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(54) **A method and apparatus for making fast to an iceberg.**

(57) The method of making fast to an iceberg comprises the steps of:

-providing a rigid, hollow, parallel-sided anchor body (24) having an open end with a rim (26) and a closed end including means (25) for making fast thereto;

-applying the open end against an iceberg (12) and sealing it thereto by sinking the rim into the ice; and

-ensuring that the body is filled with water and then pumping (17) the water out via an opening in or near the closed end of the body to create a pressure differential tending to thrust the body into the iceberg, whereby the means for making fast to the closed end of the anchor body provide a secure point for making fast to the iceberg once the anchor body has been sunk into the iceberg. The invention also provides a submersible rig for performing this method under water, thereby facilitating the filling of the anchor body with water, and also having the advantage of a greater pressure differential with increasing depth under water.

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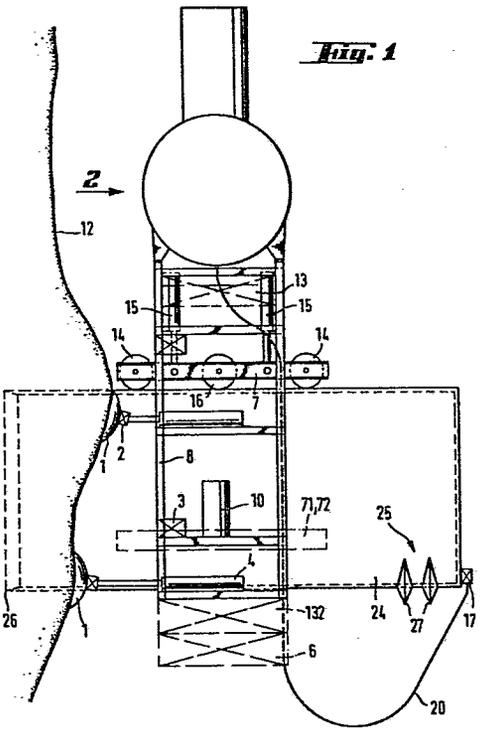
Fig. 1



A METHOD AND APPARATUS FOR MAKING FAST TO AN ICEBERG

The present invention relates to a method and to apparatus for making fast to an iceberg. In other words, to a method for obtaining a purchase on the ice of an iceberg so that a force may be applied thereto.

There have been various proposals for towing tabular icebergs from the Antarctic to coastal regions in need of water. Attempts at moving such icebergs require fixing points on the iceberg itself in order to apply tractive forces thereto, and also in order to moor protective devices to the iceberg to prevent excessive damage from wave action and from melting in warm tropical waters.

In a first aspect the present invention provides a method of making fast to an iceberg, the method comprising the steps of :

- providing a rigid, hollow, parallel-sided anchor body having an open end with a rim, and a closed end including means for making fast thereto ;
- applying the open end against an iceberg and sealing it thereto by sinking the rim into the ice ; and
- ensuring that the body is filled with water and then pumping the water out via an opening in or near the closed end of the body to create a pressure differential tending to thrust the body into the iceberg, whereby the means for making fast to the closed end of the anchor body provide a secure point for making fast to the iceberg once the anchor body has been sunk into the iceberg.

This method is preferably carried out under water, thereby facilitating the filling of the anchor body with water, and also having the advantage of a greater pressure differential with increasing depth under water.

The parallel-sided anchor body will preferably be in the form of a cylinder of steel, for example a length of standard steel tubing with a cover plate welded to one end to close it.

In a second aspect, the present invention provides apparatus for performing the method defined above. The apparatus comprises a submersible rig for holding an anchor

body and including controllable ballast tanks for submerging the rig together with an anchor body to a predetermined depth, means for obtaining a temporary grip on the flank of an iceberg, means for advancing the anchor body until the rim of its leading edge is completely embedded in the flank of the iceberg, and means for pumping out water from the anchor body to cause it to sink progressively into the iceberg.

Preferably the means for obtaining a temporary grip on the flank of an iceberg comprises a plurality of iceberg-gripping heads mounted on the ends of respective arms of variable length. Suitable gripping heads include suction cups which are preferably mounted on the ends of respective hydraulic rams serving as the said arms. The lengths of the arms can then be varied independently of each other to accomodate irregularities in the flank of an iceberg, or simultaneously to move the entire rig towards or away from the said flank.

Normally the rig will be ballasted to remain on an even keel, and will operate at depths where the effect of waves is negligible, but if the rig should tilt undesirably, for example, during manoeuvering to obtain a temporary grip on the iceberg, it is also useful to be able to move its variable length arms in concert to correct its orientation, i.e. to move the arms simultaneously but by different amounts and possibly in different directions.

Embodiments of the rig are described by way of example with reference to the accompanying drawings, in which :

- Figure 1 is a side view of the first rig showing an anchor body partially engaged in the flank of an iceberg ;
- Figure 2 is a front view of the first rig as shown figure 1 ;
- Figure 3 is a side view similar to figure 1 but in which some components have been omitted in order to show other components more clearly, with particular emphasis on suction cups and TV viewing arrangements ;

- Figure 4 is a front view of the first rig as shown in figure 3 ;
- Figure 5 is a side view similar to figures 1 and 3 with particular emphasis on means for advancing the anchor body, with the near side of the rig removed ;
- Figure 6 is a front view of figure 5 ;
- Figure 7 is a detail view of a retractable anchor body guide ;
- Figure 8 is a side view similar to figures 1, 3 and 5 of a variant rig with particular emphasis on jacks for initial sinking of the rim of the anchor body in the ice ;
- Figure 9 is a front view of figure 8 ;
- Figure 10 is a cross-section through a variant device for obtaining an initial grip on an iceberg ;
- Figures 11 and 12 are a side view and a front view of alternative means for moving an anchor body into the ice ; and
- Figures 13 and 14 show two positions of a further variant of means for moving the anchor body into the ice.

A first embodiment of a submersible rig in accordance with the invention for use in making fast to an iceberg is described with reference to figures 1 to 9. These figures all show substantially the same rig with only slight modifications from one set of figures to the next. However, to keep the drawings uncluttered, many elements common to all the variants are only shown in a few. In particular, the structure of the rig per se and of its various means for manoeuvering are substantially identical throughout, even if not explicitly shown in all the drawings, the main variations concern different ways of initially embedding the anchor body in the flank of an iceberg and different ways of performing the step of pumping it out.

With reference in particular to figures 1 to 4, the flank 12 of an iceberg is shown being penetrated by an anchor body in the form of a parallel-sided cylinder 24 with an open end having a sharp rim 26 and a closed end fitted with means 25 for making fast to the cylinder 24. The

cylinder 24 is supported by a rig which essentially comprises a main tank 5 from which there is suspended a horse-shoe shaped frame 8 arranged astride the cylinder 24. The frame is made from a welded assembly of 120 mm square box section bars which may be dismantled for transporting the rig on land or by ship and which are held in the horse shoe configuration by corner struts 19. The tank 5 is attached to the horizontal member 83 of the rig by means of six brackets 21, arranged in two lines of three.

The main tank 5 serves as a main buoyancy chamber and also as a housing for machinery. An airlock 23 provides access to its interior. The rig is ballasted by ballast (e.g. lead shot) contained in respective chambers 6 located at the foot of each frame vertical 81 and 82. The arrangement provides the basic means for keeping the rig at substantially neutral buoyancy and the right way up. In an emergency, the chambers 6 can be jettisoned by means 18 allowing the rig to return to the surface. For vertical movement and also for trimming, the rig is also provided with a ballast tank 13 at the head of each frame vertical (or slightly inboard thereof see fig 9) and ballast tanks 131 and 132 at the foot of the verticals 81 and 82 respectively. The rig can be submerged to a desired depth and maintained at that depth by appropriate pumping of seawater into and out of the ballast tanks 13, 131 and 132.

In addition to buoyancy control over vertical position, there are two vertically oriented, shrouded thrusters 10, one mounted on the lower half of each vertical 81 and 82. Two horizontally oriented shrouded thrusters 11 are provided in the corners below the frame horizontal 83 (see fig 9) or in the frame horizontal 83 itself (see 2) and are for use in moving the rig towards or away from the flank 12 of an iceberg. At close range, horizontal movement is controlled more accurately by hydraulic rams 4 which engage the flank 12 via respective suction cups 1 and universal joints 2. There may be four or six such ram/suction cup assemblies, two per vertical 81 or 82 and optionally two on

the cross-piece 83 (see figs.3 and 4). The suction cups 1 have a diameter of 1/2 metres and are connected to pumping means, not shown, to provide a temporary grip on the flank 12, while the hydraulic rams 4 are capable of exerting a thrust of up to 25 tonnes to enable the rig to be pushed or pulled directly with respect to the flank 12. The rams 4 also make it possible to accommodate any irregularities in the surface of the flank 12. Other iceberg-gripping heads could be devised, e.g. including means for piercing into the ice, and likewise other forms of arm, e.g. with more or fewer degrees of freedom of movement could also be devised. Our preferred variant iceberg-gripping arm is described with reference to figure 10.

To facilitate proper control of the arms, a TV camera/floodlight assembly 3 is provided in association with each arm. The TV pictures are intended for a remote operator on a surface vessel, but alternatively the main tank 5 could be equipped with crew quarters in addition to housing machinery.

The anchor body cylinder 24 is held in place between the three limbs of the horse shoe shaped frame 8 by means of three retractable sets 7, 71, 72 of guide wheels 14, 16, the sets being at 120° spacing. Each set comprises three wheels arranged in line to run along a generator line of the cylinder 24. The upper set 7 is vertically retractable towards the frame horizontal 83, while the lower sets 71 and 72 are rotatably retractable towards their respective frame verticals 81 and 82. A pair of jacks 15 control the retraction of each of the sets (see e.g. figure 7). The middle wheel 16 of each set of wheels is motorized for driving the cylinder longitudinally, while the leading and trailing wheels 14 are idler wheels.

The sharp rim 25 at the leading edge of the cylinder 24 aids initial penetration into the ice of the flank 12. Ice is a plastic substance and melts and flows when pressure is applied to it. Thus, an initial penetration of the flank is obtained by mechanically thrusting the cylinder 24 into

the ice. Thus, with the hydraulic rams 4 at their maximum extension compatible with the uneven surface of the ice, the cylinder 24 is moved forward by the motor wheels 16 until the sharp rim 26 comes into contact with the ice. Then, with the wheels 16 locked, the hydraulic rams 4 are progressively shortened at a rate which is sufficiently slow not to lose contact at the suction cups, thereby slowly embedding the rim of the cylinder in the ice. This operation may need repeating more than once, i.e. the rig may need to be reversed along the cylinder and the process repeated. Alternatively it may be possible to apply sufficient thrust using the motor wheels 16 on their own.

In a variant shown in figures 8 and 9, the cylinder 24 is provided with outwardly directed, diametrically opposed lugs engaged in hydraulic rams 9. This provides for direct thrust connection between the rig and the cylinder and the rams 8 can then be reserved for use in positioning the rig against the ice flank 12. So long as the lugs are not large, their extra resistance to passage of the cylinder 24 through the ice in the next stage of operation is not objectionable. This arises from the fact that even at depths of only a few tens of metres, the pressure difference available for thrusting the cylinder into the ice is large.

Whichever method is actually used to embed the rim 26 in the ice, there follows the step of pumping the water out of the cylinder 24 via its closed end so that the cylinder becomes progressively embedded deeper and deeper into the ice. A first arrangement for performing this step is shown in figures 1 and 2. A pump 17 (e.g. an electrically driven turbine pump) is located on the closed end of the cylinder 24 and a power lead 20 runs from the pump to the main tank 5. The power for the pump is generated by machinery in the main tank 5. Alternatively, a hydraulic pump can be used and then the power supply means and the power lead 20 are adapted accordingly.

A second arrangement is shown in figures 3 to 9. In this arrangement the rig is remotely operated from the surface. A more powerful pump 171 is used and it includes both a first powerline 201 from the main tank 5 and a second powerline 202 from the surface. Also the pump 171 is shown on the top of the cylinder 24 instead of on its end ; the top position facilitates evacuating any air which may be trapped in the cylinder, but the air is evacuated at some stage and either position is satisfactory provided that the valve arrangement is near the end so that the cylinder can be sunk a substantial distance into the ice. It can advantageously be provided with a sensor to indicate contact with the flank 12 of the iceberg so that pumping is stopped before it becomes impossible to sink the cylinder 24 any further into the ice. Such an arrangement helps to avoid the possibility that a projecting portion of ice inside the cylinder 24 could deform, or even perhaps rupture the end of the cylinder 24 during the final stages of pumping.

The first powerline 201 is used essentially during the initial stages of embedding the rim 26 in the ice. This enables any pumping at that stage to be properly co-ordinated with the mechanical action of pushing the cylinder into the ice.

An umbilical cable 203 for both power and telecommunications is shown leaving the main tank 5 and extending towards the surface.

Once the cylinder 24 has been sunk into the ice, the rig is free to return to the surface to collect another cylinder and repeat the procedure at a different point in the flank 12 of the iceberg. The means 25 for making fast to the cylinder 24 shown near its closed end comprise two check pieces 27 which provide a slot for guiding and retaining a belt which is placed around the cylinder 24. Such a belt can be used to anchor a floating tower acting as part of a protective barrier around the iceberg, or for any other purpose for which there is a need to apply a thrust in a direction substantially parallel to the flank 12 of

the iceberg. An alternative arrangement for making fast would be to put a neck in the cylinder 24 near to its closed end. Such a neck would be more difficult to make from standard metal tubing, but it could extend further around the cylinder without interfering with the guide systems.

Figure 10 shows an alternative iceberg-gripping arm to replace the sucker/hydraulic ram arrangements described with reference to figures 1 to 9. One of the frame verticals is indicated by its fore and aft vertical bars 84 and 85. This iceberg-gripping arm operates on the same principle as the main system for embedding an anchor body in the iceberg.

The arm shown in figure 10 comprises a torpedo 31 provided with a shrouded propeller 30 at an aft end and a cylindrical iceberg-penetrating body 32 at a leading end. The propeller 30 is used for the initial penetration of the leading edge of the body 32 into the ice, power being provided via a power lead 204. Once the leading edge is sufficiently embedded, the body 32 is pumped out in the same way as the anchor body 24. The pump is shown in section at 174, it is a turbine pump arranged axially along the fore part of the torpedo 31, together with valves and means for pumping water into the iceberg-penetrating body 32 as well as out of it. This last feature is required when the rig is to leave the site after implanting an anchor body 24 in the flank of the iceberg. A further feature is the TV camera and floodlight assembly 3 which is located to look inside the iceberg-penetrating body 32.

Figures 11 and 12 show a further method of advancing an anchor body. In these figures the anchor body 241 is a cylinder of smaller diameter and greater length than the cylinder 24 shown in figures 1 to 9. The small diameter cylinder 24 is held in the horseshoe of the frame 8 by two collars 41 and 42 arranged in a drive system 40 for urging the anchor body 24 forwards. The system thrust is provided by a set of hydraulic cylinders 43. In a first stroke the cylinder 241 is held by the collar 41 which is fixed while the collar 42 is loosed and moved backwards by the hydraulic

cylinders 43. Then the moving collar 42 is tightened to grip the cylinder 24 and the fixed collar 41 is loosened. A second, or drive, stroke follows in which the moving collar 42 is pulled forwards by the hydraulic cylinders 43. At the end of the drive stroke the fixed collar 41 is tightened and the moving collar 42 is loosened to repeat the first stroke. This operation is continued until the cylinder can be more easily moved by pumping from pump 171 as before. Clearly, this thrusting can only be performed after an adequate temporary grip on the iceberg has been obtained by means of the suction cups 1, for example, or equivalent.

The moving collar 42 is shown in elevation in figure 12. It is essentially composed of three 120° circumferential sectors which are hinged together and operated, for tightening and loosening, by two tangentially disposed hydraulic cylinders 425 and 426.

Figures 13 and 14 are partial sections through a variant of the motor wheel 16. To obtain a greater tractive surface two motor wheels 161 and 162 are arranged side by side with individual motors 163 and 164. Further, they are pivoted so as to be able to adapt to cylinders of different diameters. This effect can readily be understood on comparing figure 13 showing a small diameter 241 and figure 14 showing the large diameter cylinder 24. A small jack 165 provides the thrust needed for such position varying of the motor wheels 161 and 162.

REFERENCE NUMERALS

1. suction cups
2. universal joints
3. TV camera/ floodlight assembly
4. hydraulic rams
5. main tank
6. ballast chamber
7, 71, 72 } sets of guide wheels
8. horseshoe-shaped frame
9. ram
10. vertical thruster
11. horizontal thruster
12. flank of an iceberg
13, 131, 132 } trimming ballast tanks
14. guide wheels
15. jacks for retracting sets of wheels
16. motor wheels
17. pump
18. ballast jettisoning means
19. corner struts
20. flexible pipe
21. brackets
23. airlock
24. cylinder = anchor body
25. means for making fast to cylinder
26. rim
27. cheek pieces
30. propeller
31. torpedo-shaped body
40. drive system
41. fixed collar
42. moving collar
43. hydraulic cylinder

81, 82 } frame verticals

83. frame horizontal

84. fore bar

85. aft bar

161, 162 } motor wheels

163, 164 } motors

165. jack

171. second pump

174. torpedo pump

201. first pipe

202. second pipe

203. umbilical TV and power

241. small diameter cylinder

421, 422, 423 } sectors of collar

425, 426 } tightening/loosening hyraulic cylinders

CLAIMS

1. A method of making fast to an iceberg, the method comprising the steps of :
- providing a rigid, hollow, parallel-sided anchor body having an open end with a rim, and a closed end including means for making fast thereto ;
- applying the open end against an iceberg and sealing it thereto by sinking the rim into the ice ; and
- ensuring that the body is filled with water and then pumping the water out via an opening on or near the closed end of the body to create a pressure differential tending to thrust the body into the iceberg, whereby the means for making fast to the closed end of the anchor body provide a secure point for making fast to the iceberg once the anchor body has been sunk into the iceberg.

2. A method according to claim 1 wherein the method is performed under water.

3. A method according to claim 1 or 2, wherein the parallel-sided anchor body is in the form of a cylinder.

4. A method according to claim 3 wherein the cylinder is made from a length of steel tubing.

5. Apparatus for performing the method according to claim 1, 2, 3 or 4, wherein the apparatus comprises a submersible rig for holding an anchor body and including controllable ballast tanks for submerging the rig together with an anchor body to a predetermined depth, means for obtaining a temporary grip on the flank of an iceberg, means for advancing the anchor body until the rim of its leading edge is completely embedded in the flank of the iceberg, and means for pumping out water from the anchor body to cause it to sink progressively into the iceberg.

6. Apparatus according to claim 5 wherein the means for obtaining a temporary grip on the flank of an iceberg comprises a plurality of iceberg-gripping heads mounted on the ends of respective arms of variable length.

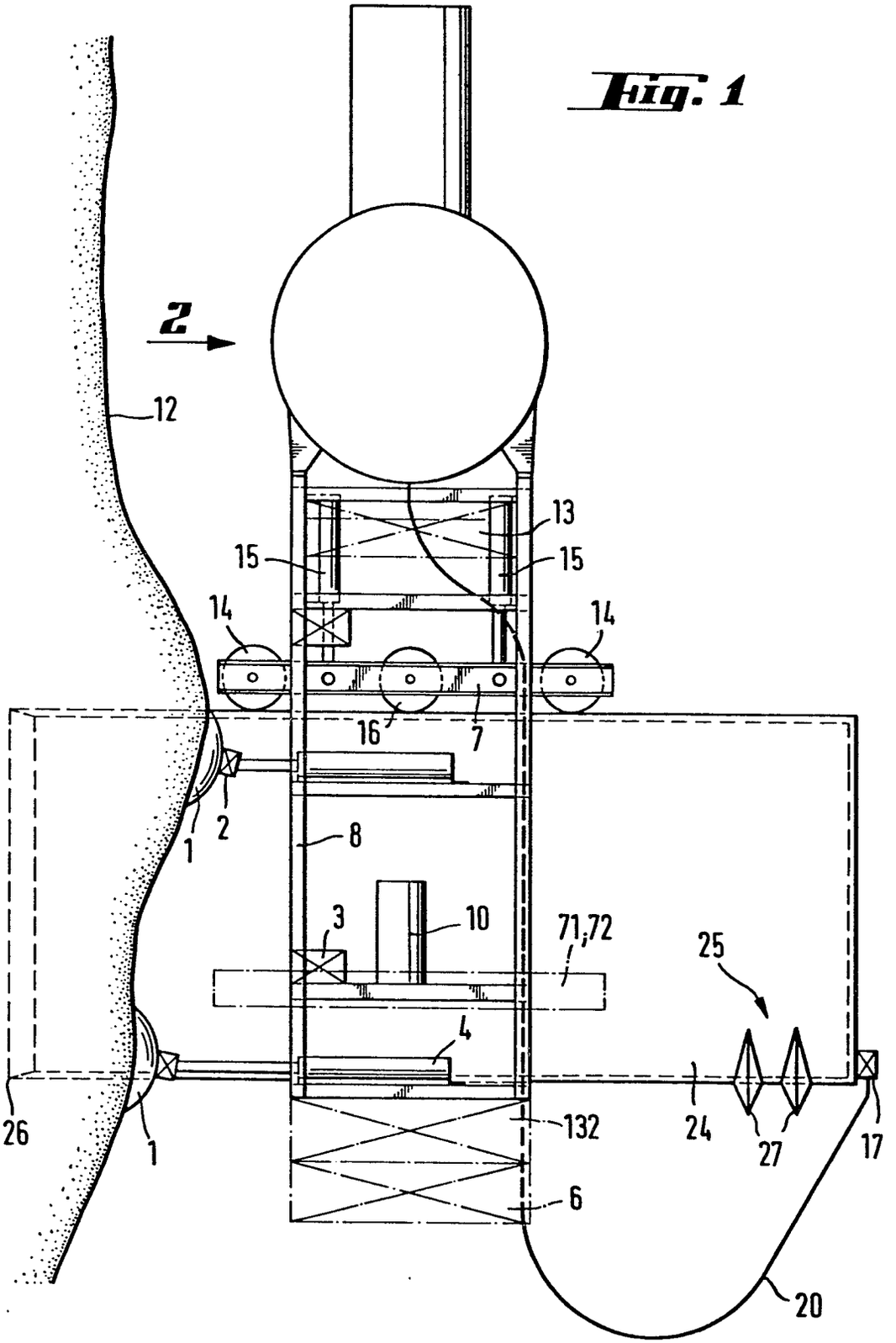
7. Apparatus according to claim 6, wherein the iceberg-

gripping heads include suction cups.

8. Apparatus according to claim 6 or 7, wherein the arms of variable length are constituted by hydraulic rams.

9. Apparatus according to claim 6, 7, or 8, wherein the arms of variable length are connected to control means permitting them to be varied independently of each other or together with each other.

Fig. 1



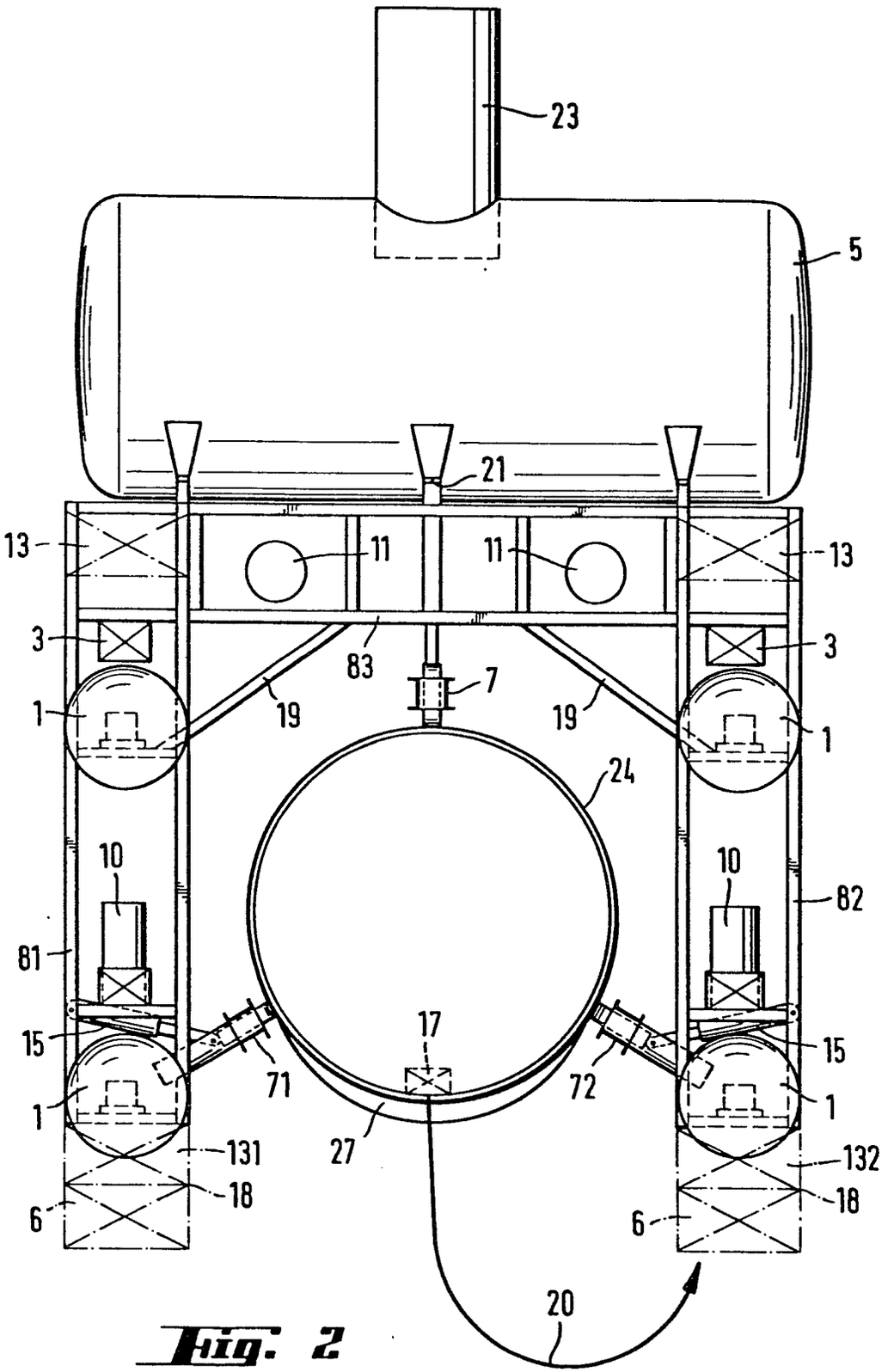

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Fig. 2

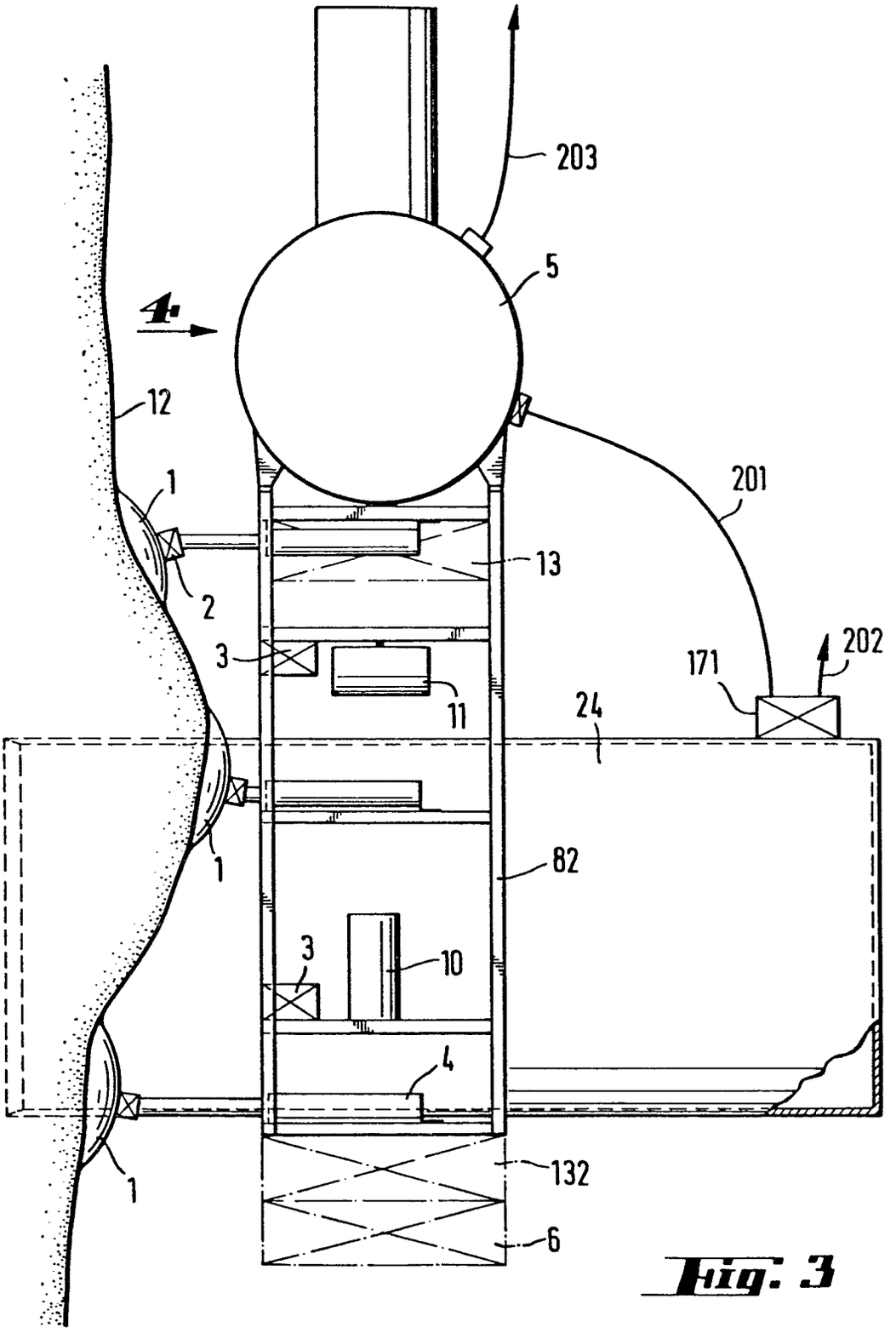


Fig. 3

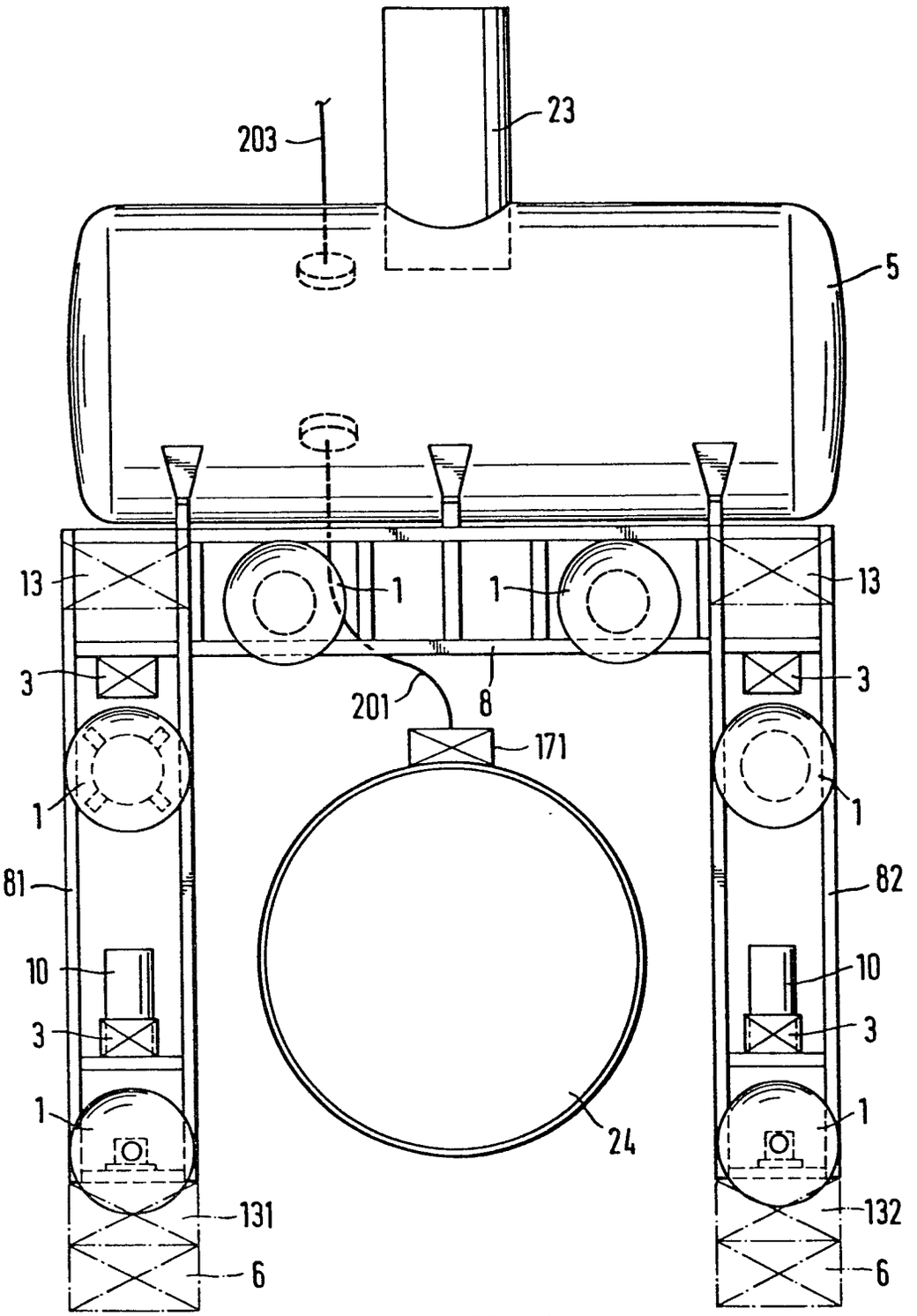
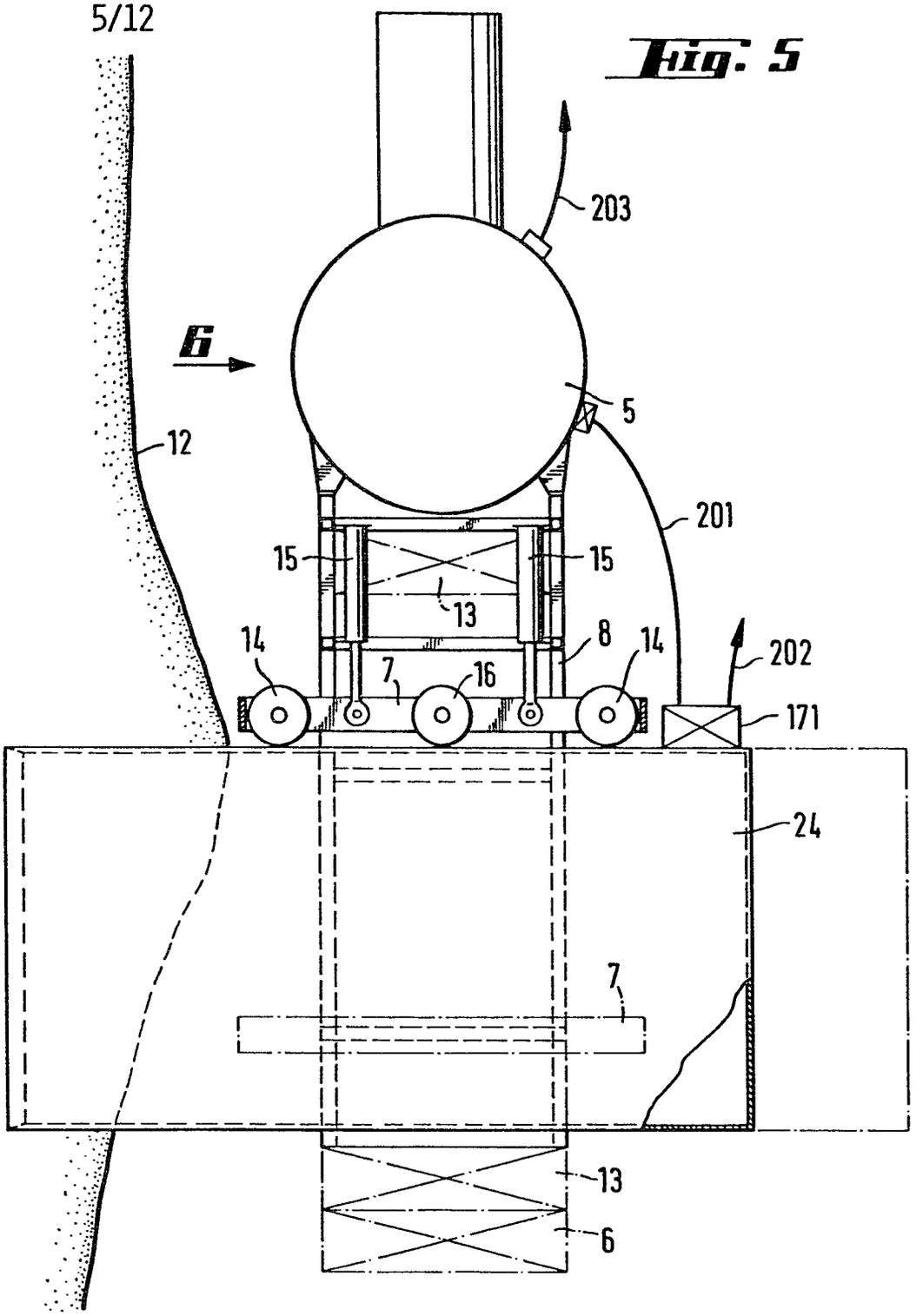


Fig. 4

Fig. 5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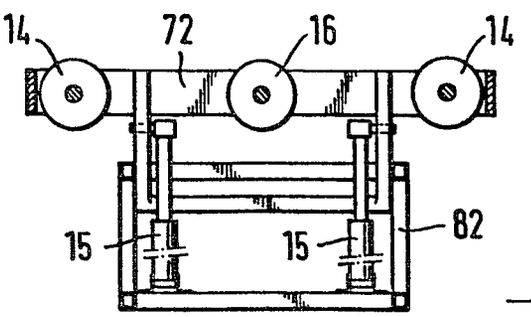
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Fig. 7

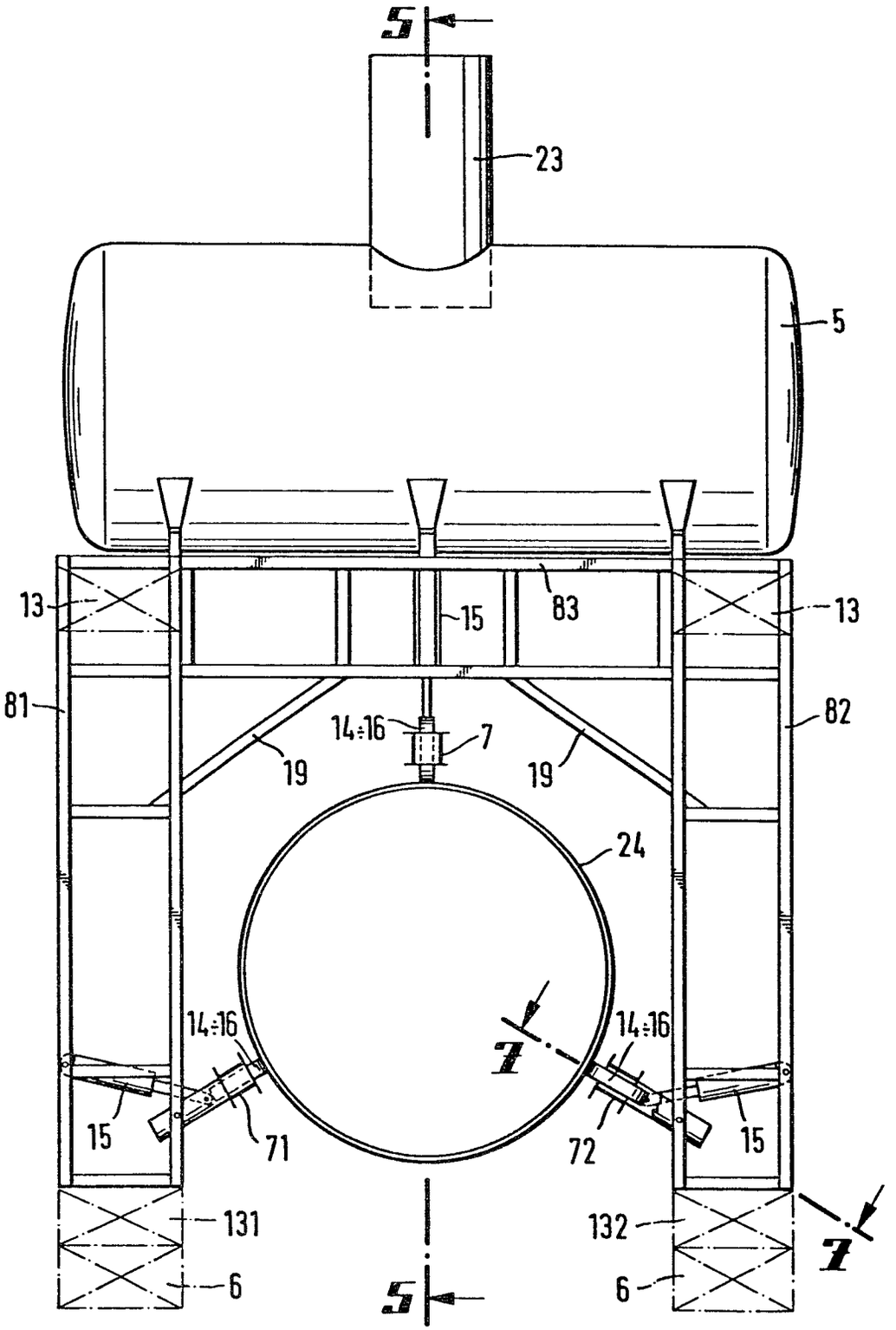
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Fig. 6

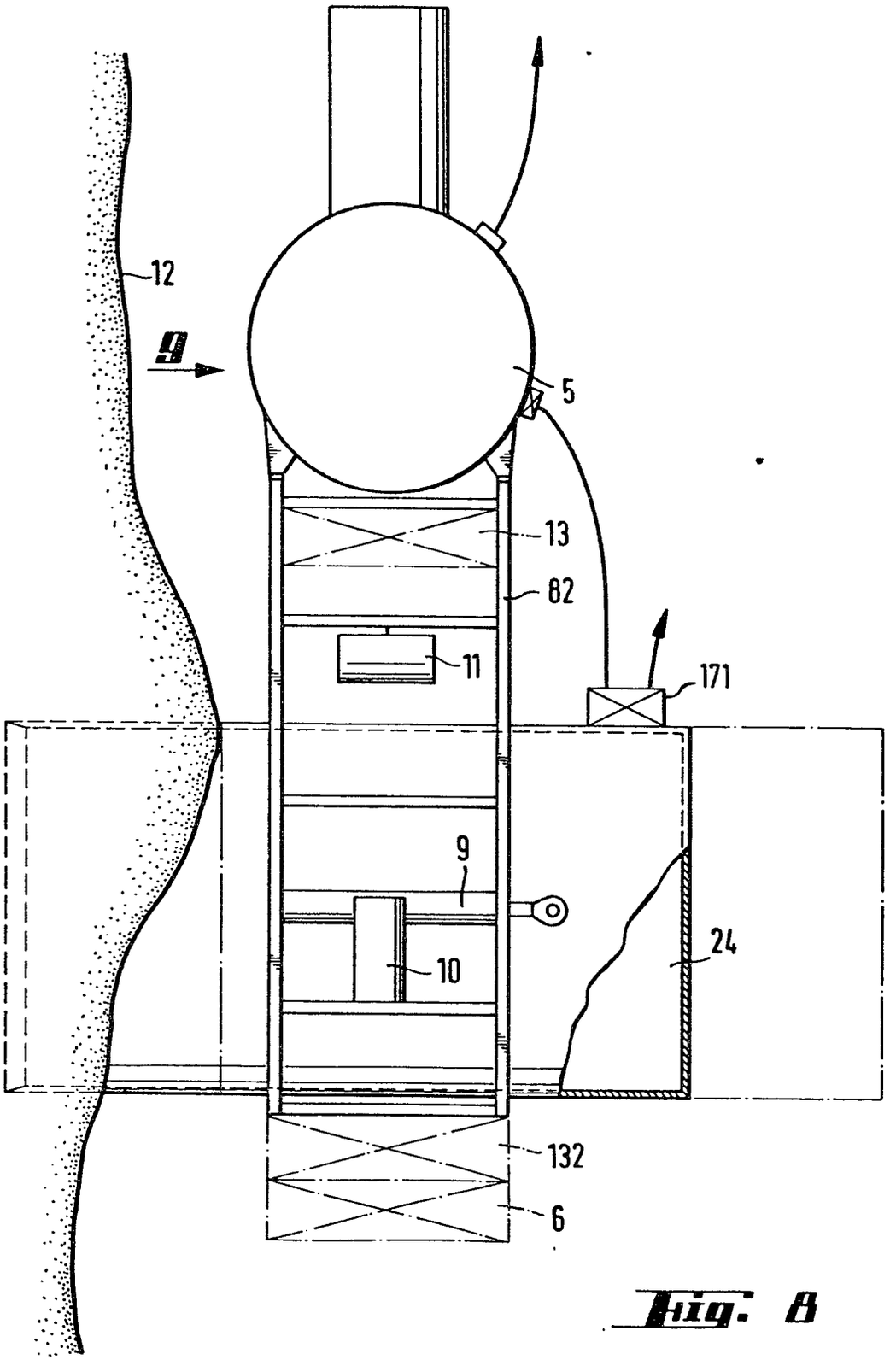


Fig. 8

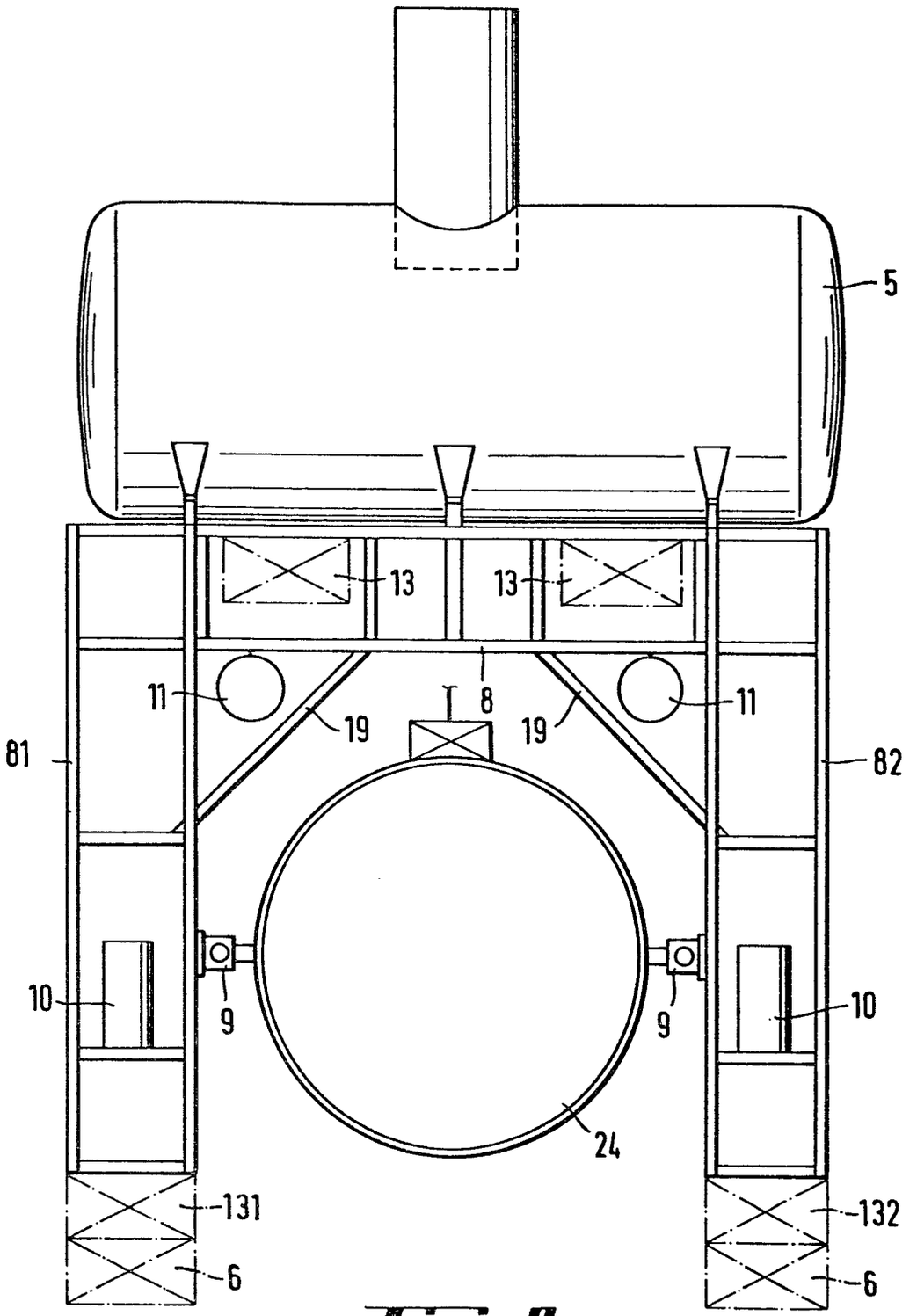


Fig. 9

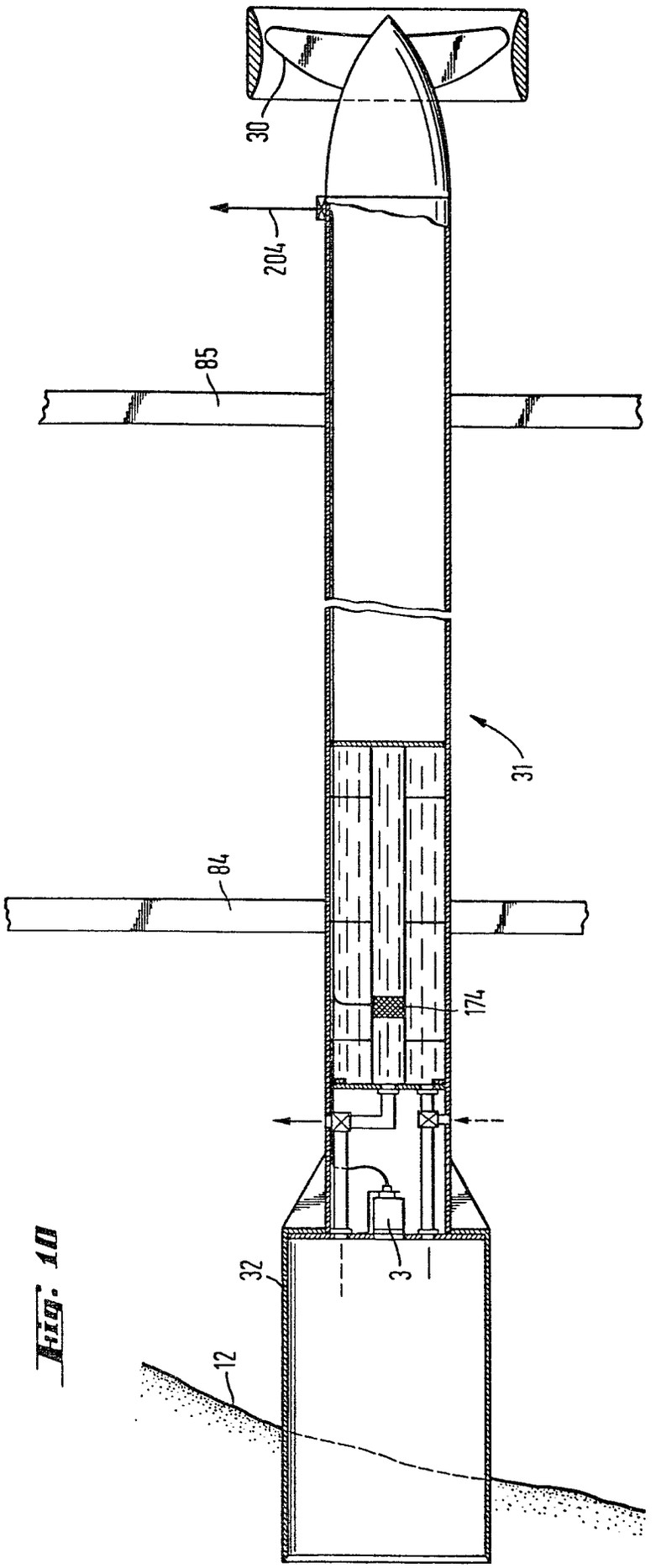


FIG. 10

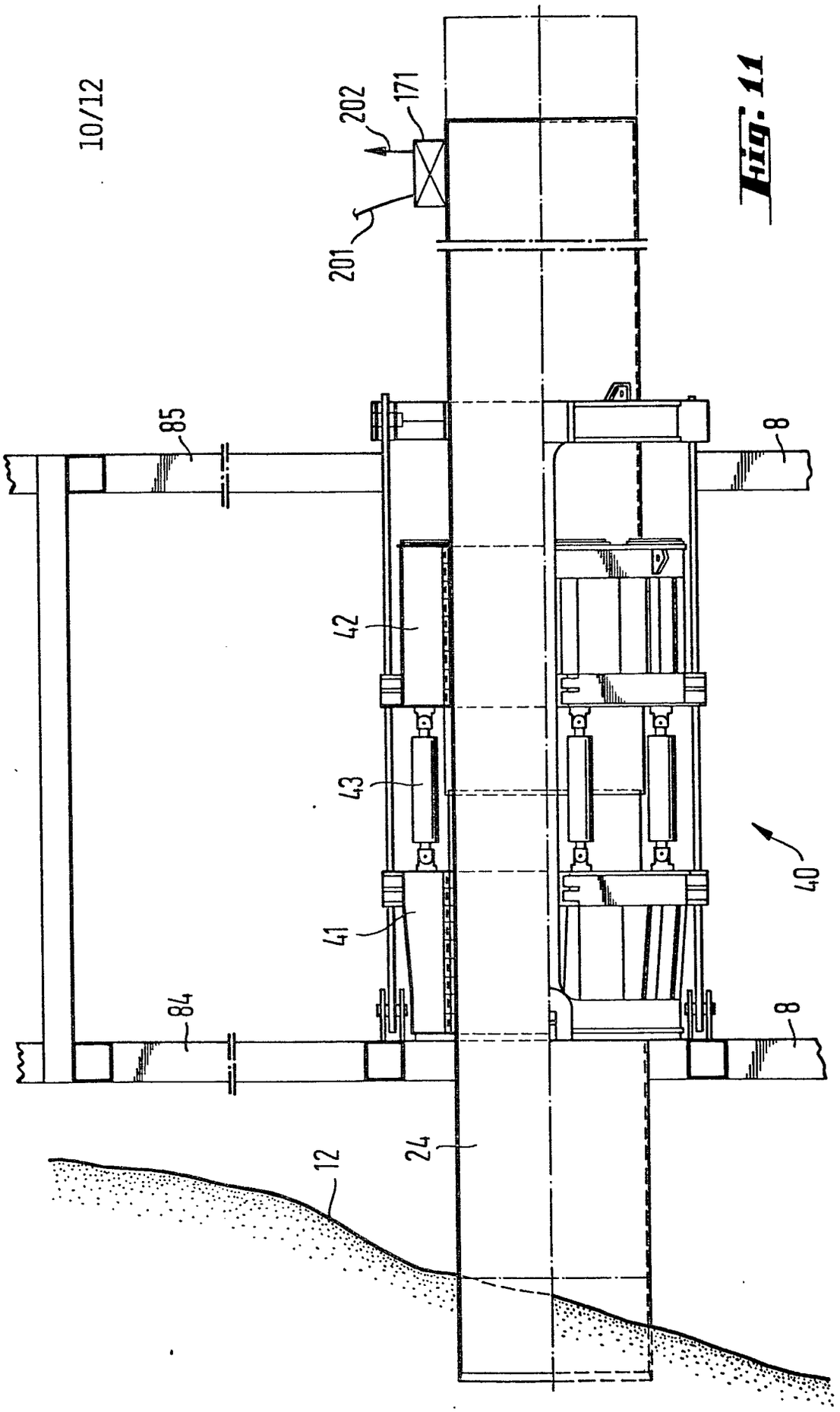


Fig. 11

Fig. 12

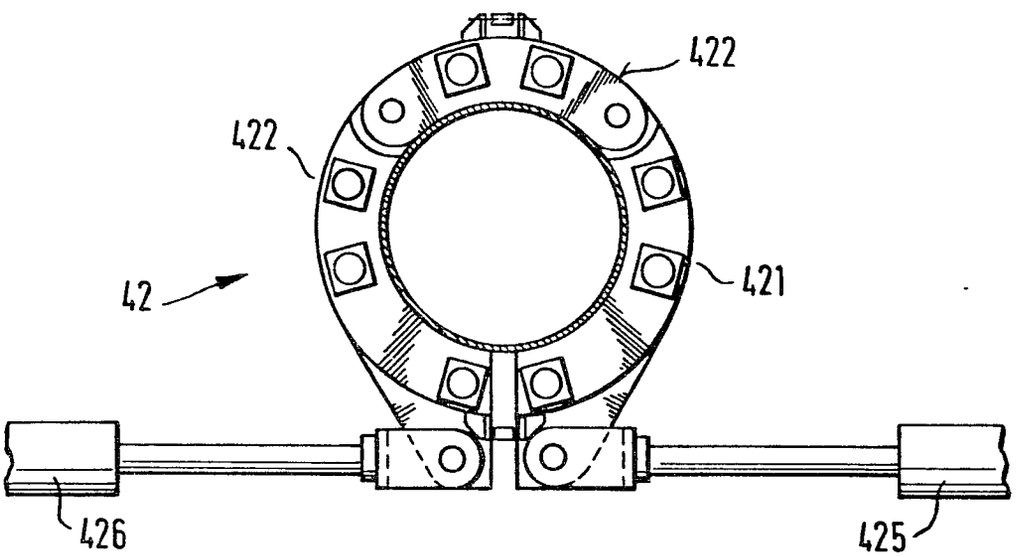


Fig. 13

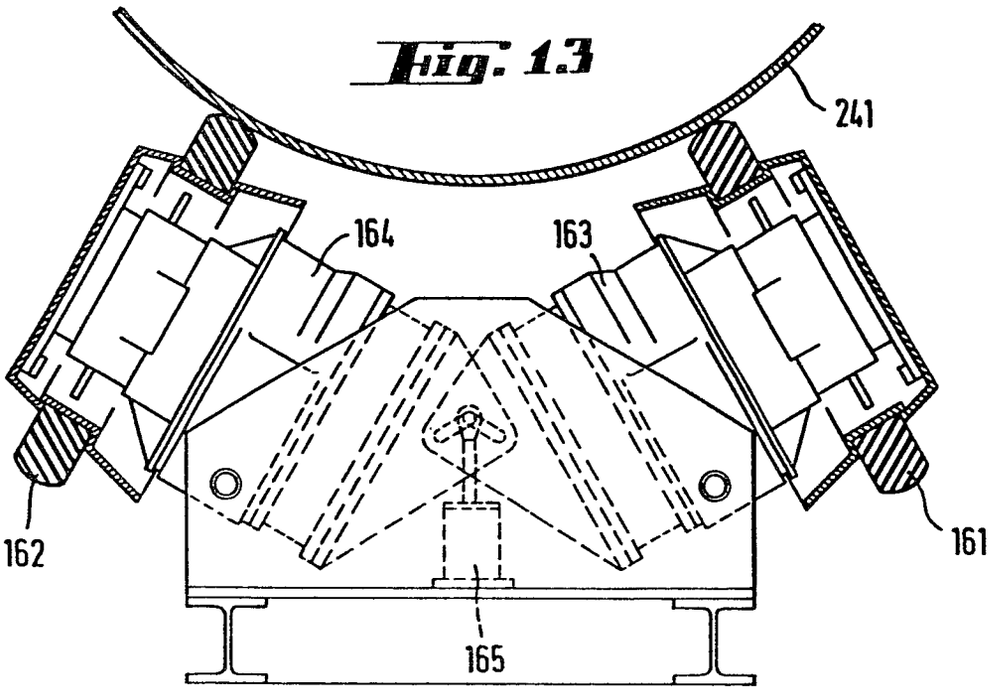
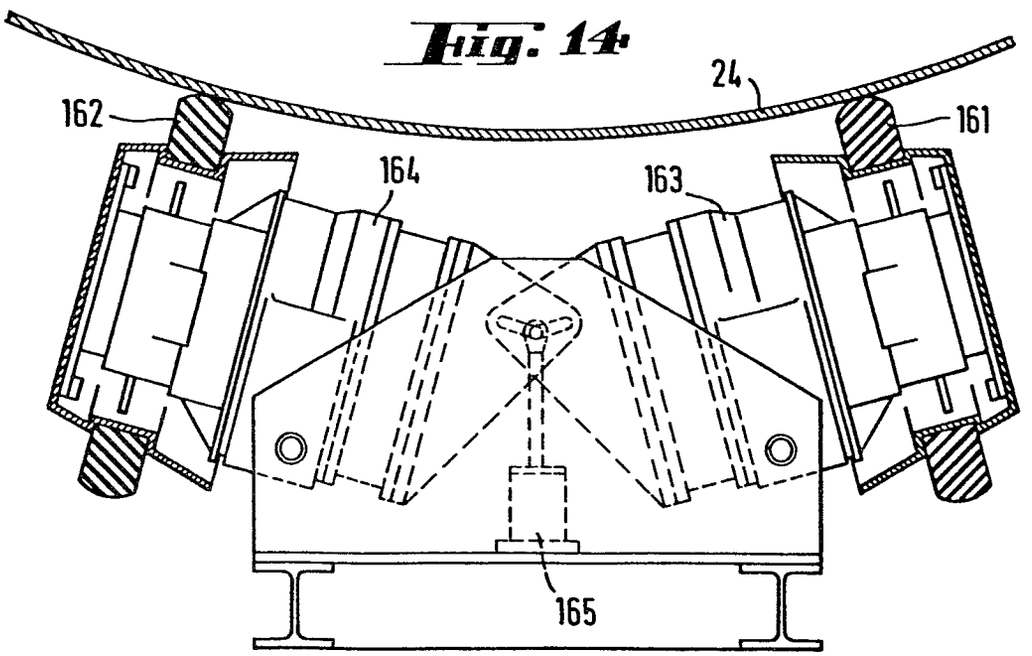


Fig. 14



European Patent Office

EUROPEAN SEARCH REPORT

0025802
Application number
EP 79 10 3518

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	FR - A - 2 387 844 (MOUGIN) * In its entirety * --	1-5
	FR - A - 2 388 091 (MOUGIN) * Figures 3,4; page 3; claim 1 * --	1,3,4
	GB - A - 2 010 202 (THE SECRETARY OF STATE FOR INDUSTRIE) * Figure 5; page 1, lines 1-16 * ----	1-5

CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)

B 63 B 35/02
21/27
E 03 B 3/00

TECHNICAL FIELDS SEARCHED (Int.Cl. ³)

B 63 B 35/02
21/27

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
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P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	08-05-1980	LUKAS

EPO Form 1503.1 06.78