(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 837 192 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
22.04.1998 Bulletin 1998/17

(51) Int. Cl.[6]: **E02F 3/90**, E02F 3/88, E02F 7/00

(21) Application number: **97203091.0**

(22) Date of filing: **07.10.1997**

(84) Designated Contracting States:
AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV RO SI

(30) Priority: **07.10.1996 NL 1004218**

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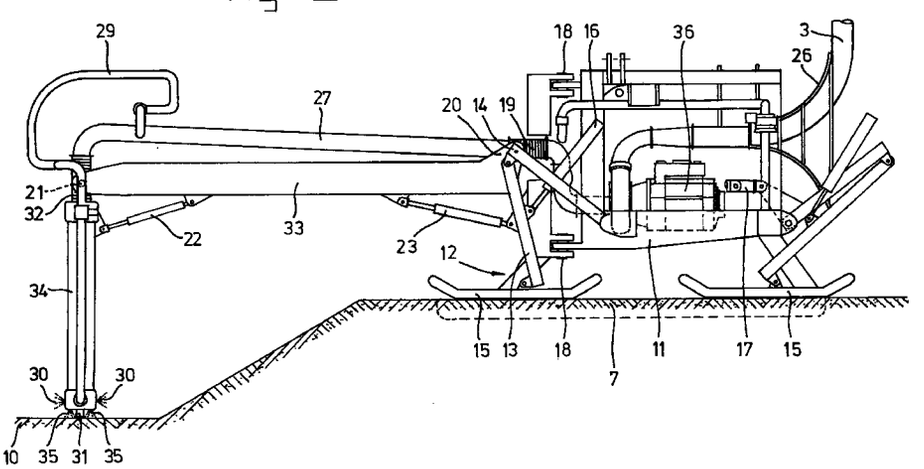
Remarks:
Amended claims in accordance with Rule 86 (2) EPC.

(54) Method and device for removing material from the seabed

(57) Method and device for removing material, such as sediment containing diamond or other minerals, from the seabed. A device which is movable over the seabed and can be controlled from the sea surface is proposed for this purpose. This device comprises a frame provided with movement means, and an articulated arm provided near the free end with a suction nozzle is also fitted on the frame. Various positions of the seabed can be explored by means of the arm, and the suction nozzle situated near the free end of the arm is used to take material from the seabed to the sea surface and carry out separation there. The method is realised such that the horizontal surface is explored according to a predetermined pattern, whilst the vertical position of the suction nozzle is controlled by proximity sensors. A predetermined surface is preferably explored a number of times.

Fig-2



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Description

The present invention relates to a method according to the preamble of claim 1.

Such a device is particularly, but not exclusively, intended for diamond extraction. Diamonds deposited in earlier times occur on certain rock formations lying below the sea surface. A layer of sediment is often present on top of them. If that layer of sediment is relatively thick and/or the rocky bed lies at relatively great depth, in practice it is almost impossible to examine such a seabed for the presence of diamonds, and then to extract those diamonds, in any way other than by mechanical means.

A number of methods for extracting diamonds are proposed in the prior art. One method comprises moving drilling gear over the seabed. This drilling gear produces in succession a large number of holes, and while a hole is being drilled the material being removed in the process is taken to the sea surface, where it is separated into waste material and diamonds. In this way, a certain part of the seabed is provided with a large number of holes. It will be understood that such a method is extremely time-consuming and expensive. Besides, the depth to which drilling can be carried out in relatively soft sediment is limited, because the hole which has just been drilled caves in again immediately after the drill. This drilling is carried out with a drill of relatively large diameter, in order to keep the number of bores limited. This means that drilling is not necessarily carried out in the sediment alone, but also in part of the rock bed, for this rock bed has elevations and troughs, and pieces of diamond often lie in those troughs. This makes it necessary to drill through the hard rock material.

From the French patent specification 1,553,816 a method is known for removing large quantities of material from the seabed. To that end a carter pillar vehicle is lowered on the seabd to the frame of which an arm is projected being connected with cutting means to which withdrawal means connect and the material found is displaced through a hose to a vessel being at the sea surface. This device is intended for the removal of complete layers with considerable thickness. The material is substantially from one level, i.e. after processing a flat surface remains.

During mining of diamonds and the like on the bed often very hard layers are present and it is particularly time consuming to process such hard layers.

Because of that the subject invention aims to further improve the method described such that the bed material is selectively processed.

This aim is realised with the characterising features of claim 1.

The invention is based on the idea to explore the bed in a systematic way step by step and position by position. I.e. the process of removing the sediment layer with possible diamonds is effected as much as possible from the sea bed. The arm fixed to the vessel can carry out a multiplicity of movements depending on the type of sediment which is encountered. If a relatively hard bed is encountered, a large number of openings can be made in the sediment layer by "pricking" in a manner which corresponds to what has been described above. If the sediment layer is softer, the arm can systematically explore a part of the seabed by swivelling and moving to and fro.

For a soft seabed it is not necessary to take further measures for moving material into the suction nozzle. Using an airlift system or a dredger pump for example, it is possible to introduce material near the suction nozzle into the suction nozzle and convey it to the water surface.

The horizontal movement over a certain part of the seabed can be determined by a control system which is present in the device according to the invention and/or in the vessel on the sea surface. The way in which a certain area is explored can also be decided there. The movement in the vertical direction is preferably determined by the presence of proximity sensors near the suction nozzle fitted on the free end of the arm. These proximity sensors can comprise pressure sensors by means of which the arm is taken down so far with the suction nozzle that this suction nozzle just touches the rock bed. It is possible to store the vertical coordinate of such a movement in a memory depending on the horizontal position. This is important if, according to an advantageous embodiment of the invention, the seabed is being explored in two steps. During a first operation the first, major part of the material is removed roughly. The actual "cleaning" of the seabed, where the relatively heavy diamonds are sucked up, is carried out in a second operation. This second operation can be carried out relatively quickly because values relating to the vertical position of the suction nozzle are present in the memory, so that the arm can be manoeuvred at relatively high speed. This further operation, i.e. the cleaning, can be carried out during the movement of the frame to a subsequent position. It is also possible to carry out this operation if this movement has already been carried out, or during the preparation of such a movement. The latter applies in particular if forward movement is achieved by means of legs. The use of legs is preferable because, compared with caterpillars, relatively large obstacles can be negotiated with them, and accurate positioning of the frame is possible. When a step is being carried out, the frame will first be placed on the seabed, the legs will move at some distance from the seabed, and will subsequently push up the device again and carry out the appropriate movement of the frame.

The invention also relates to a device for realising the method as described above. This device comprises a frame provided with conveyor means for moving over the seabed and also provided with an arm, said arm being provided at the free end with a suction nozzle

which is connected by way of a line to a vessel situated on the sea surface, said arm being embodied or fixed to the frame respectively in such a way that the suction nozzle can move in three directions relative to the frame, wherein near the extremity of the suction nozzle proximity sensors are provided, being connected to a control, said control controlling the movement of said arm and comprising first means for exploring a horizontal surface of a predetermined area of the seabed by the suction arm through a predetermined pattern, and second means for displacing said frame over the seabed after exploring said area.

Such a device functions satisfactory at a relatively soft bottom. However, if the material becomes harder, it is necessary to fit material-loosening means. Such means for loosening rocky parts or hard sediment layers are generally known in the prior art. Examples are jet systems and cutter systems. With the construction according to the invention, it is no longer necessary to break away the original rock material, for the arm according to the present invention can follow the rock bed in an accurately controlled manner. In other words, depressions in the seabed in which diamond material can collect can be reached without adjacent elevations having to be removed, as in the prior art.

In order to be able to position the arm in the optimum manner, said arm in an advantageous embodiment is fitted in such a way that in the operating position it swings both in the horizontal plane and in the vertical plane relative to the frame. The lines which are situated in the arm and are connected to the suction nozzle and/or which provide the jets can be connected to the frame of the device, and from the latter to the water surface, insofar as this is necessary, by means of any hinge means known in the prior art, such as swivels. It will be understood that the power supply preferably also comes from a vessel situated on the water surface. The arm can be controlled by, for example, hydraulic cylinders. According to an advantageous embodiment, the arm consists of at least two arm parts which are hingedly connected to each other, and the hinge pin of which is essentially horizontal when in the operating position.

The invention will be explained in greater detail below with reference to an exemplary embodiment illustrated in the drawing, in which:

Fig. 1 shows diagrammatically in side view the device according to the invention connected to a vessel situated on the water surface;
Fig. 2 shows diagrammatically in side view the device according to the invention in detail;
Fig. 3 shows diagrammatically in top view the device according to the invention;
Fig. 4 shows a first example of the use of the device according to the invention;
Fig. 5 shows a second example of the use of the device according to the invention; and
Fig. 6 shows movement of the device over an obstacle.

Fig. 1 indicates by 1 a vessel situated on the sea surface. This vessel is provided with all constructions which are necessary for making the device 2 operational. Only control system 9 is shown. However, it should be understood that an electric generator will be situated on the vessel, by means of which energy is supplied through line 4. In addition, a mechanism for processing material coming from hose 3 is present. A lifting device for operating lifting line 5 is also present.

Device 2 is installed in sea 6 and lies on bed 7.

Further details of device 2 can be seen in Figs. 2 and 3. The device consists of a frame 11 to which the various parts are attached. A control system 8 (Fig. 1), interacting with the control system 9 present on the vessel 1, is present. Frame 11 is provided with four legs 12, each consisting of two leg parts 13, 14 respectively. A support 15 is attached to the underside of each leg part. All these parts are hingedly connected to each other. Leg part 13 is operated by means of hydraulic cylinder 16, and leg part 14 is operated by means of hydraulic cylinder 17. These cylinders are shown only diagrammatically and for a single leg, but it should be understood that cylinders 16 and 17 are always present for each pair. An arm part 33 is fitted on frame 11. Arm part 33 can pivot in the horizontal plane by means of hinges 18, while it can be seen from Fig. 3 that movement in the vertical plane is possible by means of hinges 20. It can also be seen from Fig. 3 that lines 27 and 28, which are connected to the frame by means of swivels 19 and 25, are present. Line 3, which is connected to line 27, is fixed by means of a hose feed device in the frame, and is connected there to a dredger pump 36. It is possible to omit this dredger pump 36 and to bring material to the sea surface through lines 27 and 3 by means of an airlift system. A jet system is present, and water is supplied through line 28. Line 28 is connected by means of a flexible hose 29 to the arm part 34. The line in arm part 34 opens out in jet nozzles 30 near the free end of arm part 34. Arm part 34 is connected by means of hinge 21 to arm part 33, and the control thereof is achieved by cylinder 22.

The movement of arm part 33 in the vertical plane relative to the frame 11 is controlled by cylinder 23. Movement in the horizontal plane is controlled by cylinders 24. Near the free end of arm part 33 there is also a suction nozzle 31, which is connected to line 27. Two proximity sensors 35, and more particularly pressure sensors, are also present.

It can be seen from Fig. 2 that the supports 15 of the legs are situated on a part of the seabed which has not been worked. So much material has been removed by means of the suction nozzle 31 that a recessed part of the seabed, indicated by 10, has been produced as a result. There may be diamond in the extracted material.

With the construction described above, it is possible to carry out various operations, and it is also possi-

ble to carry out the operations repeatedly. For the latter, a memory which stores the depth position of arm part 34 relative to the device depending on the horizontal position thereof is present in at least one of the control systems. This means that during repeated exploration of a particular surface region a relatively rapid lowering of the arm 34 can be achieved. Positioning of the free end of arm 34 can be achieved either by pivoting arm part 33 relative to frame 11 or by pivoting arm part 34 relative to arm part 33.

With the device described above, it is possible, for example, to combine an up and down movement of arm part 34 with a swivelling movement of arm part 33 in the horizontal plane during a first phase in the removal of the largest amount of sediment. During a second phase, in which the residual cleaning of the rock surface is carried out, a combination of forward/backward movement of arm 34 and swivelling of arm 33 can be carried out. Since the depth position of the suction nozzle is approximately known, there is no danger during the forward/backward movement of arm 34, i.e. the pivoting about point 21, that suction nozzle 31 will accidentally touch rock material and consequently be damaged. It will be understood that all this greatly depends on the local conditions.

The construction described above, with legs whose various positions will be explained in greater detail with reference to Figs. 4 - 6, is preferred to caterpillars for various reasons. First, caterpillars are heavier and are less reliable, due to the larger number of parts. Besides, there is a problem in controlling systems with caterpillars, especially in soft ground, while special measures have to be taken to position the frame in the vertical direction relative to such caterpillars, which again incurs further expense. There is also a problem with the initial installation of device 2 on the seabed, for when the device is being lowered by means of cable 5 from vessel 1 in heavy swell there is a great risk of damage when the device first touches the seabed as the vessel moves down through the swell. Such damage is extremely simple to prevent by means of the abovementioned legs. Of course, further measures can be taken to provide for a soft landing of device 2, such measures being generally known in the prior art.

A first example of the movement of the device over the seabed will be described with reference to Fig. 4. It is assumed here that the movement is over a relatively stable bed. In the position shown in Fig. 4a the first removal of a large quantity of material (dredging) is being carried out. In this case arm 34 is moved up and down, and arm 33 carries out a swivelling movement. Fig. 4b shows the movement of frame 11 relative to the legs 12 in the vertical direction to the right. At the end of such a stroke, the frame 11 is placed on the bed, as appears from Figs. 4c and 4d. During this operation it is possible to explore the bed again, i.e. to remove the remaining material from it, by pivoting arm part 34 relative to arm part 33. When the device is lying on the seabed, as shown in Figs. 4c and 4d, the legs 12 can be moved further to the right, and the "dredging operation" can be continued.

Fig. 5 shows the course of the movement in a case where the bed is particularly soft. In such a case the device will dredge an opening around itself and will itself come to rest on the hard rock bed, as shown in Fig. 5a. The relatively soft material can be removed easily here by pivoting arm part 34 relative to arm part 33, as can be seen from Fig. 5b. The effective range can be increased by moving frame 11 relative to the legs 12. After the full movement stroke has been used, the device can be moved, as can be seen from Figs. 5c-d, while at the same time the cleaning action for remaining material described above is carried out. Fig. 5e shows the situation in which the dredging is continued.

Fig. 6 shows the situation when an obstacle such as a boulder 37 is encountered. Fig. 6 relates to a soft bed, but can, of course, also be applied in the case of a load-bearing bed. It can be seen from Figs. 6c and 6d that, through the use of the legs, the device can be moved in a relatively simple manner past or over obstacle 37, without encountering any hindrance from that obstacle.

Although the invention is described above with reference to a preferred embodiment, designed in particular for diamond extraction, it must be understood that numerous modifications can be made thereto without going beyond the scope of the present application. For example, it is possible to extract other relatively precious materials with the device. Instead of the nozzles 30, it is equally possible to fit cutting devices or any other constructions known in the prior art for the removal of material. The proximity sensors can be in the form of load cells, but they can also be designed as optical means. These and further variants are all considered to lie within the scope of the present claims.

Claims

1. Method for removing material from the seabed, comprising placing on the seabed a device which has a frame provided with conveyor means and an arm which is swivellably attached thereto, said arm being at the free end connected to a suction nozzle which is movable in three directions relative to the frame and is connected by a line to a vessel situated on the surface, said nozzle being provided with proximity sensors, characterised in that said horizontal face is explored by the arm according to a predetermined pattern, and the vertical position of the suction nozzle is determined by a control system connected to the proximity sensors, and after the exploration of a particular region the frame is moved relative to the seabed, and a following region is explored.

2. Method according to Claim 1, wherein the vertical

position of the suction nozzle is stored in a memory depending on the horizontal position, and a second exploration is carried out on the same positions after a first exploration, while during said second exploration data for the vertical position of the suction nozzle is taken from said memory.

3. Method according to Claim 2, in which a (preparatory) part of the movement of the frame is carried out during the second exploration.

4. Device (2) for removing material from the seabed, comprising a frame (11) provided with conveyor means for moving over the seabed, and also provided with an arm, said arm being provided at the free end with a suction nozzle (31) which is connected by way of a line (3, 27) to a vessel (1) situated on the sea surface, said arm being embodied or fixed to the frame respectively in such a way, that the suction nozzle can move in three directions relative to the frame, wherein near the extremity of the suction nozzle proximity sensors (35) are provided, being connected to a control, said control (8,9) controlling the vertical movement of said arm and comprising first means for exploring a horizontal surface of a determined area of the seabed by the struction arm through a predetermined pattern, and second means for displacing said frame over the seabed after exploring said area.

5. Device according to Claim 4, wherein the suction nozzle is provided with material-loosening means (30).

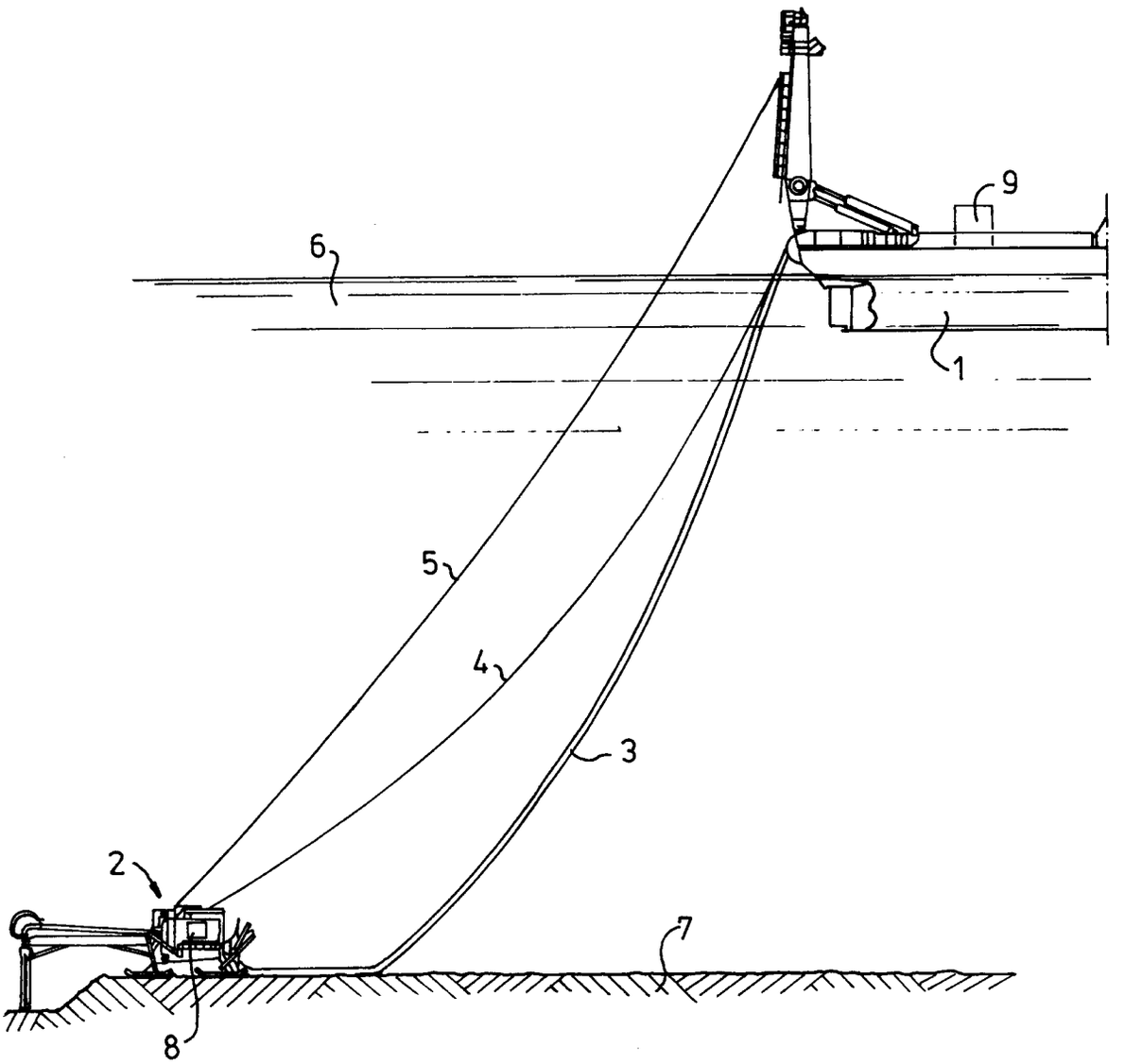
6. Device according to one of the claims 4 or 5, wherein said arm is fitted in such a way that in the operating position it swings both in the horizontal plane and in the vertical plane relative to the frame.

7. Device according to one of claims 4-6, wherein said arm comprises at least two arm parts (33, 34) which are hingedly connected to each other, and the hinge pin (21) of which is essentially horizontal when in the operating position.

8. Device according to Claim 7, comprising a memory for storing the positions of the suction nozzle.

9. Device according to one of the claims 4-8, in which said conveyor means comprise at least three legs which are movable relative to the frame.

Fig-1



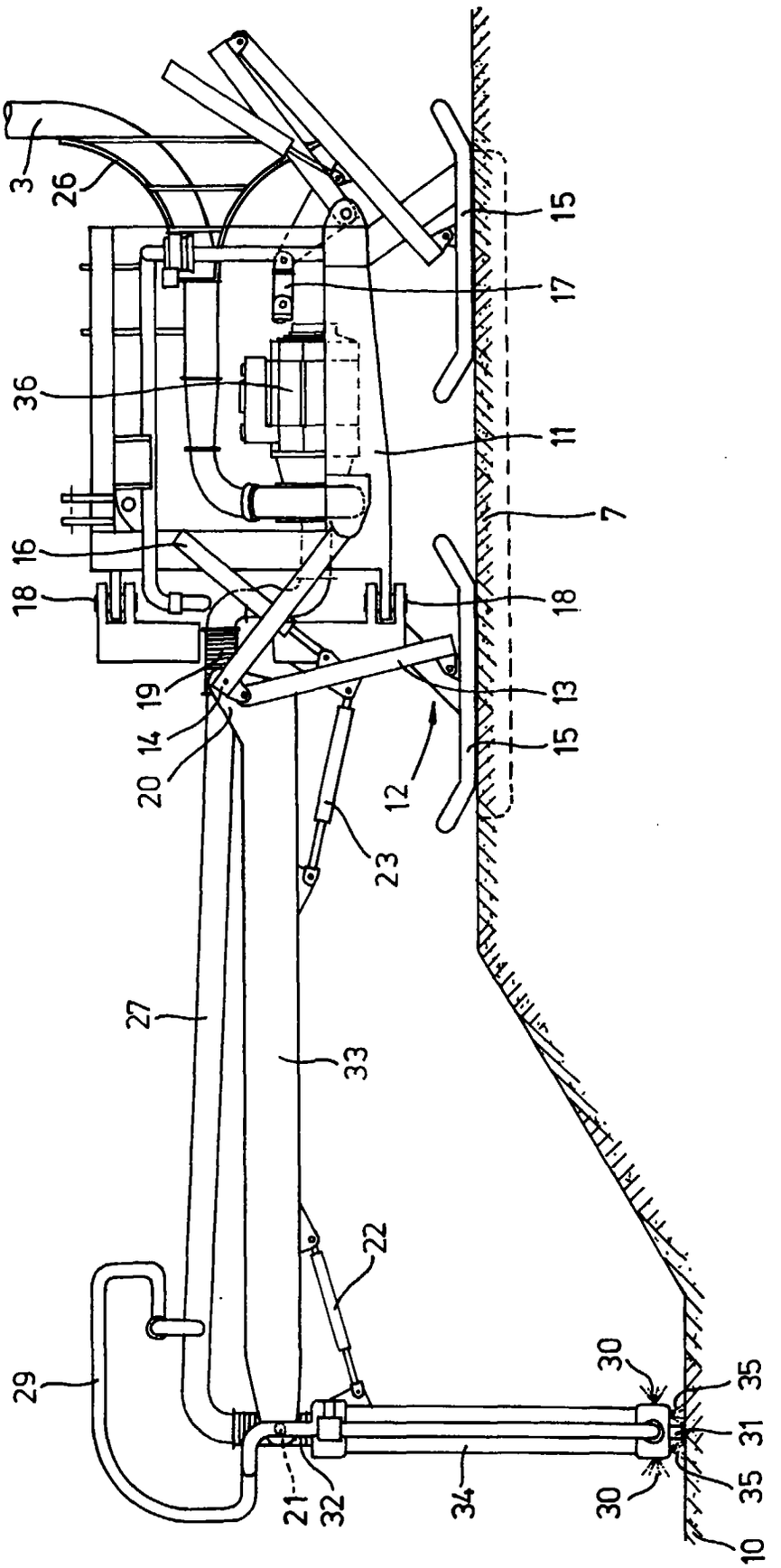

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fig-2

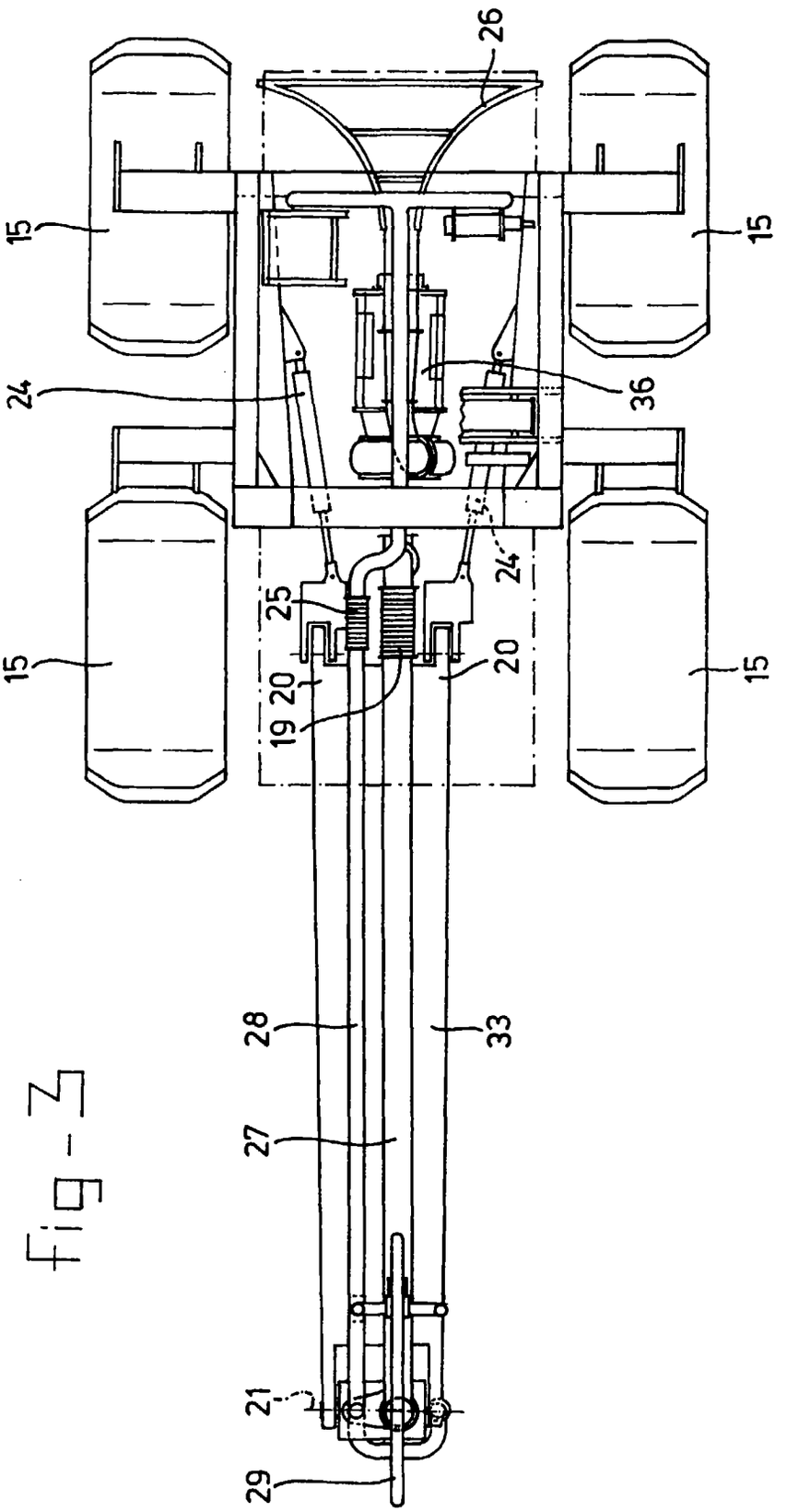


Fig-2

Fig-4a

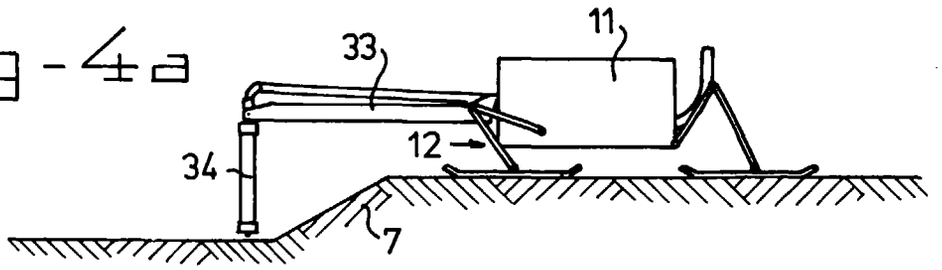


Fig-4b

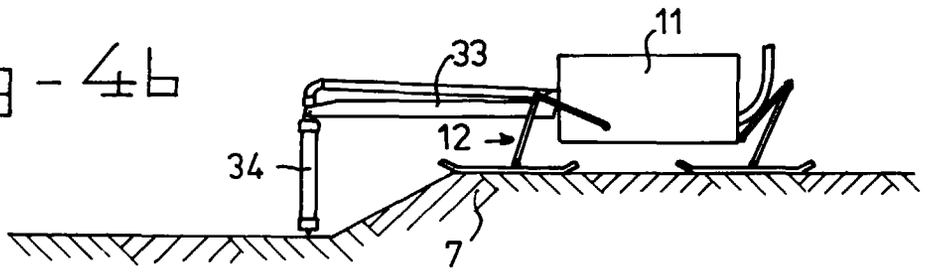


Fig-4c

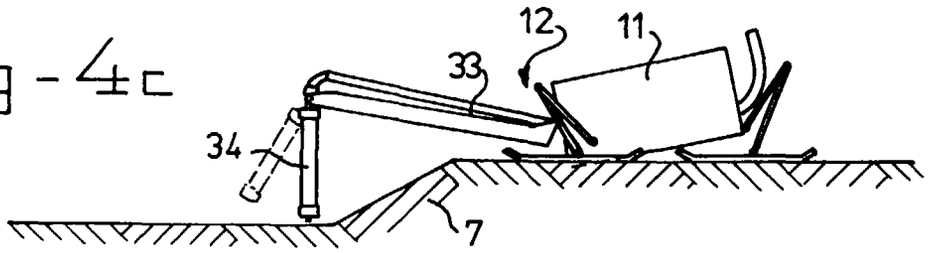


Fig-4d

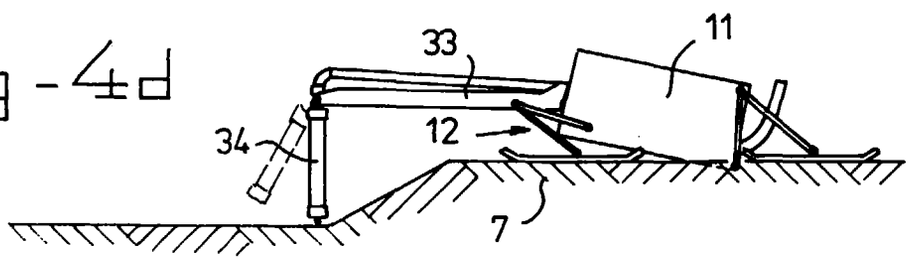


Fig-4e

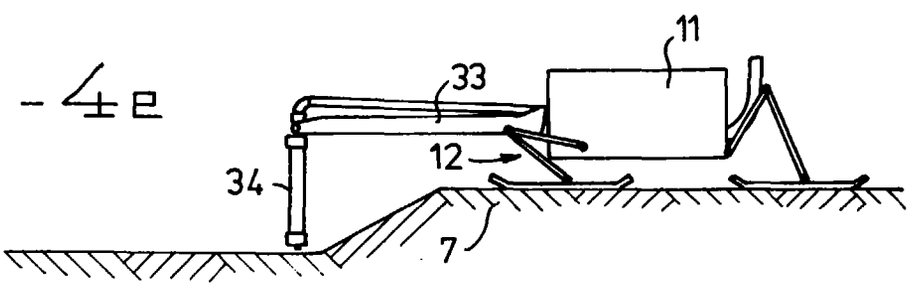


Fig - 5a

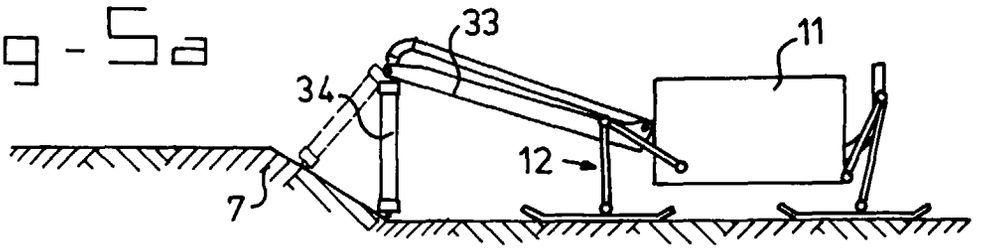


Fig - 5b

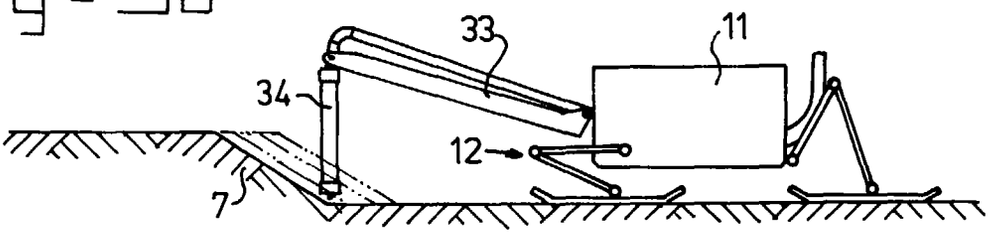


Fig - 5c

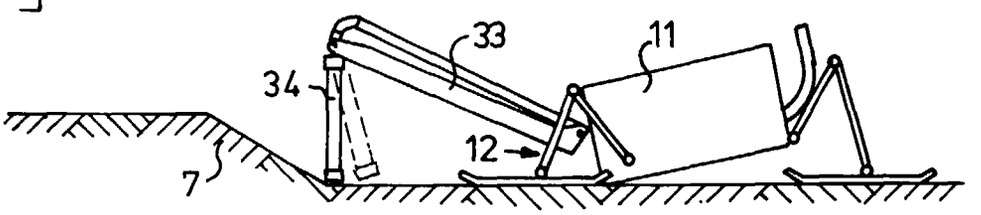


Fig - 5d

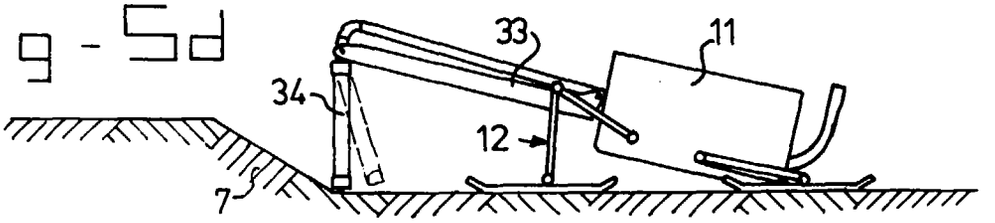


Fig - 5e

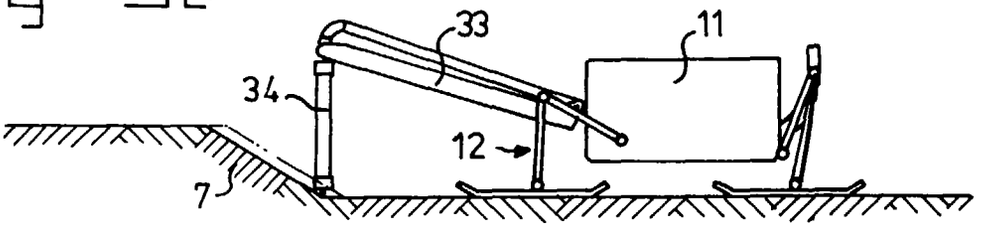


Fig-6a

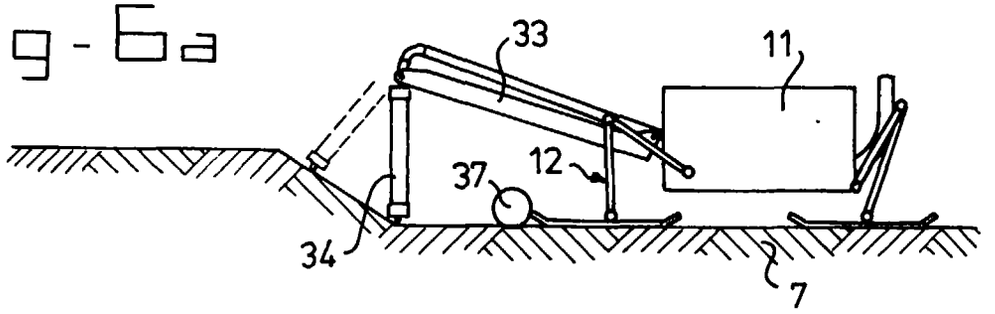


Fig-6b

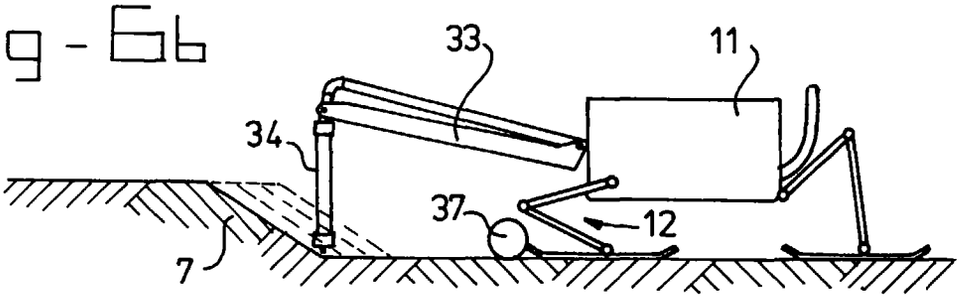


Fig-6c

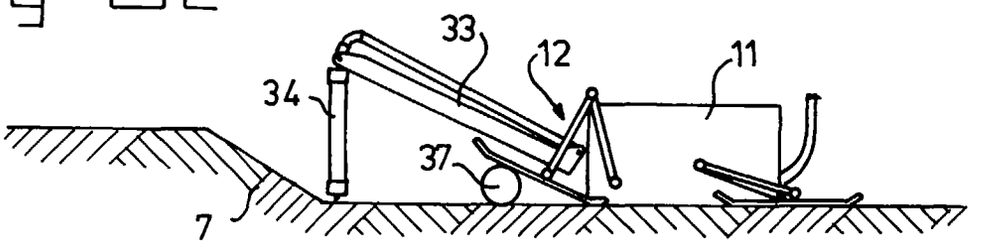


Fig-6d

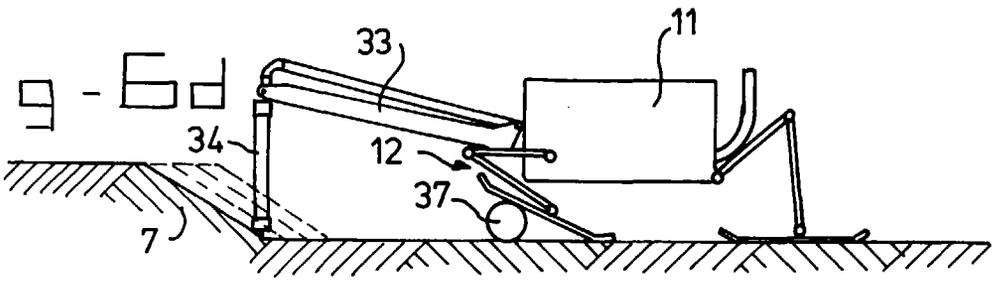
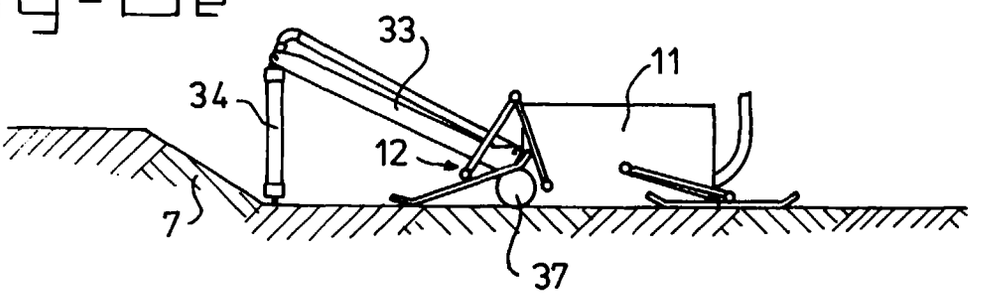


Fig-6e



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 20 3091

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y A	FR 1 553 816 A (CHABANIER) 17 January 1969 * page 1, left-hand column, line 31 - right-hand column, line 12 * * page 3, left-hand column, line 6 - line 21 * * page 3, left-hand column, line 32 - line 58 * * page 3, right-hand column, line 4 - line 54 * * page 4, left-hand column, line 51 - page 5, left-hand column, line 16 * * page 5, left-hand column, line 49 - line 57 * * page 6, left-hand column - page 7, left-hand column * * page 8, right-hand column, line 3 - line 12 * * figures *	4-7 1,3	E02F3/90 E02F3/88 E02F7/00
Y	US 4 232 903 A (WELLING ET AL.) * figures 33,34 * * column 21, line 43 - line 54 * * column 22, line 3 - line 46 *	4-7	TECHNICAL FIELDS SEARCHED (Int.Cl.6) E02F
Y	NL 8 005 464 A (AANNEMINGSMAATSCHAPPIJ V H J P) * claims 1-3 *	4-7	
A	US 4 503 629 A (UCHIDA MASAAKI) 12 March 1985 * figures 11,12 * * column 5, line 13 - line 45 *	5	
A	US 3 930 324 A (WIGHTMAN DAVID DOUGLAS ET AL) 6 January 1976 * column 5, line 60 - column 6, line 16 * * figures 1,10,11 *	1,4	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	16 December 1997	Guthmuller, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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& : member of the same patent family, corresponding document

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