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(54) **Device for producing a sheeted trench**

(57) Device for producing a sheeted trench (3), characterised in that it (1) consists of a series of sheeting elements (5) in the form of shaft segments (30); a cuttershoe (7) with a cutting edge (8) oriented downwards; a frame (10) that is movable in at least the longitudinal direction of the trench (3) provided with means (9) to systematically push the cuttershoe (7) vertically into the ground (11) by machine over a depth essentially corresponding to the height of the sheeting elements (5); means (23) for evacuating the earth upwards from the trench (3) by machine in order to form the trench (3), means to systematically bring the sheeting elements (5) into place in order to support the trench (3) obtained.

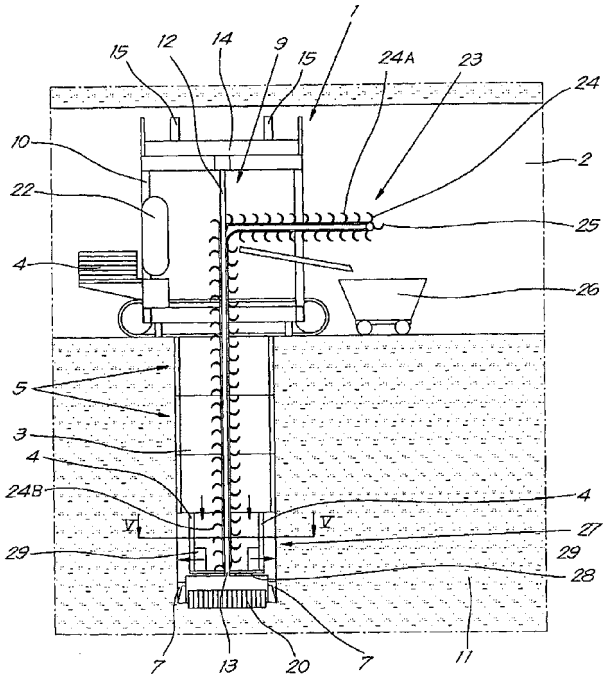

Fig.4

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Description

[0001] The present invention relates to a device for producing a sheeted trench.

[0002] For the realisation of foundations in underground excavations, the technique of the "sheeted trench" is frequently applied today.

[0003] This technique consists of making a trench by manually digging down vertically and then systematically sheeting the excavated trench with prefabricated concrete plates to support the walls of the excavated trench in order to absorb the pressure of the earth and thus prevent cave-ins or collapses.

[0004] Once the trench is complete, after affixing reinforcement, concrete is poured into the trench to form a concrete wall, for example an underground tunnel wall or car park, and after the concrete has set the earth next to the wall is excavated, for example to clear the space of the tunnel or the car park.

[0005] The technique is primarily applied when there is insufficient space above ground to deploy large earth-moving machines for the realisation of the trench, for example on account of the presence of buildings or similar.

[0006] Then the work starts with a horizontal tunnel that is first dug out, after which the trench is manually excavated vertically downwards from the tunnel in the aforementioned manner.

[0007] The height of the sheeting elements and the steps for realising the sheeted trench are determined such that, taking the local specific internal angle of friction of the soil into account, the excavation can be done vertically to a depth of 20 metres and more without the risk of subsidence. For the stability, from a soil mechanics point of view, the effects of the horizontal arching action and vertical vaulting action are taken into account.

[0008] A disadvantage of such a construction technique is that the earthworks and the installation of the sheeting must be done completely manually, which is not without risk with regard to the personal safety of the worker.

[0009] Another disadvantage is that manual earthworks are very labour intensive and consequently expensive, and detrimentally affect the duration of the construction site.

[0010] Another disadvantage is that the concrete plates used for the sheeting are lost.

[0011] The purpose of the present invention is to provide a solution to one or more of the aforementioned and other disadvantages, by providing a device that enables sheeted trenches to be realised in mechanised way, whereby the worker does not have to work down in the trench, safety is absolutely guaranteed, and whereby the efficiency can be increased by a number of times with respect to the traditional method and the duration of the construction site can be substantially reduced.

[0012] To this end the invention concerns a device for producing a sheeted trench, more specifically a trench made in the ground with a desired depth whose walls are supported by sheeting elements that are fitted together vertically, whereby the device consists of a series of sheeting elements in the form of shaft segments or elements to compose such shaft segments; a cuttershoe in the form of a frame with a cutting edge oriented downwards of which the outer dimensions of the horizontal cross-section essentially match the outer dimensions of the rings; a frame that is movable in at least the longitudinal direction of the trench provided with means to systematically push the cuttershoe vertically into the ground by machine over a depth essentially corresponding to the height of the shaft segments; means for evacuating the earth upwards from the trench by machine in order to form the trench, means to systematically bring the sheeting elements into place as the cuttershoe is pushed deeper into the ground in order to support the trench obtained.

[0013] With such a device according to the invention vertical sheeted shafts fitted next to one another are realised successively along the length of the trench, which are then cast with concrete in order to form a wall.

[0014] With this device, practically all operations and activities that are necessary for the realisation of a sheeted trench are mechanised, more specifically the activities that are necessary for excavating the trench and for affixing the sheeting.

[0015] Preferably the cuttershoe is equipped with a ground cutter to loosen the earth at the level of the cutting edge in order to be able to evacuate the loosened earth upwards more easily, for example by means of a bucket chain or a ground bucket.

[0016] This is certainly necessary for soil types with a high hardness, for example rocky soil (up to 50 MPa) or frozen soil.

[0017] Preferably the frame and the aforementioned means are designed to be movable in a horizontal tunnel with a diameter of three metres for example, such that the device can be applied in situations where there is insufficient space above ground for the larger traditional excavating machines.

[0018] Preferably the sheeting elements are of a rectangular shape, such that flat concrete walls can be realised.

[0019] The device can also be applied beneficially above ground, as with known above-ground methods for forming concrete walls, for example diaphragm walls, flat walls are not obtained, which has the disadvantage that after the walls are released, an extra wall lining must be provided to make the walls even.

[0020] According to a preferred embodiment, the sheeting elements are constructed as reusable shaft segments that are stacked on one another on the cuttershoe one by one and pushed into the ground together with the cuttershoe by means of a pressure crown and hydraulic pressure cylinders.

[0021] The sheeting elements stacked on one another and the cuttershoe are systematically pulled upwards when concrete is poured into the trench, as the level of

the concrete rises in the trench, and the sheeting elements are removed one by one as they are pulled out of the trench for subsequent use.

[0022] In order to be able to pull the cuttershoe and the sheeting elements out of the trench, coupling means are provided to fasten the cuttershoe and the sheeting elements together.

[0023] With the intention of better showing the characteristics of the invention, a few preferred embodiments of a device according to the invention for producing a sheeted trench are described hereinafter by way of an example, without any limiting nature, with reference to the accompanying drawings, wherein:

Figure 1 schematically shows a vertical cross-section of a device according to the invention in use for the realisation of a sheeted trench;
figure 2 schematically shows a vertical cross-section perpendicular to the plane of the cross-section of figure 1;
figure 3 shows on a larger scale the part indicated by the box F3 in figure 2;
figure 4 shows the device of figure 1 during a subsequent stage of usage;
figure 5 shows a cross-section on a larger scale according to the line V-V in figure 1;
figure 6 shows a sheeting element of the device according to the invention;
figure 7 shows an alternative embodiment of a device according to the invention during the use thereof;
figure 8 shows the device of figure 7 during a subsequent stage of usage.

[0024] The device 1 shown in figure 1 is deployed in a movable manner in a horizontal tunnel 2 for the realisation of a vertical sheeted trench 3.

[0025] The device makes use of plates that can be put together to form a sheeting element 5 in the form of a shaft segment with rectangular cross-section, as shown in figure 5.

[0026] The plates 4 are preferably prefabricated concrete plates that are strong enough to be able to absorb the pressure of the earth.

[0027] The ends of two opposite plates have a drop 6 into which the short plates can click when being affixed in the trench 3.

[0028] The device 1 contains a cuttershoe 7 in the form of a frame with a cutting edge 8 oriented downwards, of which the outer dimensions of the horizontal cross-section essentially match the outer dimensions of the sheeting elements, essentially corresponding to the inner dimensions of the trench 3 to be produced.

[0029] The device 1 is further provided with means 9 to push the cuttershoe 7 vertically into the ground, and these means 9 are affixed on a frame 10 that can move in the longitudinal direction of the tunnel 2, which in this case is mounted on a tracked machine.

[0030] These means 9 for pushing the cuttershoe 7 into the ground 11 are formed by a rod 12 whose bottom end 13 is secured to the cuttershoe 7 and which is affixed movably in a vertical guide of the frame 10 and which can be operated by means of a press 14 on the frame 10.

[0031] The press can be provided with struts 15 in order to transmit the compression forces, for pushing the cuttershoe 7 into the ground, to the walls of the tunnel 2, more specifically to the ceiling of the tunnel 2.

[0032] The aforementioned rod 12 can be extended by means of extension pieces, not shown in the drawings, that can be connected together in line with one another as the depth of the trench 3 increases.

[0033] In this case a drill carriage of a known type can be used as a frame 10 for example, whereby the drill is replaced by the rod 12.

[0034] During use the cuttershoe 7 has at least two upward-oriented parallel cutter walls 16 at a distance from one another over the width of the trench 3, whereby the device 1 contains means 17 to reduce the distance between the cutter walls 16 in order to be able to pull the cuttershoe 7 out of the sheeted trench 3 without removing the sheeting elements 5.

[0035] To this end, in the example shown the cutter walls 16 concerned are fastened to the end of a transom 18 which, as indicated by the arrows A in figure 3, can be tilted upwards around a horizontal shaft 19 that is secured to the aforementioned rod 12.

[0036] Alternatively the cutter walls 16 can for example be fastened to the end of a transverse jack, not shown, that is secured transversely on the aforementioned rod 12 in order to be able to pull the cutter walls 16 towards the rod 12.

[0037] At the cuttershoe 7 the device 1 is equipped with a ground cutter 20 to loosen the earth at the level of the cutting edge 8 of the cuttershoe 7 in order to be able to evacuate the loosened earth upwards more easily.

[0038] This ground cutter 20 is for example fastened detachably to the rod 12 and hydraulically driven around a horizontal shaft 21, for example by means of a hydraulic unit 22 on the frame 10.

[0039] Furthermore the device 1 contains means 23 for evacuating the earth upwards from the trench 3 by machine in order to form the trench 3. In the example of figure 1, these means 23 are formed by a bucket chain 24 with dredging buckets 25, whereby the bucket chain 24 contains a horizontal section 24A and a vertical section 24B whose length can be adjusted to the depth of the trench 3 already excavated, and whereby the vertical section 24B extends to just above the ground cutter 20.

[0040] The earth evacuated from the trench is received in a container 26 in order to be taken away.

[0041] Moreover the device 1 contains means 27 to systematically put the plates 4 of the sheeting elements 5 in place as the trench becomes deeper, in order to support the trench 3.

[0042] The means 27 are formed for example by a lift 28 that can move up and down on the rod 12, for example, to supply the plates 4 from the tunnel 2 to the place where

a section of trench is released between the cuttershoe and a sheeting element 5 already installed, whereby the lift 28 is provided with means 29 to push the plates 4 laterally against the wall of the released trench 3 section.

[0043] The method for producing a sheeted trench 3 with a device 1 according to the invention is simple and as follows.

[0044] Figure 1 shows a situation in which a sheeted trench 3 has already been realised up to a certain depth.

[0045] In order to make the trench deeper, the cuttershoe 7 is pushed downwards more deeply, whereby if necessary the rod 12 can be made longer by affixing an additional length of the rod 12.

[0046] The earth under the cutter is loosened by the turning of the ground cutter and moved to above the cutter from where it is scooped up by the dredging buckets 25 of the bucket chain 24 and evacuated to the container 26 in the tunnel.

[0047] Thus the trench 3 is further deepened below the sheeting elements 5 already present, such that a section of unsheeted trench wall is released at the bottom.

[0048] When this released section is high enough to fit a new sheeting element, the necessary plates 5 for this are brought into position with the lift 28 and pushed in place against the trench wall with the means 29 on the lift 28, whereby the plates 5 click together thanks to the elasticity of the trench wall.

[0049] This action is continually repeated whereby the trench 3 is systematically sheeted up to the desired depth.

[0050] When the sheeted trench is complete, the cuttershoe 7, the ground cutter 20, the rod 12, the lift 28 and the bucket chain 24 are removed from the sheeted trench 3, such that only the sheeting elements remain in place.

[0051] Then reinforcement is affixed in the sheeted trench 3 and it is filled with concrete and the excavation of a subsequent sheeted trench 3 is started a few shaft lengths further on in the longitudinal direction of the tunnel 2, outside the zone of influence of the shaft just realised. To this end the device is moved over a distance corresponding to a few lengths of the shafts measured in the longitudinal direction of the tunnel 3.

[0052] Thus a wall of close-fitting concrete shafts is realised, which together form an underground wall, an underground car park or similar, at least insofar the earth next to the sheeted trench 5 is removed for this purpose.

[0053] It is clear that the sheeting elements 5 left behind cannot be recovered and are thus lost.

[0054] It is also clear that the walls thus obtained are fairly even walls that do not necessarily require any final processing.

[0055] Figure 6 portrays an alternative embodiment of a sheeting element 5 that is constructed as a double-walled reusable shaft segment 30 with walls 31 made of sheet steel, 3 to 4 mm thick for example.

[0056] This sheeting element 5 is provided with coupling means 32-33 in order to fasten the sheeting elements 5, stacked on one another, together and to the cuttershoe 7, which also has suitable coupling means to this end.

[0057] The end sides of the outer wall 31 of the sheeting element 5 are provided with a tongue 34 and a groove 35 with which the sheeting elements, fitted against one another, fit into one another.

[0058] If necessary a further vertical groove 35 can be provided in the tongue and groove that is suitable for affixing an (additional) seal, for example in the form of an inflatable hose.

[0059] These sheeting elements are used for example with a variant device according to the invention, as illustrated in figure 7.

[0060] In this case the frame 10 is a gantry 36 that can be moved on rails 37.

[0061] A ground bucket 38 is suspended from the gantry 36 that can be operated by means of cables 39 and can be lowered into the sheeted trench 3, and which can be moved in the horizontal direction up to above a conveyor belt 40 for example.

[0062] The frame 10 is further provided with a pressure crown 41 with four vertical dual-action hydraulic cylinders 42 with which the cuttershoe 7 or a stack of cuttershoes 7 and sheeting elements can be pushed into the ground and pulled from the trench 3.

[0063] To this end the pressure crown 41 is also equipped with coupling means for fastening to the sheeting elements 5 or to the cuttershoe 7.

[0064] The cylinders 42 can be controlled independently in order to be able to make control corrections during pressing, whereby the pressure crown is equipped with measuring apparatus to measure the horizontality in order to be able to adjust when necessary.

[0065] In this case the cuttershoe 7 is also equipped with a detachable ground cutter 20. However, the cuttershoe does not necessarily have to be provided with retractable walls as was the case with the previous embodiment of figure 1.

[0066] As a result of the monolithic structure of the sheeting elements the sheeted trench is self-stable without intermediate stays.

[0067] As a result, the workspace is larger and free of obstructions, firstly for excavating and removing the earth, and secondly for installing the reinforcement.

[0068] The use of such a device according to the figure 7 is somewhat different to the case of the device of figure 1.

[0069] At the start of the works, a sheeting element 5, provided with a cuttershoe 7 underneath, is fastened to the pressure crown 41 in order to push the cuttershoe 7 into the ground.

[0070] The earth under the ground cutter 20 is cut loose and is systematically evacuated as the cuttershoe descends more deeply, if applicable with a ground bucket 38 or a bucket chain 24, as in figure 4.

[0071] As soon as the first sheeting element 5 has sunk down, a new sheeting element is screwed on and sunk in.

[0072] This is systematically repeated as illustrated in

figures 7 and 8, until the trench 3 has reached the desired depth.

[0073] Then the ground cutter 20 is manually removed from the cuttershoe 7 and the affixing of the reinforcement in the trench can begin. As the entire opening of the trench is clear, the reinforcing basket is also sunk in modularly in elements as high as the workspace allows.

[0074] Now it can be concreted from the trench base up, while the sheeting is systematically pulled up as the level of the liquid concrete in the trench 3 rises, whereby the concrete takes over the supporting function of the retaining wall.

[0075] The sheeting elements are dismantled one by one as they come out of the trench 3 and are stored for re-use for the realisation of a subsequent shaft.

[0076] This last method has a number of advantages with respect to the previous method, i.e.:

- no lost sheeting materiel;
- due to the exclusion of intermediate stays there is a large clear space in the trench while digging and then when fitting the reinforcement;
- no personnel are required in the trench for digging;
- the reinforcement can be fitted and sunk in sections, whereby on account of the possible mechanisation of this the implementation speed can be increased with respect to manual implementation;
- environmentally-friendly on account of the non-application of lost sheeting, or in other words a sustainable technological development;
- more accurate excavations compared to manual work, such that there is less risk of subsidence;
- in this case in every situation the ground is supported over the entire height;
- no need for post-injection;
- savings on the costs of specialised excavation personnel;
- the investment in the sheeting modules is more than offset by the savings in lost sheeting material;
- simple realisation of the tongue-groove connection between the wall sections due to suitable sheeting modules;
- fairly even walls that (if applicable) do not require any final processing;
- space saving of 10 cm wall thickness;
- logistical saving on account of the elimination of lost sheeting;
- the excavation with the ground cutter can also operate in frozen ground, thus without drainage.

[0077] For large projects the "slime method" can be considered for the earth transport, whereby the bucket 38 is replaced by a highconsistency pump in the trenches with pipes to the exit from the workspace.

[0078] It is clear that a device according to the invention can also be used above ground. In this case it may be necessary to embed extra anchors in the ground in order to keep the frame in place during the pushing if this frame 10 is not heavy enough to exert a sufficient pressing force on the cuttershoe 7 and/or sheeting elements 5.

[0079] The present invention is by no means limited to the embodiments described as an example and shown in the drawings, but a device according to the invention for producing a sheeted trench can be realised in all kinds of variants, without departing from the scope of the invention.

Claims

1. Device for producing a sheeted trench (3), more specifically a trench (3) made in the ground (11) with a desired depth whose walls are supported by sheeting elements (5) that are fitted together vertically, **characterised in that** the device (1) consists of a series of sheeting elements (5) in the form of shaft segments (30) or elements (4) to compose such shaft segments (30); a cuttershoe (7) with a cutting edge (8) oriented downwards of which the outer dimensions of the horizontal cross-section essentially match the outer dimensions of the sheeting elements (5); a frame (10) that is movable in at least the longitudinal direction of the trench (3) provided with means (9) to systematically push the cuttershoe (7) mechinacally vertically into the ground (11) by machine over a depth essentially corresponding to the height of the sheeting elements (5); means (23) for mechanically evacuating the earth upwards from the trench (3) by machine in order to form the trench (3), means to systematically bring the sheeting elements (5) into place as the cuttershoe (7) is pushed deeper into the ground in order to support the trench (3) obtained.

2. Device according to claim 1, **characterised in that** the sheeting elements (5) have a rectangular cross-section.

3. Device according to claim 1 or 2, **characterised in that** there is a ground cutter (20) at the level of the cuttershoe (7) to loosen the earth (11) at the level of the cuttershoe (7) in order to be able to evacuate the loosened earth.

4. Device according to any one of the previous claims, **characterised in that** the ground cutter (20) is detached or can be detached from the cuttershoe (7).

5. Device according to any one of the previous claims, **characterised in that** the means (9) for pushing the cuttershoe (7) into the ground (11) are formed by a rod (12) that is fastened by its bottom end (13) to the cuttershoe (7), and which can be affixed movably in a vertical guide of the frame (10) and which can be operated by means of a press (14).

6. Device according to claim 5, **characterised in that** the rod (12) can be extended by extension pieces that can be connected in line with one another.

7. Device according to any one of the previous claims, **characterised in that** during use the cuttershoe (7) contains at least two upward-oriented parallel cutter walls (16) over the width of the trench (3), and that the device contains means (17) to reduce the distance between the cutter walls (16) in order to be able to pull the cuttershoe (7) out of the sheeted trench (3).

8. Device according to claim 7, **characterised in that** each of the aforementioned cutter walls (16) are fastened to the end of a transom (17) that can be tilted around a horizontal shaft (19) that is fastened to the aforementioned rod (12).

9. Device according to claim 7, **characterised in that** each of the aforementioned cutter walls (16) are fastened to the end of a transverse jack that is fastened transversely to the aforementioned rod (12).

10. Device according to any one of the claims 7 to 9, **characterised in that** the sheeting elements (5) stacked on one another in the trench (3) constitute lost formwork for casting concrete when the sheeted trench (3) is complete, and the cuttershoe (7) with its ground cutter (20) is removed and the reinforcement is affixed.

11. Device according to any one of the previous claims, **characterised in that** the sheeting elements (5) are rectangular shaft segments that can consist of four plates (4) that are pushed against the trench wall and which have a click connection (6) at their ends that click into one another when pushing the plates (4) against the trench wall.

12. Device according to claim 11, **characterised in that** it is equipped with a lift (28) to move the plates (4) up to opposite an excavated section of trench wall between the cuttershoe (7) and an already installed sheeting element (5), and that the lift (28) is provided with means (29) to push the plates (4) against this section of trench wall.

13. Device according to claim 1 to 4, **characterised in that** the sheeting elements (5) are constructed as reusable shaft segments (30), and that the means for pushing the cuttershoe (7) into the ground (11) are formed by a pressure crown (41) with upward-oriented dual-action jacks (42) with which a vertical push and pull can be exerted directly on the cuttershoe (7) or indirectly via the sheeting elements (5) that are stacked on it.

14. Device according to claim 13, **characterised in that** the cuttershoe (7) and the sheeting elements (5) are provided with coupling means (32-33) to fasten sheeting elements (5), stacked on one another, together and to the cuttershoe (7) and that the pressure crown (41) has coupling means for a fixed coupling to the sheeting elements (5) in order to pull the sheeting elements (5) fastened to one another and the cuttershoe (7) upwards, and together, out of the trench (3) by means of an upward movement of the pressure crown (41).

15. Device according to any one of the previous claims, **characterised in that** the means (23) to evacuate the earth upwards from the trench (3) by machine are formed by a bucket chain (24) with a horizontal section (24A) and a vertical section (24B), whose length is adjustable to the depth of the trench (3).

16. Device according to any one of the claims 1 to 14, **characterised in that** the means (23) for evacuating the earth upwards from the trench (3) by machine are formed by a ground bucket (38) suspended from the frame (10) and with cable operation.

17. Device according to any one of the claims 1 to 14, **characterised in that** the means (23) for evacuating the earth upwards from the trench (3) by machine are formed by a highconsistency pump in the trenches with pipes to the exit of the workplace for the application of the "slime method".

18. Device according to any one of the previous claims, **characterised in that** the frame (10) and the aforementioned means are constructed to be movable in a horizontal tunnel with a maximum clear height of 5 metres, preferably with a maximum clear height of three metres.

19. Device according to claim 18, **characterised in that** the press or the frame (10) are equipped with struts (15) to transmit the compression forces, for pushing the cuttershoe (7) into the ground, to the walls of the tunnel (2).

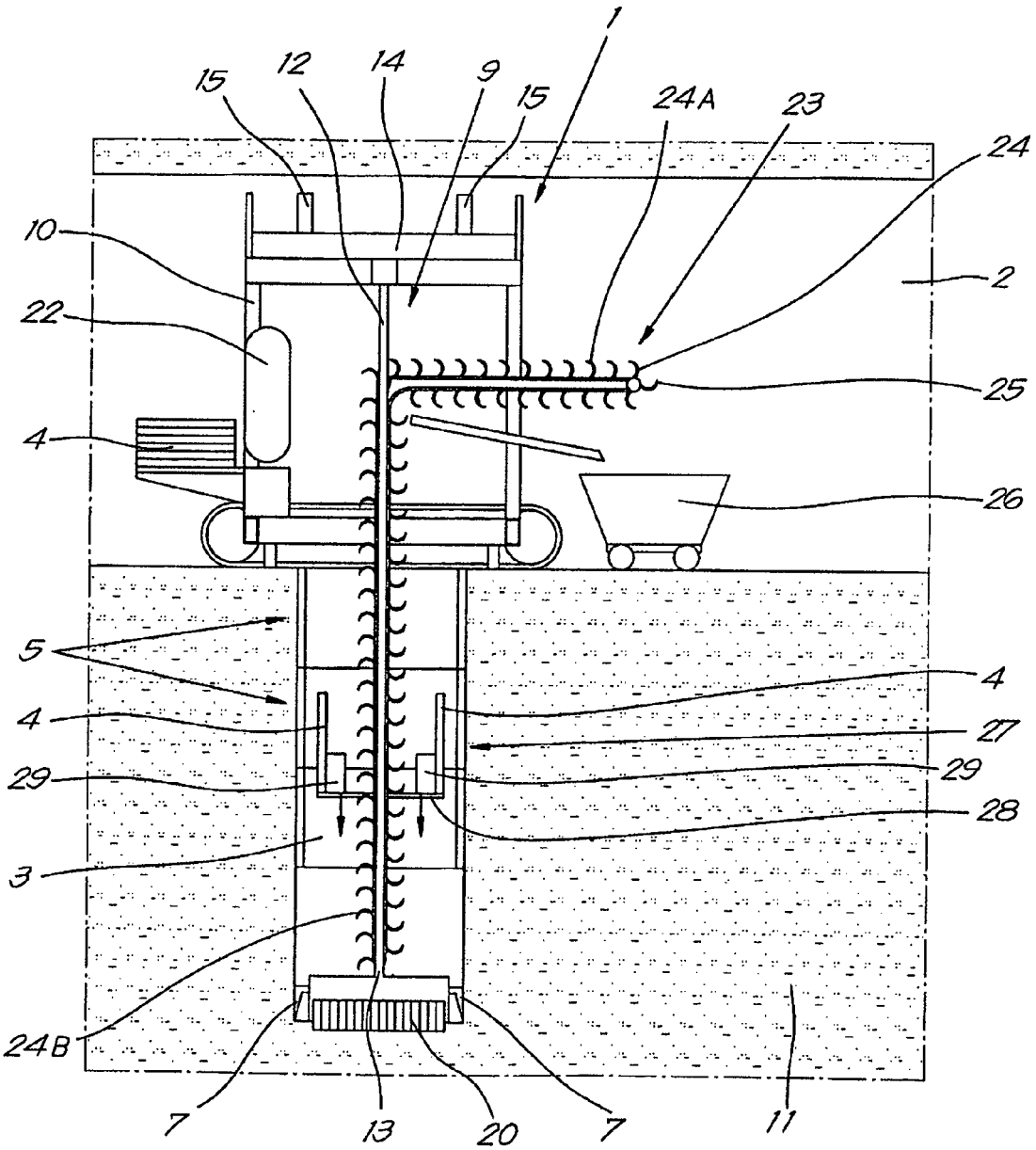
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Fig. 1

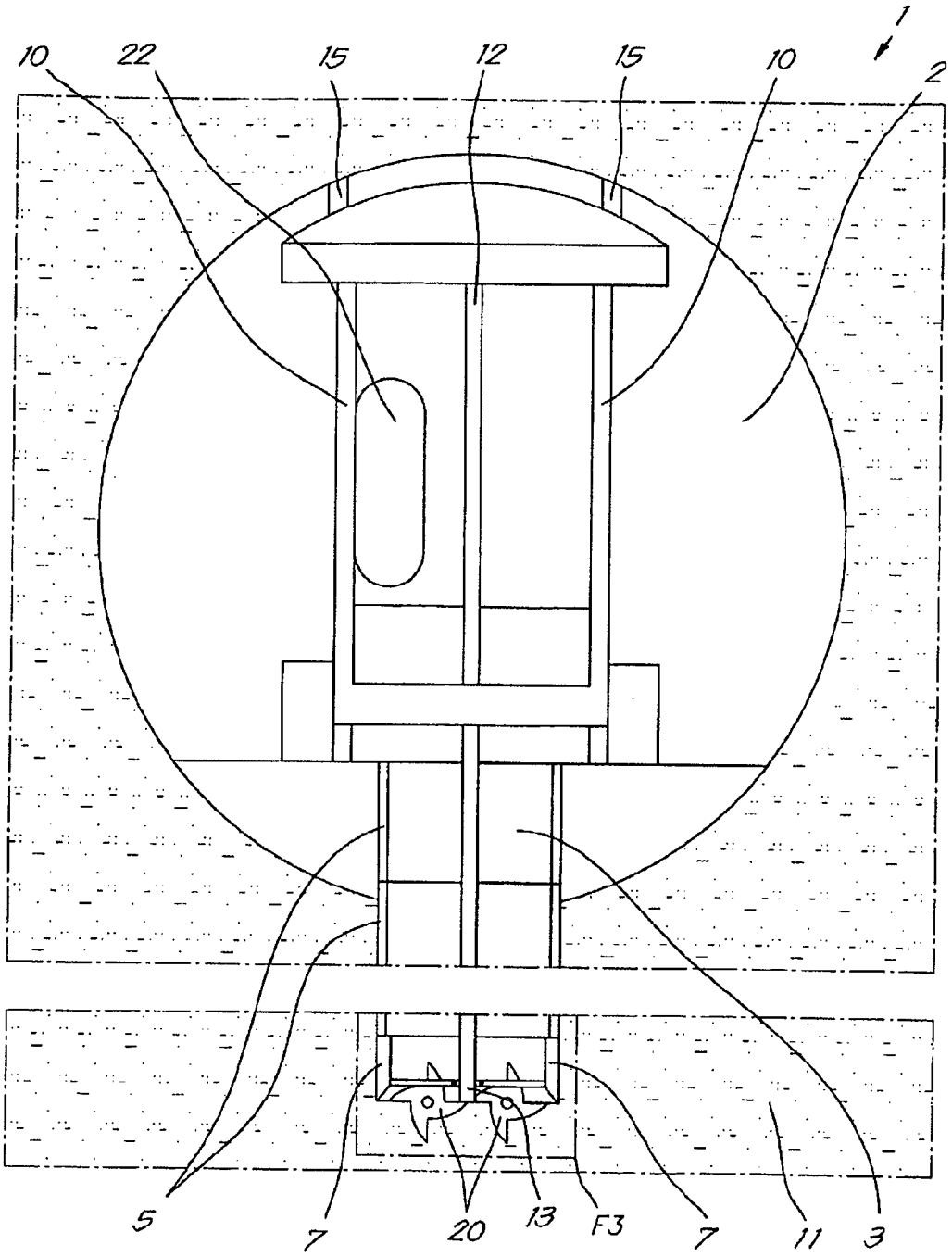

Fig.2

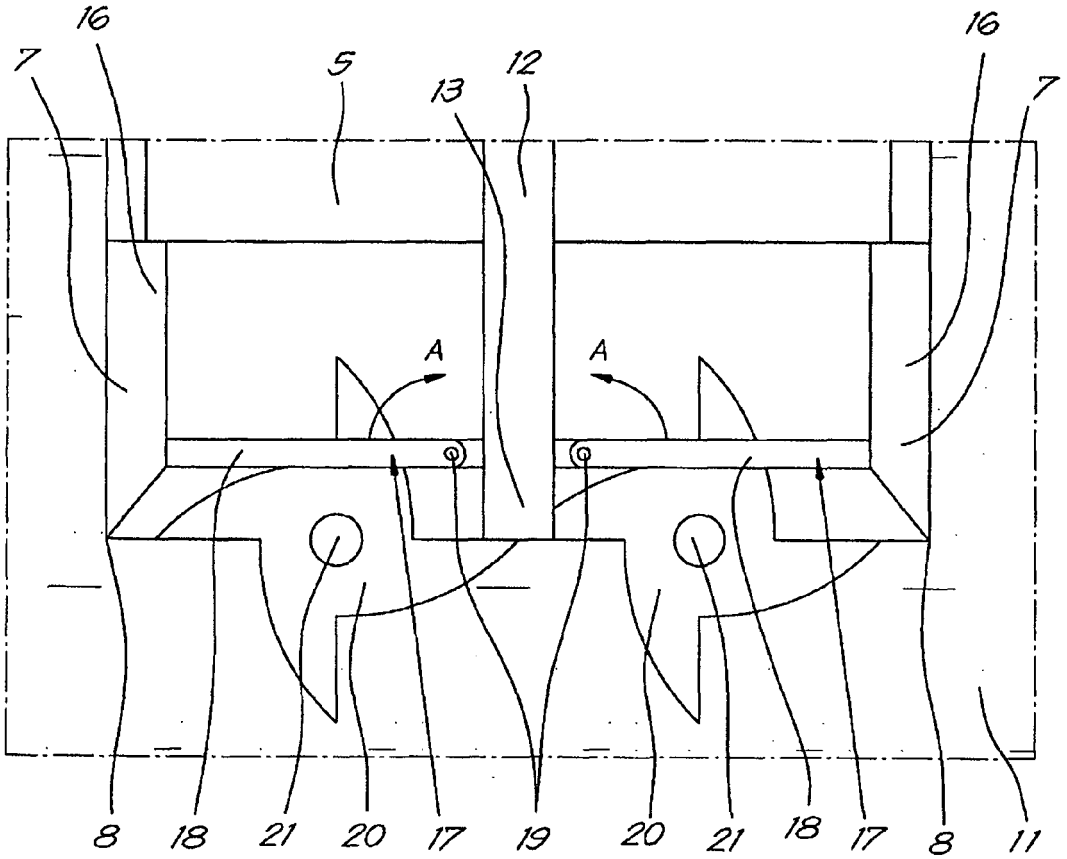

Fig.3

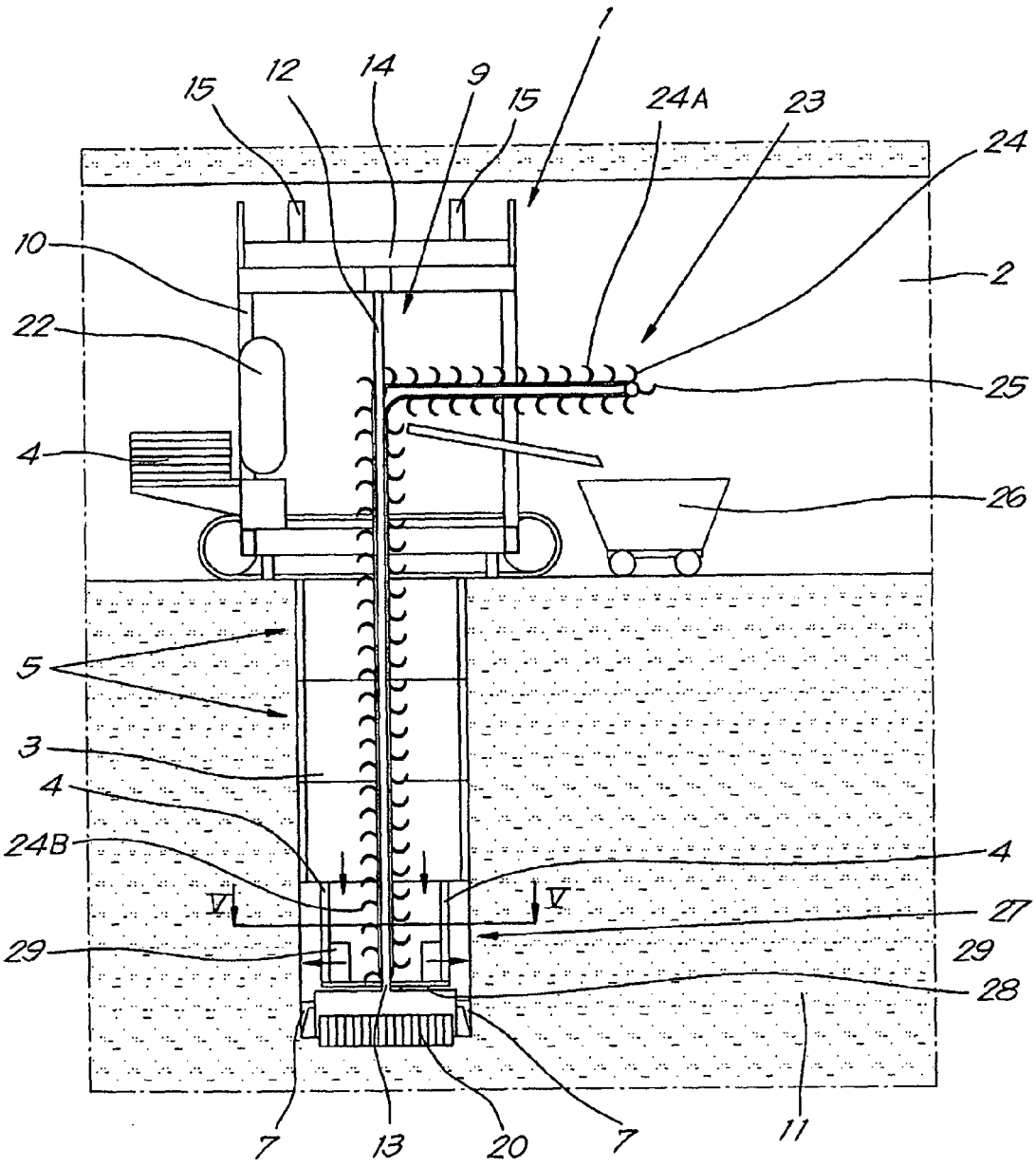
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Fig. 4

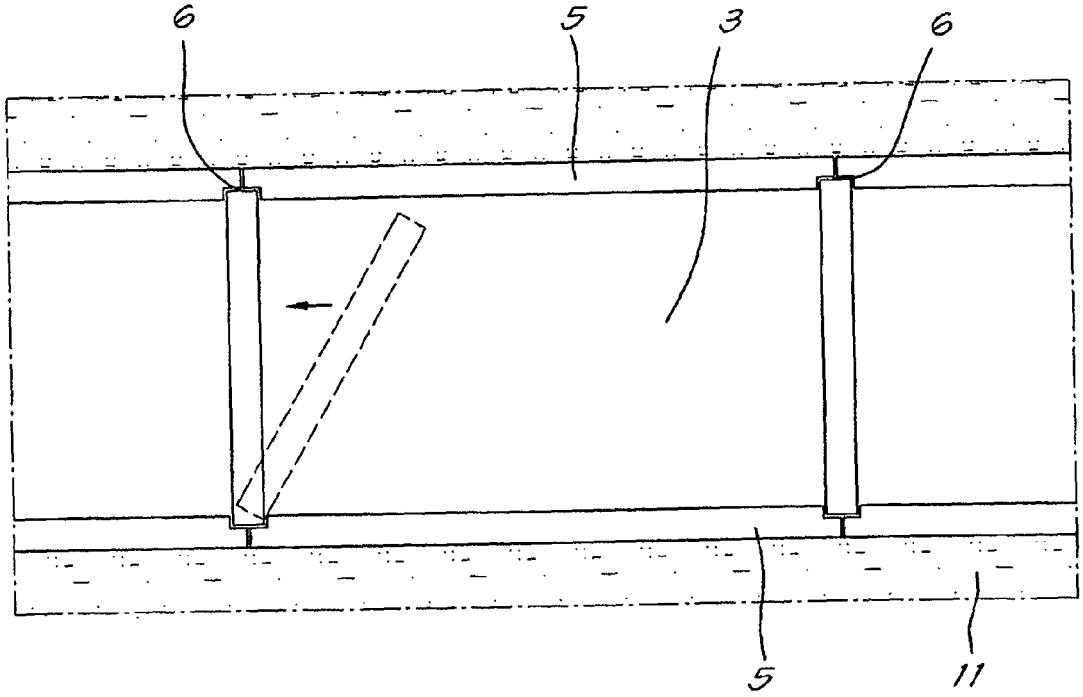

Fig.5

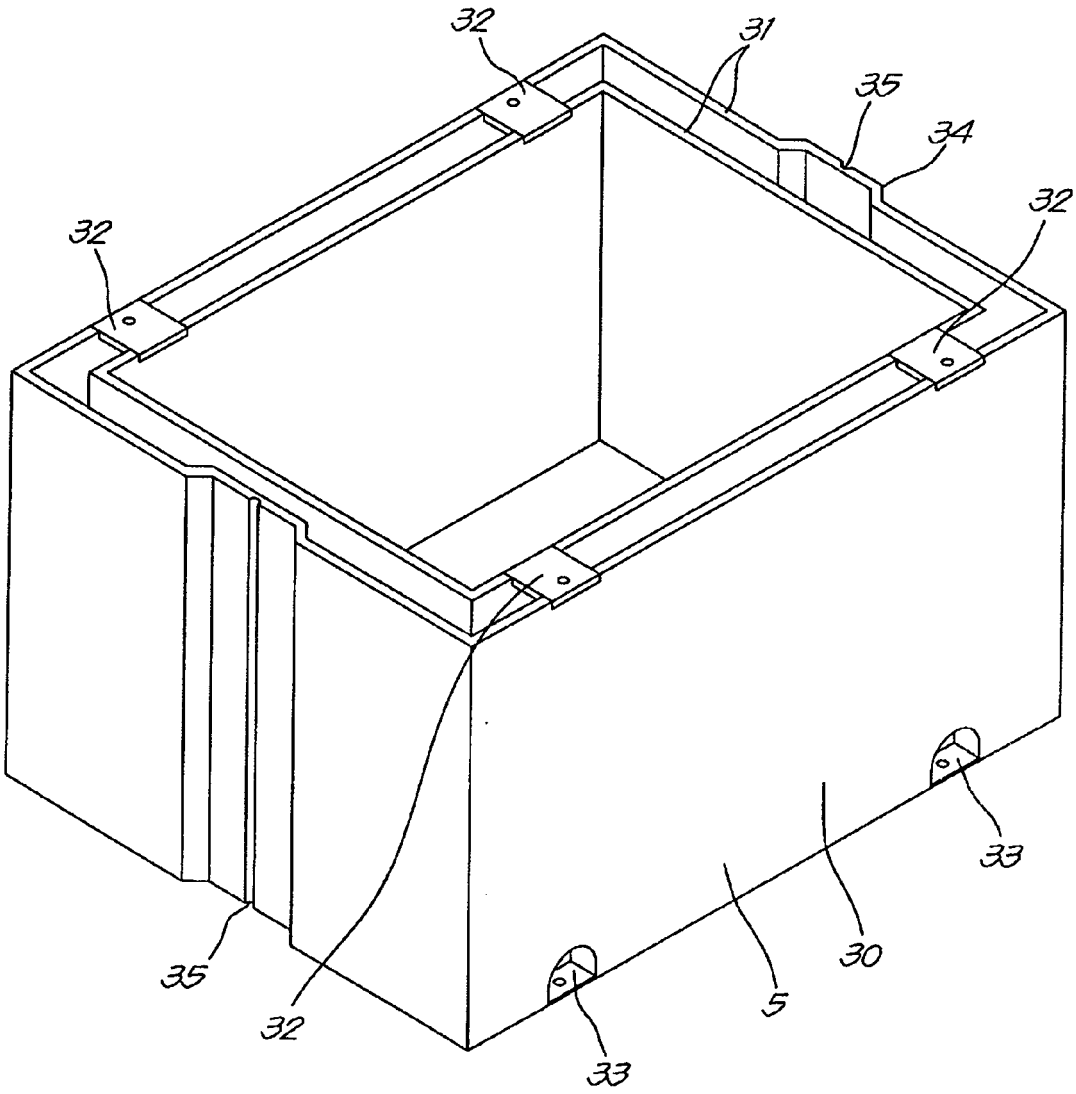

Fig.6

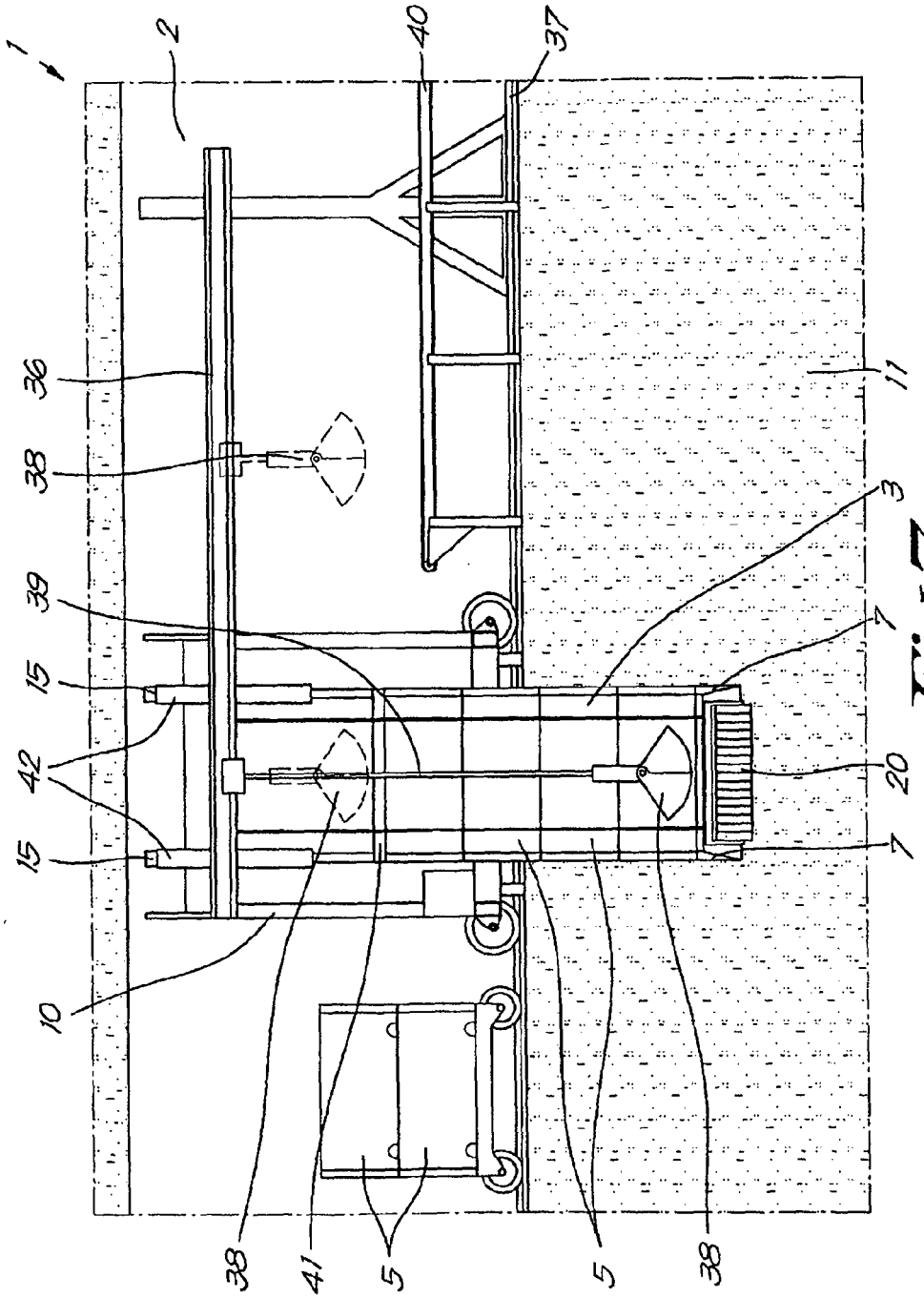

Fig.7

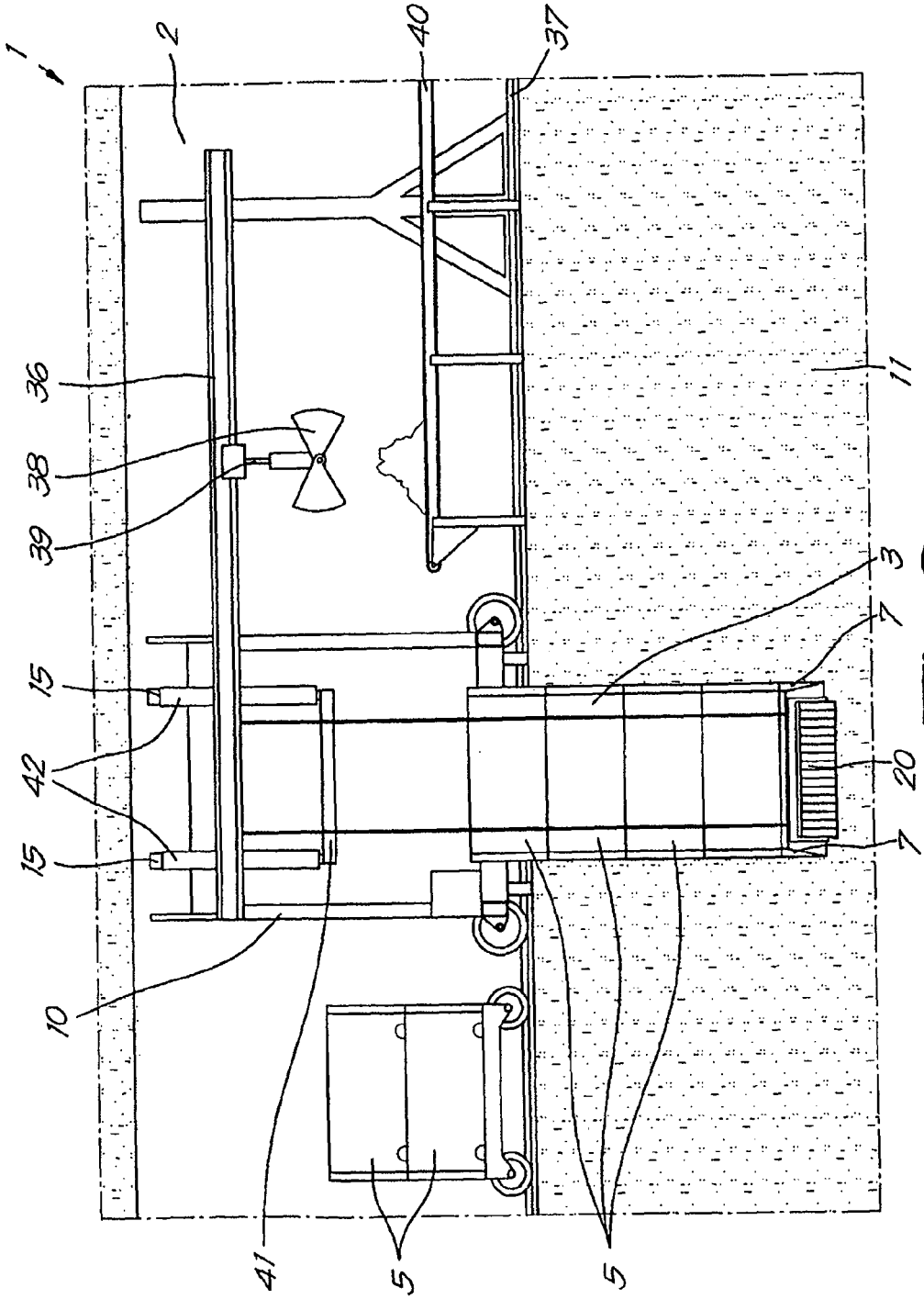

Fig.8

Europäisches Patentamt
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EUROPEAN SEARCH REPORT

Application Number
EP 12 00 3861

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y A	JP 61 134428 A (TAKENAKA KOMUTEN CO; TAKENAKA DOBOKU) 21 June 1986 (1986-06-21) * abstract; figures 1-5,10b *	1-4,11, 13-19 7,10 5,6,8,9, 12	INV. E02D17/08 E02D17/13
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Place of search	Date of completion of the search	Examiner
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