

[54] SHIPBORNE CONVEYING MEANS

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[58] Field of Search 214/15; 244/115, 116, 114; 114/43.5; 104/147, 40, 41, 42

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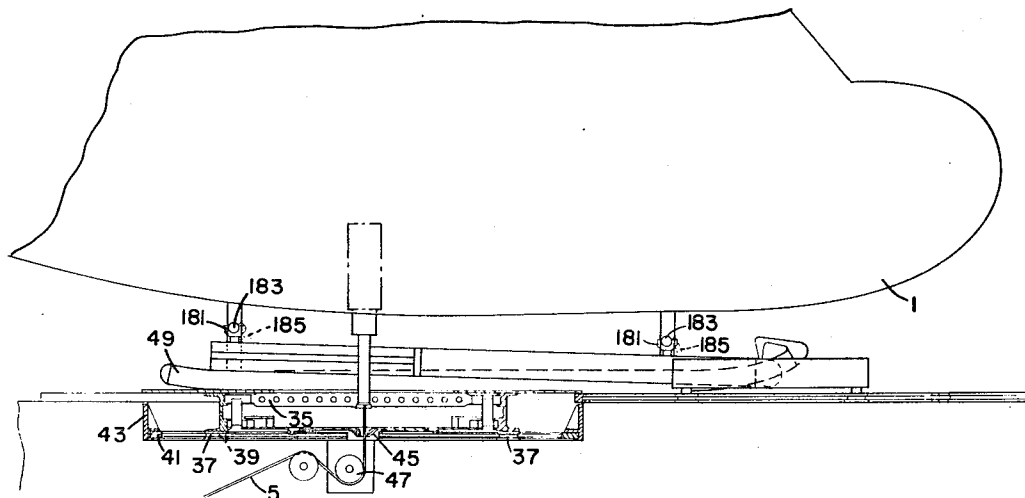
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[57] ABSTRACT

The disclosure relates to means for transporting a landed helicopter on the deck of a ship at sea. A probe on the helicopter is grasped in a trap device mounted on a turntable provided on the deck of the ship. A dolly device is then moved into position and the helicopter clamped to it. The dolly device is guided by suitable rails so that, once the helicopter is clamped to it and unclamped from the trap device, the helicopter under full restraint can be moved along the deck to a parking space.

17 Claims, 11 Drawing Figures



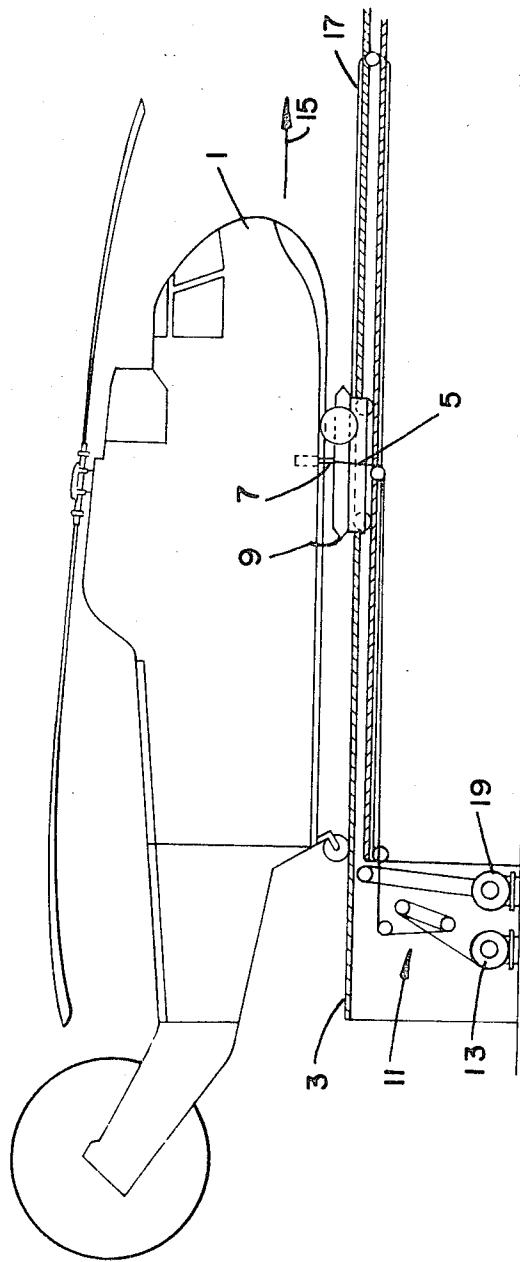


FIG. 1

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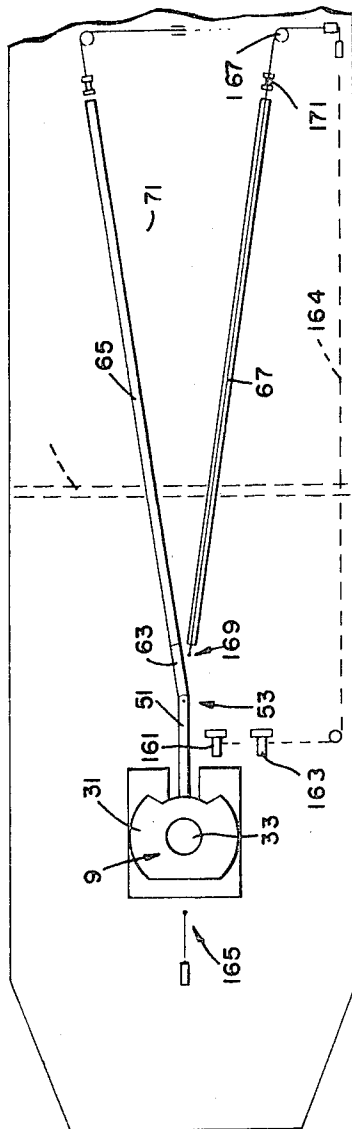


FIG. 2

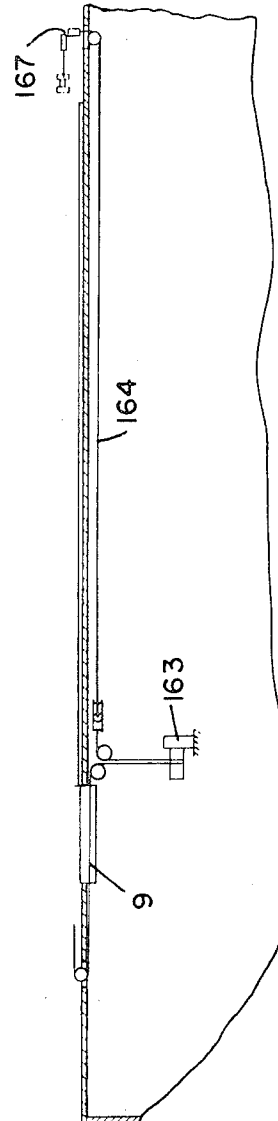


FIG. 3

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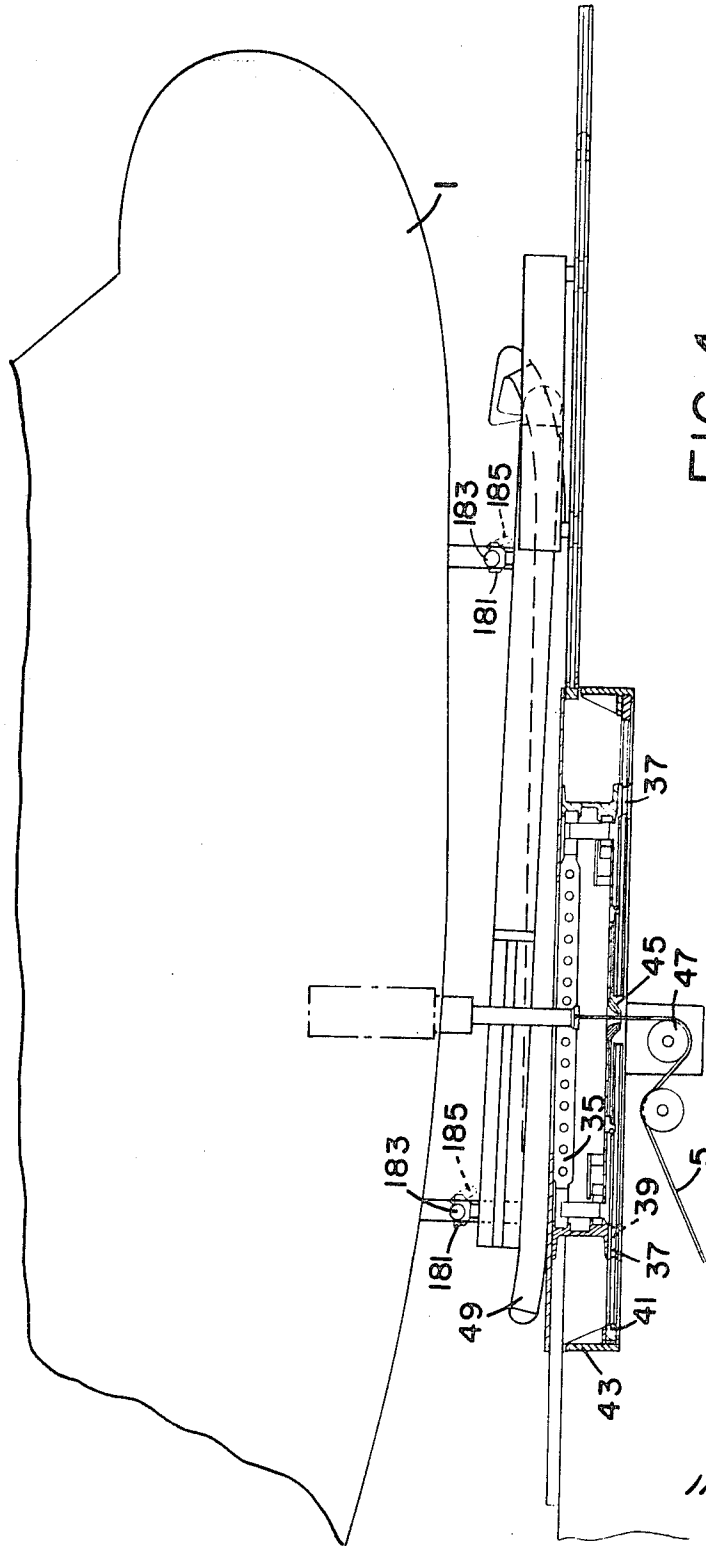


FIG. 4

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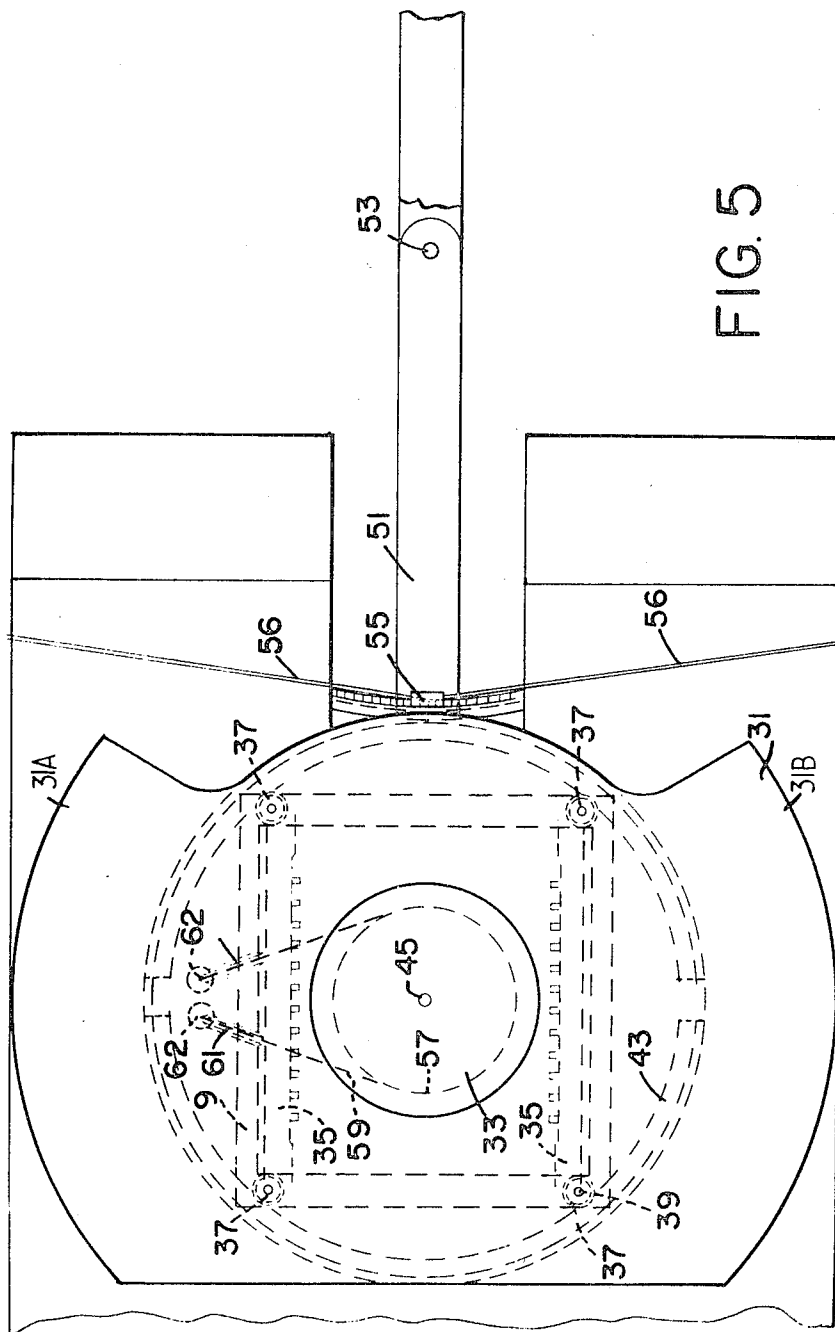
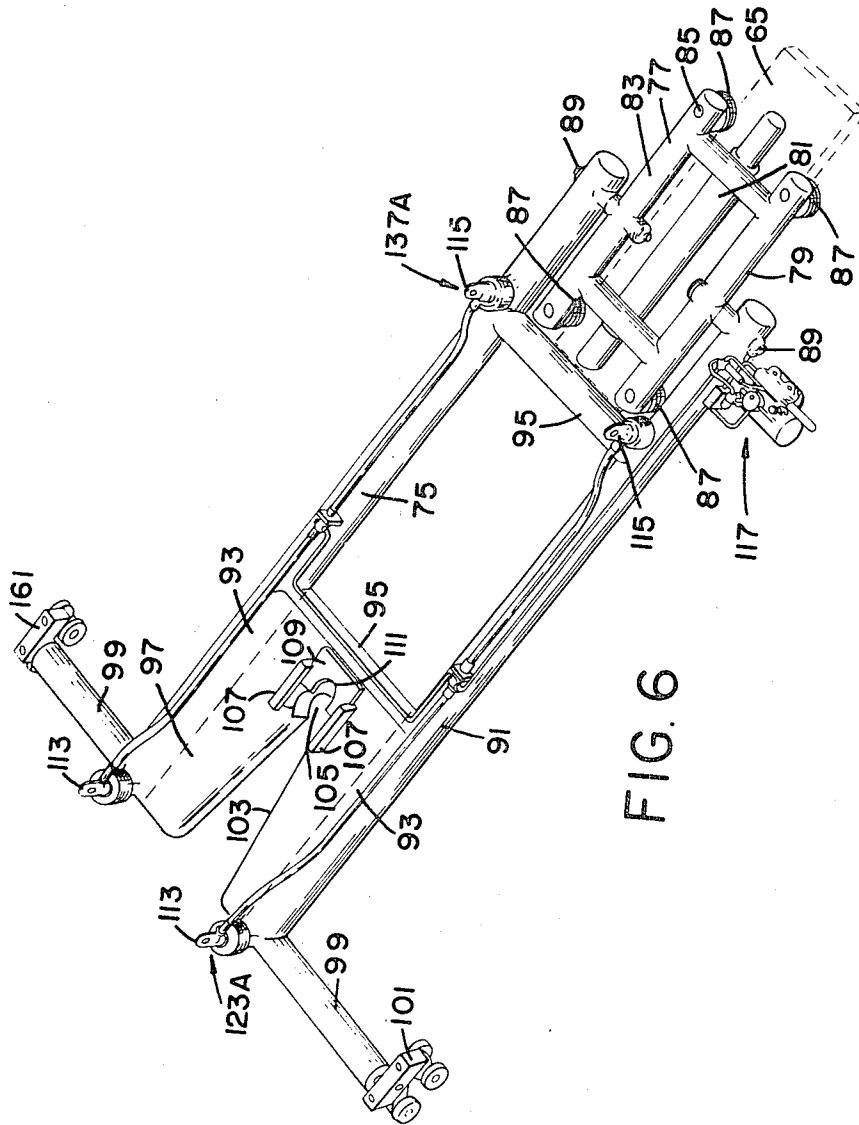


FIG. 5

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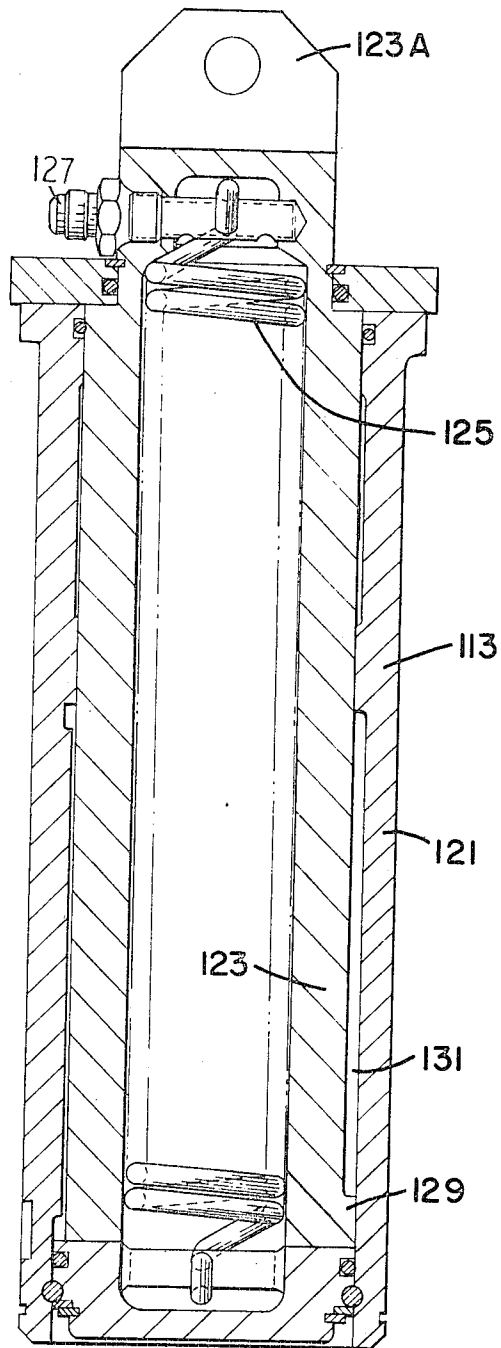


FIG. 7

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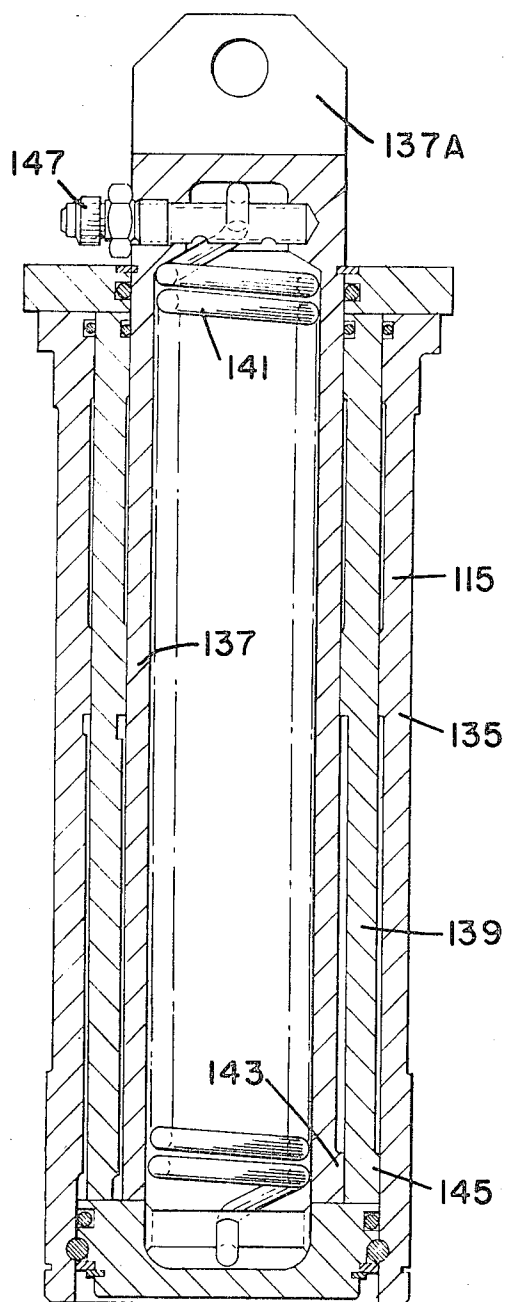


FIG. 8

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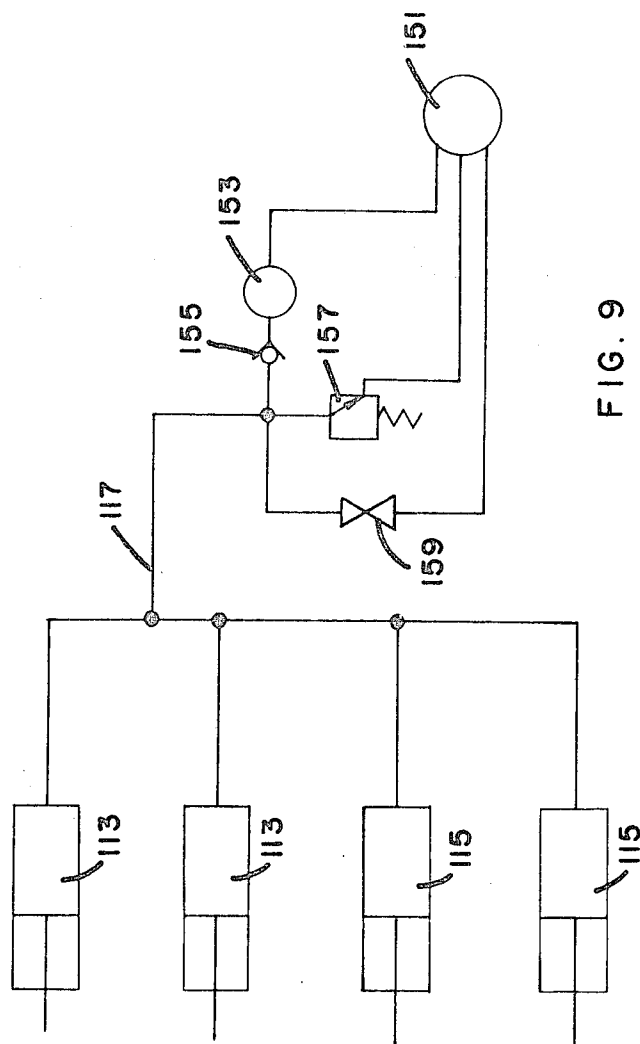


FIG. 9

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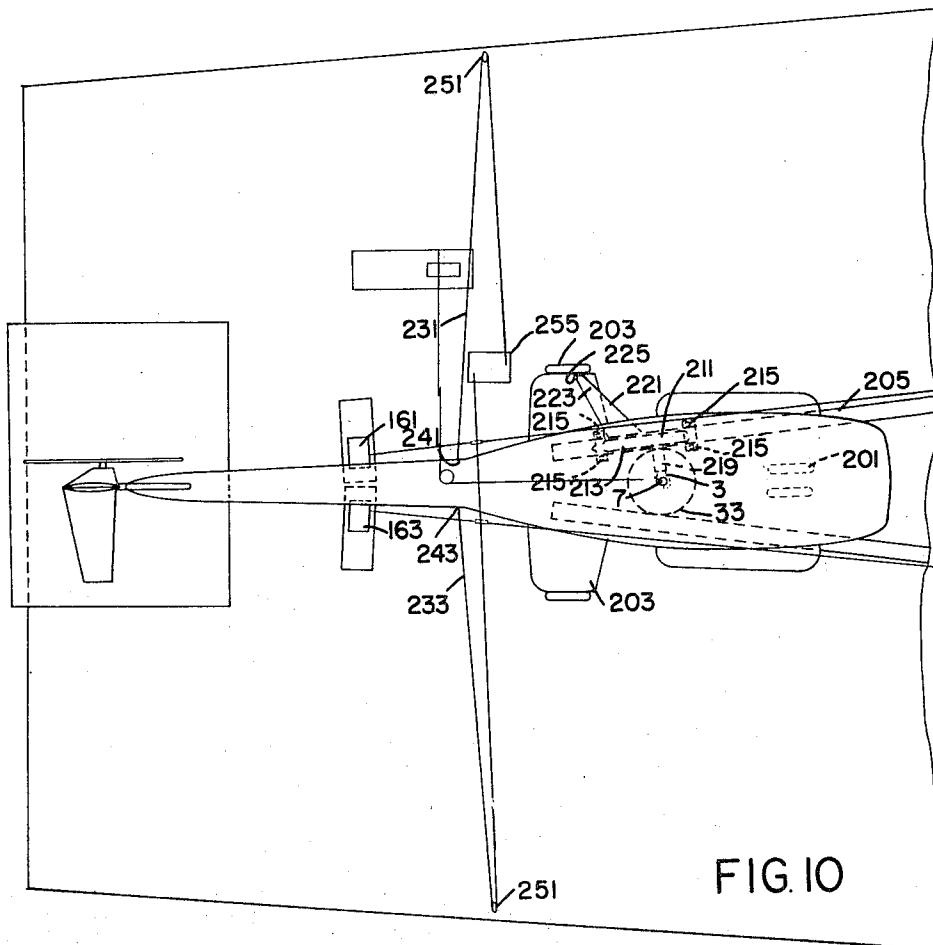
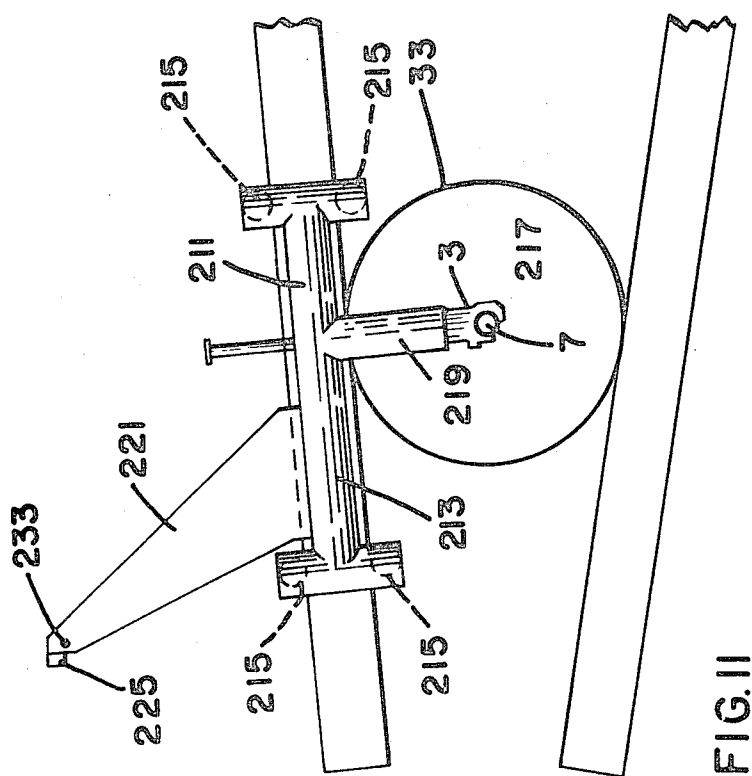


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SHIPBORNE CONVEYING MEANS

This invention relates to means for the conveyance of loads on the deck of a ship, and finds particular application to the transportation of a helicopter landed on the deck of a ship at sea, although the invention is not limited to that application.

The problem of landing a helicopter on the deck of a ship, and the use of a trap device to grab a downwardly extending probe carried by the helicopter when the helicopter has been brought down to the deck of the ship under the control of a cable and a winch carried by the ship, is set out in considerable detail in prior Canadian Pat. Nos. 781,808 and 782,930.

Having landed a helicopter on the deck of a ship, it is often desirable to move the helicopter out of the way in order that the same equipment may be used to land a second helicopter, and/or in order that the helicopter may be moved into the shelter of a hangar for servicing.

According to the present invention, means for the conveyance of loads on the deck of a ship comprise a load carrier, guide means for the load carrier fixed relative to the deck, and anchor means associated with the load carrier and operable to secure the load to the load carrier, whereby in use the load is first secured to the load carrier and the load is then moved bodily about the deck by the load carrier under the guidance of the guide means.

In the context of a helicopter landed on the deck of a ship, the helicopter forms the load, and the load carrier is moved up to the landed helicopter, the anchor means are used to anchor the helicopter to the load carrier, the helicopter probe is then released from the trap used in landing, and the helicopter is then moved bodily about the deck by the load carrier under the guidance of the guide means, suitably into a hangar.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a side elevation of a helicopter landed on the deck of the ship under the control of a hauldown winch and having a probe secured in a trap device;

FIG. 2 is a plan view of the aft end of a ship provided with load conveying means according to the present invention;

FIG. 3 is a sectional side elevation of the aft end of the ship shown in FIG. 2, and shows merely the arrangement of traversing cables indicated in FIG. 2;

FIG. 4 is a sectional side elevation of the trap device shown in FIG. 1 and shows its manner of mounting on the deck of the ship;

FIG. 5 is a plan view of the trap device shown in FIG. 4;

FIG. 6 is a perspective drawing of a dolly utilized in connection with the trap device;

FIG. 7 is a sectional side elevation of an aft jack shown in FIG. 6;

FIG. 8 is a sectional side elevation of a fore jack shown in FIG. 6;

FIG. 9 is a diagrammatic representation of a hydraulic system of the dolly shown in FIG. 6;

FIG. 10 is a plan view of a helicopter and shows an alternative form for the dolly shown in FIG. 6;

FIG. 11 is a plan view of the alternative form of dolly shown in FIG. 10, and is drawn to a larger scale than FIG. 10.

Referring first to FIG. 1, this Figure shows the usual system of landing a helicopter 1 on the deck 3 of a ship under the control of a hauldown cable 5, the underside of the helicopter being provided with a downwardly extending probe 7 and the deck of the ship being provided with a normally fixed but movable trap device 9. This trap device has two parallel arresting beams normally held apart to present an opening into which the probe 7 can be lowered, but movable together at high speed to grip the probe 7. The cable 5 passes over suitable pulleys to a rope accumulator 11 and then to a hauldown winch 13. This winch can be a constant tension type of winch or it can be a normal winch used in conjunction with a constant cable tension control system. The arrangement shown is that used in prior proposals, in which the trap device 9 with the helicopter can be moved forwardly of the ship in the direction shown by the arrow 15 by means of cable 17 wrapped round the drum of a traversing winch 19.

To land the helicopter, the pilot flies the aircraft over the flight deck 3 from astern and establishes a 16-18 foot hover. A messenger cable is lowered from the helicopter to the deck 3, where it is seized with grounded tongs (to discharge static electricity) and coupled to the hauldown cable 5. The messenger cable is then reeled back into the aircraft, where a coupling at the upper end of cable 5 is locked in place inside the probe 7. A landing safety officer at a control console on the ship then applies through the winch 13 a constant tension of 1,500 pounds to the cable 5 and this tends to anchor the helicopter, assisting the pilot to maintain an accurate hover.

The two criteria necessary before initiating a descent to the deck of the ship are a proper hover position over the trap device 9 and a "steady deck." Even in heavy seas steady deck periods occur at regular intervals, and usually last for 7 to 11 seconds. When these two requirements are met simultaneously, the landing safety officer applies between 3,000 and 4,000 pounds of tension to the cable 5, and by his radio link instructs the pilot to land. The pilot then establishes a rapid rate of descent (say 6 feet per second). The opening between the two arresting beams is about 4 feet square, and to make a landing the probe 7 must descend into the opening. Once the probe is inside the opening, the landing safety officer releases the two arresting beams, which rapidly move together and seize the probe. Their grip on the probe and their manner of fixture in the trap device is sufficient for the whole helicopter to be held firmly despite rolling and pitching of the ship.

The present invention is directed to the movement of the helicopter after it has been landed and seized by the trap device in the manner described above. In the prior proposal, shown in FIG. 1, the whole trap device 9 was moved bodily forward of the ship into a hangar for the helicopter. This meant that only one helicopter could possibly be handled by the ship, unless in the hangar the helicopter was to be disconnected from the trap device. In a ship in heavy seas, this could be a dangerous procedure.

Referring now to FIG. 2, in this arrangement the trap device is fixedly mounted on the deck of the ship, i.e., it is not able to take part in forward movement of the helicopter into a hangar. The trap device 9 lies under, and is concealed by, a securing device landing plate 31 formed with a circular central aperture 33 which overlies the opening between the arresting beams 35 (see FIG. 5) of the trap device. The trap device, which is substantially square in plan view, is provided near each corner with a grooved wheel 37 rotatably mounted on a pivot pin 39 carried by the trap device, the grooves of these wheels being engaged by a horizontally inwardly extending circular track 41 itself mounted in a rigid circular trough 43 some 93 inches in diameter and 8 inches deep, which is securely attached to the deck of the ship. Thus, the whole trap device 9 is free to rotate relative to the deck about a vertical axis which is coaxial with the optimum central position of the probe 7 within the trap 9. Also coaxial with the center of rotation is a bellmouth opening 45 through which cable 5 extends downwardly to a sheave 47 provided with cable tension indicating means used, as described in the above-mentioned patent applications, in the control of the tension in that cable. As will be seen from FIG. 5, the landing plate 31 includes two wings 31A and 31B which are of sufficient size to act as supports for the landing skids 49 of a helicopter of the kind indicated in FIG. 4. The front part of the landing plate is cut back over an arc of about 90° as far as the outside of the trough 43. This enables a pickup rail 51, consisting of a metal plate 9 inches wide and 1 inch thick, and pivoted about a vertical axis at 53, to extend up close to the trough 43. The arrangement of this pickup rail 51 is such that it can be swung horizontally through such an angle that its axis can be directed at any point lying inside the landing plate aperture 33. It will be appreciated that when a helicopter lands, the probe may be anchored by the arresting beams anywhere inside the aperture 33, and thus the pickup rail 51 can be directed towards the axis of that probe wherever it may lie. A double-ratchet arrangement 55 mounted on the rail 51 and engaging a complementary device on the ship's deck, enables the rail 51 to be

locked in adjusted position, while cables 56 facilitate this movement of rail 51.

As shown most clearly in FIG. 5, the underneath of the trap device 9 is provided with a pulley 57 which is concentric with the axis of rotation of the trap device, and a cable 59 fitted part way round that pulley extends to two tangentially arranged pulleys 61 and then downwardly to the drum of a hydraulic actuators 62 by which the cable can be moved axially and thus the trap device 9 rotated through a limited angle, i.e., through 45° each way from the central position shown in FIG. 5.

Referring now to FIGS. 2 and 3, it will be seen that the pickup rail 51 is continued as a switch rail 63 and then as to guide rails 65 and 67. Rail 65 is inclined outwardly relative to the centerline of the ship towards the portside, and continues through a hangar doorway 69 into a hangar 71. This hangar is large enough to accommodate two helicopters side by side, their lifting rotors being folded beforehand in orthodox manner. Rail 67 is inclined outwardly towards the starboard side, and the arrangement is such that, as described below, a first helicopter can after landing be moved into a port half of the hangar and a second helicopter can after landing be moved into a starboard half of the hangar.

To convey a landed helicopter from the trap device 9 into the hangar, a transporting dolly 75 is used. FIG. 6 illustrates the general form of the dolly, and it will be seen that it includes a guide assembly 77 consisting of three parallel horizontally extending tubular members 79, 81 and 83, the outer two members each carrying at each end on a vertical axle 85 a grooved guide wheel 87. These wheels are so arranged and mounted that in use they engage the outer edges of the guide rail 65 or the guide rail 67, whichever is being used, while when desired the dolly can be moved towards the trap device 9 until the guide wheels 87 engage first the switch rail 63 and then the pickup rail 51. Each of the two outer members 79 and 83 is provided at about its midlength with an outwardly extending axle 89, and pivotally mounted on these two axles 89 is the main part 91 of the dolly. The general form of the main part 91 is best understood from an inspection of FIG. 6: it comprises two tubular side members 93 joined by tubular cross members 95, and at its aft end includes a thick metal plate 97 welded to the top of the members 93. At its aft end, two laterally extending horizontal tubular members 99 carry out their outer ends wheeled trollies 101 which support this end of the main part 91 on the ship's deck.

The plate 97 is formed with a forwardly convergent notch 103 terminating in a part-circular aperture 105. At the sides of this aperture are provided guide members 107 for a locking plate 109 formed with a U-shaped slot 111 of lesser width than the aperture 105. The main part 91 of the dolly also carries four hydraulic jacks, a pair of aft jacks 113 located at the aft ends of the members 93, and a pair of fore jacks 115 mounted on the members 93 near the aft end of the guide assembly 77. The main part 91 also carries a hydraulic system 117 associated with these jacks, and shown in more detail in FIG. 9.

FIG. 7 illustrates the form of the aft jacks 113, each of which includes a tubular outer casing 121 and a tubular ram 123 having a closed upper end, a tension spring 125 being coupled at its upper and lower ends respectively to the ram 123 and to the casing 121 and tending to move the jack ram to its lowered position shown. A supply/exhaust coupling 127 for hydraulic fluid is connected to the top of the ram 123, and the ram is provided with a lateral projection 129 extending into a groove 131 in the casing and serving to act as a stop preventing overextension of the ram relative to the casing and to prevent rotation of the ram.

FIG. 8 illustrates the form of the fore jacks 115. These are generally similar to the aft jacks, but since they are required to extend to a greater length, they comprise a tubular outer casing 135 closed at its lower end, a tubular inner ram member 137 closed at its upper end, and a tubular intermediate member 139 acting as an annular ram member. A tension spring 141 acts between the ram member 137 and the casing

135 and tends to return the ram to its retracted position, and lateral projections 143 and 145 respectively on the ram member and on the intermediate member serve to limit extension of the ram relative to the intermediate member and extension of the intermediate member relative to the casing. They also prevent rotation of the ram and of the intermediate member. A supply/exhaust coupling 147 is connected to the upper end of the ram.

All four jacks have their upper ends formed as laterally apertured lugs 123A or 137A. Since the rams cannot turn in their casings, this orientation is permanent.

FIG. 9 illustrates the hydraulic system 117. The system includes a nonpressurized storage tank 151 and a hand operated pump 153 associated with a nonreturn valve 155, by which hydraulic fluid can be pumped from the tank to the four jacks to extend their rams. A spring-loaded pressure relief valve 157 protects the system from excessive fluid pressure, and a manually operated valve 159 in parallel with the relief valve enables the jacks to be lowered simultaneously at a desired rate by venting of hydraulic fluid to the tank 151.

Two dolly traverse winches 161 and 163 are provided, associated respectively with the port rail 65 and with the starboard rail 67. The cable 164 associated with winch 163 extends from a coupling 165 which can be fixed to the aft end of the dolly, round the winch 163 and via a suitable system of guide pulleys to a pulley 167 at the forward end of rail 67, then aft along the rail to a coupling 169 which can be coupled to the fore end of the dolly. Operation of winch 163 can thus move the dolly in the desired direction along the guide rail 67, while a hydraulic shock absorber 171 limits forward movement of the dolly. The cable associated with winch 161 is similar arranged, and it will be appreciated that only one of these cables will be used at a time, depending upon which half of the hangar is to be used.

It is convenient to use two dollies, one associated with each half of the hangar, so that the helicopter can be left secured to the dolly and thus be securely anchored in the hangar.

In use of the apparatus described above, the helicopter is landed in the manner described, the probe 7 being clamped between the arresting beams of the trap device. At this stage, the helicopter is securely held, with its weight carried through its two skids on the landing plate 31. It will be appreciated that although the helicopter pilot attempts to land with the probe central in the aperture 33, he will rarely achieve this, and further despite his best efforts it is quite possible that the fore-and-aft axis of the helicopter will not be accurately parallel to the fore-and-aft axis of the ship.

The dolly 75 is now run out along the guide rail and the switch rail 63 to the pickup rail 51, which is set by the ground crew so that it points straight towards the probe 7 and is locked in that position by the ratchet arrangement 55. The hydraulic actuators 62 associated with cable 59 are energized to rotate the whole trap device, including the landing plate 31 and the helicopter perched on that plate, to bring the fore-and-aft axis of the helicopter into alignment with the longitudinal axis of the pickup rail 51 and thus into alignment with the probe 7 inside the aperture 105, and the locking plate 109 put in position. The slot in this plate is a relatively close fit to the probe, and locates the dolly relative to the probe. When this has been done, the jacks are raised by operation of the pump 153 and the jack lugs 123A and 137A are located inside clevis fittings 181 on the helicopter. Locking pins 183 provided with retaining members 185 are then fitted in place through the clevis fittings 181 and the lugs 123A and 137A and serve to anchor the helicopter to the dolly.

Once the helicopter has been securely anchored to the dolly, the cable 5 is uncoupled from the probe 7 by the landing safety officer operating his controls to increase the cable tension to a value above a "release" value for an automatic coupling inside the probe. The upper end of cable 5 then falls down below the trap, a fitting on the cable end preventing it from falling through the opening 45. The helicopter is now

free from the trap, and the dolly, with the helicopter anchored to it, is moved forwardly by means of the cable 164 into the starboard side of hangar 71.

It is not essential that a second dolly be provided for use with the portside of the hangar, since once the helicopter is in the starboard side of the hangar it can be shackled down to the deck, the jacks released from the clevis fittings on the helicopter, the probe 7 retracted upwardly clear of the plate 97 (after forward movement of the locking plate 111) through the aperture 105, and the dolly moved aft under the helicopter back towards the trap device, for use with the cable serving the portside of the hangar.

The dolly described above is suitable for use with a helicopter equipped with landing skids, and for use with a helicopter equipped with a tricycle undercarriage of the type having two wheels at the front and one at the rear, the landing plate being extended aft to accent the rear wheel. In the case of the single rear wheel, it will usually be difficult to avoid using two dollies, since usually it will not be possible to move the dolly aft under the helicopter when it is in the hangar, the tailwheel being in the way.

However, many helicopters have a tricycle carriage with one wheel at the front and two wheels further back. It is not possible to utilize the form of dolly shown in FIG. 6 when the helicopter has such an undercarriage, since the nosewheel will be in the way of the dolly and instead the arrangement of FIGS. 10 and 11 can be used. In FIG. 10, the front wheels 201 and the rear wheels 203 of the tricycle undercarriage are indicated, as is the central aperture 33 of the landing plate and the probe 7. The guide rail 205 from the portside of the hangar passes the front wheels 201 on the portside and extends past the aperture 33. The dolly 211 comprises a tubular body 213 provided near its ends with crossmembers carrying four grooved guide wheels 215 similar to the guide wheels 87 of the dolly of FIG. 6. The dolly body 213 carries a probe clamp 217 which can be moved transversely of the dolly body in its mounting 219 to secure the probe 7 whatever the position of the probe 7 in the aperture 33. The dolly body 213 also carries a laterally extending wing 221 provided at its outer end with a clamp 223 suited to easy attachment to the standard towing lug 225 provided on the understructure of the helicopter.

In use of this alternative form of dolly, after the helicopter has landed it is first swung until its fore-and-aft axis is parallel to the fore-and-aft axis of the rail 206. This is facilitated by the use of two cables 231 and 233 which can be coupled at 241 and 243 respectively to the port and the starboard sides of the helicopter aft of the probe 7, and which extend respectively round pulleys 251 and 253 to a winch 255. Operation of this winch in one direction will slew the tail to port, and operation in the opposite direction will slew the tail to starboard. The dolly 211 is then secured to the probe 7 and to the towing lug 225, the probe is released from the trap, and the dolly moved forwardly into the hangar by a traversing winch in the manner described above in connection with FIGS. 2 and 3.

In the arrangement of FIGS. 10 and 11, it is not essential that the trap device be mounted on a turntable so that it can be rotated as indicated in the embodiments of FIGS. 2 to 9. The turntable is desirable for skid-equipped helicopters, but where wheeled helicopters are to be handled, these wheels are invariably such as to permit the helicopter readily to be slewed while on the deck of the ship.

It will be appreciated that in any practical installation some of the features of the first embodiment may be combined with some of the features of the second embodiment. It may, for example, be desirable to provide a trap device which can rotate (to accommodate skid-equipped helicopters) together with an offset dolly (as in FIGS. 10 and 11) to accommodate helicopters with nosewheels. Further, the cables for slewing the helicopter can be considered as an alternative to the means for rotating the landing plate 31.

By the present invention, it is possible to move a large and heavy load about the deck of a ship sailing in rough seas in complete safety and under complete control. Although in the

embodiments described above, the load is a landed helicopter, the invention clearly is applicable to other loads.

I claim:

1. Means arranged and adapted for the conveyance of a helicopter on the deck of a ship, comprising:
 - a. a load carrier;
 - b. guide means fixed in relation to a deck of the ship; the guide means being adapted to restrain and to guide the load carrier and to position the load carrier under the helicopter after the helicopter has landed;
 - c. a central member provided on the underside of the helicopter;
 - d. anchor means carried by the load carrier; and
 - e. operating means whereby the anchor means can be operated partially to embrace that central member to anchor the helicopter relative to the load carrier;
 whereby in use the landed helicopter is first secured to the load carrier, and the helicopter is then moved bodily about the deck by the load carrier under the guidance of the guide means.
2. Means for the conveyance of a helicopter according to claim 1, and in which:
 - a. a guide rail constitutes the guide means; and
 - b. wheels are provided on the load carrier, these wheels being arranged to engage the guide rail and to locate the load carrier relative to the guide rail against all movements except movements along the guide rail.
3. Means for the conveyance of a helicopter according to claim 2, and in which:
 - a. the guide rail is in the form of a metal strip shaped on opposite sides to form two guide tracks; and
 - b. the said wheels include a plurality of wheels arranged to engage a first of the guide tracks, and at least one wheel arranged to engage the second of the guide tracks.
4. Means for the conveyance of a helicopter according to claim 1, and in which:
 - a. the helicopter carrier is arranged to guide the load; and
 - b. the weight of the helicopter is transferred directly to the said deck or to members, other than the load carrier, carried by the said deck.
5. Means for the conveyance of a helicopter according to claim 1, and in which:
 the helicopter carrier is arranged both to guide the load and to carry its weight.
6. Means for the conveyance of a helicopter according to claim 1, and in which:
 - a. the load carrier is arranged both to guide the helicopter and to carry the weight of the helicopter;
 - b. a first part of the load carrier is acted on by the guide means;
 - c. a second part of the load carrier is connected to the first part in a manner ensuring that most of the weight of the helicopter will not be transferred to the guide means; and
 - d. the said second part is provided with wheels by which the weight of the helicopter is at least for the most part carried by the deck of the ship and not by the said first part and by the guide means.
7. Means for the conveyance of a helicopter according to claim 1, and in which:
 - a. the load carrier is arranged both to guide the helicopter and to carry the weight of the helicopter;
 - b. a first part of the load carrier is acted on by the guide means;
 - c. a second part of the load carrier is connected to the first part in a manner ensuring that most of the weight of the helicopter will not be transferred to the guide means;
 - d. the said second part is provided with wheels by which the weight of the helicopter is at least for the most part carried by the deck of the ship and not by the said first part and by the guide means;
 - e. the second part of the load carrier is arranged for movement axially of the guide means to a position in which it can assume the weight of the helicopter; and

f. jack means provided on the said second part by which the weight of the helicopter can be assumed by the said second part.

8. Means for the conveyance of a helicopter according to claim 1, and in which:

- a. wheels are provided on the load carrier and engage a deck of the ship to carry the weight of the helicopter; and
- b. jack means provided on the helicopter carrier are operable to transfer the weight of the load from the deck to the wheeled load carrier.

9. Means for the conveyance of a helicopter according to claim 8, and in which:

- a. the jack means are hydraulic jacks; and
- b. a complete hydraulic system for the raising and lowering of the said jacks is carried by the load carrier.

10. Means for the conveyance of a helicopter according to claim 1, and in which:

- a. the central member is a probe carried by the helicopter;
- b. a trap device carried by the ship is arranged to seize and secure the probe when the helicopter lands; and
- c. the trap device is arranged to release the probe only when the helicopter has been secured to the wheeled load carrier.

11. Means for the conveyance of a helicopter according to claim 10, and in which:

- a. skid-type landing gear is provided on the helicopter;
- b. a turntable on the deck of the ship carries the trap device;
- c. the wheeled load carrier is movable between the skids into position to engage the probe after the turntable has been turned to bring the skids of the landing gear into parallelism with a longitudinal axis of the guide means.

12. Means for the conveyance of a helicopter according to claim 1, and in which:

- a. the load carrier is arranged to move axially of the guide means into proper relationship to the helicopter;
- b. a central member is provided on the helicopter;
- c. the anchor means are arranged to move laterally of the guide means to anchor the said central member of the helicopter to the load carrier.

13. Means for the conveyance of a helicopter according to claim 12, and in which:

- a. a probe carried by the helicopter constitutes the said central member;
- b. a trap device is fixed to the deck of the ship and is

adapted to seize the said probe when the helicopter lands on the deck; and

c. the probe is released from the said trap device only after the helicopter is anchored to the load carrier.

14. Means for the conveyance of a helicopter according to claim 13, and in which:

- a. the helicopter has forward landing wheels;
- b. the guide means are arranged to guide the load carrier to pass to one side of these forward landing wheels to a position axially opposite the center of mass of the helicopter;
- c. a further anchoring point is provided on the helicopter displaced both axially and laterally, relative to the helicopter longitudinal axis, relative to the probe; and
- d. the load carrier is adapted for securement both to the said probe and to that further anchoring point.

15. Means for the conveyance of a helicopter according to claim 1, and in which:

- a turntable device is provided by which the helicopter can be reoriented before being anchored to the load carrier;
- whereby a desired fore-and-aft axis of the helicopter can be reoriented into alignment or parallelism with a fore-and-aft axis of the load carrier.

16. Means for the conveyance of a helicopter according to claim 1, in combination with:

- a. a turntable device on which the helicopter can be reoriented before anchoring to the load carrier; and
- b. power means by which the turntable device can be rotated to effect reorientation thereof;
- whereby a desired fore-and-aft axis of the helicopter can be reoriented into alignment or parallelism with a fore-and-aft axis of the load carrier.

17. Means for the conveyance of a helicopter according to claim 1, and in which:

- a. a probe provided on the said helicopter extends downwardly below the body part of the helicopter;
- b. a turntable device is provided on the said deck;
- c. a trap device is provided on the said turntable and is adapted to grip and hold the said probe once the helicopter has landed on the deck; and
- d. a landing plate on the turntable device is arranged to support the weight of the helicopter as it lands;
- whereby the fore-and-aft axis of the landed helicopter can be reoriented by rotation of the turntable into alignment or parallelism with the fore-and-aft axis of the load carrier.

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