



(51) International Patent Classification:

B03D 1/16 (2006.01) *E04H 5/02* (2006.01)
B65D 85/68 (2006.01) *B65D 88/12* (2006.01)
B65D 88/02 (2006.01)

(21) International Application Number:

PCT/FI2015/050332

(22) International Filing Date:

13 May 2015 (13.05.2015)

(25) Filing Language:

English

(26) Publication Language:

English

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,

DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- of inventorship (Rule 4.17(iv))

Published:

- with international search report (Art. 21(3))

(54) Title: A FLOTATION PLANT AND ITS USES AND METHODS OF MAINTENANCE OF A FLOTATION PLANT

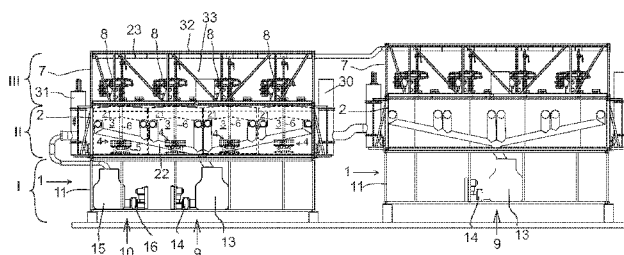


Fig. 2

(57) Abstract: A flotation plant built to a modular storeyed structure. A first storey (I) being the lowest storey of the plant comprises a main foundation (1). A second storey (II) above the first storey includes a tank module (2). The tank module includes at least one flotation tank (3). The flotation tank (3), when in use, accommodates a mixing and/or bubble forming equipment (4) including a rotor (5) connected to a rotatable drive shaft (6). The tank module (2) is a rigid and self-supporting unit capable of being transferable and hoistable as an integral entity. A third storey (III) above the second storey (II) includes a drive module (7). The drive module (7) is removably stacked on top of the tank module (2). The drive module includes at least two drive units (8) for the rotation of the drive shafts (6). The drive module is a rigid and self-supporting unit capable of being transferable and hoistable as an integral entity. The flotation plant comprises a pumping means (9, 10) for pumping, when in use, of a fluid flow obtained from the flotation tank (3) as an overflow and/or as an underflow, and the pumping means (9, 10) is disposed at the level of the first storey (I).

A FLOTATION PLANT AND ITS USES AND METHODS OF MAINTENANCE OF A FLOTATION PLANT

FIELD OF THE INVENTION

5 The present invention relates to a flotation plant. Further, the invention relates to uses of the flotation plant. Further, the invention relates methods of maintenance of a flotation plant.

SUMMARY OF THE INVENTION

According to a first aspect, the present invention provides a flotation plant. The flotation plant is built to a modular storeyed structure. The flotation plant comprises a first storey. The first storey is
15 the lowest storey of the plant and comprises a main foundation. The first storey has a height above ground. The flotation plant comprises a second storey. The second storey includes a tank module. The second storey is disposed above the first storey and defined
20 by the height of the tank module. The tank module includes at least one flotation tank. The flotation tank, when in use, accommodates a mixing and bubble forming equipment including a rotor connected to a rotatable drive shaft. The tank module is a rigid and
25 self-supporting unit capable of being transferable and hoistable as an integral entity. The flotation plant comprises a third storey. The third storey includes a drive module. The third storey is disposed above the second storey and is defined by the height of the
30 drive module. The drive module is removably stacked on top of the tank module and includes at least two drive units for the rotation of the drive shafts. The drive module is a rigid and self-supporting unit capable of being transferable and hoistable as an integral entity. The flotation plant comprises a pumping means for
35 pumping, when in use, of a fluid flow obtained from the flotation tank as an overflow and/or as an under-

flow. The pumping means is disposed at the level of the first storey.

The technical effect of the invention is that the modules being self-supporting units they can be transferred and hoisted as integral entities. The modules can be assembled and furnished at the site of manufacture, e.g. in an engineering workshop, and then transported to the site of installation as one integral entity. During transportation, hoisting and use the equipment furnished into the modules are well protected inside the self-supporting framework which acts as a delivery package and thereby eliminates need for separate transportation packages for the equipment. At the site of use the module may be placed on top of each other. When the flotation tank needs maintenance, the drive module together with its drive units can be lifted off and transferred aside to enable access to the flotation tanks. Also for the maintenance of the equipment furnished inside the drive module, if needed, the drive module can be transferred as one entity to a site of maintenance. The technical effect of the pumping means being disposed in the first storey provides that the overflow produced and discharged at the second storey level can be made to flow downwards by gravity to the lower first storey level wherein it can be arranged to settle sufficiently before it is pumped to further processing.

In this application the following definitions apply regarding flotation. Flotation involves phenomena related to the relative buoyancy of objects. The term flotation includes all flotation techniques. Flotation can be for example froth flotation, dissolved air flotation (DAF) or induced gas flotation. Froth flotation is a process for separating hydrophobic materials from hydrophilic materials by adding gas, for example air,

to process. Froth flotation could be made based on natural hydrophilic/hydrophobic difference or based on hydrophilic/hydrophobic differences made by addition of a surfactant or collector chemical. Gas can be added to the feedstock subject of flotation (slurry or pulp) by a number of different ways. In one embodiment gas can be added to the stream of feedstock subject of flotation before it is fed to the flotation tank. In one embodiment gas can be added to feedstock subject to flotation in the flotation tank. In one embodiment gas adding equipment can include gas dispersing equipment at the bottom of the tank. In one embodiment gas adding equipment can include a feedstock (slurry or pulp) jet for jetting the feedstock to air. In one embodiment gas adding equipment includes a rotor inside the tank. In one embodiment gas can be added under the rotor. In one embodiment gas is added by a pipe ending under rotor. The pipe can be inside the flotation tank. The pipe can go through the bottom of the flotation tank. In one embodiment the rotor takes gas from the surface of sludge by vortex. In one embodiment gas is added by axis of the rotor. In one embodiment mixing equipment is arranged for mixing the slurry/pulp. Mixing equipment could be for example a pump or a rotor. When the mixing is made by pump, the feedstock subject of flotation could be taken from one part of flotation tank and put back to another part of flotation tank. When mixing is made by the rotor, the rotor is inside the flotation tank. In one embodiment mixing equipment can include a rotor inside the flotation tank. In one embodiment mixing equipment can include a stator inside the flotation tank. The stator is for boosting mixing and to diffuse air to the feedstock (slurry or pulp) subject to flotation.

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In one embodiment of the flotation plant, the flotation plant comprises a foundation module. The founda-

tion module is at the level of the first storey forming the main foundation. The foundation module is a rigid and self-supporting unit capable of being transferable and hoistable as an integral entity. The tank module and the drive module are stacked on top of the foundation module.

In one embodiment of the flotation plant, the foundation module includes the pumping means for pumping of the overflow and/or the underflow.

In one embodiment of the flotation plant, the flotation plant comprises a side module, the side module being disposed on the side of and next to the main foundation at the level of the first storey, the side module being a rigid and self-supporting unit capable of being transferable and hoistable as an integral entity.

In one embodiment of the flotation plant, the side module includes the pumping means for pumping of the overflow and/or the underflow. The technical effect is that maintenance of the pumping means being disposed in the side module is easier than if the pumping means was disposed inside the foundation module. This because the tank module and the drive module do not have to be lifted away and before that the flotation tanks need not be emptied.

In one embodiment of the flotation plant, the pumping means for pumping the overflow includes an overflow sump tank. The overflow sump tank is arranged to receive the overflow to be pumped. When the flotation plant is used for froth flotation, the overflow sump tank gives the overflow (froth) a sufficient residence time for the gas to leave the overflow before the overflow is pumped away from the overflow sump tank.

In one embodiment of the flotation plant, the pumping means for pumping the overflow includes an overflow pump. The overflow pump is arranged to pump the overflow away from the overflow sump tank.

In one embodiment of the flotation plant, the pumping means for pumping the underflow includes an underflow sump tank. The underflow sump tank is arranged to receive the underflow to be pumped.

In one embodiment of the flotation plant, the pumping means for pumping the underflow includes an underflow pump. The underflow pump is arranged to pump the underflow from the underflow sump tank.

In one embodiment of the flotation plant, the flotation plant comprises an accessory module. The accessory module is disposed on the side and next to the tank module at the level of the second storey. The accessory module is a rigid and self-supporting unit capable of being transferable and hoistable as an integral entity.

In one embodiment of the flotation plant, the accessory module is removably stacked on top of the side module. The technical effect is that the side module provides a support for the accessory module. The accessory module can be easily lifted off and aside to gain access to the side module when the pumping means therein need maintenance.

In one embodiment of the flotation plant, the flotation plant comprises a side foundation at the level of the first storey. The side foundation is next to the main foundation. The accessory module is removably disposed on top of the side foundation.

In one embodiment of the flotation plant, the main foundation comprises a plurality of pillars having a height above the ground level, thereby providing a space for access below the flotation plant.

In one embodiment of the flotation plant, the side foundation is formed of a plurality of pillars, thereby providing a space for access below the flotation plant.

In one embodiment of the flotation plant, the flotation plant comprises an overflow receptacle for collecting an overflow overflowing from the flotation tank, and the overflow receptacle is disposed at a level of the second storey.

In one embodiment of the flotation plant, the overflow receptacle is connected to the tank module to be transferable and hoistable as an integral unit with the tank module.

In one embodiment of the flotation plant, the overflow receptacle is disposed inside the tank module. The technical effect is that maintenance is easy especially when the overflow receptacle is also attached to the flotation tank as an integral unit and can be transferred and hoisted as one entity.

In one embodiment of the flotation plant, the overflow receptacle is disposed outside the tank module. The technical effect is that the flotation capacity can be maximized per tank module.

In one embodiment of the flotation plant, the overflow receptacle is disposed inside the accessory module.

In one embodiment of the flotation plant, the flotation plant comprises an overflow channel. The overflow channel is disposed at the level of the second storey to conduct away the overflow from the overflow receptacle.

In one embodiment of the flotation plant, the overflow channel is connected to the tank module to be transferable and hoistable as an integral unit with the tank module.

In one embodiment of the flotation plant, the overflow channel is disposed inside the accessory module to be transferable and hoistable as an integral unit with the accessory module.

In one embodiment of the flotation plant, the drive module comprises a gas feed pipeline for supplying flotation gas.

In one embodiment of the flotation plant, the gas feed pipeline is in fluid communication with the drive shaft. The drive shaft is hollow for conducting the flotation gas supplied by the gas feed pipeline.

In one embodiment of the flotation plant, the drive module comprises a flow meter connected to the gas feed pipeline for measuring the rate of flow of the flotation gas.

In one embodiment of the flotation plant, the drive module comprises a flow rate controller connected to the gas feed pipeline for controlling the rate of flow of the flotation gas.

In one embodiment of the flotation plant, the drive module comprises measurement equipment for the measurement of liquid level in the flotation tank.

In one embodiment of the flotation plant, the drive module comprises a maintenance platform.

In one embodiment of the flotation plant, the drive module comprises a camera for detecting bubble size of the overflow.

In one embodiment of the flotation plant, the drive module comprises cabling for supplying electric power for the flow meter, for the flow rate controller, for the measurement equipment and/or for the camera.

- 5 In one embodiment of the flotation plant, the flotation plant includes a feed box for feeding feedstock subject of flotation to the flotation tank.

- 10 In one embodiment of the flotation plant, the flotation plant includes a discharge box for receiving and discharging underflow from the flotation tank.

- 15 In one embodiment of the flotation plant, the feed box and/or the discharge box is attached to the ends of the tank module and disposed outside the tank module.

- 20 In one embodiment of the flotation plant, the drive module comprises a first self-supporting framework having a shape of a rectangular parallelepiped. The first self-supporting framework is stackable with another compatible self-supporting framework of another module. The first self-supporting framework has an inner space. The drive units are disposed in the inner space of the first self-supporting framework.

In one embodiment of the flotation plant, the tank module comprises a second self-supporting framework having a shape of a rectangular parallelepiped. The second self-supporting framework is stackable with a compatible another self-supporting framework of another module. The second self-supporting framework has an inner space. The flotation tank is disposed in the inner space of the second self-supporting framework.

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In one embodiment of the flotation plant, the foundation module comprises a third self-supporting framework having a shape of a rectangular parallelepiped. The third self-supporting framework is stackable with a compatible another self-supporting framework of another module. The third self-supporting framework has an inner space.

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In one embodiment of the flotation plant, the pumping means is disposed in the inner space of the third self-supporting framework of the foundation module.

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In one embodiment of the flotation plant, the side module comprises a fourth self-supporting framework having a shape of a rectangular parallelepiped. The fourth self-supporting framework is stackable with a compatible another self-supporting framework of another module. The fourth self-supporting framework has an inner space.

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In one embodiment of the flotation plant, the accessory module comprises a fifth self-supporting framework having a shape of a rectangular parallelepiped. The fifth self-supporting framework is stackable with a compatible another self-supporting framework of another module. The fifth self-supporting framework has an inner space.

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In one embodiment of the flotation plant, each one of the modules comprises corners, and the modules are designed to be supported by the corners.

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In one embodiment of the flotation plant, the modules have widths that differ from each other no more than 20%.

10 In one embodiment of the flotation plant, the height of the module containing the pumping means is 35 - 70 % of the total height of the pumping means containing module and the tank module.

15 In one embodiment of the flotation plant, the height of the module which contains the pumping means is 40 - 65%, more preferably 45 - 55%, of the total height of the pump sump module and the tank module.

20 In one embodiment of the flotation plant, the modules have same width.

In one embodiment of the flotation plant, the tank module includes 1 to 6, preferably 1 to 4, flotation
25 tanks.

In one embodiment of the flotation plant, the volume of the flotation tank is 0.5 - 20 m³, more preferably 1 - 15 m³, most preferably 1 - 8 m³.

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In one embodiment of the flotation plant, flotation is froth flotation.

In one embodiment of the flotation plant, the flotation plant comprises gas adding equipment for adding
35 gas to the feedstock subject of flotation.

In one embodiment of the flotation plant, the flotation plant comprises gas adding equipment to the stream of the feedstock subject of flotation before entering the flotation tank.

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In one embodiment of the flotation plant, the flotation plant comprises gas adding equipment for adding gas to the feedstock subject of flotation in the flotation tank.

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In one embodiment of the flotation plant, the gas adding equipment includes a rotor inside the flotation tank.

15 In one embodiment of the flotation plant, the gas adding equipment includes a hollow rotatable drive shaft, and the rotor is connected to the drive shaft.

20 In one embodiment of the flotation plant, the feedstock subject of flotation is slurry or pulp.

In one embodiment of the flotation plant, the flotation plant comprises mixing equipment.

25 In one embodiment of the flotation plant, the mixing equipment includes a rotor inside the flotation tank.

In one embodiment of the flotation plant, the mixing equipment includes a stator inside the flotation tank.

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In one embodiment of the flotation plant, the flotation tank having a bottom is disposed inside a framework, and the stator is connected to the framework through the bottom.

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According to a second aspect of the invention, the invention provides use of the flotation plant according

to the first aspect for separating material by flotation based on differences of buoyancy properties of substances. For example there is buoyancy difference when organic material is separated from aqueous material.

According to a third aspect of the invention, the invention provides use of the flotation plant according to the first aspect for separating solid material by froth flotation based on differences of hydrophilic properties of substances. Solid materials separated by froth flotation could be oil sands, carbon, coal, talk, industrial minerals and mineral particles. The minerals may include industrial minerals and ore. Froth flotation to solid material could be made based on natural hydrophilic/hydrophobic difference or based on hydrophilic/hydrophobic differences made by addition of a surfactant or collector chemical or other chemical.

According to a fourth aspect of the invention, the invention provides use of the flotation plant according to the first aspect for concentrating ore by froth flotation. An ore is a type of rock that contains sufficient minerals with important elements including metals that can be economically extracted from the rock. Metal ores are generally oxides, sulfides, silicates, or metals such as native copper or gold. Froth flotation of ore could be made based on natural hydrophilic/hydrophobic difference or based on hydrophilic/hydrophobic differences made by addition of a surfactant or collector chemical or other chemical.

According to a fifth aspect of the invention, the invention provides use of the flotation plant according to the first aspect for flotation of substances containing abrasive material. The abrasive mineral may

be, for example, pyrite, silica, chromite. The drive module being hoistable and transferable as one unit to gain access to the tanks enables that the tanks can easily be maintained or replaced when they are outworn and are at the end of their life. This is important especially with the use in connection with abrasive material. Use of the flotation plant which is easy to maintenance is effective when flotation is made to abrasive material.

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According to a sixth aspect of the invention, the invention provides use of the flotation plant according to the first aspect for froth flotation of ore containing pyrite, silica, chromite. Use of the flotation plant which is easy to maintenance and has preferably tanks made from PE or PP is effective when flotation is made to ore containing pyrite, silica, chromite. PE and PP are durable against the ore containing pyrite, silica, chromite.

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According to a seventh aspect of the invention, the invention provides a method of maintenance of a flotation plant according to the first aspect of the invention. In the method an uppermost module in the stack of modules is subject of maintenance, and the uppermost module is hoisted up and transferred aside from the top of the lower module and the uppermost module is replaced by a another uppermost module which is placed on top of the lower module.

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According to an eighth aspect of the invention, the invention provides a method of maintenance of a flotation plant according to the first aspect of the invention. In the method a lower module underneath the uppermost module is subject of maintenance, and the uppermost module is hoisted up from the top of the lower

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module and transferred aside for gaining access to the lower module.

5 In one embodiment of the method, while the uppermost module is away from the top of the lower module, maintenance operations are performed for the lower module.

10 In one embodiment of the method, while the uppermost module is away from the top of the lower module, the lower module is replaced by another lower module.

15 According to a ninth aspect of the invention, the present invention provides a flotation plant built of self-supporting modules to form a modular storeyed structure. The self-supporting modules are transferable and hoistable as integral units stacked on top of each other. At most one self-supporting module is stacked on top of another module containing equipment
20 which requires regular maintenance.

In one embodiment of the flotation plant, the module containing equipment which requires regular maintenance is a tank module, and the equipment which requires maintenance is a flotation tank contained in
25 the tank module.

In one embodiment of the flotation plant, the equipment requiring maintenance is the pumping means.
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According to a tenth aspect of the invention, the present invention provides a method of maintenance of a flotation plant built of self-supporting modules to form a modular structure wherein the self-supporting
35 modules are transferable and hoistable as integral units stacked on top of each other. At most one self-supporting module is stacked on top of another module

containing equipment which requires maintenance. The method comprises steps of hoisting up the module from the top of another module having the equipment which requires regular maintenance to gain access to the equipment requiring maintenance, and performing maintenance to the equipment.

The embodiments of the invention described hereinbefore may be used in any combination with each other. Several of the embodiments may be combined together to form a further embodiment of the invention. An apparatus, a method, a composition or a use, to which the invention is related, may comprise at least one of the embodiments of the invention described hereinbefore.

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BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and constitute a part of this specification, illustrate embodiments of the invention and together with the description help to explain the principles of the invention. In the drawings:

Figure 1 shows a perspective view of one embodiment of the three-storeyed flotation plant according to the invention,

Figure 2 is a schematic side view of a second embodiment of the three-storeyed flotation plant according to the invention,

Figures 3 to 10 show as a schematic cross-sectional views eight examples of different kinds combinations of modular three-storeyed flotation plants that can be assembled from the modules.

DETAILED DESCRIPTION OF THE INVENTION

Although flotation is disclosed in the following examples by reference to froth flotation, it should be noted that the principles according to the invention can be implemented regardless of the specific type of the flotation, i.e. the flotation technique can be any of the known *per se* flotation techniques, such as froth flotation, dissolved air flotation or induced gas flotation.

Referring to Figures 1 and 2, the froth flotation plant is built to a modular three-storeyed structure. The froth flotation plant has been assembled from self-supporting modules that together form a modular froth flotation plant. The modules from which the froth flotation plant has been built are removably stacked on top of each other to form the three-storeyed structure having a first storey I at the bottom, a second storey II in the middle above the first storey I and a top storey III above the second storey II.

The first storey I is the lowest storey of the froth flotation plant and comprises a main foundation 1.

As illustrated in Figures 2 to 4, and 6 to 10, the main foundation 1 may be formed of a foundation module 11 at the level of the first storey I. The foundation module 11 is a rigid and self-supporting unit that can be transferred and hoisted as an integral entity. The tank module 2 and the drive module 7 are stacked on top of the foundation module 11. As shown in Figure 5 the main foundation 1 may alternatively be formed of pillars 19.

The second storey II includes a tank module 2. The height of the tank module 2 defines the second storey II. The tank module 2 includes one to six froth flota-

tion tanks 3. The neighboring flotation tanks 3 are in fluid communication with each other so that a continuous flow of underflow can flow through the successive flotation tanks. In the example shown in Figure 2, the tank module 2 includes four froth flotation tanks 3. Preferably, the froth flotation tanks 3 are placed in the inner space 33 of the second self-supporting framework 34 without being attached to the framework bottom and framework sidewalls to provide for easy installing and replacing of the tanks. The volume of the froth flotation tank 3 is 0.5 to 20 m³, more preferably 1 to 14 m³, most preferably 1 to 8 m³. The froth flotation tanks 3 and the overflow receptacle 21 are preferably made of a thermoplastic polymer, such as polyethylene PE or polypropylene PP which materials have good resistance against abrasion.

Referring to Figure 3, the froth flotation tanks 3, when in use, each accommodate a mixing and bubble forming equipment 4 including a rotor 5 connected to a rotatable drive shaft 6. A stationary stator 44 is arranged to surround the rotor 5. The stator 44 is attached through the bottom 45 of the flotation tank 3 to the framework 34 of the tank module 2. The tank module 2 is a rigid and self-supporting unit that can be transferred and hoisted as an integral entity. For that purpose the tank module 2 comprises a second self-supporting framework 34 having a shape of a rectangular parallelepiped. The second self-supporting framework 34 is stackable with a compatible another self-supporting framework of another module. The second self-supporting framework has an inner space 35 and the froth flotation tanks 3 are disposed in the inner space of the second self-supporting framework 34. Preferably, the froth flotation tanks 3

As shown in Figure 2, the froth flotation plant includes a feed box 30 for feeding feedstock subject of froth flotation to the flotation tank 3 and a discharge box 31 for receiving and discharging underflow from the flotation tank 3. The feed box 30 and the discharge box 31 are attached to the ends of the tank module 2 and disposed outside the tank module 2.

The third storey III includes a drive module 7. The third storey III is defined by the height of the drive module 7. The drive module 7 is removably stacked on top of the tank module 2. The drive module 2 includes two to six drive units 8 corresponding to the number of the froth flotation tanks 3 in the tank module 2. In the example shown in Figure 2 the drive module 2 includes four drive units 8. The drive units 8 are arranged to rotate the drive shafts 6. The drive module 2 is a rigid and self-supporting unit that can be transferred and hoisted as an integral entity. For that purpose the drive module 7 comprises a first self-supporting framework 32 having a shape of a rectangular parallelepiped. The first self-supporting framework is stackable with another compatible self-supporting framework of another module. The first self-supporting framework has an inner space 33, and the drive units 8 are disposed in the inner space 33 of the first self-supporting framework 32.

As shown in Figures 2 to 10 the froth flotation plant comprises pumping means 9, 10 for pumping, when in use, of a fluid flow obtained from the froth flotation tank 3 as an overflow and/or as an underflow. The pumping means 9, 10 is disposed at the level of the first storey I.

In the examples shown in Figures 2 - 4, 8 and 9 the pumping means 9 for pumping the overflow are disposed

inside the foundation module 11 which supports the stack formed of the tank module 2 and the drive module 7. Figure 2 shows that the same foundation module 11 that accommodates the pumping means 9 for pumping the overflow may also accommodate the pumping means 10 for pumping the underflow. The foundation module 11 comprises a third self-supporting framework 36 having a shape of a rectangular parallelepiped. The third self-supporting framework 36 being stackable with a compatible another self-supporting framework of another module. The third self-supporting framework has an inner space 37. The pumping means 9, 10 are disposed in the inner space 37 of the third self-supporting framework 36 of the foundation module 11.

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In the examples shown in Figures 5, 6, 7, 9 and 10 the froth flotation plant comprises a side module 12. The side module 12 is disposed on the side of and next to the main foundation 1 at the level of the first storey I. The side module 12 is a rigid and self-supporting unit that can be transferred and hoisted as an integral entity. The side module 12 may include the pumping means 9, 10 for pumping of the overflow and/or the underflow. In the example shown in Figure 9, the side module 12 acts only as a support for the accessory module 17 which is placed removably on top of the side module 12. The side module 12 comprises a fourth self-supporting framework 38 having a shape of a rectangular parallelepiped. The fourth self-supporting framework is stackable with a compatible another self-supporting framework of another module. The fourth self-supporting framework has an inner space 39 that can accommodate the pumping means 9, 10 for pumping of the overflow and/or the underflow.

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As can be seen in Figures 2 - 10 the pumping means 9 for pumping the overflow include an overflow sump tank

13. The overflow sump tank 13 is arranged to receive the overflow that is collected by overflow receptacles 21 and conducted via overflow channel 22 to the overflow sump tank 13. An overflow pump 14 is arranged to pump the overflow away from the overflow sump tank 13. Referring to Figure 2, the pumping means 10 for pumping the underflow is a similar arrangement. An underflow sump tank 15 is arranged to receive the underflow of the froth flotation process coming via a pipeline from the discharge box 31 to the underflow sump tank 15. The pumping means 10 for pumping the underflow includes an underflow pump 16. The underflow pump 16 is arranged to pump the underflow away from the underflow sump tank 15.

In order to be able to create a continuous gravity flow of the overflow the height of the foundation module 11 or the side module 12 containing the pumping means 9, 10 is 35 - 70 % of the total height of the pumping means containing module 11, 12 and the tank module 2. The height of the module which contains the pumping means is 40 - 65%, more preferably 45 - 55%, of the total height of the pumping means containing module 11, 12 and the tank module 7.

As illustrated in Figures 5 - 10, the froth flotation plant may comprise an accessory module 17. The accessory module 17 is disposed on the side and next to the tank module 2 at the level of the second storey II. The accessory module 17 is a rigid and self-supporting unit that can be transferred and hoisted as an integral entity. The accessory module 17 is removably stacked on top of the side module 12. The accessory module 17 comprises a fifth self-supporting framework 40 having a shape of a rectangular parallelepiped. The fifth self-supporting framework 40 is stackable with a compatible another self-supporting framework of another

er module. The fifth self-supporting framework 40 of the accessory module 17 has an inner space 41. A gangway 43 can be disposed on top of the fifth self-supporting framework 40.

5

Each one of the above disclosed modules 11, 2, 7, 12, 17 comprises corners, and the modules are designed to be supported by the corners. To provide stackability of the modules on top of each other, the modules 11, 2, 7, 12, 17 have widths that differ from each other no more than 20%. Preferably, the modules 1, 2, 7, 12, 17 have same width. A preferable embodiment of all the modules is that they are compatible to intermodal freight container standards whereby they have dimensions and corner fittings which enable intermodal transportability.

The example in Figure 8 shows that the froth flotation plant may comprise a side foundation 18 at the level of the first storey I. The side foundation 18 is formed of a plurality of pillars 20 and is disposed next to the main foundation 1. The accessory module 17 is removably disposed on top of the side foundation 18. The side foundation 18 formed of pillars 20 provide a free space having the height of the first storey I so that the space below the froth flotation plant can be accessed.

The example in Figure 5 shows that also the main foundation 1 may be formed of a plurality of pillars 19 having a height above the ground level thereby providing a free space having the height of the first storey I so that the space below the froth flotation plant can be accessed.

35

With reference to Figures 2 - 10, the froth flotation plant comprises overflow receptacles 21 for collecting

an overflow overflowing from the froth flotation tanks 3. The overflow receptacles 21 are disposed at a level of the second storey II.

5 In the example shown in Figure 4, the overflow receptacle 21 is on one side of the tank module 2 and connected by brackets to the tank module 2 so as to be transferable and hoistable as an integral unit with the tank module 2.

10

In the examples shown in Figures 2, 3, 5, 6, 8, 9 and 10 the overflow receptacle 21 is disposed inside the tank module 2 at the tapered upper part of each froth flotation tank 3.

15

In the examples shown in Figures 4 and 7 the overflow receptacle 21 may be disposed outside the tank module 2. Figure 7 shows that the overflow receptacle 21 may be disposed in the inner space 41 of fifth self-supporting framework 40 of the accessory module 17 and connected by brackets to the fifth self-supporting framework 40.

20

As can be seen in Figures 2 - 10 the froth flotation plant comprises an overflow channel 22. The overflow channel 22 is disposed at the level of the second storey II to conduct away the overflow from the overflow receptacle 21.

25

30 In the examples shown in Figure 3 and 4 the overflow channel 22 are connected brackets to the second self-supporting framework 34 of the tank module 2 so as to be transferable and hoistable as an integral unit with the tank module 2.

35

In the examples shown in Figures 5 - 10 the overflow channel 22 is disposed in the inner space 41 of the

fifth self-supporting framework 41 inside the accessory module 17 to be transferable and hoistable as an integral unit with the accessory module.

5 In all the shown examples of Figures 2 - 10 the drive modules 7 are identical. The various equipment furnished in the drive module 7 are disclosed in the following with reference to Figure 3. The drive module 7 comprises a gas feed pipeline 23 for supplying flotation gas. The gas feed pipeline 23 is disposed in the inner space 33 of the first self-supporting framework 32 and supported to the first self-supporting framework 32. The gas feed pipeline 23 is connected in fluid communication with the drive shaft 6 which is hollow and thus are able to conduct the flotation gas.

The drive module 7 comprises a cable tray 42 for supporting electric cabling 29. The cable trays and the cabling are disposed in the inner space 33 of the first self-supporting framework 32 and supported to the first self-supporting framework 32.

The gas feed pipeline 23 and the cable tray 42 are disposed in the inner space 33 of the self-supporting framework 32 so that they are above the level in relation to the level of the drive units 8. Also they are offset in relation to the drive units 8 so that they do not hinder or interfere hoisting of the drive unit 8 in an upwards direction. During installing and removing the drive units 8 pass by the gas feed pipeline 23 and the cable tray 29.

The drive module 7 further comprises a flow meter 24 which is connected to the gas feed pipeline 23 for measuring the rate of flow of the flotation gas. A flow rate controller 25 is connected to the gas feed

pipeline 23 for regulating the rate of flow of the flotation gas.

Also some additional equipment connectable to the drive module 7 are shown. The drive module 7 may also comprise measurement equipment 26 for the measurement of liquid level in each of the flotation tanks 3. The drive module 7 may also comprise a froth camera 28 for detecting bubble size of froth, when in use in froth flotation. Preferably, the self-supporting framework 2 also comprise a maintenance platform 27 that enables easy access to the inner space 33 of the self-supporting framework 32 for e.g. maintenance of the various equipment contained in the drive module 7.

15

The drive module 7 may also be equipped with a variety of other equipment that can be installed already at the manufacturing site. When needed, the drive module 7 may contain e.g.

20

- a water pipeline for supplying water to an overflow receptacle which receives the overflow from the froth flotation tank,

- a gas suction pipeline for recirculating the flotation gas (needed for work safety reasons e.g. in froth flotation of molybdenum wherein the flotation gas is poisonous),

25

- a roofing on top of the drive module, and shields that cover the sides of the self-supporting space frame metal beam framework for shielding the equipment furnished inside the framework from harsh environmental conditions (sunshine, rain, sandstorm, ice, snow etc).

30

Figure 10 shows an example of the froth flotation plant wherein the side module 12 containing the overflow sump tank 13 and the overflow pump 14 is disposed in the middle of two parallel stacks formed of the

35

foundation module 11, tank module 2 and the drive module 7. Thereby, the overflow channels 22 connected to both of the tank modules 2 can conduct the overflow to the same overflow sum tank 13.

5

Maintenance of the flotation plant is easy and can be performed quickly. If an uppermost module in the stack of modules is subject of maintenance, the uppermost module is simply hoisted up and transferred aside and is replaced by another uppermost module. If a lower module located underneath the uppermost module is subject of maintenance, then the uppermost module is hoisted up from the top of the lower module and transferred aside for gaining access to the lower module. While the uppermost module is away from the top of the lower module, maintenance operations are performed for the lower module. Alternatively, the lower module can simply be replaced by another lower module.

20 The froth flotation plant which is built of self-supporting modules to form a modular three-storeyed structure and in which the self-supporting modules are transferable and hoistable as integral units and stacked on top of each other is quick to install an dismantle. At most one self-supporting module is stacked on top of another module which contains equipment which requires regular maintenance. Maintenance of such a module is easy since only one or two modules need to be lifted off and transferred aside in order to have access to the module that requires maintenance. The module containing equipment which requires regular maintenance may be a tank module 2 wherein the equipment which requires maintenance is a froth flotation tank 3 contained in the tank module 2. The module which requires maintenance may also be the module which contains the pumping means pumping means 9, 10.

In the method of maintenance a module is hoisted up from the top of another module having the equipment which requires regular maintenance to gain access to the equipment requiring maintenance, and maintenance
5 to the equipment can be performed.

It is obvious to a person skilled in the art that with the advancement of technology, the basic idea of the invention may be implemented in various ways. The in-
10 vention and its embodiments are thus not limited to the examples described above, instead they may vary within the scope of the claims.

CLAIMS

1. A flotation plant, the flotation plant being built to a modular storeyed structure comprising

5 - a first storey, the first storey being the lowest storey of the plant and the first storey comprises a main foundation, and the first storey having a height above ground,

10 - a second storey, the second storey including a tank module and being disposed above the first storey and defined by the height of the tank module, the tank module including at least one flotation tank, the flotation tank, when in use, accommodating a mixing and/or bubble forming equipment including a rotor
15 connected to a rotatable drive shaft, the tank module being a rigid and self-supporting unit capable of being transferable and hoistable as an integral entity, and

20 - a third storey, the third storey including a drive module and being disposed above the second storey and defined by the height of the drive module, the drive module being removably stacked on top of the tank module and including at least two drive units for the rotation of the drive shafts, the drive module being
25 a rigid and self-supporting unit capable of being transferable and hoistable as an integral entity,

 and wherein the flotation plant comprises a pumping means for pumping, when in use, of a fluid flow obtained from the flotation tank as an overflow
30 and/or as an underflow, and the pumping means is disposed at the level of the first storey.

2. The flotation plant according to claim 1, wherein the flotation plant comprises

35 - a foundation module, the foundation module being at the level of the first storey forming the main foundation, the foundation module being a rigid

and self-supporting unit capable of being transferable and hoistable as an integral entity, and the tank module and the drive module are stacked on top of the foundation module.

5

3. The flotation plant according to claim 2, wherein the foundation module includes the pumping means for pumping of the overflow and/or the underflow.

10 4. The flotation plant according to any one of the claims 1 to 3, wherein the flotation plant comprises

- a side module, the side module being disposed on the side of and next to the main foundation at the level of the first storey, the side module being a rigid and self-supporting unit capable of being transferable and hoistable as an integral entity.

15

5. The flotation plant according to claim 4, wherein the side module includes the pumping means for pumping of the overflow and/or the underflow.

20

6. The flotation plant according to any one of the claims 3 to 5, wherein the pumping means for pumping the overflow includes

- an overflow sump tank, the overflow sump tank being arranged to receive the overflow to be pumped.

25

7. The flotation plant according to any one of the claims 3 to 6, wherein the pumping means for pumping the overflow includes

30

- an overflow pump, the overflow pump being arranged to pump the overflow from the overflow sump tank.

35

8. The flotation plant according to any one of the claims 3 to 7, wherein the pumping means for pumping the underflow includes

- an underflow sump tank, the underflow sump tank being arranged to receive the underflow to be pumped.

9. The flotation plant according to any one of the claims 3 to 8, wherein the pumping means for pumping the underflow includes

- an underflow pump, the underflow pump being arranged to pump the underflow from the underflow sump tank.

10. The flotation plant according to any one of the claims 1 to 9, wherein the flotation plant comprises

- an accessory module, the accessory module being disposed on the side and next to the tank module at the level of the second storey, the accessory module being a rigid and self-supporting unit capable of being transferable and hoistable as an integral entity.

11. The flotation plant according to claim 10, wherein the accessory module is removably stacked on top of the side module.

12. The flotation plant according to claim 6, wherein the flotation plant comprises

- a side foundation at the level of the first storey, the side foundation being next to the main foundation, and the accessory module is removably disposed on top of the side foundation.

13. The flotation plant according to claim 1, wherein the main foundation comprises a plurality of pillars having a height above the ground level, thereby

providing a space for access below the flotation plant.

14. The flotation plant according to claim 12 or 13,
5 wherein the side foundation is formed of a plurality of pillars, thereby providing a space for access below the flotation plant.

15. The flotation plant according to any one of the
10 claims 1 to 14, wherein the flotation plant comprises
- an overflow receptacle for collecting an overflow from the flotation tank, and the overflow receptacle is disposed at a level of the second storey.

15 16. The flotation plant according to claim 15, wherein the overflow receptacle is connected to the tank module to be transferable and hoistable as an integral unit with the tank module.

20 17. The flotation plant according to claim 15 or 16, wherein the overflow receptacle is disposed inside the tank module.

18. The flotation plant according to claim 15 or 16,
25 wherein the overflow receptacle is disposed outside the tank module.

19. The flotation plant according to claim 15, wherein the overflow receptacle is disposed inside the accessory module.
30

20. The flotation plant according to any one of the claims 1 to 19, wherein the flotation plant comprises
- an overflow channel, the overflow channel
35 being disposed at the level of the second storey to conduct away the overflow from the overflow receptacle.

21. The flotation plant according to claim 20, wherein the overflow channel is connected to the tank module to be transferable and hoistable as an integral unit
5 with the tank module.

22. The flotation plant according to claim 20 or 21, wherein the overflow channel is disposed inside the accessory module to be transferable and hoistable as
10 an integral unit with the accessory module.

23. The flotation plant according to any one of the claims 1 to 22, wherein the drive module comprises
- a gas feed pipeline for supplying flotation
15 gas.

24. The flotation plant according to claim 23, wherein
- the gas feed pipeline is in fluid communication with the drive shaft, the drive shaft being
20 hollow for conducting the flotation gas supplied by the gas feed pipeline.

25. The flotation plant according to claim 23 or 24, wherein the drive module comprises
- a flow meter connected to the gas feed pipeline for measuring the rate of flow of the flota-
25 tion gas.

26. The flotation plant according to any one of the claims 23 to 25, wherein the drive module comprises
- a flow rate controller connected to the gas feed pipeline for controlling the rate of flow of the flotation gas.
30

27. The flotation plant according to any one of the claims 1 to 26, wherein the drive module comprises

- measurement equipment for the measurement of liquid level in the flotation tank.

28. The flotation plant according to any one of the claims 1 to 27, wherein the drive module comprises

- a maintenance platform.

29. The flotation plant according to any one of the claims 1 to 28, wherein the drive module comprises

5 - a froth camera for detecting bubble size of the overflow.

30. The flotation plant according to any one of the claims 25 to 29, wherein the drive module comprises

- cabling for supplying electric power for the flow meter, for the flow rate controller, for the measurement equipment and/or for the camera.

10

31. The flotation plant according to any one of the claims 1 to 30, wherein the flotation plant includes

- a feed box for feeding feedstock subject of flotation to the flotation tank.

15

32. The flotation plant according to any one of the claims 1 to 31, wherein the flotation plant includes

- a discharge box for receiving and discharging underflow from the flotation tank.

20

33. The flotation plant according to claim 31 or 32, wherein the feed box and/or the discharge box is attached to the ends of the tank module and disposed outside the tank module.

25

34. The flotation plant according to any one of the claims 1 to 33, wherein the drive module comprises a first self-supporting framework having a shape of a

rectangular parallelepiped, the first self-supporting framework being stackable with another compatible self-supporting framework of another module, the first self-supporting framework having an inner space, and
5 the drive units are disposed in the inner space of the first self-supporting framework.

35. The flotation plant according to any one of the claims 1 to 34, wherein the tank module comprises a
10 second self-supporting framework having a shape of a rectangular parallelepiped, the second self-supporting framework being stackable with a compatible another self-supporting framework of another module, the second self-supporting framework having an inner space,
15 and the flotation tanks are disposed in the inner space of the second self-supporting framework.

36. The flotation plant according to any one of the claims 2 to 35, wherein the foundation module comprises
20 a third self-supporting framework having a shape of a rectangular parallelepiped, the third self-supporting framework being stackable with a compatible another self-supporting framework of another module, the third self-supporting framework having an inner
25 space.

37. The flotation plant according to claim 36, wherein the pumping means is disposed in the inner space of the third self-supporting framework of the foundation
30 module.

38. The flotation plant according to any one of the claims 4 to 37, wherein the side module comprises a
35 fourth self-supporting framework having a shape of a rectangular parallelepiped, the fourth self-supporting framework being stackable with a compatible another self-supporting framework of another module, the

fourth self-supporting framework having an inner space.

39. The flotation plant according to any one of the
5 claims 10 to 38, wherein the accessory module comprises a fifth self-supporting framework having a shape of a rectangular parallelepiped, the fifth self-supporting framework being stackable with a compatible
10 another self-supporting framework of another module, the fifth self-supporting framework having an inner space.

40. The flotation plant according to any one of the
15 claims 1 to 39, wherein each one of the modules comprises corners, and the modules are designed to be supported by the corners.

41. The flotation plant according to any one of the
20 claims 1 to 40, wherein the modules have widths that differ from each other no more than 20%.

42. The flotation plant according to any one of the
claims 1 to 43, wherein the modules have same width.

25 43. The flotation plant according to any one of the claims 3 to 42, wherein the height of the module containing the pumping means is 35 - 70 % of the total height of the pumping means containing module and the tank module.

30

44. The flotation plant according to claim 43, wherein the height of the module which contains the pumping means is 40 - 65%, more preferably 45 - 55%, of the total height of the pump sump module and the tank module.
35

45. The flotation plant according to any one of the claims 1 to 44, wherein the tank module includes 1 to 6, preferably 1 to 4, flotation tanks.

5 46. The flotation plant according to claim 45, wherein the volume of the flotation tank is $0.5 - 20 \text{ m}^3$, more preferably $1 - 15 \text{ m}^3$, most preferably $1 - 8 \text{ m}^3$.

10 47. The flotation plant according to any one of the claims 1 to 46, wherein flotation is froth flotation.

48. The flotation plant according to claim 47, wherein the flotation plant comprises gas adding equipment for adding gas to the feedstock subject of flotation.

15

49. The flotation plant according to claim 48, wherein the flotation plant comprises gas adding equipment to the stream of the feedstock subject of flotation before entering the flotation tank.

20

50. The flotation plant according to claim 48, wherein the flotation plant comprises gas adding equipment for adding gas to the feedstock subject of flotation in the flotation tank.

25

51. The flotation plant according to claim 50, wherein the gas adding equipment includes a rotor inside the flotation tank.

30 52. The flotation plant according to claim 51, wherein the gas adding equipment includes a hollow rotatable drive shaft, and the rotor is connected to the drive shaft.

35 53. The flotation plant according to any one of the claims 1 to 52, wherein the feedstock subject of flotation is slurry or pulp.

54. The flotation plant according to any one of the claims 1 to 53, wherein the flotation plant comprises mixing equipment.

5

55. The flotation plant according to claim 54, wherein the mixing equipment includes a rotor inside the flotation tank.

10

56. The flotation plant according to claim 55, wherein the mixing equipment includes a stator inside the flotation tank.

15

57. The flotation plant according to claim 56, wherein the flotation tank having a bottom is disposed inside a framework, and the stator is connected to the framework through the bottom.

20

58. Use of the flotation plant according to any one of the claims 1 to 57 for separating material by flotation based on differences of buoyancy properties of substances.

25

59. Use of the flotation plant according to any one of the claims 1 to 57 for separating solid material by froth flotation based on differences of hydrophilic properties of substances.

30

60. Use of the flotation plant according to any one of the claims 1 to 57 for concentrating ore by froth flotation.

35

61. Use of the flotation plant according to any one of the claims 1 to 57 for flotation of substances containing abrasive material.

62. Use of the flotation plant according to any one of the claims 1 to 57 for froth flotation of ore containing pyrite, silica, chromite.

5 63. A method of maintenance of a flotation plant according to any one of the claims 1 to 57, in which method an uppermost module is subject of maintenance, and the uppermost module is hoisted up and transferred
10 aside from the top of the lower module and the uppermost module is replaced by a another uppermost module which is placed on top of the lower module.

64. A method of maintenance of a flotation plant according to any one of the claims 1 to 57, in which
15 method a lower module, which is underneath an uppermost module, is subject of maintenance, and the uppermost module is hoisted up from the top of the lower module and transferred aside for gaining access to the lower module.

20 65. The method of maintenance according to claim 64, wherein while the uppermost module is away from the top of the lower module, maintenance operations are performed for the lower module.

25 66. The method of maintenance according to claim 64, wherein while the uppermost module is away from the top of the lower module, the lower module is replaced by another lower module.

30 67. A flotation plant built of self-supporting modules to form a modular storeyed structure, wherein the self-supporting modules are transferable and hoistable as integral units stacked on top of each other, and
35 wherein at most one self-supporting module is stacked on top of another module containing equipment which requires regular maintenance.

68. The flotation plant of claim 67, wherein the module containing equipment which requires regular maintenance is a tank module, and the equipment which
5 requires maintenance is a flotation tank contained in the tank module.

69. The flotation plant of claim 67, wherein the equipment requiring maintenance is the pumping means.
10

70. A method of maintenance of a flotation plant built of self-supporting modules to form a modular structure, wherein the self-supporting modules are transferable and hoistable as integral units stacked on top
15 of each other, and wherein at most one self-supporting module is stacked on top of another module containing equipment which requires maintenance, the method comprising steps of:

20 - hoisting up the module from the top of the another module having the equipment which requires regular maintenance to gain access to the equipment requiring maintenance, and
- performing maintenance to the equipment.

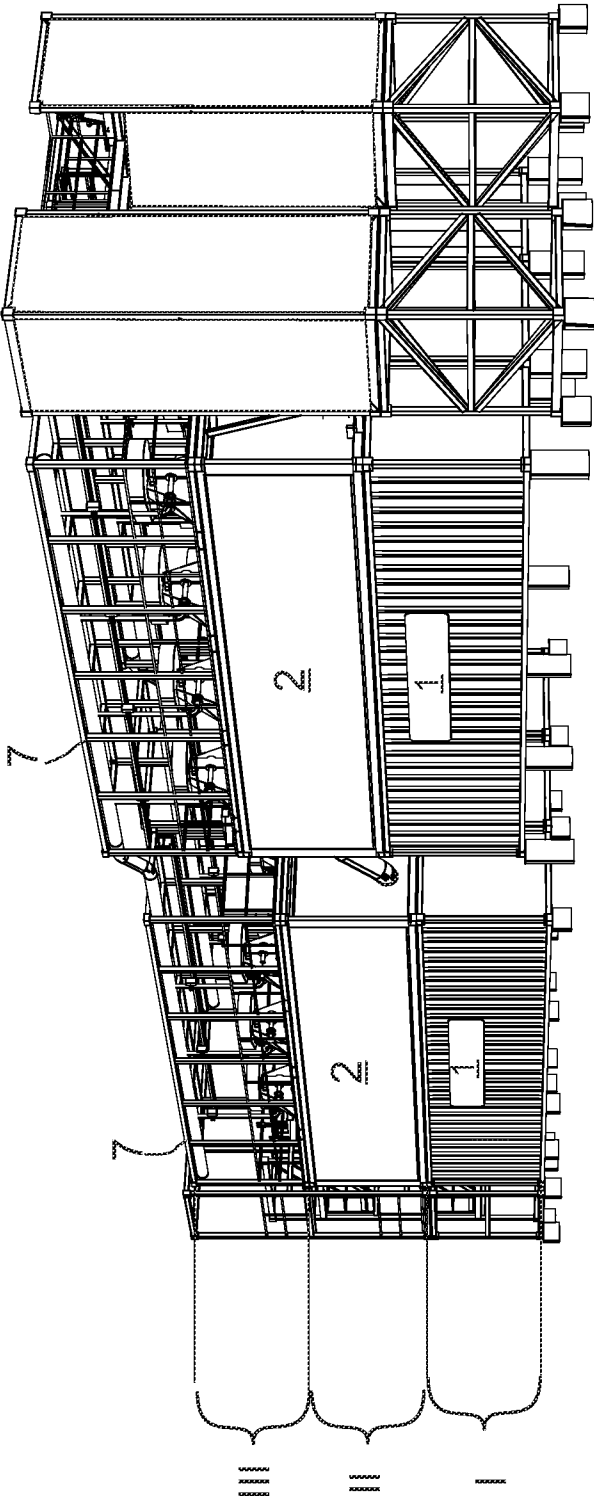


Fig. 1

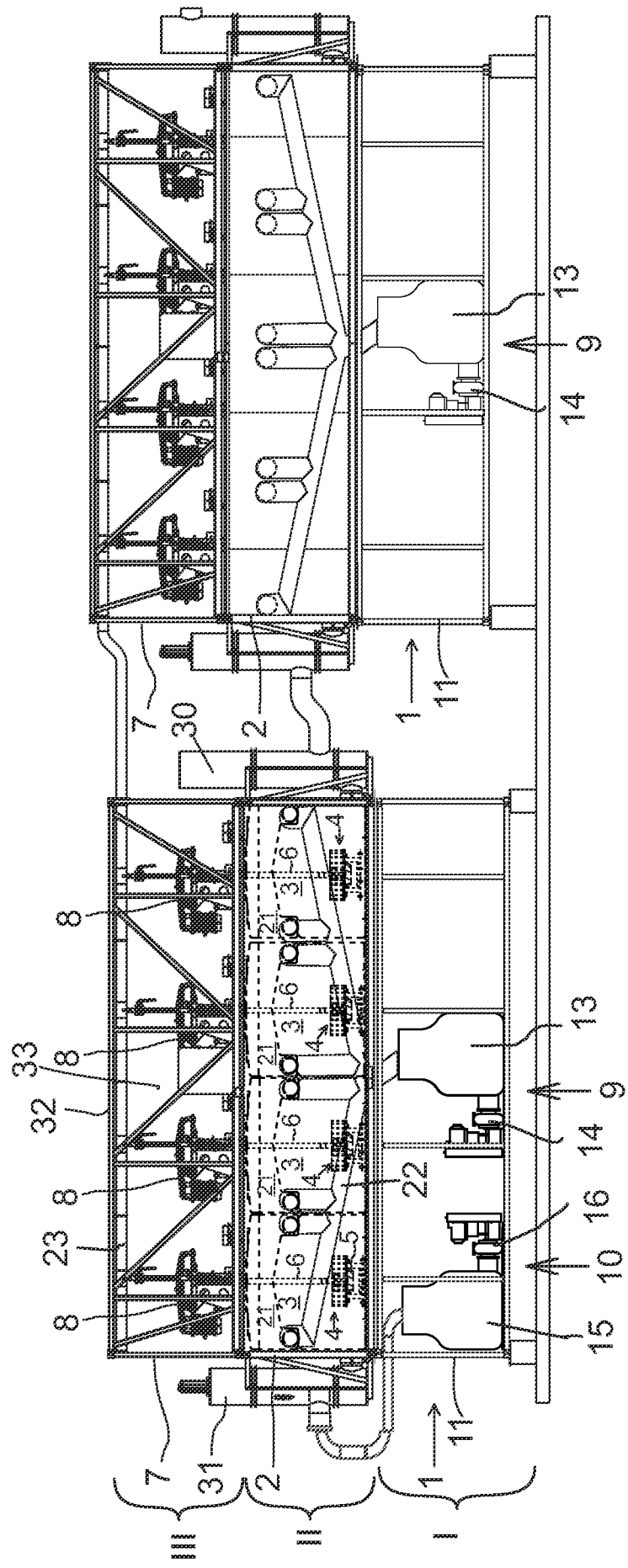


Fig. 2

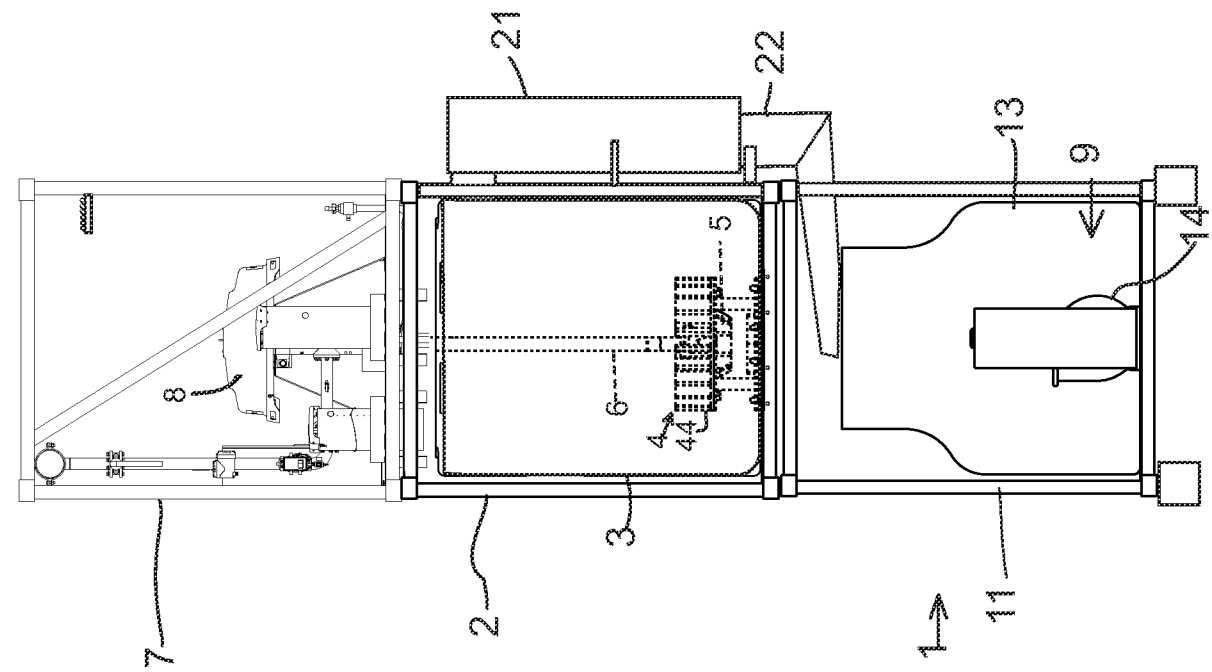


Fig. 4

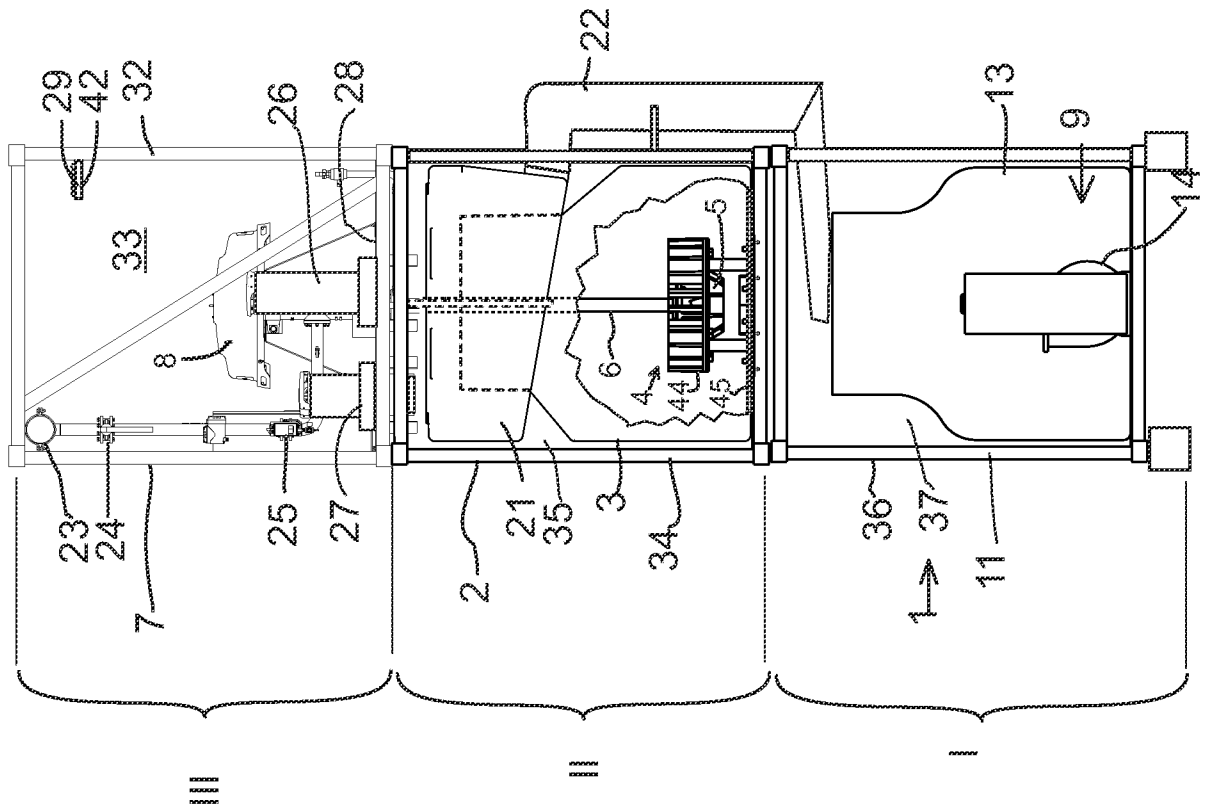


Fig. 3

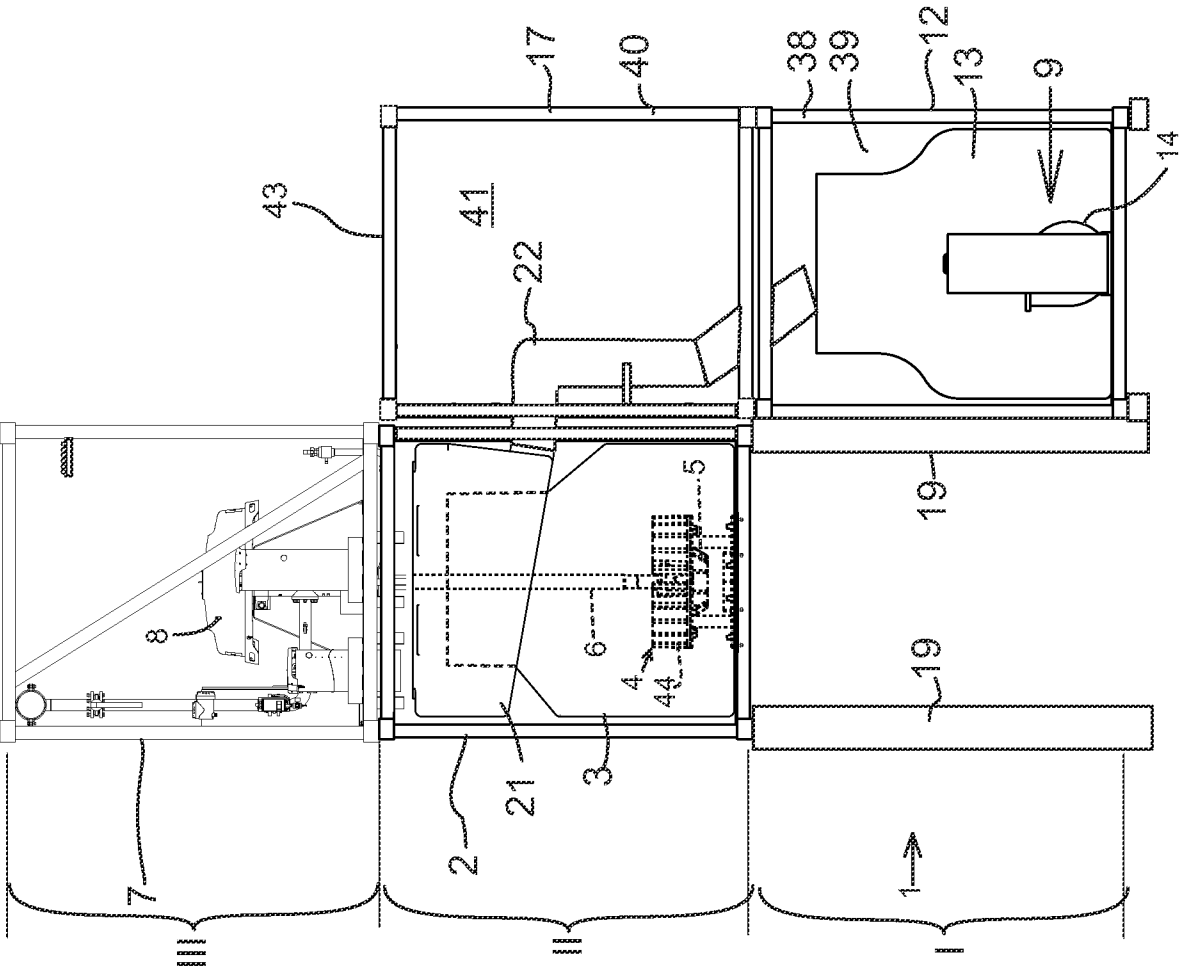


Fig. 5

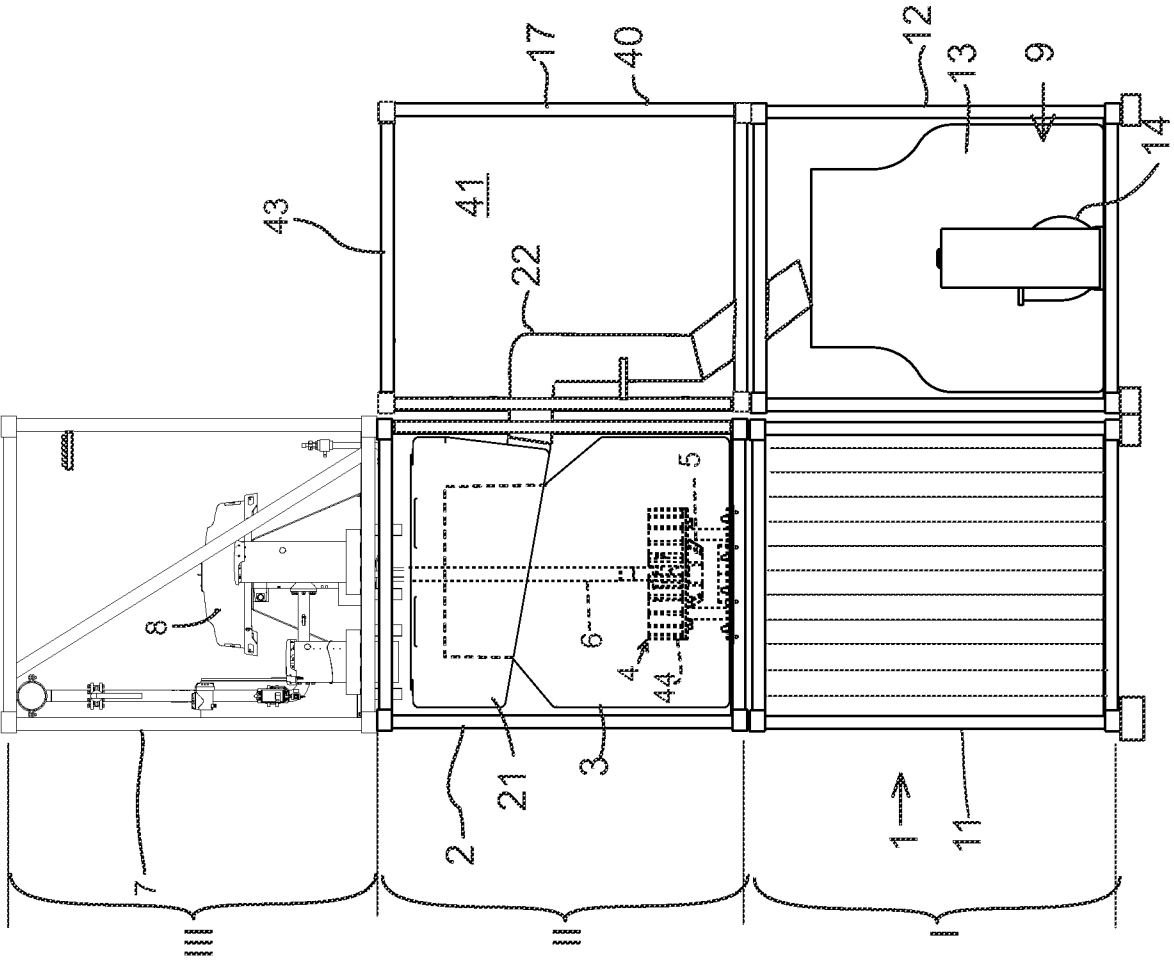


Fig. 6

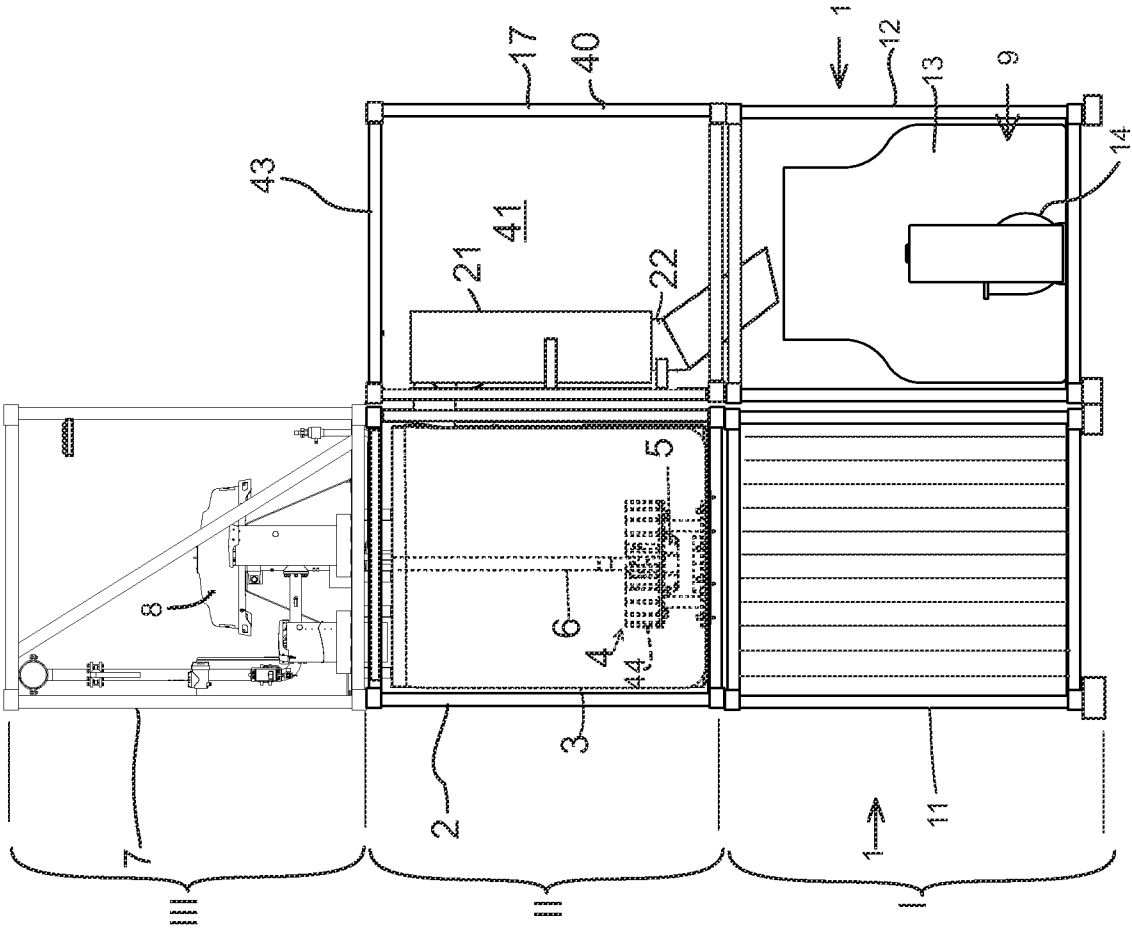


Fig. 7

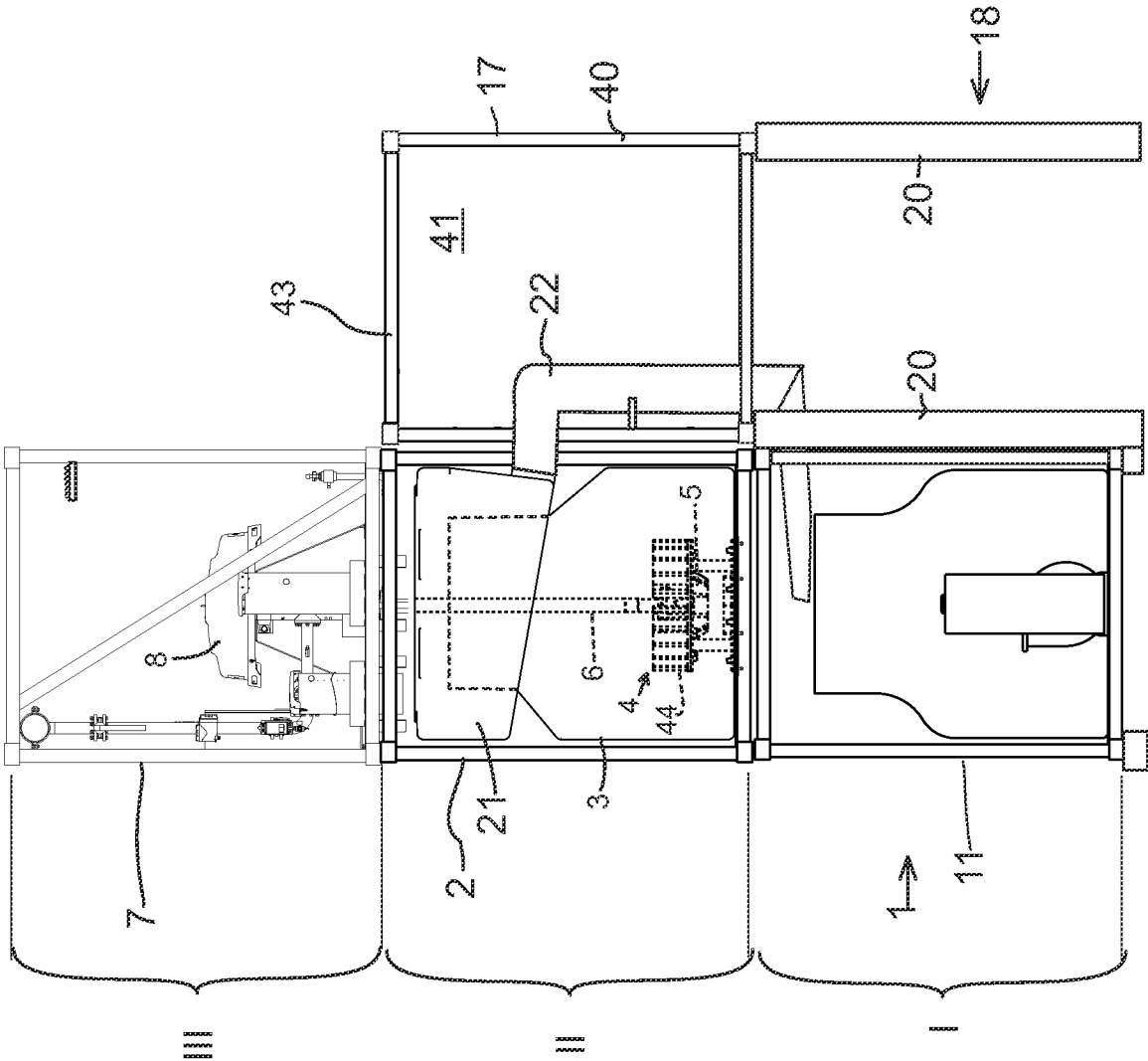


Fig. 8

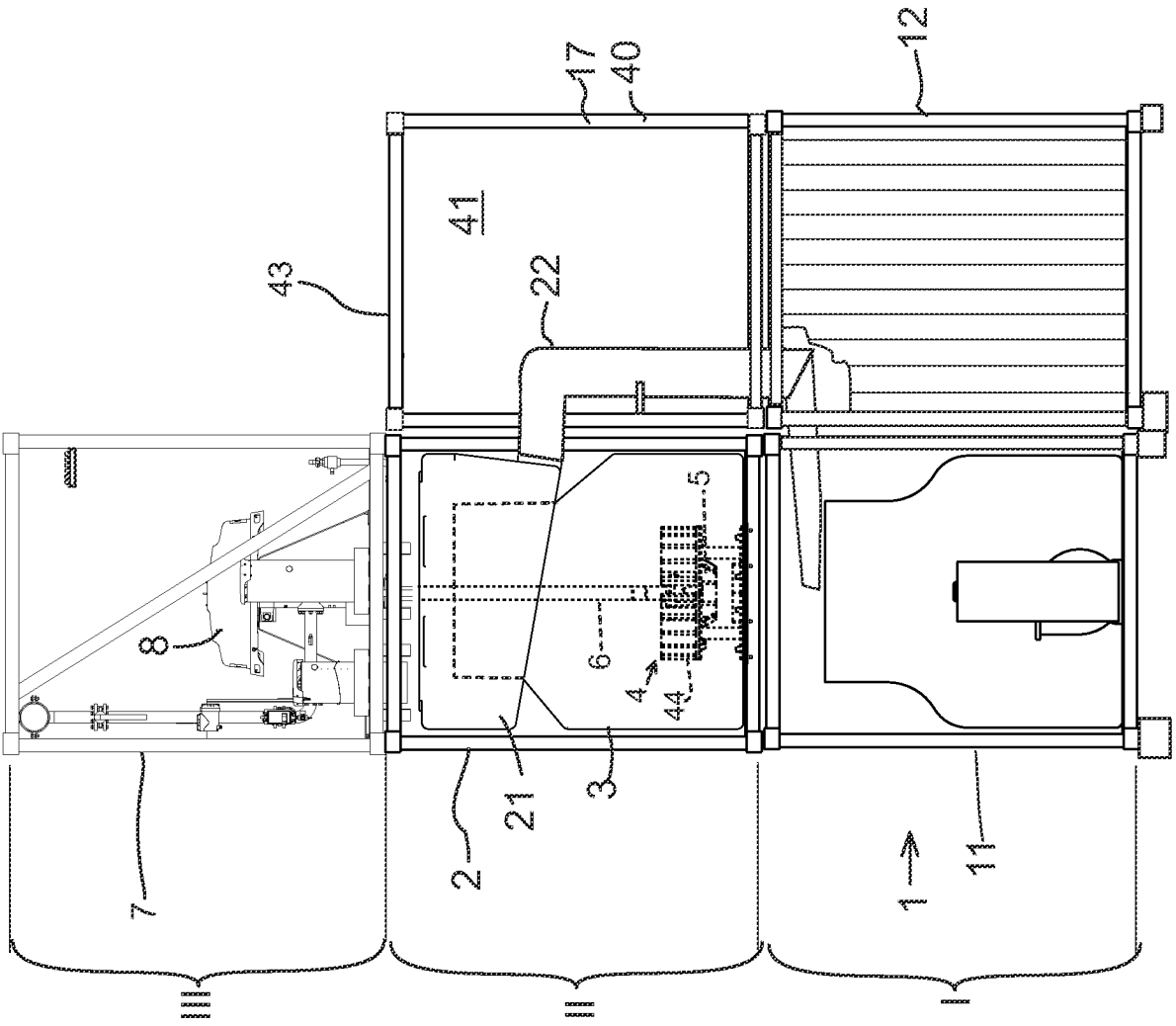


Fig. 9

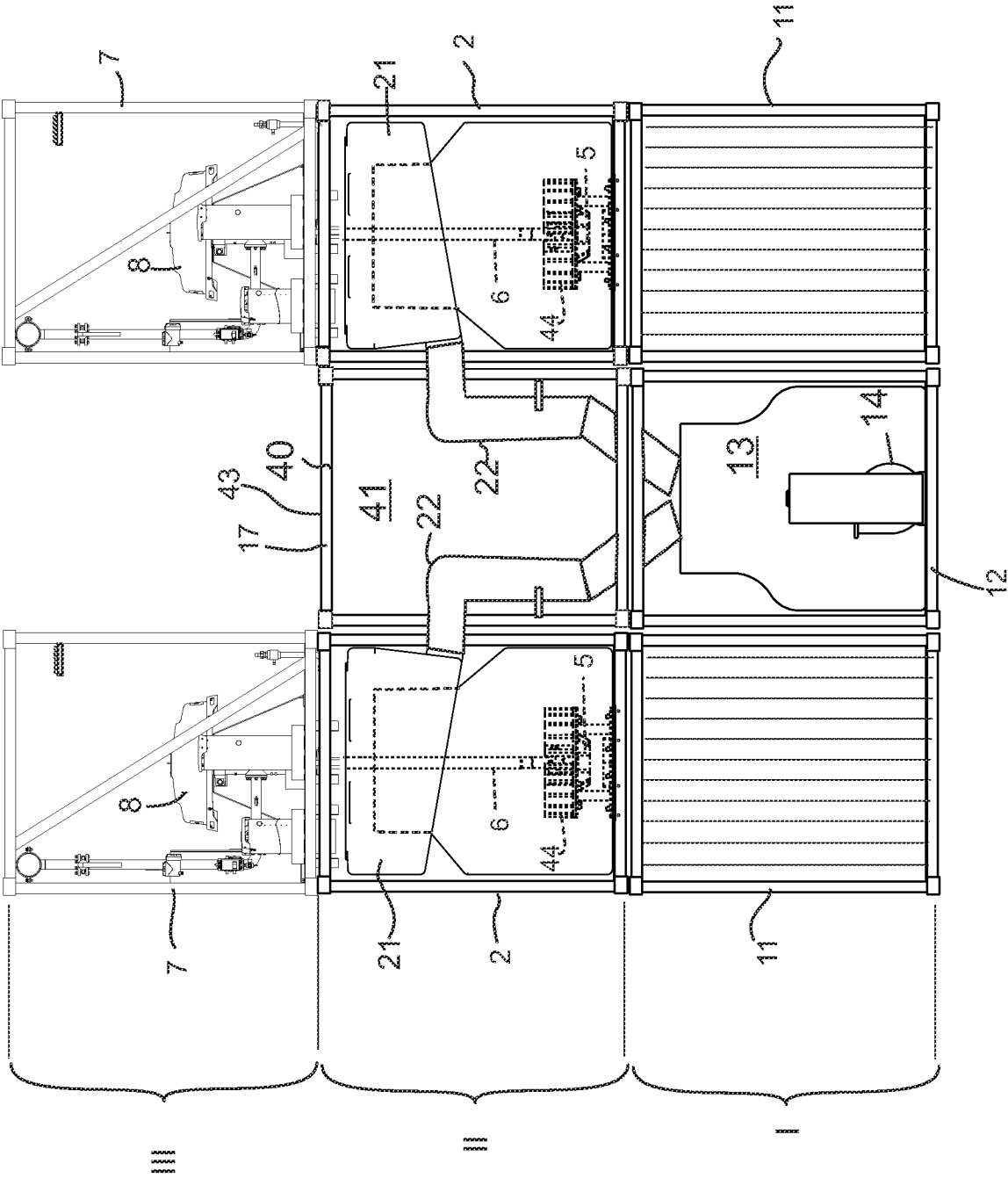


Fig. 10

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2015/050332

A. CLASSIFICATION OF SUBJECT MATTER		
See extra sheet		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
IPC: B01J, B03D, B65D, C02F, E03B, E04H		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
FI, SE, NO, DK		
Electronic data base consulted during the international search (name of data base, and, where practicable, search terms used)		
EPO-Internal, WPI, COMPENDEX, EMBASE, INSPEC		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0156699 B1 (MINEMET RECH SA [FR]) 04 February 1987 (04.02.1987)	67-70
A	claims; Figures	1-66
A	WO 2013000985 A2 (DSM IP ASSETS BV [NL]) 03 January 2013 (03.01.2013) paragraphs [0033]-[0035], [0045], [0054]; Figures 1, 3, 4, 11, 12	1-70
A	US 5474411 A (SCHOENFELD REINHARD [DE] et al.) 12 December 1995 (12.12.1995) The whole document	1-70
A	WO 2010066281 A1 (PLAGAZI AB [SE]) 17 June 2010 (17.06.2010) abstract; claims 1, 2; Figure 2	1-70
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* "A" "E" "L" "O" "P"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance earlier application or patent but published on or after the international filing date document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) document referring to an oral disclosure, use, exhibition or other means document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family
Date of the actual completion of the international search 11 August 2015 (11.08.2015)		Date of mailing of the international search report 20 August 2015 (20.08.2015)
Name and mailing address of the ISA/FI Finnish Patent and Registration Office P.O. Box 1160, FI-00101 HELSINKI, Finland Facsimile No. +358 9 6939 5328		Authorized officer Arja Leikas Telephone No. +358 9 6939 500

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2015/050332

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1208050 B1 (LINTEC GMBH & CO KG [DE]) 23 July 2003 (23.07.2003) abstract; Figure	1-70
A	US 2011146164 A1 (HANEY FRED [CA] et al.) 23 June 2011 (23.06.2011) paragraph [0029]; Figures 4-7	1-70

INTERNATIONAL SEARCH REPORT
Information on Patent Family Members

International application No.
PCT/FI2015/050332

Patent document cited in search report	Publication date	Patent family members(s)	Publication date
EP 0156699 B1	04/02/1987	EP 0156699 B1	04/02/1987
		AT 25343 T	15/02/1987
		AU 3382189 A	05/10/1989
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CLASSIFICATION OF SUBJECT MATTER

IPC
B03D 1/16 (2006.01)
B65D 85/68 (2006.01)
B65D 88/02 (2006.01)
E04H 5/02 (2006.01)
B65D 88/12 (2006.01)