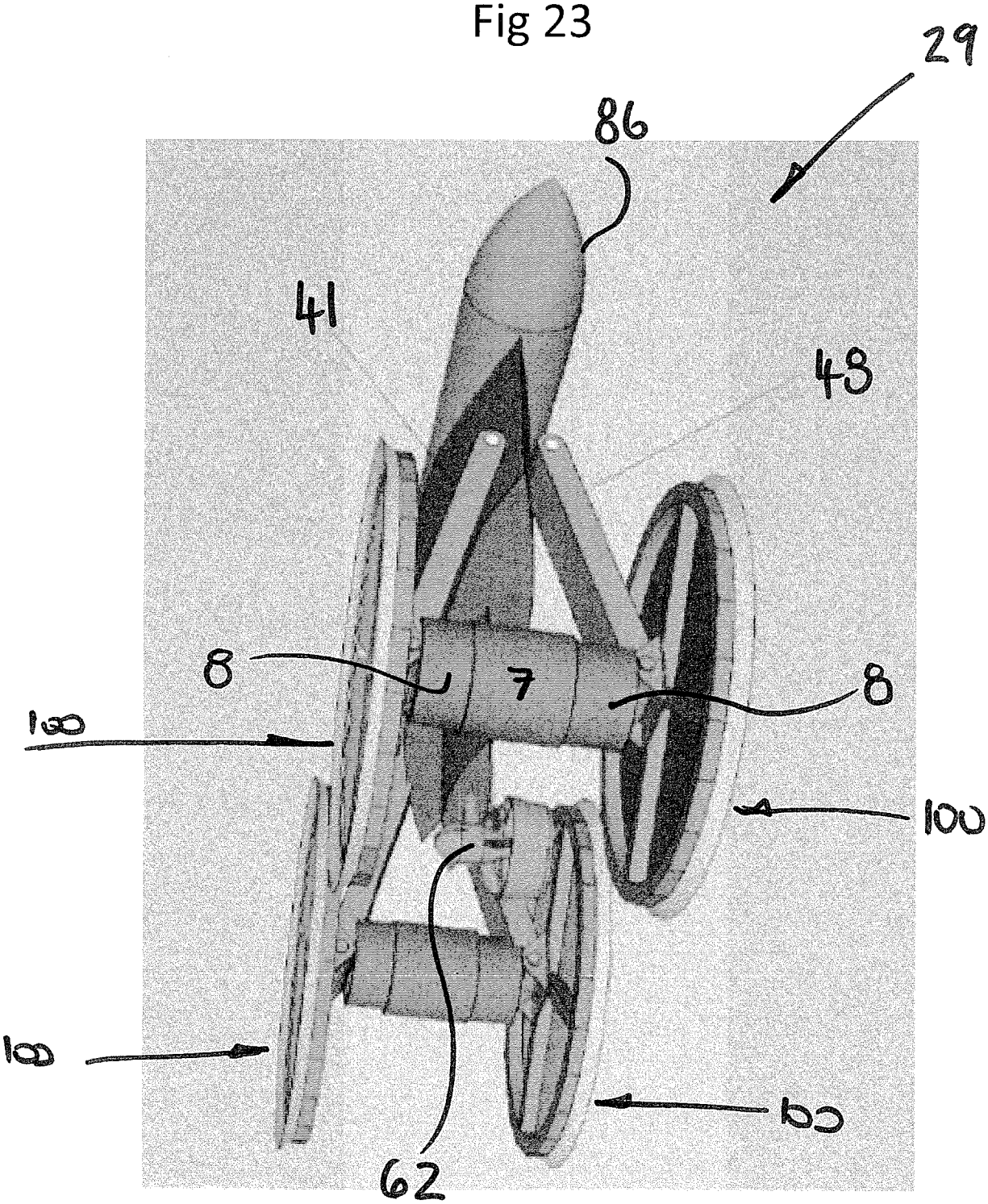


Fig 24

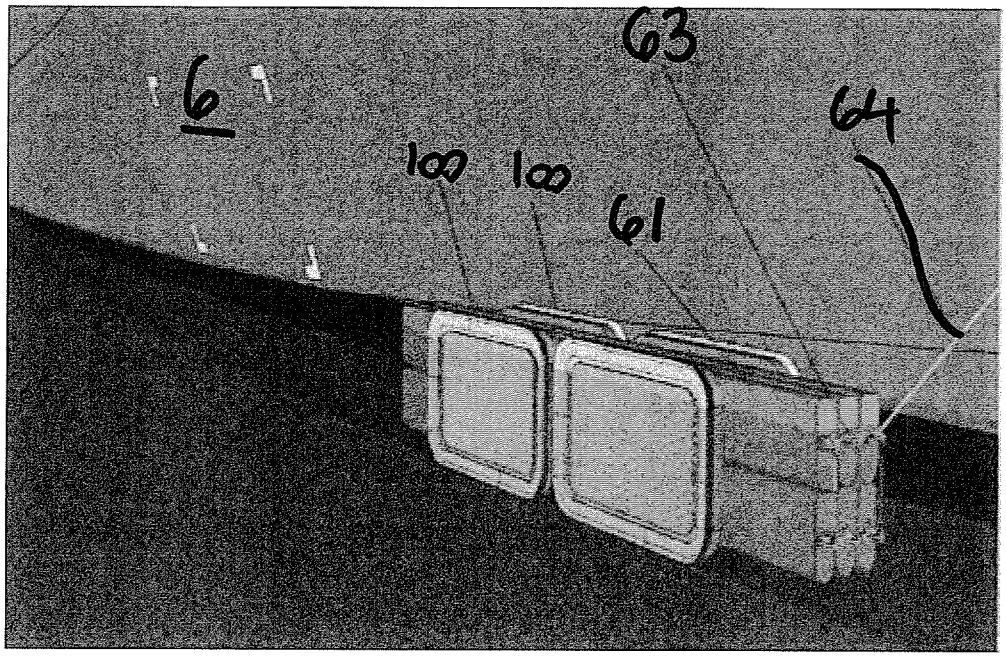
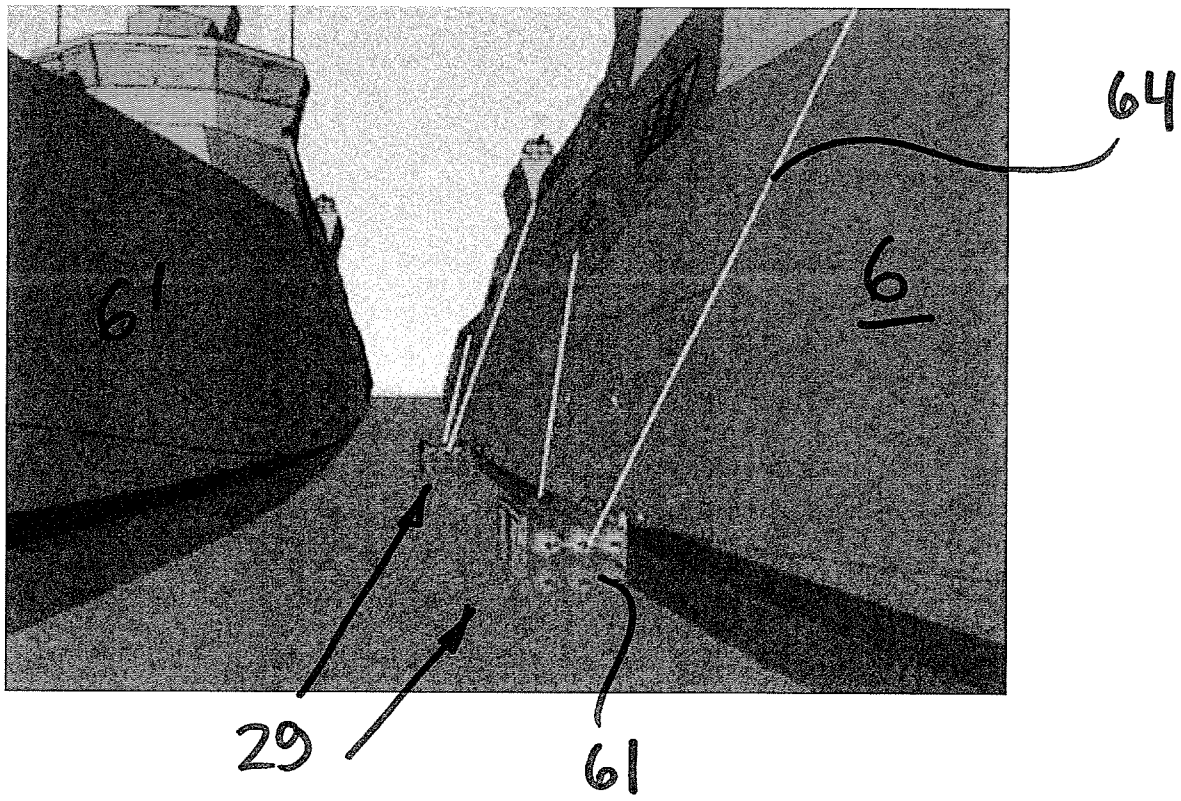


Fig 25



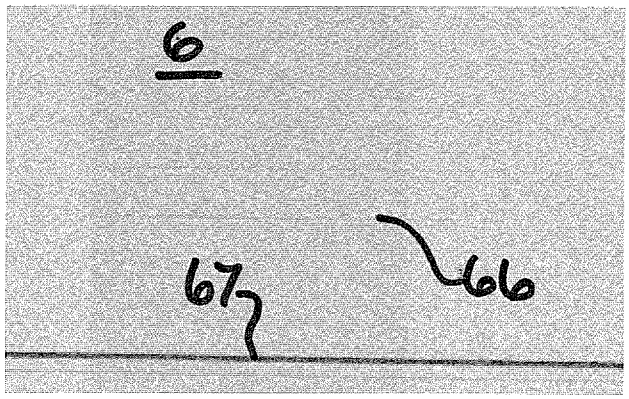


Fig 26

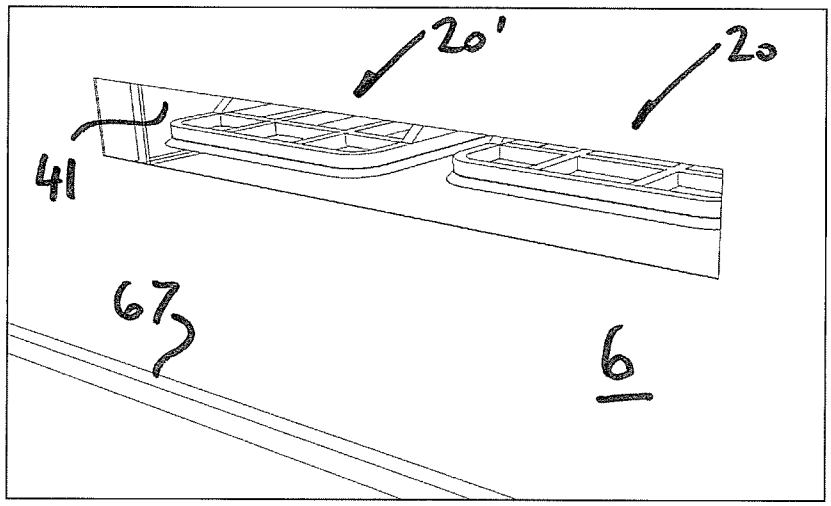


Fig 27

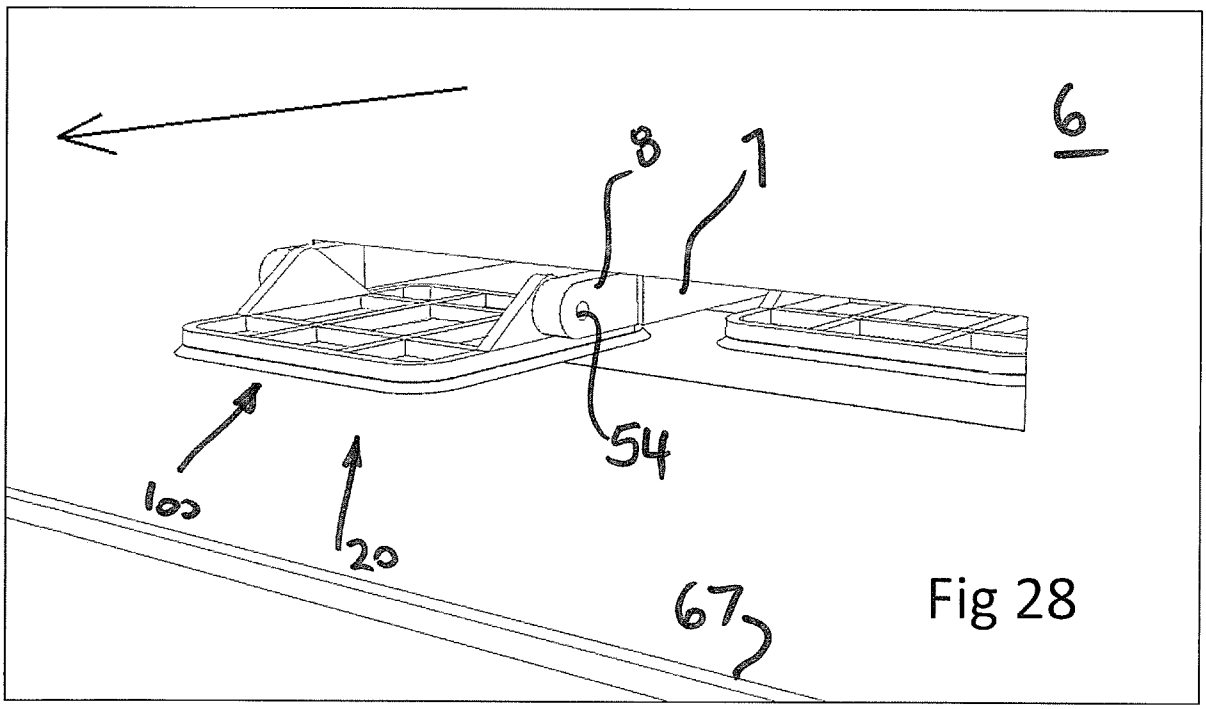


Fig 28

Fig 29

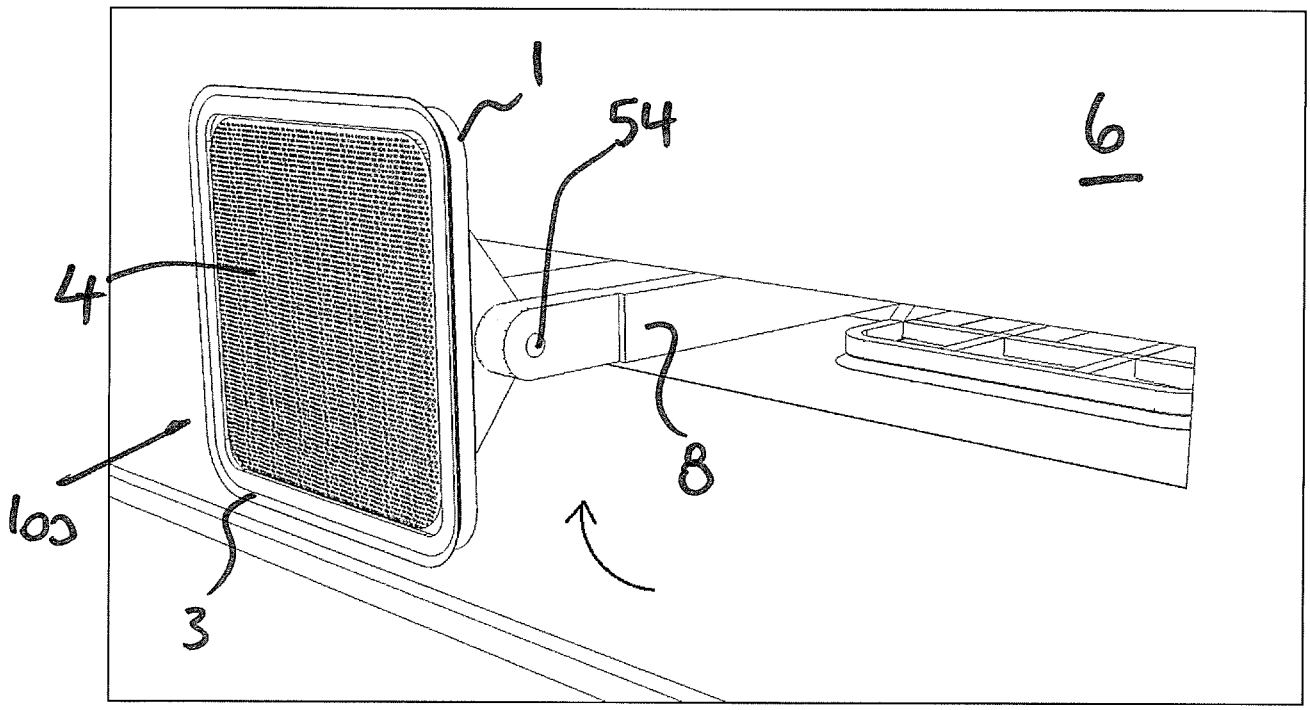


Fig 30

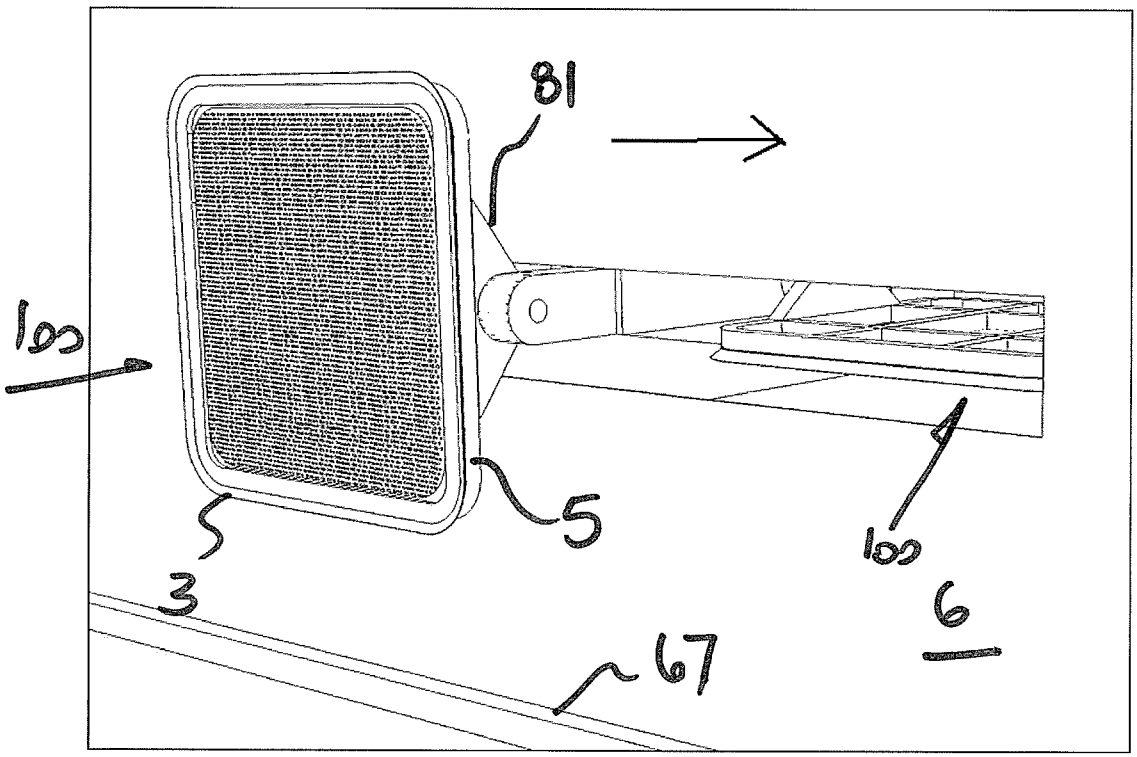


Fig 31

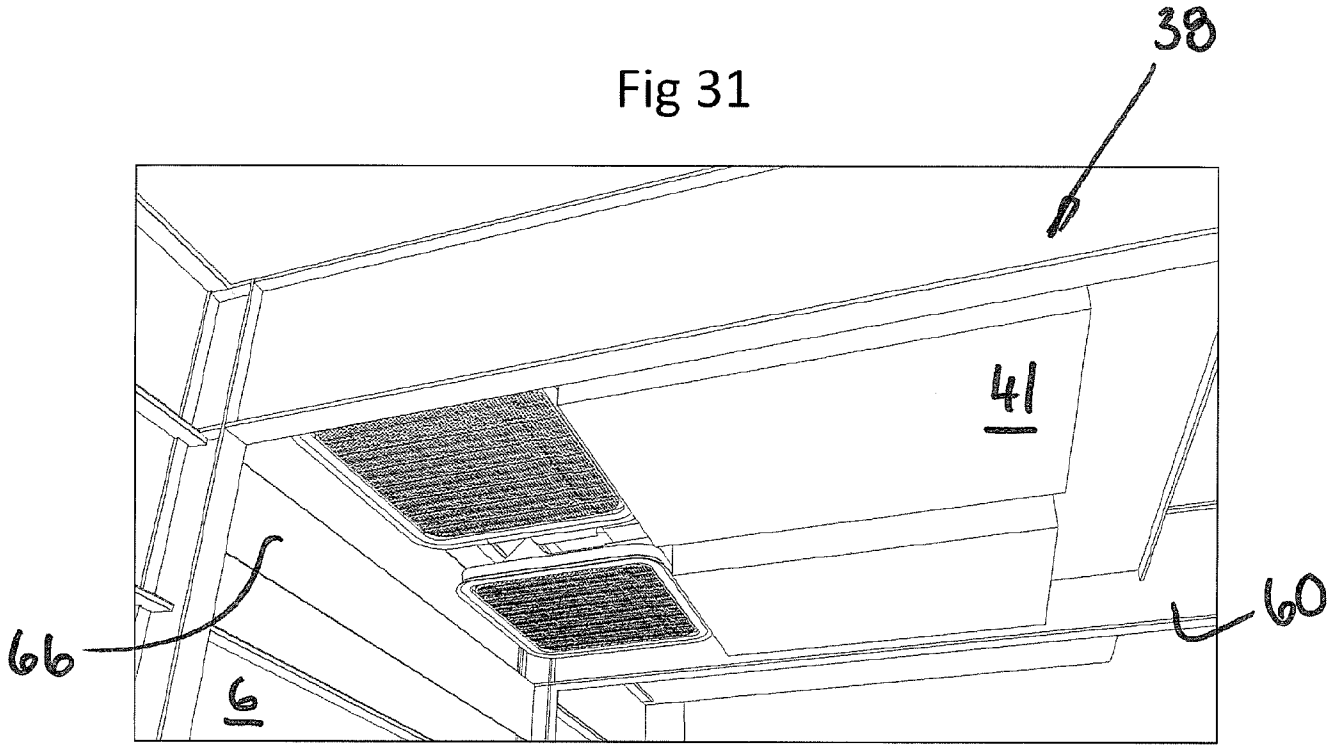
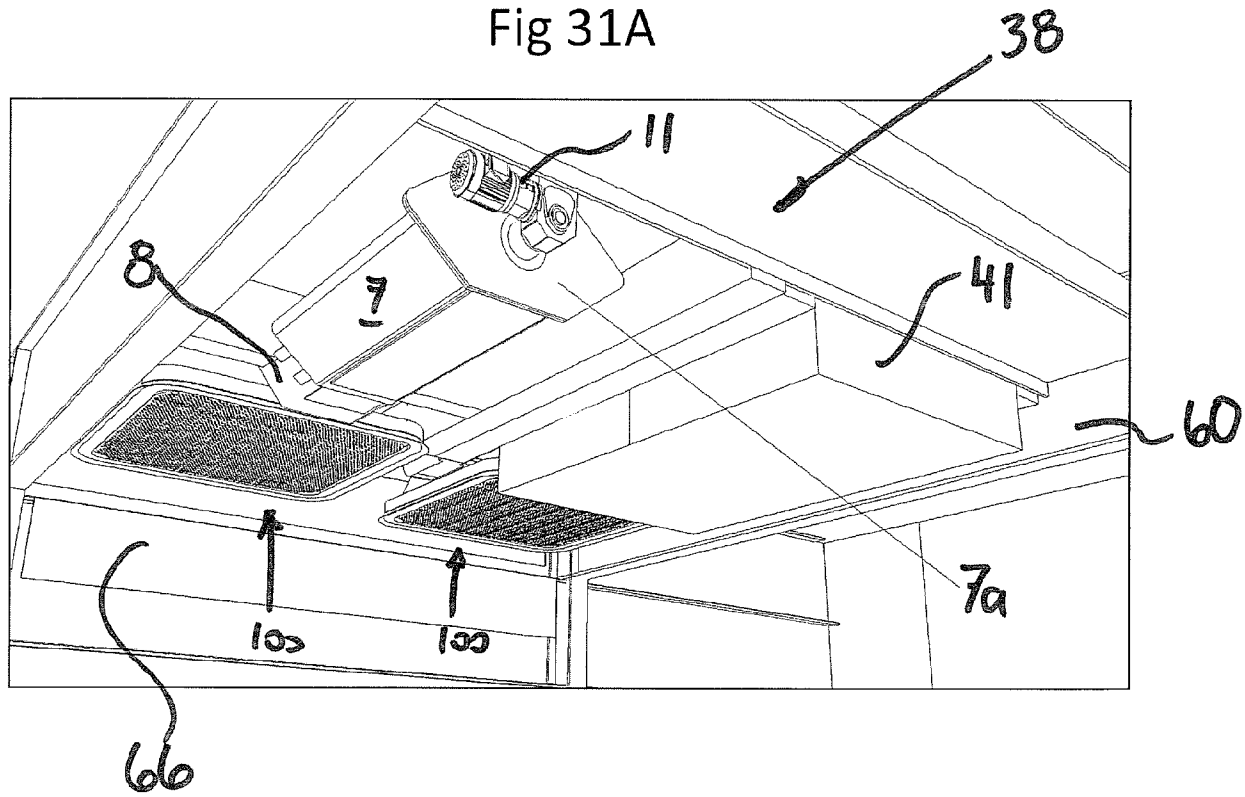


Fig 31A



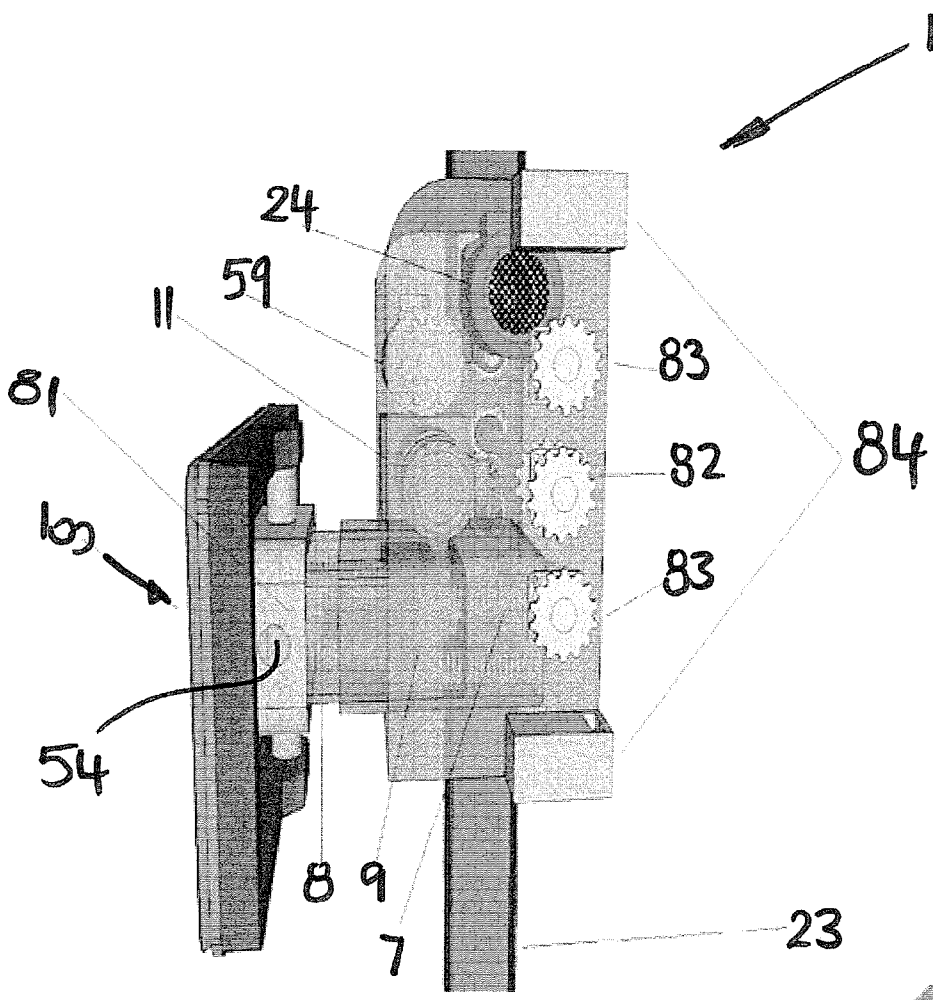


Fig 32

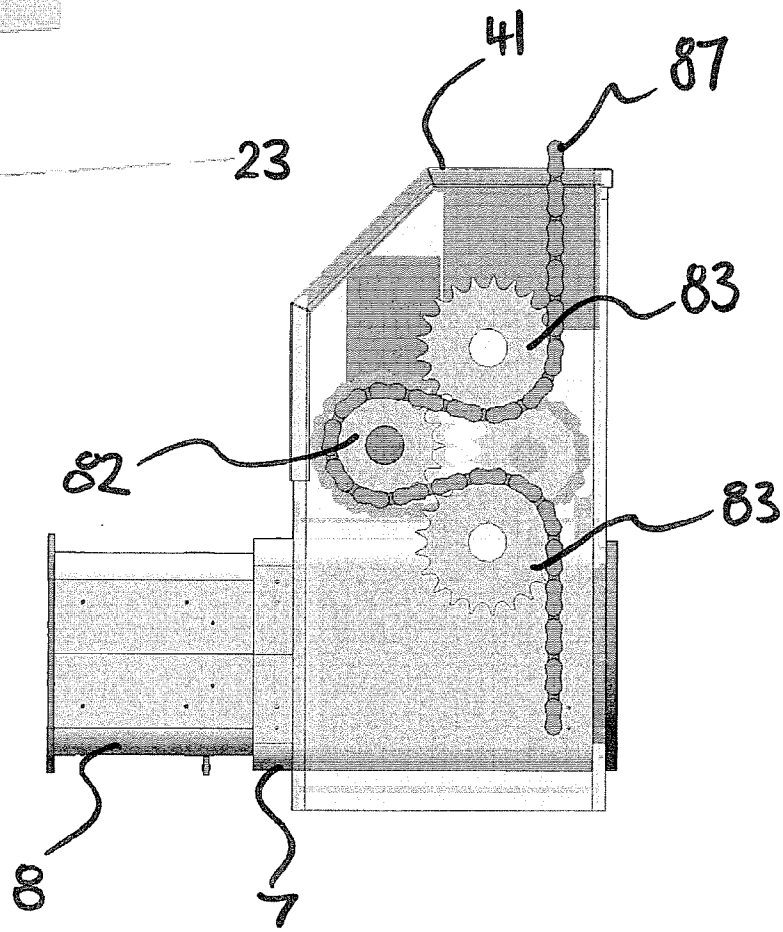


Fig 32A

Fig 33

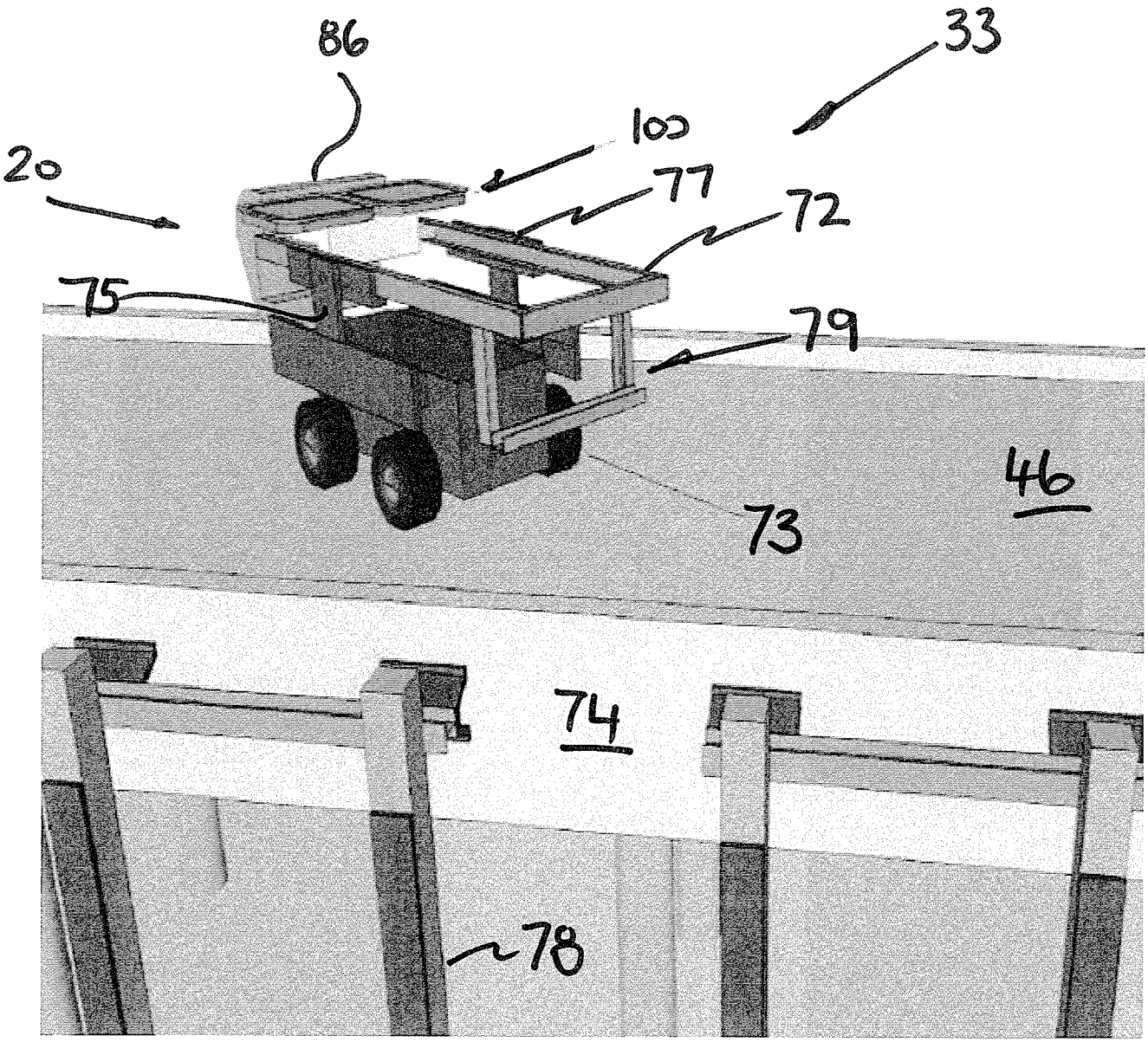


Fig 34

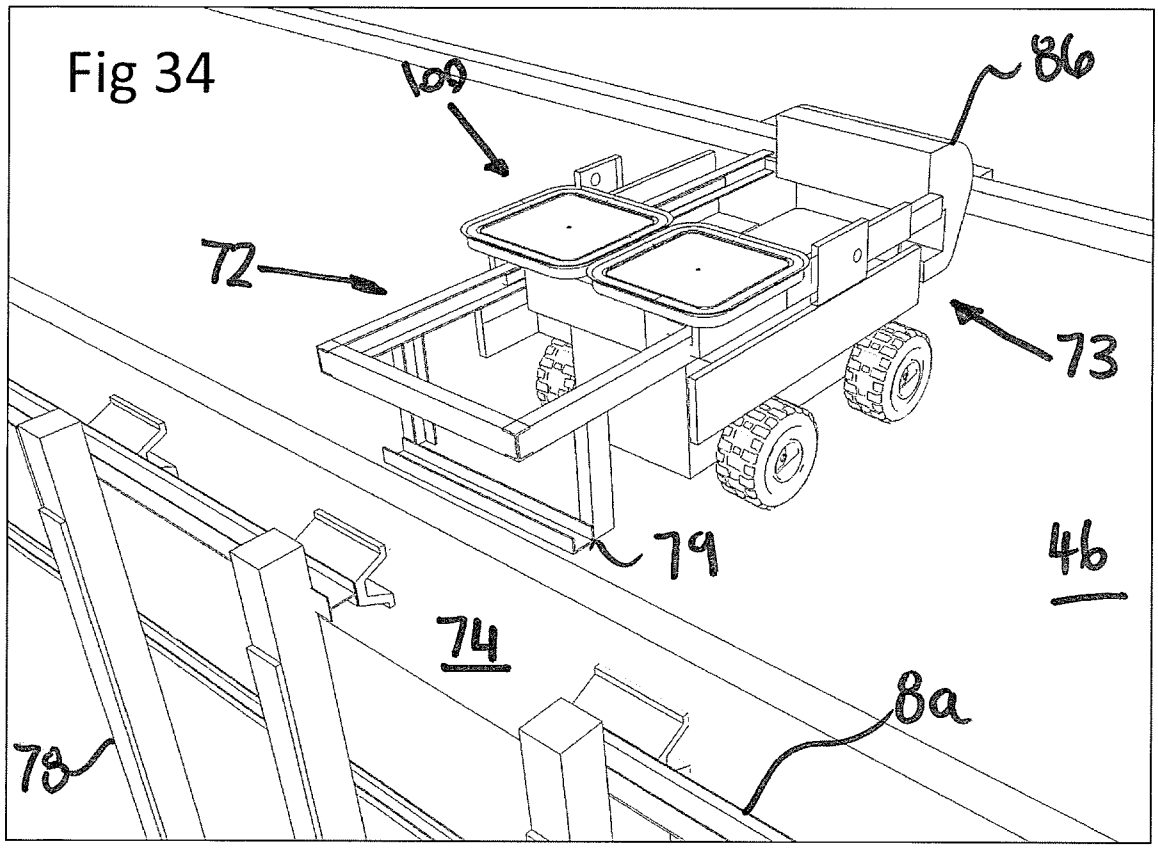


Fig 35

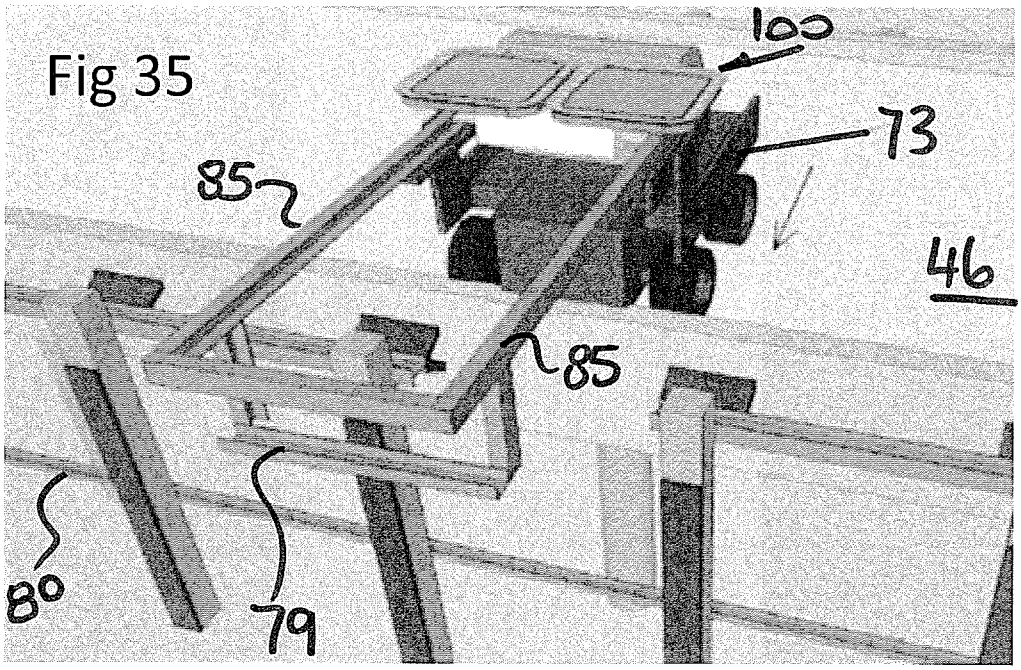


Fig 36

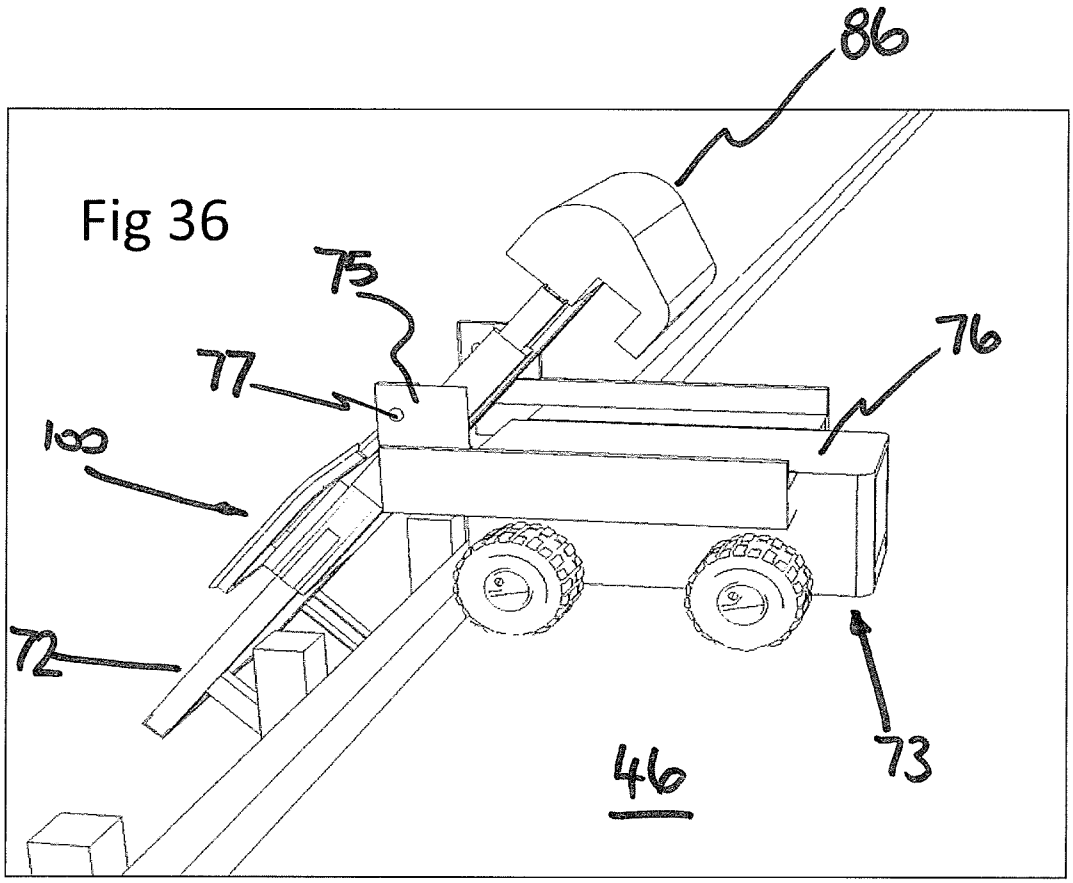


Fig 37

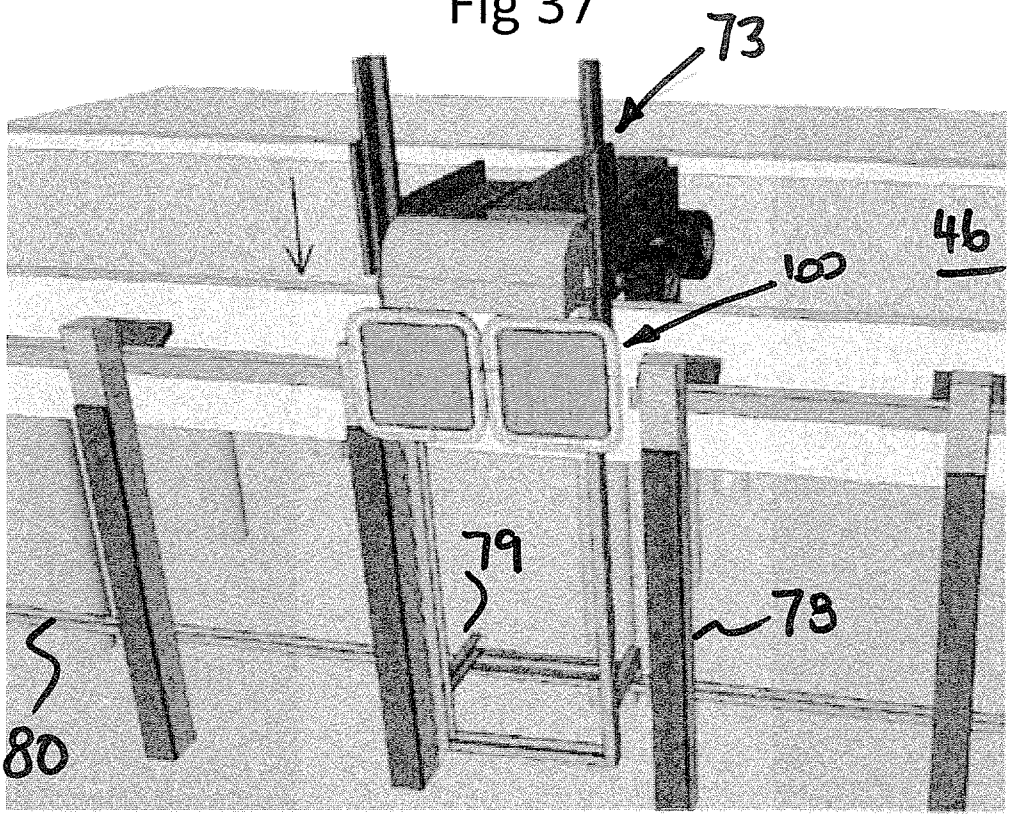
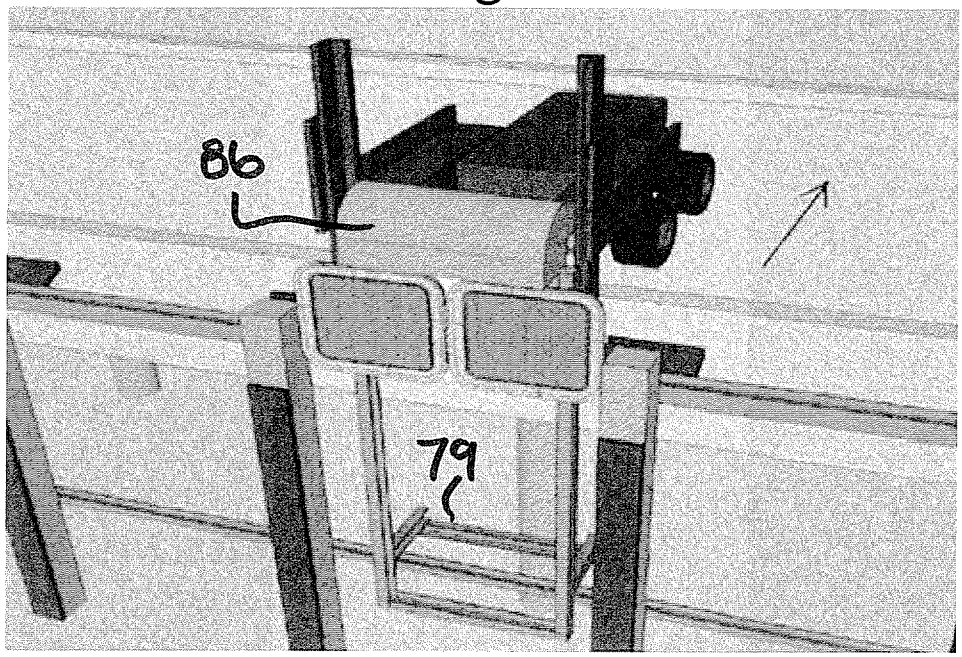


Fig 38



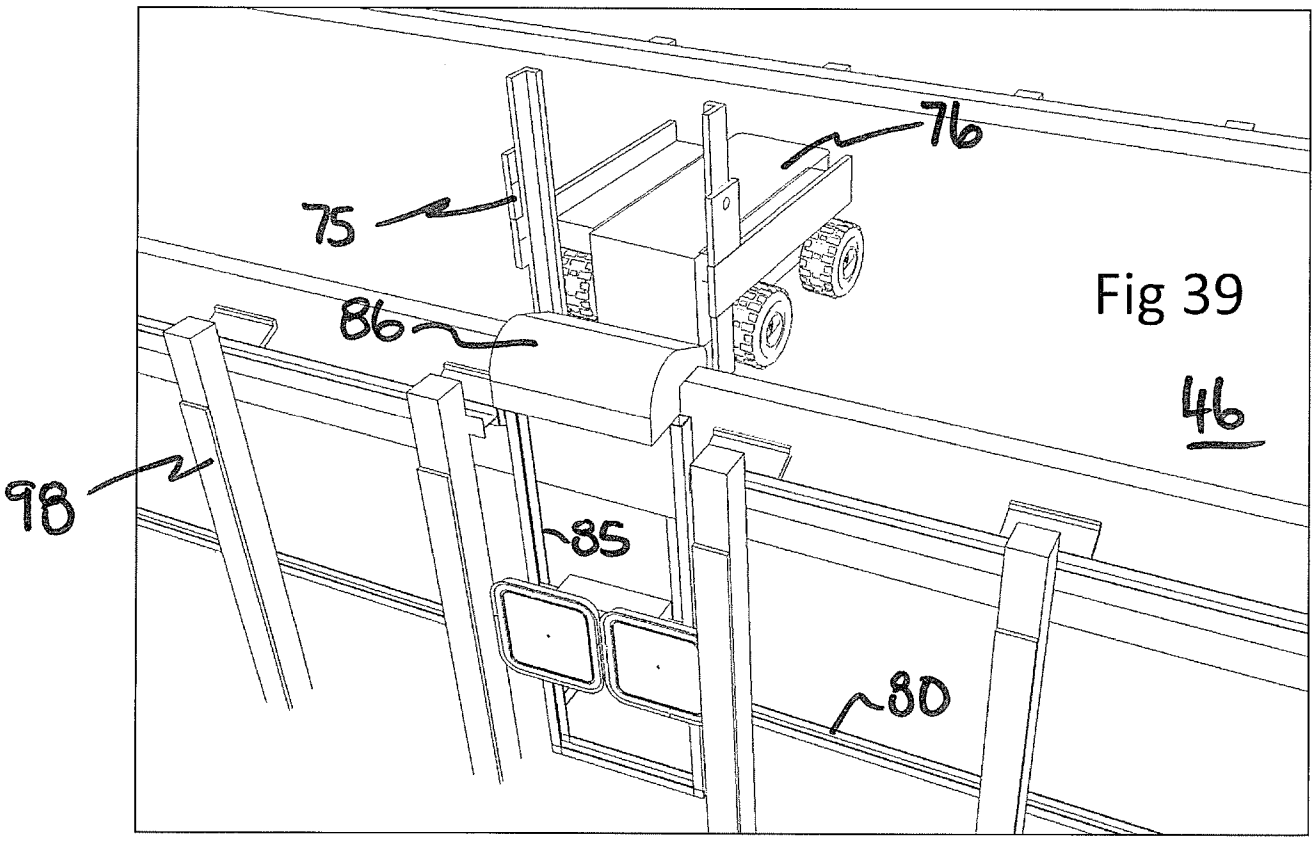


Fig 39

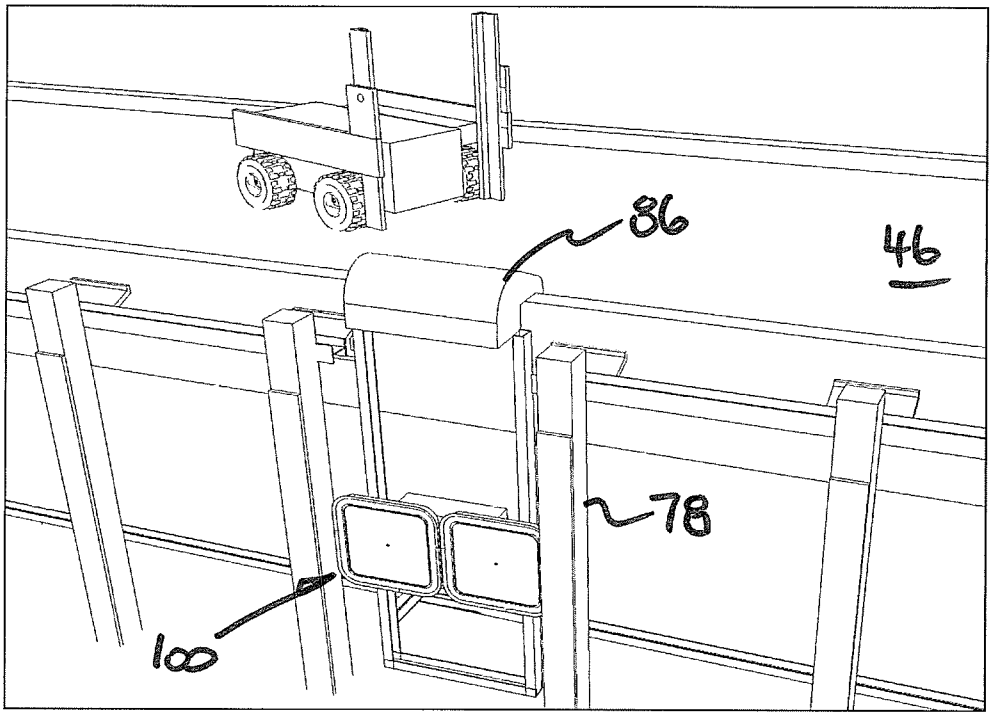
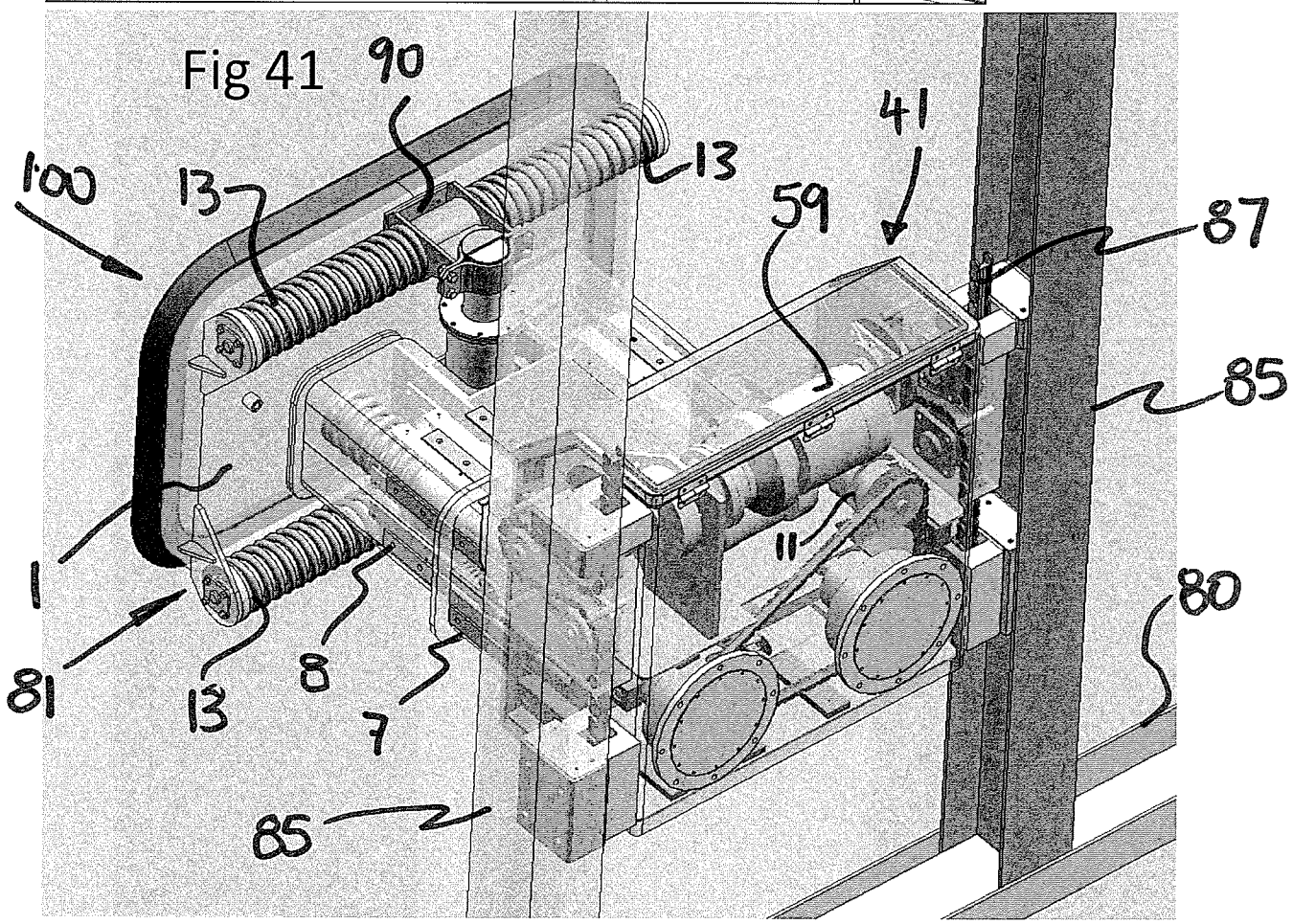


Fig 40

Fig 41



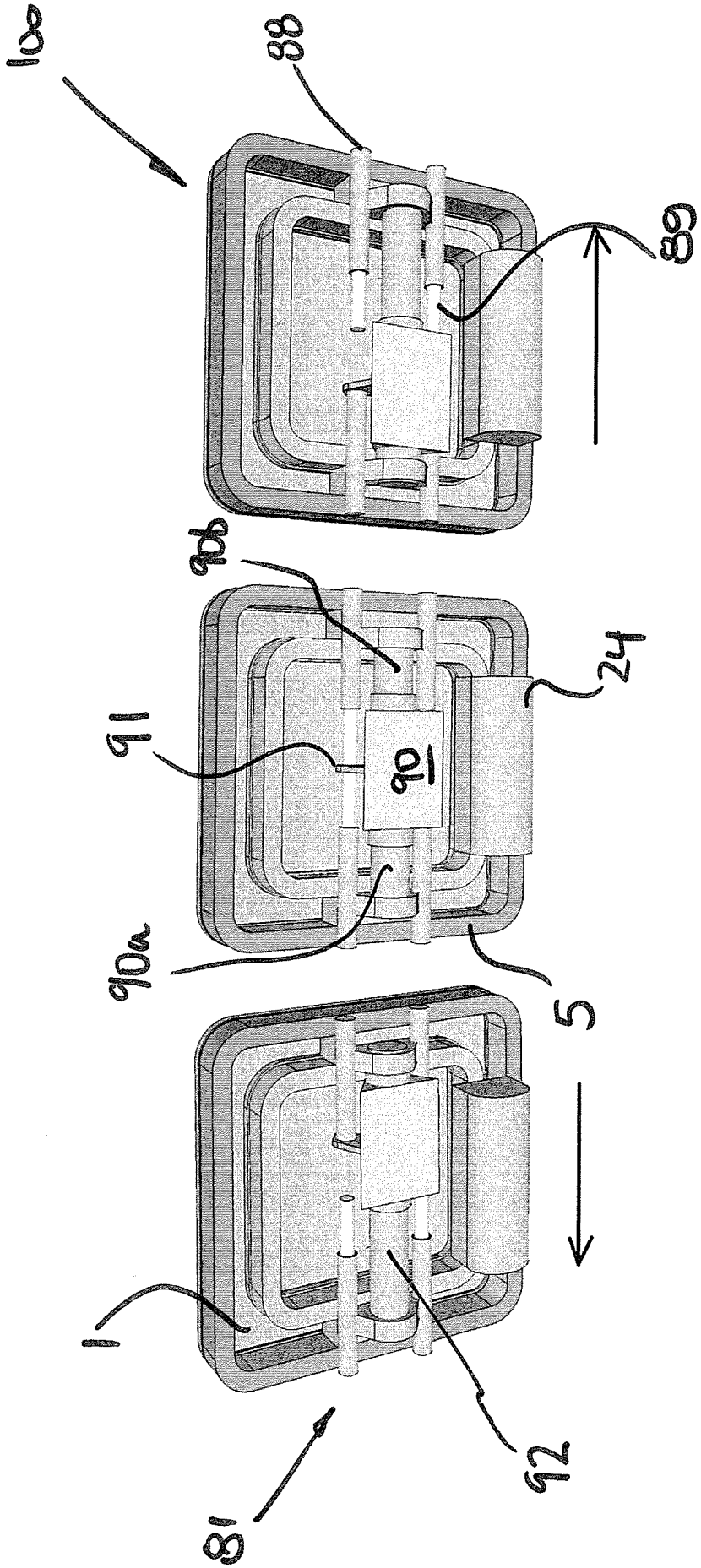


Fig 42c

Fig 42b

Fig 42a

Fig 43

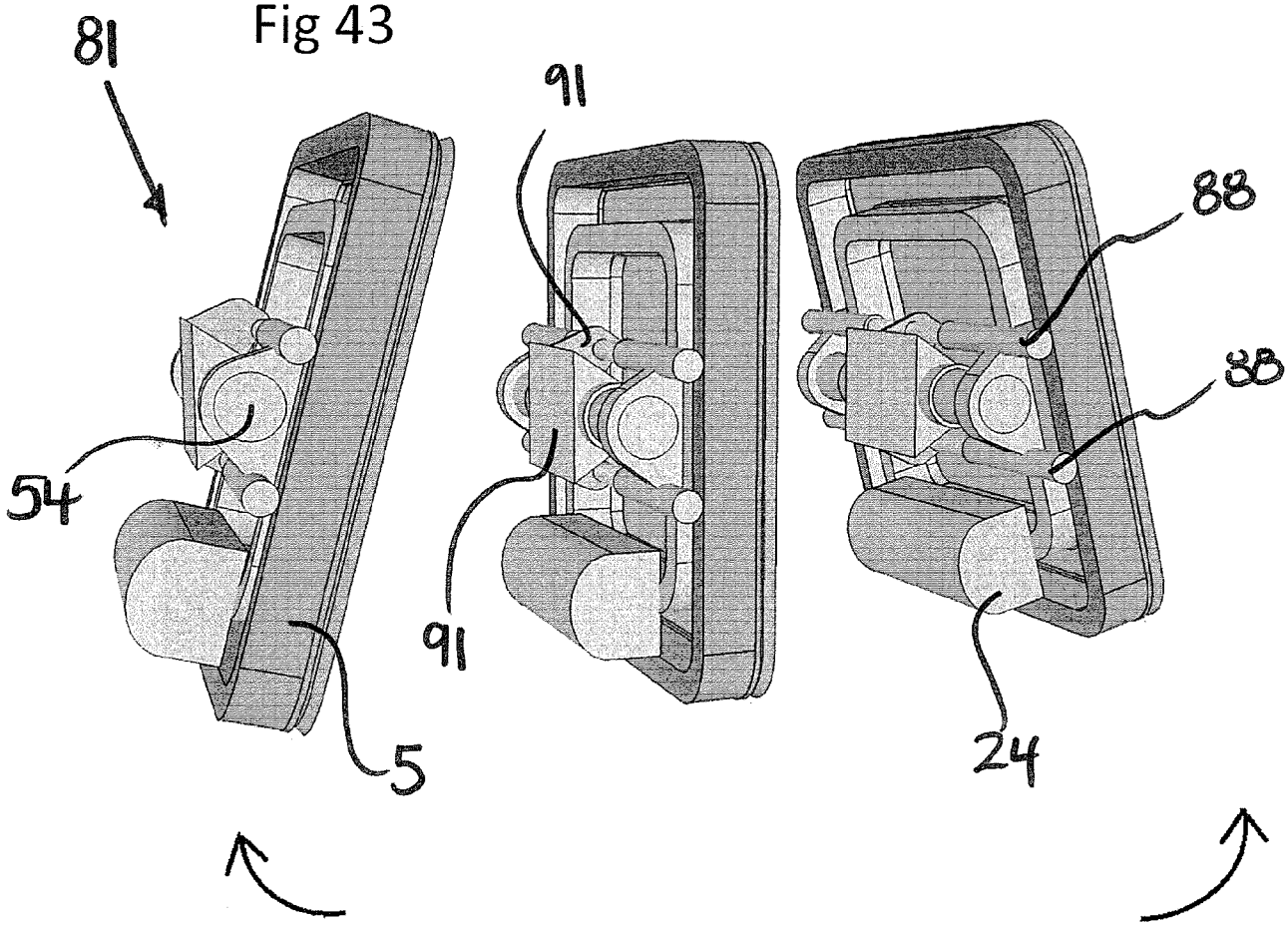
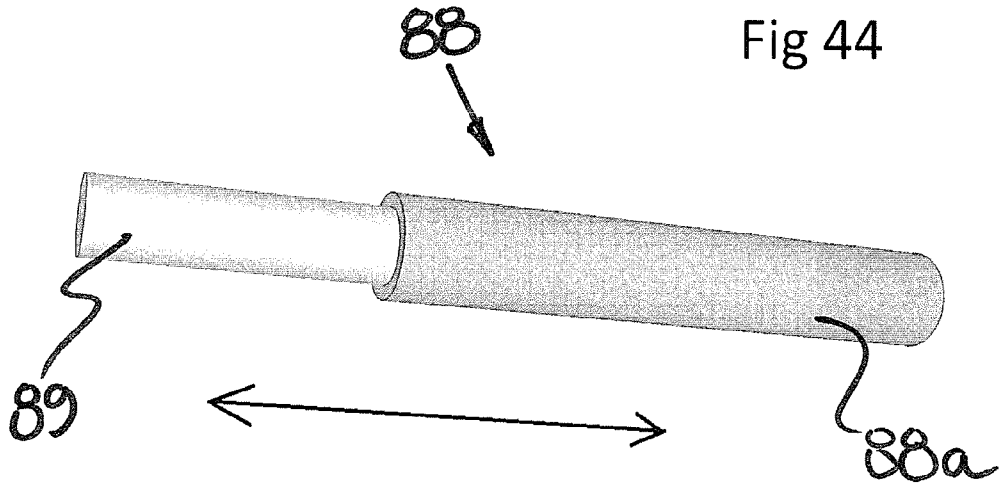


Fig 44



INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2015/000177

A. CLASSIFICATION OF SUBJECT MATTER

B63B 21/00 (2006.01) B25J 15/06 (2006.01) E02B 3/24 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPIAP, EPODOC: CPC: B63B 2021/006, IPC, CPC: B63B21/00, B25J15/06, E02B 3/24 and keywords: moor, damp and similar terms; B63B, B25J, E02B and vacuum, moor and similar terms; ultracombi on selected documents.

Applicant/Inventor name search in Espace and AusPat.

Google Patents and Google : keywords: vacuum, mooring, spring, tensioner and similar terms

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 July 2015	01 July 2015

Name and mailing address of the ISA/AU	**Authorised officer**
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au	Asanka Perera AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. 0262832373

INTERNATIONAL SEARCH REPORT C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		International application No. **PCT/AU2015/000177**
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 3974794 A (KAKITANI et al.) 17 August 1976 the entire document the entire document	1-6, 8-12, 14-19, 23-26 7, 13
X	JP H07033075 A (MITSUBISHI HEAVY IND LTD) 03 February 1995 Figures and the J-PlatPat online English Translation	1-6, 8-12, 14-16
X Y	US 6439147 B2 (COTTRELL et al.) 27 August 2002 Figures 1-4A and accompanying description Column 7, lines 25-26	1-3, 6-10, 15, 16 7, 13
X	US 8499709 B2 (LEE et al.) 06 August 2013 the entire document	1-3, 6, 8-10, 12, 14-22, 25, 26
X	DE 9207648 U1 (ROHR GMBH) 20 August 1992 Figures 1-4 and the accompanying description	1-3, 6, 8-10, 15, 16, 20, 21, 23, 24
X	US 8215256 B2 (MONTGOMERY et al.) 10 July 2012 the entire document	1-3, 6, 8-10, 12, 14-19, 25, 26
X	US 3463114 A (LOVELL) 26 August 1969 the entire document	1-3, 6, 8-10, 12, 14-19, 25, 26
X	US 2004/0154518 A1 (HADCROFT et al.) 12 August 2004 the entire document	1-3, 6, 8-10, 12, 14-19, 25, 26
X	WO 2009/048342 A2 (CAVOTEC MSL HOLDINGS LIMITED) 16 April 2009 the entire document	1-3, 6, 8-10, 12, 14-19, 25, 26
X	WO 2009/041834 A1 (CAVOTEC MSL HOLDINGS LIMITED) 02 April 2009 the entire document	1-3, 6, 8-10, 12, 14-19, 25, 26
X	"Cavotec MoorMaster Reference List" published March 2012 obtained from: http://www.cavotec.com/en/ports-maritime/automated-mooring-systems_36/moormaster%e2%84%a2-i-400_43/ See page 11 of the "Cavotec MoorMaster Reference List"	23, 24
A	WO 2003/055740 A1 (MOORING SYSTEMS LIMITED) 10 July 2003 the entire document	23, 24

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2015/000177

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:

because they relate to subject matter not required to be searched by this Authority, namely:

the subject matter listed in Rule 39 on which, under Article 17(2)(a)(i), an international search is not required to be carried out, including

2. ☐ Claims Nos.:

because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos:

because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Supplemental Box for Details

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

Supplemental Box

Continuation of: **Box III**

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

This Authority has found that there are different inventions based on the following features that separate the claims into distinct groups:

Claims 1-11, 15, 16 are directed to a mooring device for mooring a first structure to a second structure and a mooring unit. The feature of an engagement member for releasably engaging the first structure; a dampener having a first portion movably connected to a second portion, the first portion being connected to the engagement member and the second portion being connected to the second structure, wherein the dampener is configured to damp load transfer between the first and second portions of the dampener and thereby damp relative motion between the first and second structures is specific to this group of claims.

Claims 12, 13, 14 are directed to a method of engaging an engagement member on a mooring device to a vessel (claims 12, 13) and a vacuum engagement member for engaging a vessel to a mooring device (claim 14). The feature of storing a negative pressure in a vacuum storage cavity in the engagement member, wherein the negative pressure is generated before the engagement member contacts a vessel; contacting a vacuum pad of the engagement member with the vessel so to create a suction cavity; and transferring air from the suction cavity into the vacuum storage cavity to create a vacuum pressure in the suction cavity thereby holding the engagement member to the vessel (claim 12) and a vacuum pad supported by a frame and a perimeter seal extending around the vacuum pad on the frame; the engagement member including a vacuum storage cavity in communication with the vacuum pad so that when the vacuum pad contacts a vessel a suction pressure is created through air transferring from between the vacuum pad and vessel into the vacuum storage cavity (claim 14) is specific to this group of claims.

Claims 17-19 are directed to an adjustable mooring unit for mooring a vessel to a dock. The feature of a mooring device having an engagement member for releasably engaging a vessel; a guide on which the mooring device is mounted; and an adjustment system for moving the mooring device along the guide is specific to this group of claims.

Claims 20-22 are directed to an apparatus for mooring a vessel to a structure. The feature of a body comprising a float by which the apparatus remains buoyant in water; and an attachment system supported by the body for attaching the vessel and structure to the apparatus is specific to this group of claims.

Claims 23, 24 are directed to ship mounted mooring unit, for mooring a ship to a structure. The feature a mooring device having an engagement member for releasably engaging the structure; and a support for mounting the mooring unit within a cavity of the ship, wherein the mooring device selectively moves between an operative condition, where the engagement member is oriented to engage the structure, and a stowage condition, where the engagement member is retracted to be stowed within the cavity is specific to this group of claims.

Claims 25, 26 are directed to a portable mooring device for mooring a vessel to a structure. The feature of a guide configured to detachably engage with a structure; and an engagement assembly movably mounted to the guide such that the engagement assembly can be moved to a predetermined position along the guide, wherein the engagement assembly releasably engages the vessel to moor the vessel to the structure is specific to this group of claims.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

When there is no special technical feature common to all the claimed inventions there is no unity of invention.

In the above groups of claims, the identified features may have the potential to make a contribution over the prior art but are not common to all the claimed inventions and therefore cannot provide the required technical relationship. Therefore there is no special technical feature common to all the claimed inventions and the requirements for unity of invention are consequently not satisfied *a priori*.

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2015/000177**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
US 3974794 A	17 August 1976	AU 498119 B2	08 Feb 1979
		AU 7486474 A	06 May 1976
		BR 7409240 A	11 May 1976
		DE 2451501 A1	07 May 1975
		DK 572074 A	07 Jul 1975
		ES 431643 A1	01 Nov 1976
		FR 2249801 A1	30 May 1975
		GB 1491511 A	09 Nov 1977
		IT 1030777 B	10 Apr 1979
		JP S5073396 A	17 Jun 1975
		JP S5630234 B2	13 Jul 1981
		JP S5088930 A	17 Jul 1975
		NL 7414096 A	09 May 1975
		NO 743949 A	02 Jun 1975
JP H07033075 A	03 February 1995	None	
US 6439147 B2	27 August 2002	US 6439147 B2	27 Aug 2002
		AU 2761801 A	24 Jul 2001
		JP 2003520725 A	08 Jul 2003
		WO 0151345 A1	19 Jul 2001
US 8499709 B2	06 August 2013	US 8499709 B2	06 Aug 2013
		CN 102464213 A	23 May 2012
		CN 102464213 B	10 Sep 2014
		EP 2450271 A2	09 May 2012
		EP 2450271 B1	10 Dec 2014
		KR 20120047659 A	14 May 2012
		KR 101198829 B1	07 Nov 2012
		WO 2012060511 A1	10 May 2012
DE 9207648 U1	20 August 1992		
US 8215256 B2	10 July 2012	US 8215256 B2	10 Jul 2012
		AU 2002328455 A1	23 Feb 2004
		AU 2003281692 A1	16 Feb 2004
		AU 2003281692 B2	19 Nov 2009
		CA 2494529 A1	05 Feb 2004

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2015/000177**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		**Patent Family Member/s**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
		CN 1647282 A	27 Jul 2005
		CN 1671592 A	21 Sep 2005
		EP 1534583 A1	01 Jun 2005
		EP 1534583 B1	20 May 2009
		HK 1076782 A1	20 Aug 2010
		JP 2005534554 A	17 Nov 2005
		JP 4355288 B2	28 Oct 2009
		JP 2009274719 A	26 Nov 2009
		JP 5002617 B2	15 Aug 2012
		JP 2005534974 A	17 Nov 2005
		KR 20040012153 A	11 Feb 2004
		KR 100878237 B1	13 Jan 2009
		KR 20060009809 A	01 Feb 2006
		KR 100982483 B1	16 Sep 2010
		NO 20050938 A	21 Feb 2005
		NO 332019 B1	29 May 2012
		NO 20120525 A	21 Feb 2005
		NZ 520450 A	24 Dec 2004
		TW 200413801 A	01 Aug 2004
		TW I249641 B	21 Feb 2006
		US 2006081166 A1	20 Apr 2006
		US 7293519 B2	13 Nov 2007
		US 2006097262 A1	11 May 2006
		US 7700948 B2	20 Apr 2010
		US 2010148180 A1	17 Jun 2010
		US 7910927 B2	22 Mar 2011
		US 2008156244 A1	03 Jul 2008
		WO 2004011326 A1	05 Feb 2004
		WO 2004013913 A1	12 Feb 2004

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Patent Document/s Cited in Search Report		**Patent Family Member/s**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
US 3463114 A	26 August 1969		
US 2004/0154518 A1	12 August 2004	US 6910435 B2	28 Jun 2005
		AU 3624701 A	03 Sep 2001
		AU 3624801 A	03 Sep 2001
		AU 2001236247 B2	07 Apr 2005
		AU 2001236248 B2	10 Mar 2005
		CA 2401235 A1	30 Aug 2001
		CA 2401237 A1	30 Aug 2001
		EP 1259418 A2	27 Nov 2002
		EP 1259418 B1	14 Jun 2006
		EP 1259419 A1	27 Nov 2002
		EP 1259419 B1	19 Sep 2007
		HK 1051019 A1	29 Aug 2008
		HK 1051020 A1	13 Oct 2006
		JP 2003533391 A	11 Nov 2003
		JP 4768190 B2	07 Sep 2011
		JP 2004500276 A	08 Jan 2004
		JP 5128744 B2	23 Jan 2013
		JP 2011157069 A	18 Aug 2011
		NO 20024063 A	26 Sep 2002
		NO 329874 B1	17 Jan 2011
		NO 20024064 A	02 Oct 2002
		NO 330678 B1	06 Jun 2011
		NZ 521551 A	27 Feb 2004
		NZ 521552 A	27 May 2005
		US 2005087118 A1	28 Apr 2005
		US 7055448 B2	06 Jun 2006
		WO 0162584 A2	30 Aug 2001
		WO 0162585 A1	30 Aug 2001
WO 2009/048342 A2	16 April 2009	PA 8798501 A1	15 May 2009
WO 2009/041834 A1	02 April 2009	AU 2008317580 A1	30 Apr 2009
		AU 2008317580 B2	12 Jun 2014
		BR PI0818858 A2	14 Apr 2015

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Patent Document/s Cited in Search Report		**Patent Family Member/s**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
		CA 2703658 A1	30 Apr 2009
		CN 101918269 A	15 Dec 2010
		EP 2203346 A1	07 Jul 2010
		JP 2011502067 A	20 Jan 2011
		JP 5291113 B2	18 Sep 2013
		KR 20100072361 A	30 Jun 2010
		US 2010272517 A1	28 Oct 2010
		US 8408153 B2	02 Apr 2013
		WO 2009054739 A1	30 Apr 2009
WO 2003/055740 A1	10 July 2003	AU 2003206459 A1	15 Jul 2003

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.