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(54) TRAILING SUCTION HOPPER DREDGER HAVING A RECYCLE SYSTEM FOR EFFLUENT AND METHOD FOR SUCTION DREDGING

LADERAUMSAUGBAGGER MIT EINEM RÜCKFÜHRUNGSSYSTEM FÜR ABWASSER UND VERFAHREN ZUM ABSAUGEN

DRAGUE À TRÉMIE À ASPIRATION ARRIÈRE DOTÉE D'UN SYSTÈME DE RECYCLAGE POUR EFFLUENT ET PROCÉDÉ DE DRAGAGE PAR ASPIRATION

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Description

[0001] The invention relates to trailing suction hopper dredgers having a recycle system for effluent.

[0002] US3975842 discloses a trailing suction hopper dredger comprising a suction head carried by a suction pipe, with which soil can be sucked from a sea bottom and transported into a hopper of the vessel. Transport fluid is supplied to the suction head enclosure through a fluid pipe and is used for transporting the soil into the hopper. The transport fluid is separated from the soil in the hopper, as an effluent, and is recycled to the suction head enclosure to be used for further transport. In this system the fluid pipe opens into the suction head at a side opposite a side from which the soil with the transport fluid is sucked into the suction pipe. Inside the hopper a suction basket is provided, carried by a suspension mechanism with which an inlet of the suction basket is held in a position in which said effluent can be sucked into the suction basket whereas the soil can sink to the bottom of the hopper.

[0003] Similar trailing suction hopper dredgers are known from for example WO2010/112640 and US5603171. In these systems affluent fluid is fed back into the suction head under pressure through at least one pressure nozzle.

[0004] By removing part of the transportation fluid as an effluent from the hopper the efficiency of the dredging process can be increased. More solid material can be received in the hopper and the stability of the vessel can be improved. By returning the effluent back to the suction head the fluid can again be used as a transportation fluid, which means that less water has to be sucked into the suction head from the surrounding sea. Moreover by recycling the transportation fluid the moment of overflow is suspended, and/or less overflow of effluent is necessary, which is advantageous for the environment, since the effluent as overflow will still comprise an amount of solids, especially fine grained solids. By preventing these solids to an extend from being disposed with the overflow, it is furthermore easier to meet environmental requirements and regulations.

[0005] It has been found that even with such systems still more sediment is lost into the environment for the suction head than desirable. Moreover in these system effectiveness and efficiency of suction and dredging may be lost to some extend due to returning effluent. Hence there is a desire for an alternative dredger or dredging method.

[0006] An aim of the present disclosure is to provide for a dredger having an alternative effluent recycling system. An aim is to provide for a dredger having a recycling system for effluent which provides for an improved dredging process and preferably for less spilling of sediment. An aim is to provide for a dredger having an improved efficiency. An aim is to provide for an alternative method of dredging. An aim is to provide for a method of dredging having an improved efficiency. An aim is to provide for a method of dredging reducing spillage of sediment.

[0007] The invention is defined in independent claims 1 and 14 with preferred embodiments defined in the dependent claims.

[0008] In embodiments the recycle line may have at least one outlet, provided outside the suction space of the suction head, especially to a side of the suction head. The at least one outlet may be designed and/or used such that effluent flowing out of the said outlet is sucked into the suction space of the suction head, limiting water surrounding said head being sucked into said space. In embodiments the effluent flowing from the said outlet openings may substantially prevent water surrounding said head being sucked into said suction space. Preferably at least one outlet opening is provided on either side of the head, more preferably a series of such outlets on either side or an elongated outlet.

[0009] Surprisingly it has been found that by feeding effluent to an outside of the sides of the suction head, preferably relatively close to a lower edge of a side wall of the suction head or at least of a suction space thereof, may increase efficiency of the suction head. It will reduce or even prevent water from the surroundings of the head from being sucked into the said space, hence increasing the percentage of effluent in the flow of sediment, water and effluent, i.e. dredging sludge, relative to the percentage of water in said sludge being sucked into the suction pipe. In embodiments the flow of effluent at the sides of the suction head may be controlled such that the flow pattern of water, sludge and/or effluent within the suction head is not changed by such flow.

[0010] In embodiments the recycle line may have at least one outlet, opening into the suction space of the suction head, near a trailing end of the suction head.

[0011] In embodiments a dredging head may be used in which both at least one outlet is provided on a side of said head and at least one outlet opening into said space. In such embodiments preferably at least one distributor, for example a valve, is provided for directing effluent to the different outlets, such that either the or each outlet to a side of the head or the or each outlet opening into the suction space can be used or a combination thereof.

[0012] In embodiments in which during use returned effluent is injected into the suction space preferably the or each outlet opening into the said suction space has an injection direction including an angle with a jetting direction of jets jetting water into the suction space. Said water can be salt or fresh water and can at least partly be effluent. In embodiments during use the injection direction includes an angle between about 0 and 120 degrees with the jetting direction, for example between 0 and 90, such as for example between 45 and 90 degrees. The injection direction and the jetting directions may provide at least in part for a counter flow of water and effluent. In embodiments the pressure with which the effluent is injected during use into the suction space may be less than the pressure of the jets, preferably less than 50% of said pressure, more preferably less than 25%, even

more preferably about 10% or less of said pressure. Surprisingly a relatively low pressure will result in a change of flow within the suction chamber which may increase efficiency and may reduce spillage of sediment from the rear side of the suction head.

[0013] The outflow direction of one or more of the outlets may be adjustable. The pressure of effluent and/or the flow speed of effluent flow out of at least one of the outlets may be adjustable.

[0014] In embodiments the effluent may be expelled from outlets outside the suction chamber of said head, close to an edge of said head near the water bottom. The effluent may be expelled such that during suction of sludge into and/or through the suction chamber the returned effluent is sucked into said chamber. In such embodiments the effluent may flow out of said at least one outlet at a pressure substantially equal to or just above water pressure surrounding the suction head.

[0015] An advantage of providing outlets to side of the suction head, outside the suction chamber may be that pressure inside the suction chamber is not substantially influenced by such flow, contrary to when such effluent would be fed into the suction chamber directly.

[0016] In embodiments additionally or alternatively effluent may be ejected out of outlets, opening into the suction chamber near a trailing end of the chamber, such that returned effluent is injected into the suction chamber. Such effluent may be injected into said suction space at an angle and/or in a direction including an angle with a jetting direction in which said water is jetted into the suction chamber. In such embodiments the effluent may be injected into the suction space at a pressure substantially lower than the pressure of water jetted into the suction chamber. In embodiments water may be jetted into the suction chamber at or close to a lower edge of a leading side of the suction chamber whereas said effluent may be injected into said suction space at or near a trailing side. In embodiments the water jetted into said suction space may have a jetting direction which intersects with an injection direction of at least one of said outlets, such that in at least part of the suction chamber a counter flow is obtained.

[0017] As discussed in suction dredging normally water is sucked into the suction chamber from the environment of the suction head. An aim of the present disclosure is to replace at least part of such water normally sucked into the suction chamber during dredging by effluent returned from the vessel. In embodiments according to the present disclosure effluent my be returned such that substantially no water is sucked into the suction space from the environment of the suction head. In embodiments substantially all liquid in the dredging sludge sucked into the suction pipe may be resulting from returned effluent. In such embodiments water injected into the suction space may also be formed by or at least comprise returned effluent. In alternative embodiments effluent may be provided to the suction head such that still water is sucked into said suction chamber or such that more effluent is provided to the suction head than is sucked into the suction pipe.

[0018] Feeding effluent into the suction chamber from a trailing end in a direction substantially towards a leading edge may have the advantage that such effluent flow aids in releasing sediment from the bottom, further increasing efficiency.

[0019] In a hopper of the dredger or any other vessel receiving the dredging sludge effluent can be separated from the sludge by at least gravity, by allowing sediment in the sludge to sink and settle at a bottom of the hopper, allowing effluent, formed by water with relatively light sediment to accumulate above the settled sediment. In such dredger the recycle line may have an inlet end which is connected to a mechanism for raising and/or lowering said inlet end in said hopper, wherein the mechanism is preferably designed for moving the inlet up and down, depending on an effluent level in the hopper.

[0020] In clarification of the disclosure, exemplary embodiments of a trailing suction hopper dredger, method and suction dredging head according to the invention will be further elucidated with reference to the drawings. In the drawings:

Fig. 1 schematically shows, in top view, part of a dredger;

Fig. 1A schematically shows part of a dredging assembly comprising lines and a dredging suction head;

Fig. 2A schematically shows in cross sectional side view an embodiment of a suction dredging head connected to a suction pipe, showing very general and schematic a counter flow configuration resulting from jets near a leading end and effluent outlets near a trailing end of the suction head;

Fig. 2B schematically shows in cross sectional rear view an embodiment of a suction dredging head connected to a suction pipe, showing very general and schematic a side flow configuration resulting from effluent outlets at sides of the suction head;

Fig. 3 and 3A schematically partly show in top view and in cross sectional side view along the line A - A in fig. 3 respectively, a configuration of a suction head for counter flow;

Fig. 4, 4A and 4B schematically and partly show, in top view, in cross sectional side view along the line B - B in fig. 4 and cross sectional rear view along the line C - C in fig. 4A respectively, a configuration of a suction head comprising effluent outlets to sides of the suction chamber;

Fig. 4C shows in perspective view a head comprising means for counter flow and side outlets for side flow;

Fig. 5A schematically shows the main flow directions of the jets and first outlets;

Fig. 5B schematically shows flows of sludge resulting mainly from jetting water and flow of effluent from the first outlets, impinging forming an impact area or line;

Fig. 6 schematically in side view, partly in cross section, a head with side outlets and a diffusor.

[0021] In this description, identical or corresponding parts have identical or corresponding reference numerals. In the drawings, embodiments are given only as examples. The parts used there are mentioned merely an as example and should not be construed to be limitative in any manner. Other parts too can be utilized within the framework of the present disclosure.

[0022] In the present disclosure dredging sludge should be understood as at least meaning a mixture of a liquid and solids, which may also be referred to as sediment derived from a water bottom such as of a body of salt water, such as a sea or ocean, or of a body of fresh water such as a river or harbor, or a body of brackish water. The liquid can be water or effluent. Effluent should be understood as at least meaning water or a mixture of water and solids, preferably retrieved from dredging sludge of which preferably at least part of the sediment has been removed, for example but not limited to by gravity. Sediment can be any type of solid dredged, such as but not limited to sand, clay, rock, gravel, oar and combinations thereof. In this description water fed to and jetted out through jets into a suction head has to be understood as meaning at least water provided from the body of water directly or indirectly or effluent, or a mixture thereof.

[0023] In the present disclosure a suction head should be understood as at least meaning a device comprising a suction chamber connected to a suction pipe, for sucking sediment released from a bottom as a sludge into the suction pipe. During use a pressure lower than the pressure in the surrounding water is obtained in the suction chamber, such that the dredging sludge is sucked into the suction pipe. Such suction head is during use moved, especially pulled along the bottom of a body of water, for removing sediment from the bottom. The sediment may be released from the bottom by at least jetting water or effluent against the bottom near a leading end of the suction head. Dredging sludge is commonly fed to a hopper of a vessel, such as a dredging vessel, by the suction pipe. In the hopper the dredging sludge is allowed to separate into sediment inking towards the bottom of the hopper and effluent which will form a fluid layer on top of the settled sediment. In this description suction space and suction chamber are used as interchangeable, as having the same meaning.

[0024] In the present disclosure underpressure or reduced pressure will be understood as at least meaning pressure inside a space, for example a chamber or tube, which is lower than the pressure directly outside such space. Underpressure or reduced pressure may be subatmospheric pressure and can for example be a pressure prevailing in the suction chamber due to sucking by a pump in the suction pipe.

[0025] In the present disclosure trailing suction hopper dredgers are disclosed. Such dredgers comprise a vessel with at least one suction head which during dredging is moved along the bottom of a body of water, behind or to a side of the vessel and hence trailing the vessel. The speed of the head along the bottom may for example be, but is not limited to in the order of decimeters to meters per second, for example about 0,5 m/sec.

[0026] Fig. 1 schematically shows, in top view, a dredging vessel 1, comprising a hopper 2 for receiving dredging sludge 3. A suction head 4 is provided to be pulled along by the vessel 1 in the direction F. The suction head 4 is connected to the vessel 1 by at least one suction pipe 5. Further there may be at least one jet line 6 and at least one recycle line 7 connected to the head 4, as shown in fig. 1 and 1A, or the jet line 6 and recycle line 7 may be combined into one line, with a distributor for distributing the effluent over jets and outlets as will be described.

[0027] The suction pipe 5 has an inlet end 8 connected to a suction chamber 24 of the suction head 4, and an outlet end 10 opening into the hopper 2. The recycle line 7 has an inlet end 11 which is connected to a mechanism 12 for raising and/or lowering said inlet end 11, and an opposite second end 13 connected to the suction head 4. The mechanism 12 is preferably designed for moving the inlet end 11 up and down, depending on a lower effluent level L_{low} in the hopper. Lower effluent level L_{low} in this disclosure should be understood as meaning a level within the hopper 2 at which effluent 14 rests on settled sediment 15 within the hopper 2. A pump 37 is provided in the recycle line 7, for example attached to the mechanism 12, for sucking effluent 14 from the hopper 2 above the lower effluent level L_{low}.

[0028] The jet line 6 may be connected with a first end 9 to the head 4, especially to jets 16, whereas the opposite second end 9A may be connected to a pump 50 in a known manner, for supplying water sucked from the body of water in which the vessel 1 is present.

[0029] Fig. 2A schematically shows in cross sectional side view an embodiment of a suction dredging head 4 connected to a suction pipe 5. The suction head 4 may have two side walls 22, and a curved top wall 23. The suction space or chamber 24 is generally enclosed between the side walls 22, the top wall 23 and a substantially open bottom side 52. At the trailing end 19 of the head 4 the top wall 23 has a lower edge 26, to be positioned close to the bottom 20 of the body of water 21, whereas the suction pipe 5 is connected to and opens into the suction chamber 24, at or above a level B preferably higher than the level A of the edge 25 when lower edges 26 of the side walls 22 are placed on a substantially flat part of e.g. the bottom 20. The side walls 22 may have a curved corner 27 at a leading end thereof.

[0030] Fig. 2A very generally and schematically shows a counter flow configuration resulting from jetting flow J from jets 16 near the leading end 17 of the suction head 4 and first effluent outlets 18 near the trailing end 19 of the suction head 4. In the embodiment shown the jets 16 are positioned at or near the level B, for example directly below the end 13 of the suction pipe 5. In the embodiment

shown the or each jet 16 has a jetting flow J with a main jetting flow direction J_1 directed towards the bottom 20 of the body of water 21. The or each jet 16 may be provided such that over a substantial part of the width of the suction head 4 at or near the leading end 17 within the chamber 24 jet flow J is provided, releasing sediment out of and/or from the bottom 20.

[0031] One or more first outlets 18 are provided at the trailing end 19, preferably relatively close to the lower edge 26. The outlets 18 open into the chamber 24. The or each outlet 18 provides during used for a flow S of effluent having a main outflow direction J_2, which may include an angle α with a jet direction J_1 of the at least one jet 16, for example an angle α of between 0 and 180 degrees, for example between 30 and 150 degrees, such as for example between 60 and 120 degrees. The angle α can for example be close to or about 90 degrees.

[0032] During use water and/or effluent jetted from the jets 16 will jet into the bottom 20 and flow along a curved portion 30 of the bottom obtained by said jetting, and flow towards the trailing side of the chamber 24, indicated in fig. 2A by flow E. The flow S from the or each outlet 18 will impede on the flow E, at least in part. This will substantially prevent sludge and more in particular sediment 15 to leave the suction chamber 24 at the trailing end 19, passing below the edge 25. This will therefore prevent or at least limit spillage of sediment and pollution of water surrounding the head 4.

[0033] Preferably the main outflow direction J_2 of the first outlet or outlets 18 is such that it is directed substantially away from an inlet opening 32 of the suction pipe 5 and/or at least during use has a pressure or speed of flow such that it will not flow directly into the said inlet opening 32. In embodiments the outlet or outlets 18 may be adjustable, especially for adjusting the main direction of flow J_2 and/or the pressure and/or the speed of flow thereof.

[0034] In embodiments the pressure of the effluent 14 flowing from the first outlet or outlets 18 may be substantially lower than the pressure of the water and/or effluent jetted from the jet or jets 16, preferably less than 50% of said pressure, more preferably less than 25%, even more preferably about 10% or less of said pressure. Surprisingly a relatively low pressure will result in a change of flow within the suction chamber 24 which may increase efficiency and may reduce spillage of sediment from the rear side of the suction head. By preventing the effluent 14 flowing from the first outlet or outlets 18 from flowing directly into the suction pipe 5 suction in the suction chamber 24 may be maintained at a desired level.

[0035] Fig. 2B schematically shows in cross sectional rear view an embodiment of a suction dredging head 4 connected to a suction pipe 5. The head 4 generally may have a configuration as discussed in relation to fig. 2A. Fig. 2B shows very generally and schematically a side flow configuration resulting from second effluent outlets 31 at sides 22 of the suction head 4, more in particular outside the suction space 24.

[0036] As can be seen in fig. 2B the one or more second outlets 31 can be provided, preferably at least one on either side of the head 4, for example against an outside of the side wall 22. The outlet 31 can be positioned such that it opens substantially next to the lower edge 26. During use effluent 14 may be fed to the second outlets 31, through for example a recirculation line 7. The effluent will flow out of the outlets 31 preferably at low pressure, for example about the same pressure as the pressure of the water surrounding the head 4 or just above it. Reduced pressure inside the chamber 24 resulting from suction of dredging sludge into the suction pipe 5 will tend to suck effluent 14 fed through the second outlets 31 into the suction space 24, passing the lower edge 26 of the side wall 22. The flows of effluent 14 may act as a curtain preventing to at least an extend water from the surrounding body of water 21 to be sucked into said suction space 24. In embodiments the flow from the second outlets 31 is controlled such that the flow pattern within the suction space 24, which may also be referred to as suction chamber 24, is substantially not influenced by said flow.

[0037] In embodiments both first and second outlets 18, 31 may be provided in a suction head 4. Preferably then a distribution system 33 (fig. 4C) is provided in or for the recycling line 7, for dividing a flow of recirculated effluent 14 fed by the recycling line 7 between the different outlets 18, 31. All of the effluent may be fed to either the first outlets 18 or the second outlets 31 or partly to both. In embodiments the distribution system 33 may comprise a manifold for distributing recirculated effluent over different first outlets 18 and/or different second outlets 31.

[0038] In embodiments there can be a single first outlet 18, extending over a substantial part of the width W_h of the head 4, for example more than 50% of said width, for example at least 75% of said width. The width W_{18} of said outlet 18 may be about 85% or more of said width W_h of the head 4, for example between 85 and 100% of said width W_h. In embodiments there may be two or more first outlets 18, which may be distributed over the width W_h of the head 4, for example in a regular pattern along a line substantially parallel to rear side of the head 4. In such embodiments the main direction of flow of each first outlet may be chosen such that they are substantially parallel to each other, when viewed in top view. In embodiments the main direction of flow of the or each first outlet may be adjustable, for example by tilting or rotating the or each outlet 18. In embodiments having multiple first outlets 18 they may be individually adjustable or in one or more groups.

[0039] In embodiments there can be a single second outlet 31 on each side of the head 4, extending over a substantial part of the length L_h of the suction chamber of the head 4, for example more than 50% of said length, for example at least 75% of said length. The length L_{31} of said outlet 31 may be about 85% or more of said length L_h of the head 4 , for example between 85 and 100% of said length L_h. In embodiments there may be two or more

second outlets 31, which may be distributed over the length L_h of the head 4, for example in a regular pattern along a line substantially parallel to the relevant side of the head 4. In such embodiments the main direction of flow of each second outlet may be chosen such that they are substantially parallel to each other, when viewed in top view. In embodiments the main direction of flow of the or each second outlet 31 may be adjustable, for example by tilting or rotating the or each outlet 31. In embodiments having multiple first outlets 31 they may be individually adjustable or in one or more groups. In embodiments the or each second outlet 31 may be formed by or open into a channel 34 extending alongside on outer face or side of the head, which channel 34 is substantially only open in a downward direction or underside 35.

[0040] In embodiments a series of jets 16 is provided, each jet preferably having a main direction of flow or jetting J, which is substantially downward, as is known in the art. Preferably jets 16 are distributed over the width W_{24} of the suction chamber 24, preferably such that during use water jetted out of the jets 16 substantially covers the full width W_{24} of the suction chamber 24 at a level where said jetted water hits the bottom 20 of the body of water for removing sediment from said bottom 20.

[0041] Fig. 3 schematically shows in top view a head 4 connected to a suction pipe 5, a jet line 6 and a recirculation line 7. Fig. 3A shows the head 4 schematically in cross sectional side view along the line A - A in fig. 3. As can be seen in fig. 3A, jets 16 are provided below the inlet opening 32 or inlet end 8 of the suction pipe 5. A connecting line 6A connects the jet line or jet pipe 6 to the jets 16. To this end all jets 16 may be fed through the same connection line 6A or two or more such connecting lines 6A may be provided, each feeding one or more jets 16. In fig. 3 two such connecting lines 6A are provided, extending along opposite sides of the head4, which may for example each feed half of the number of jets 16.

[0042] As can be seen in fig. 3A schematically water W_{jet} jetted from the jets 16 is forced against the bottom 20 with such force that sediment is dislodged from the bottom 20. The jet water W_{jet} with dislodged sediment will form a flow of sludge E mainly in the direction of the trailing end 19 of the head 4.

[0043] At the trailing end 19 of the head first outlets 18 are shown, close to a lower edge 26. In the embodiment by way of example four such first outlets 18 are shown, at regular intervals D_{18} in the width direction of the head 4. In fig. 3 and 3A connecting channels 7A extending between the recirculation line 7 and the first outlets 18 have been indicated by striped lines. As discussed, each of the outlets 18 may be connected to the recirculation line directly or through a unit or distribution system 33, such as a manifold. As is schematically shown in fig. 5A, the outlets 18 have a main direction of flow J_2 including an angle α with a main jet direction J_1 of the at least one jet 16. Said angle α may for example be but is not limited to between 30 and 100 degrees, for example between 30 and 90 degrees, such as for example between 45 and 65 degrees. In the embodiment shown the main jet direction J_1 includes an angle β with a horizontal plane P of about 80 to 90 degrees. In the embodiment shown the main direction of flow J_2 is directed towards the bottom 20 and towards the leading end 17 of the head 4. The main direction of flow J_2 of the first outlets 18 in this embodiment includes or is set to include an angle y with the horizontal plane P for example between 30 and 60 degrees and provided for a flow of effluent in the suction chamber 24, for example along the bottom 20 countering the flow of sludge S. The flow of effluent from the first outlets 18 thus largely prevents sludge from spilling from the rear or trailing end 19 of the head 4.

[0044] Preferably the main direction of flow J_2 of the first outlets 18 is such that it intersects with the main direction of flow J1 of the jets 16 below the inlet end 8 of the suction pipe 5, preferably below the jets 16. Thus effluent flowing from the first outlets is mainly prevented from flowing or being sucked directly into the suction pipe 5.

[0045] As is schematically shown in fig. 5B, an area SP where the flow of effluent from the first outlets 18 intersects with the flow S of sludge resulting largely from the flow of water and/or effluent jetted from the jets 16 may be referred to as an impact or propelling area or line, which extends preferably across substantially the width of the head 4 and preferably relatively close to the rear or trailing edge 25 of the suction chamber 24, which is also commonly referred to as visor of the head 4. Relatively close should in this respect be understood as at least meaning but not limited to within 50 % of the length of the suction chamber 4 measured from the trailing edge 25, preferably within about 25% of said length from the trailing edge, more preferably within about 10% of said length, wherein the length is measured as the shortest distance between the trailing and leading edges of the suction chamber 24.

[0046] The jet or jets 16 may be provided in an overhang 16A extending into the suction space 24, such that the overhang 16A provides for a barrier between the jets 16 and the inlet end 8 of the suction pipe 5. The counter flow from the first outlets 18 improves efficiency of the suction head 4 and reduces or even eliminates spillage of sediment from the suction chamber 24. By using effluent recycled from the hopper efficiency is even further improved and spillage and pollution further reduced. However, part of all of the counter flow from the first outlets 18 could also be obtained by using water in stead of or mixed with recycled effluent.

[0047] As shown by way of example in fig. 3 and 3A, the first outlets 18 can be mounted on a common rail 18A with which their position and especially the main direction of flow J_2 can be adjusted, by rotation of said rail 18A, for example around an axis substantially parallel to the trailing end 19. Any suitable means can be used for initiating and control of such rotation, such as for example a motor or a wire control 18B.

[0048] As can be seen in fig. 3A the jet flow and sludge

flow E, together with the counter flows of effluent will form an indentation or ditch 36 in the bottom 20, where the sediment is removed. Within the suction chamber 24 a partly circular current of sludge will occur, which will be directed to the inlet end 8 of the suction pipe 5. Substantially all sludge will be sucked into the suction pipe 5 and delivered to the hopper.

[0049] Fig. 4 schematically shows an embodiment of a head 4, in top view, which is again connected to a suction pipe 5, a jet line 6 and a recirculation line 7. In this embodiment second outlets 31 are provided to the sides of the head 4, outside the suction space 24. In this embodiment two second outlets 31 are provided on either side of the head 4, opening into a channel 34 extending alongside an outer face or side of the head 4. Again connecting channels 7A between the recirculation line 7 and the or each second outlet 31 are indicated schematically by striped line. The second outlets 31 on a side may be individually connected to the recirculation line 7, or as a group. Each channel 34 is open in a downward direction or underside 35, towards the bottom 20. In this embodiment the channels 34 extend in a length direction L of the head 4, especially of the suction chamber 24, over substantially the full length L of the suction chamber 24.

[0050] As can be seen in fig. 4A and, especially, fig. 4B below the indentation or ditch 36 will extend below the open side 35 of the channel 34. Effluent flowing from the outlets 31 will flow out of the channel 34 into the suction chamber below the lower edge 26 of the relevant side wall 22, due to inter alia a pressure inside the suction chamber 24 lower than in said channels 34. The flow of effluent into the suction chamber may significantly reduce or even prevent inflow of water into the suction chamber from the surrounding body of water. Again this may increase efficiency of the suction head 4 and reduce spillage of sediment. Again preferably recirculated effluent is used for feeding through the second outlets, increasing efficiency of the dredging process, although also water can be used or mixed with such effluent.

[0051] In fig. 6 a further alternative embodiment is shown, in which second outlet or outlets 31 open(s) into a channel 34. In said channel at least one diffusor 34A for diffusing the flow of effluent flowing from the or each second outlet 31. In embodiments by way of example the diffusor 34A can be a plate 34B extending across the channel 34 and provided with series of holes 34C allowing effluent to pass, distributing the effluent flow over the outlet area of the channel 34 near the lower edge or underside 35. Such diffusion may reduce the speed of the flow of effluent and/or may provided for a more uniform flow of said effluent near said underside 35.In fig. 3, 3A and 4, 4A and 4B two different embodiments are shown of a head 4. It shall be clear that these two embodiments can also be combined into one head 4, having both first and second outlets 18, 31, as schematically shown in fig. 4C, which in this embodiment has two first outlets connected to outlet ends 18D, and two second outlets 31 on either side, connected to outlet ends 31B. A distribution system or unit 33 can be provided for directing a flow of effluent from the recirculation line 7 to one or more of the first outlets 18, one or more of the second outlets 31 or a combination of the two. In embodiments third outlets 37 can be provided, for example next to or replacing one or more of the first and/or second outlets 18, 31. Flow from such third outlets can for example be different from that of the first and/or second outlets, for example having a higher or lower debit, higher or lower speed, more or less spread flow pattern, a different main direction of flow or the like.

[0052] In embodiments at least two series of second outlets 31 may provided, wherein a series of third outlets is provided, for example between or next to one of the at least two series of second outlets. During use effluent may be expelled from the third outlets at a pressure different from the second outlets and/or effluent may be expelled from the third outlets at a speed different from the speed with which effluent is expelled from the second outlets.

[0053] With a trailing suction hopper dredger with recirculation through the head as disclosed a dredging method can be performed for example comprising the steps of jetting water into a suction chamber of the suction head, wherein dredging sludge is sucked from the water bottom using said suction head. The dredging sludge is dumped into the hopper of a vessel, wherein effluent is separated out of said sludge. The separation can be obtained in any suitable way. For example by allowing the sediment to settled at the bottom of the hopper, effluent rising to the surface of such sediment forming a layer of effluent on top of the settled sediment. Other methods can comprise filtering, centrifuging or the like known methods. The effluent is returned to said suction head. At the suction head the effluent may be expelled from outlets.

[0054] Such outlets can be outlets outside the suction chamber of said head, close to an edge of said head near the water bottom. During suction of sludge into and/or through the suction chamber or at least into the suction pipe the thus returned effluent is sucked into said chamber, at least in part.

[0055] Such outlets can additionally or alternatively be outlets opening into the suction chamber such that returned effluent is injected into the suction chamber. Such injection is preferably at an angle and/or in a direction including an angle with a jetting direction in which said water is jetted into the suction chamber. Hence a counter flow is obtained in said suction chamber, preventing at least part and preferably substantially all sediment from spilling from the suction chamber at or near a trailing end of the head.

[0056] In embodiments a large percentage of the volume of effluent returned to the head is sucked into the chamber, for example at least about 90 % of the volume of effluent returned to the head is sucked into the chamber, preferably at least 95 %, more preferably about 97 %.

[0057] When using a configuration of a head 4 com-

prising means for arranging a counter flow in the suction chamber 24, for example by providing one or more first outlets 18, as for example shown in fig. 2A, 3 and/or 4C, the angle y of the main flow direction J_2 of the outlets 18 may be set such that spillage of sludge or at least sediment passing the trailing end 19 of the head is minimized. The pressure at which the effluent or water is injected from the first outlets 18 may be regulated, for example depending inter alia on the pressure of the water jetted from the jets 16. The pressure of the effluent or water injected from the first outlets 18 may for example be below 25% of that of the pressure of water jetted from the jets 16, both measure at leaving the outlets 18 and jets 16 respectively. Preferably the said pressure is about 10% or less of that of the water jetted from the jets 16, such as for example 5% or less. By injecting effluent or water in counter flow to the flow of sludge E resulting from the water jetted from the jets 16 said effluent or water flow S may aid in releasing sediment from the bottom 20, further increasing efficiency of the suction head during use.

[0058] When using a configuration of the head 4 comprising means for allowing recirculated effluent to be sucked into the suction chamber from sides of said space, i.e. not being injected into said space at pressures higher than the pressure prevailing in the said chamber, such as the second outlets 31, an advantage may be obtained that the pressure inside the chamber during use is not substantially influenced by said effluent sucked into said chamber. Inside the chamber 24 an under pressure, i.e. a pressure below the pressure in the body of water 21 at the level at which the head 4 is position is prevailing, actively induced by at least suction in the suction pipe 5, such that any material such as sludge is sucked out of said chamber into the suction head. Increasing said pressure by injecting effluent from the sides could negatively influence efficiency of the dredging process.

[0059] During use the amount of recycled effluent through the outlets 18, 31, especially through the second outlets 31 can preferably be regulated. In suction heads known in the art without side outlets according to the present disclosure, during use a volume of water is sucked into the suction chamber per time unit, passing below lower edges of the side walls of the suction chamber, from the body of water in which the suction head is used. In the present disclosure at least part of that volume of water is replaced per time unit by recycled effluent. In embodiments the amount of effluent recirculated through the second outlets per time unit may be chosen such that it equals the said volume of water per time unit, thus substantially preventing water being sucked into said suction chamber. In embodiments the amount of effluent recirculated through the second outlets per time unit may be chosen such that it is less than the said volume of water per time unit, thus still allowing a volume of water being sucked into said suction chamber per time unit. For example the volume of effluent recycled through said second outlets 31 per time unit may be chosen in the order between 25 and 100% of said volume of water per time unit, for example between 50 and 100%. In embodiments the amount of effluent recirculated through the second outlets per time unit may be chosen such that it is more than the said volume of water per time unit, thus preventing water being sucked into said suction chamber per time unit and even allowing part of the effluent to be expelled into said body of water. For example the volume of effluent recycled through said second outlets 31 per time unit may be chosen in the order between 175 and 100% of said volume of water per time unit, for example between 150 and 100%.

[0060] The return of effluent to the head 4, through the first outlets 18 and/or the second outlets 31, especially through the second outlets 31, as discussed here above can be controlled such that the amount of effluent per unit of time that is expelled through said outlets is controlled. For example in embodiments the return through the outlets, especially the second outlets 31 can be controlled such that substantially all of the effluent expelled through the second outlets 31 is sucked into the suction chamber 24. In embodiments the amount of effluent expelled through the outlets, especially the second outlets 31 can be controlled such that still some water is sucked into the chamber 24 with the effluent, but preferably the amount is controlled such that no additional water is sucked into the suction chamber.

[0061] In embodiments the return through the outlets, especially the second outlets 31 can be controlled such that only part of the effluent expelled through the second outlets 31 is sucked into the suction chamber 24, the remaining part being expelled outside the suction head 4. This can be advantageous for returning solids to the bottom of the body of water which would otherwise be expelled by an overflow of the hopper at or near the surface of the body of water and would hence form a trail of effluent, especially solids in the water behind the vessel, polluting the water at least for a period of time in which the solids would sink to the bottom. By expelling the said part of the effluent and especially the solids therein directly to the bottom this is avoided.

[0062] In embodiments effluent returned to the first and/or second outlets can be a mixture of water and sediment. In embodiments effluent returned to the first and/or second outlets can be sludge substantially as introduced into the hopper, that is substantially without allowing sediment to settle from it within the hopper. In embodiments effluent returned to the first and/or second outlets can be substantially water without any sediment such as remaining solids. During dredging instead of water also effluent as discussed can be jetted through some or all of the jets 16.

[0063] Returned effluent can be expelled at least in part at two opposite sides of the head, preferably at a pressure substantially equal to or just above the water pressure surrounding the head, which pressure may be applicable directly above said at least one outlet. Returned effluent may be at least in part injected at a rear

side of the head, seen in a direction of movement of the head, preferably at a pressure sufficient to impinge on a flow of sludge resulting from at least water jetting from the jets, in order to change a direction of flow thereof. In such methods water may be jetted into the suction chamber near a leading end of a lower side of the head, near the bottom. Returned effluent may be injected into said suction chamber near a trailing end, in a direction substantially towards the leading end.

[0064] The invention is by no means limited to the embodiments shown and discussed, which are referred to by way of example only. Many alternatives are possible within the scope of the appended claims, including but not limited to combinations of embodiments or parts thereof as shown or discussed. For example the jets 16 can be fed with effluent or a mixture of effluent and water instead of with only water from the body of water. The orientation of the lines 5, 6 and/or 7 can be chosen differently. The second outlets 31 have been shown outside the suction space but they can also be placed in the side walls of the head or directly against in inside of said outer side walls, as long as they limit the amount of water sucked into the chamber, preferably close to zero, and more preferably also do not significantly influence the flow pattern of sludge and/or the pressure inside the chamber 24 during dredging. The head 4 can be pulled along the bottom by the vessel 1 and/or can be moved along the bottom by other means, for example self propelled. Effluent can be retrieved from a hopper different from the hopper into which the sludge is deposited, for example when dredging sludge having relatively light sediment which settles slowly.

Claims

1. Trailing suction hopper dredger, comprising a hopper (2) and a suction pipe (5) extending from the hopper (2), wherein a suction head (4) is provided at a distal end of the suction pipe (5), and an outlet end at an opposite proximal end of the suction pipe (5) for disposing dredging sludge into the hopper (2), the suction head (4) having a leading end (17), a trailing end (19), and opposite lateral sides (22),
wherein a recycle line (7) is provided between the hopper (2) and the suction head (4) for feeding effluent from the hopper (2) to the suction head (4), wherein the recycle line (7) is connected to the suction head (4), **characterized in that** at least one jet pipe (6) is connected to the suction head (4) for jetting water into a suction chamber (24) of the suction head through said at least one jet pipe (6), near the leading end of the suction head (4) towards a lower side of the suction chamber for releasing sediment of a bottom of a body of water, wherein:

   - the recycle line (7) has at least one outlet (31) at a lateral side (22) of the suction head (4), such that effluent flowing out of the said outlet (31) is sucked into the said suction chamber (24); and/or
   - the recycle line (7) has at least one outlet (18), opening into the suction chamber (24) of the suction head (4), near the trailing end (19) of the suction head (4).

2. Trailing suction hopper dredger according to claim 1, wherein the recycle line (7) has at least two outlets outside the suction chamber (24) of the suction head (4), especially at least one at each of opposite sides of said suction head, preferably a series of outlets of each of said sides.

3. Trailing suction hopper dredger according to claim 1 or 2, wherein the at least one outlet (31) outside the suction chamber (24) of the suction head (4) is or are positioned such that effluent flowing out of the said outlet is sucked into the said suction chamber, preferably limiting and more preferably substantially preventing water surrounding said head (4) being sucked into said suction chamber.

4. Trailing suction hopper dredger according to any one of claims 1 - 3, wherein the recycle line (7) has at least one outlet (18) and preferably at least two outlets opening into the suction chamber (24) of the suction head (4), near a trailing end of the suction head, preferably at an end of the suction head opposite a connection between the suction pipe (5) and the suction chamber of the suction head, wherein the or each outlet (18) has an outlet direction including an angle with a jet direction of the at least one jet wherein the angle of the outlet direction of at least one outlet (18) is preferably adjustable.

5. Trailing suction hopper dredger according to anyone of the preceding claims, wherein at least one further outlet is provided opening into said suction chamber, preferably directly.

6. Trailing suction hopper dredger according to any one of the previous claims, wherein the pressure of effluent flowing out of at least one of the outlets is adjustable.

7. Trailing suction hopper dredger according to anyone of preceding claims, wherein the layout of the suction pipe (5) and outlets is such that during dredging substantially no water is sucked into the suction chamber from a body of water directly surrounding the suction head.

8. Trailing suction hopper dredger according to anyone of the preceding claims, wherein the suction head (4) has a substantially open bottom side, defined by at least a lower edge of a wall of said suction head,

wherein the at least one outlet outside the suction head is provided close to said edge.

9. Trailing suction hopper dredger according to anyone of the preceding claims, wherein the suction head (4) comprises a suction chamber (24) defined by at least two sidewall parts, a front wall part, a rear wall part and a top, a suction opening provided in the front wall part, opening into the suction pipe (5), wherein:

at least one outlet opening is provided adjacent a lower edge of each sidewall part, at an outside thereof, and/or
at least one outlet opening adjacent a lower edge of the rear wall part.

10. Trailing suction hopper dredger according to anyone of the preceding claims, wherein
at least the recycle line (7) and at least one outlet are designed for expelling effluent at a pressure during use substantially equal to or slightly above ambient pressure of water surrounding the suction head (4).

11. Trailing suction hopper dredger according to anyone of the preceding claims, wherein at a rear side of the suction head (4), extending between said two opposite sides, at least one series of first outlets is provided, and at two opposite sides of the suction head a series of second outlets is provided and wherein during use effluent is expelled from the second outlets:

- at a pressure the same as or lower than the pressure at the first outlets and/or
- at a speed the same as or lower than the speed at which effluent is expelled from the first outlets wherein preferably two series of second outlets are provided, wherein a series of third outlets is provided between the two series of second outlets, wherein during use effluent is expelled from the third outlets:
- at a pressure different from the second outlets and/or
- at a speed different from the speed with which effluent is expelled from the second outlets.

12. Trailing suction hopper dredger according to anyone of the preceding claims, wherein the recycle line (7) has an inlet end (11) which is connected to a mechanism for raising and/or lowering said inlet end, wherein the mechanism is preferably designed for moving the inlet up and down, depending on an effluent level and/or a sediment level in a hopper (2) of the vessel (1).

13. Trailing suction hopper dredger according to any one of the previous claims, wherein the at least one outlet, opening into the suction chamber (24) of the suction head, near a trailing end of the suction head (4) is set such that during dredging effluent expelled from said at least one outlet impinges on a flow of sludge (3) resulting from the jetting water relatively close to the trailing edge.

14. Method for trailing suction dredging, utilizing a suction head (4) having a leading end (17), a trailing end (19), and opposite lateral side walls (22), wherein water is jetted into a suction chamber (24) of the suction head (4) at the leading end (17), into the bottom of a body of water for releasing sediment and forming a dredging sludge (3), and wherein the dredging sludge is sucked from the water bottom using said suction head (4) and dumped into a hopper (2) of a vessel (1), wherein effluent is separated out of said sludge, wherein the effluent is returned to said suction head and expelled, wherein the effluent is expelled from:

- outlets (31) to at least one lateral side of the suction chamber (24) and, wherein the outlets are close to an edge of said suction head near the water bottom, such that during suction of sludge (3) into and/or through the suction chamber the returned effluent is sucked into said chamber; and/or
- outlets opening (18) into the suction chamber (24), near the trailing end (19) of the suction head (4), such that returned effluent is injected into the suction chamber, at an angle and/or in a direction including an angle with a jetting direction in which said water is jetted into the suction chamber.

15. Method according to claim 14, wherein at least about 90 % of the volume of effluent returned to the suction head (4) is sucked into the suction chamber. preferably at least 95 %, more preferably about 97 % and/or wherein substantially no water is sucked into the suction chamber (24) from the body of water directly surrounding the suction head (4).

16. Method according to claim 14 or 15, wherein returned effluent is expelled at least in part at two opposite sides of the suction head (4), preferably at a pressure substantially equal to or just above the water pressure surrounding the suction head.

17. Method according to anyone of claims 14 - 16, wherein returned effluent is at least in part injected at a rear side of the suction head, seen in a direction of movement of the suction head (4), wherein the returned effluent is preferably injected at a pressure sufficient to impinge on a flow of sludge resulting from at least water jetting from jets, in order to change a direction of flow thereof, wherein preferably water

is jetted into the suction chamber (24) near a leading end of the suction head (4), towards the bottom, and returned effluent is injected into said suction chamber near a trailing end, in a direction substantially towards the leading end.

Patentansprüche

1. Hopperbagger mit einem Trichter (2) und einem Saugrohr (5), das sich von dem Trichter (2) erstreckt, wobei ein Saugkopf (4) an einem distalen Ende des Saugrohrs (5) und ein Auslassende an einem gegenüberliegenden proximalen Ende des Saugrohrs (5) bereitgestellt ist, um Baggerschlamm in den Trichter (2) zu entsorgen, wobei der Saugkopf (4) ein vorderes Ende (17), ein hinteres Ende (19) und gegenüberliegende laterale Seiten (22) aufweist,
wobei eine Rückführleitung (7) zwischen dem Trichter (2) und dem Saugkopf (4) zum Zuführen von Abwasser aus dem Trichter (2) zu dem Saugkopf (4) bereitgestellt ist, wobei die Rückführleitung (7) mit dem Saugkopf (4) verbunden ist, **dadurch gekennzeichnet, dass** wenigstens ein Strahlrohr (6) mit dem Saugkopf (4) verbunden ist, um Wasser in eine Saugkammer (24) des Saugkopfes durch das wenigstens eine Strahlrohr (6) in der Nähe des vorderen Endes des Saugkopfes (4) in Richtung einer unteren Seite der Saugkammer zu strahlen, um Sediment von einem Boden eines Gewässers zu lösen, wobei:

- die Rückführleitung (7) wenigstens einen Auslass (31) an einer Seite (22) des Saugkopfs (4) aufweist, so dass aus dem Auslass (31) austretendes Abwasser in die Saugkammer (24) gesaugt wird; und/oder
- die Rückführleitung (7) wenigstens einen Auslass (18) aufweist, der in der Nähe des hinteren Endes (19) des Saugkopfes (4) in die Saugkammer (24) des Saugkopfes (4) mündet.

2. Hopperbagger nach Anspruch 1, wobei die Rückführleitung (7) wenigstens zwei Auslässe außerhalb der Saugkammer (24) des Saugkopfes (4) aufweist, insbesondere wenigstens einen an jeder der gegenüberliegenden Seiten des Saugkopfes, vorzugsweise eine Reihe von Auslässen an jeder der Seiten.

3. Hopperbagger nach Anspruch 1 oder 2, wobei der wenigstens eine Auslass (31) außerhalb der Saugkammer (24) des Saugkopfes (4) so positioniert ist oder sind, dass aus dem Auslass fließendes Abwasser in die Saugkammer gesaugt wird, wobei vorzugsweise das Ansaugen von Wasser aus der Umgebung des Kopfes (4) in die Saugkammer begrenzt und bevorzugter im Wesentlichen verhindert wird.

4. Hopperbagger nach einem der Ansprüche 1 bis 3, wobei die Rückführleitung (7) wenigstens einen Auslass (18) und vorzugsweise wenigstens zwei Auslässe aufweist, die in die Saugkammer (24) des Saugkopfes (4) münden, in der Nähe eines hinteren Endes des Saugkopfes, vorzugsweise an einem Ende des Saugkopfes gegenüber einer Verbindung zwischen dem Saugrohr (5) und der Saugkammer des Saugkopfes, wobei der oder jeder Auslass (18) eine Auslassrichtung aufweist, die einen Winkel mit einer Strahlrichtung des wenigstens einen Strahls einschließt, wobei der Winkel der Auslassrichtung des wenigstens einen Auslasses (18) vorzugsweise einstellbar ist.

5. Hopperbagger nach einem der vorhergehenden Ansprüche, wobei wenigstens ein weiterer Auslass bereitgestellt ist, der in die Saugkammer mündet, vorzugsweise direkt.

6. Hopperbagger nach einem der vorhergehenden Ansprüche, wobei der Druck des aus wenigstens einem der Auslässe ausströmenden Abwassers einstellbar ist.

7. Hopperbagger nach einem der vorhergehenden Ansprüche, wobei die Auslegung des Saugrohrs (5) und der Auslässe so ist, dass während des Baggerns im Wesentlichen kein Wasser aus einem den Saugkopf unmittelbar umgebenden Gewässer in die Saugkammer gesaugt wird.

8. Hopperbagger nach einem der vorhergehenden Ansprüche, wobei der Saugkopf (4) eine im Wesentlichen offene Unterseite aufweist, die durch wenigstens eine untere Kante einer Wand des Saugkopfes definiert ist, wobei der wenigstens eine Auslass außerhalb des Saugkopfes nahe dieser Kante bereitgestellt ist.

9. Hopperbagger nach einem der vorhergehenden Ansprüche, wobei der Saugkopf (4) eine Saugkammer (24) umfasst, die durch wenigstens zwei Seitenwandteile, einen vorderen Wandteil, einen hinteren Wandteil und eine Oberseite definiert ist, wobei in dem vorderen Wandteil eine Saugöffnung bereitgestellt ist, die in das Saugrohr (5) mündet, wobei:

wenigstens eine Auslassöffnung neben einer unteren Kante jedes Seitenwandteils an dessen Außenseite bereitgestellt ist und/oder
wenigstens eine Auslassöffnung neben einer unteren Kante des Rückwandteils.

10. Hopperbagger nach einem der vorhergehenden Ansprüche, wobei wenigstens die Rückführleitung (7) und wenigstens ein Auslass so ausgelegt sind, dass sie das Abwasser bei einem Druck ausstoßen, der während des Gebrauchs im Wesentlichen dem Um-

gebungsdruck des den Saugkopf (4) umgebenden Wassers entspricht oder leicht darüber liegt.

11. Hopperbagger nach einem der vorhergehenden Ansprüche, wobei an einer Rückseite des Saugkopfes (4), die sich zwischen den beiden gegenüberliegenden Seiten erstreckt, wenigstens eine Reihe von ersten Auslässen bereitgestellt ist und an zwei gegenüberliegenden Seiten des Saugkopfes eine Reihe von zweiten Auslässen bereitgestellt ist und wobei während der Benutzung Abwasser aus den zweiten Auslässen ausgestoßen wird:

- bei einem Druck, der gleich oder niedriger ist als der Druck an den ersten Auslässen und/oder
- mit einer Geschwindigkeit, die gleich oder niedriger als die Geschwindigkeit ist, mit der Abwasser aus den ersten Auslässen ausgestoßen wird, wobei vorzugsweise zwei Reihen von zweiten Auslässen bereitgestellt sind, wobei eine Reihe von dritten Auslässen zwischen den zwei Reihen von zweiten Auslässen bereitgestellt ist, wobei während des Gebrauchs Abwasser aus den dritten Auslässen ausgestoßen wird:
  - bei einem anderen Druck als an den zweiten Auslässen und/oder
  - mit einer anderen Geschwindigkeit als die Geschwindigkeit, mit der Abwässer aus den zweiten Auslässen ausgestoßen wird.

12. Hopperbagger nach einem der vorhergehenden Ansprüche, wobei die Rückführleitung (7) ein Einlassende (11) aufweist, das mit einem Mechanismus zum Anheben und/oder Absenken des Einlassendes verbunden ist, wobei der Mechanismus vorzugsweise zum Bewegen des Einlasses nach oben und unten in Abhängigkeit von einem Abwasserpegel und/oder einem Sedimentpegel in einem Trichter (2) des Schiffes (1) ausgelegt ist.

13. Hopperbagger nach einem der vorhergehenden Ansprüche, wobei der wenigstens eine Auslass, der in die Saugkammer (24) des Saugkopfes mündet, in der Nähe eines hinteren Endes des Saugkopfes (4) so eingestellt ist, dass während des Baggerns das aus dem wenigstens einen Auslass ausgestoßene Abwasser auf einen Schlammstrom (3) auftrifft, der sich aus dem Strahlwasser relativ nahe der hinteren Kante ergibt.

14. Verfahren zum Baggern mit einem Hopperbagger das einen Saugkopf (4) mit einem vorderen Ende (17), einem hinteren Ende (19) und gegenüberliegenden seitlichen Seitenwänden (22) verwendet, wobei Wasser in eine Saugkammer (24) des Saugkopfes (4) am vorderen Ende (17) auf den Boden eines Gewässers gestrahlt wird, um Sediment zu lösen und einen Baggerschlamm (3) zu bilden, und wobei der Baggerschlamm unter Verwendung des Saugkopfes (4) vom Wasserboden gesaugt und in einen Trichter (2) eines Schiffes (1) gekippt wird, wobei das Abwasser aus dem Schlamm abgetrennt wird, wobei das Abwasser zu dem Saugkopf zurückgeführt und ausgestoßen wird, wobei das Abwasser ausgestoßen wird aus:

- Auslässen (31) an wenigstens einer seitlichen Seite der Saugkammer (24) und, wobei die Auslässe nahe an einer Kante des Saugkopfes in der Nähe des Wasserbodens liegen, so dass während des Ansaugens des Schlamms (3) in und/oder durch die Saugkammer das zurückgeführte Abwasser in die Kammer gesaugt wird; und/oder
- Auslässen, die in die Saugkammer (24), in der Nähe des hinteren Endes (19) des Saugkopfes (4) münden (18), so dass das zurückgeführte Abwasser in die Saugkammer unter einem Winkel und/oder in einer Richtung eingespritzt wird, die einen Winkel mit einer Strahlrichtung einschließt, in der das Wasser in die Saugkammer gestrahlt wird.

15. Verfahren nach Anspruch 14, wobei wenigstens etwa 90 % des Volumens des zum Saugkopf (4) zurückgeführten Abwassers in die Saugkammer gesaugt wird, vorzugsweise wenigstens 95 %, bevorzugter etwa 97 % und/oder wobei im Wesentlichen kein Wasser aus dem den Saugkopf (4) unmittelbar umgebenden Gewässer in die Saugkammer (24) gesaugt wird.

16. Verfahren nach Anspruch 14 oder 15, wobei das zurückgeführte Abwasser wenigstens teilweise an zwei gegenüberliegenden Seiten des Saugkopfes (4) ausgestoßen wird, vorzugsweise mit einem Druck, der im Wesentlichen gleich oder knapp über dem den Saugkopf umgebenden Wasserdruck liegt.

17. Verfahren nach einem der Ansprüche 14 bis 16, wobei zurückgeführtes Abwasser wenigstens teilweise an einer Rückseite des Saugkopfes, in Bewegungsrichtung des Saugkopfes (4) gesehen, eingespritzt wird, wobei das zurückgeführte Abwasser vorzugsweise mit einem Druck eingespritzt wird, der ausreicht, um auf einen Schlammstrom aufzutreffen, der wenigstens durch Wasserstrahlen aus Düsen entsteht, um dessen Strömungsrichtung zu ändern, wobei vorzugsweise Wasser in die Saugkammer (24) in der Nähe eines vorderen Endes des Saugkopfes (4) in Richtung des Bodens eingespritzt wird und zurückgeführtes Abwasser in die Saugkammer in der Nähe eines hinteren Endes in einer Richtung im Wesentlichen in Richtung des vorderen Endes eingespritzt wird.

Revendications

1. Drague suceuse autoporteuse comprenant une cale (2) et un tuyau d'aspiration (5) qui s'étend depuis la cale (2), dans laquelle une tête d'aspiration (4) est placée à une extrémité distale du tuyau d'aspiration (5), et une extrémité de sortie à une extrémité proximale opposée du tuyau d'aspiration (5) pour déposer les boues de dragage dans la cale (2), la tête d'aspiration (4) ayant une extrémité antérieure (17), une extrémité postérieure (19) et des côtés latéraux opposés (22),
dans laquelle une conduite de recyclage (7) est placée entre la cale (2) et la tête d'aspiration (4) pour envoyer un effluent de la cale (2) à la tête d'aspiration (4), dans laquelle la conduite de recyclage (7) est connectée à la tête d'aspiration (4), **caractérisée en ce qu'**au moins un tuyau de jet (6) est relié à la tête d'aspiration (4) pour projeter de l'eau dans une chambre d'aspiration (24) de la tête d'aspiration via ledit au moins un tuyau de jet (6), près de l'extrémité antérieure de la tête d'aspiration (4) vers un côté inférieur de la chambre d'aspiration pour dégager le sédiment du fond d'une masse d'eau, dans laquelle :

   - la conduite de recyclage (7) a au moins une sortie (31) sur un côté latéral (22) de la tête d'aspiration (4), de sorte que l'effluent qui sort par ladite sortie (31) est aspiré dans ladite chambre d'aspiration (24) ; et/ou
   - la conduite de recyclage (7) a au moins une sortie (18) débouchant dans la chambre d'aspiration (24) de la tête d'aspiration (4), près de l'extrémité postérieure (19) de la tête d'aspiration (4).

2. Drague suceuse autoporteuse selon la revendication 1, dans laquelle la conduite de recyclage (7) a au moins deux sorties à l'extérieur de la chambre d'aspiration (24) de la tête d'aspiration (4), notamment au moins une sur chacun des côtés opposés de ladite tête d'aspiration, de préférence une série de sorties sur chacun desdits côtés.

3. Drague suceuse autoporteuse selon la revendication 1 ou 2, dans laquelle ladite au moins une sortie (31) à l'extérieur de la chambre d'aspiration (24) de la tête d'aspiration (4) est ou sont positionnée(s) de telle manière que l'effluent sortant par ladite sortie est aspiré dans ladite chambre d'aspiration, de préférence en limitant, et mieux encore en empêchant substantiellement l'eau entourant ladite tête (4) d'être aspirée dans ladite chambre d'aspiration.

4. Drague suceuse autoporteuse selon l'une quelconque des revendications 1 à 3, dans laquelle la conduite de recyclage (7) a au moins une sortie (18) et de préférence au moins deux sorties débouchant dans la chambre d'aspiration (24) de la tête d'aspiration (4), près d'une extrémité postérieure de la tête d'aspiration, de préférence à une extrémité de la tête d'aspiration située à l'opposé d'un raccordement entre le tuyau d'aspiration (5) et la chambre d'aspiration de la tête d'aspiration, dans laquelle la ou chaque sortie (18) a une direction de sortie incluant un angle avec une direction de jet dudit au moins un jet, l'angle de la direction de sortie d'au moins une sortie (18) étant de préférence réglable.

5. Drague suceuse autoporteuse selon l'une quelconque des revendications précédentes, dans laquelle au moins une autre sortie est prévue, débouchant dans ladite chambre d'aspiration, de préférence directement.

6. Drague suceuse autoporteuse selon l'une quelconque des revendications précédentes, dans laquelle la pression de l'effluent sortant par au moins l'une des sorties est réglable.

7. Drague suceuse autoporteuse selon l'une quelconque des revendications précédentes, dans laquelle la disposition du tuyau d'aspiration (5) et des sorties est telle que pendant le dragage, il n'y a substantiellement pas d'aspiration d'eau dans la chambre d'aspiration provenant d'une masse d'eau qui entoure directement la tête d'aspiration.

8. Drague suceuse autoporteuse selon l'une quelconque des revendications précédentes, dans laquelle la tête d'aspiration (4) a un côté inférieur substantiellement ouvert, défini par au moins un bord inférieur d'une paroi de ladite tête d'aspiration, dans laquelle ladite au moins une sortie à l'extérieur de la tête d'aspiration est placée à proximité dudit bord.

9. Drague suceuse autoporteuse selon l'une quelconque des revendications précédentes, dans laquelle la tête d'aspiration (4) comprend une chambre d'aspiration (24) définie par au moins deux parties de paroi latérale, une partie de paroi avant, une partie de paroi arrière et un dessus, une ouverture d'aspiration formée dans la partie de paroi avant, débouchant dans le tuyau d'aspiration (5), dans laquelle :

   au moins une ouverture de sortie est placée en position adjacente à un bord inférieur de chaque partie de paroi latérale, à l'extérieur de celle-ci, et/ou
   au moins une sortie débouchant en une position adjacente à un bord inférieur de la partie de paroi arrière.

10. Drague suceuse autoporteuse selon l'une quelconque des revendications précédentes, dans laquelle au moins la conduite de recyclage (7) et au moins

une sortie sont conçues pour refouler l'effluent à une pression en utilisation qui est sensiblement égale ou légèrement supérieure à la pression ambiante de l'eau qui entoure la tête d'aspiration (4).

11. Drague suceuse autoporteuse selon l'une quelconque des revendications précédentes, dans laquelle sur un côté arrière de la tête d'aspiration (4), s'étendant entre lesdits deux côtés opposés, au moins une série de premières sorties est prévue, et sur deux côtés opposés de la tête d'aspiration une série de deuxièmes sorties est prévue, et dans laquelle en utilisation l'effluent est refoulé par les deuxièmes sorties :

- à une pression inférieure ou égale à la pression aux premières sorties et/ou
- à une vitesse inférieure ou égale à la vitesse à laquelle l'effluent est refoulé par les premières sorties, dans laquelle de préférence deux séries de deuxièmes sorties sont prévues, dans laquelle une série de troisièmes sorties est placée entre les deux séries de deuxièmes sorties, dans laquelle en utilisation l'effluent est refoulé par les troisièmes sorties :
- à une pression différente des deuxièmes sorties et/ou
- à une vitesse différente de la vitesse à laquelle l'effluent est refoulé par les deuxièmes sorties.

12. Drague suceuse autoporteuse selon l'une quelconque des revendications précédentes, dans laquelle la conduite de recyclage (7) a une extrémité d'entrée (11) qui est reliée à un mécanisme servant à lever et/ou abaisser ladite extrémité d'entrée, dans laquelle ce mécanisme est de préférence conçu pour déplacer l'entrée vers le haut et vers le bas, en fonction d'un niveau d'effluent et/ou d'un niveau de sédiment dans une cale (2) du navire (1).

13. Drague suceuse autoporteuse selon l'une quelconque des revendications précédentes, dans laquelle ladite au moins une sortie débouchant dans la chambre d'aspiration (24) de la tête d'aspiration, près d'une extrémité postérieure de la tête d'aspiration (4) est établie de telle manière que pendant le dragage, l'effluent refoulé par ladite au moins une sortie heurte un flux de boues (3) résultant de l'eau projetée relativement près du bord postérieur.

14. Procédé de dragage par suceuse autoporteuse, utilisant une tête d'aspiration (4) ayant une extrémité antérieure (17), une extrémité postérieure (19) et des parois de côtés latéraux opposés (22), dans lequel on projette de l'eau dans une chambre d'aspiration (24) de la tête d'aspiration (4) à l'extrémité antérieure (17), dans le fond d'une masse d'eau pour dégager le sédiment et former des boues de dragage (3), et dans lequel les boues de dragage sont aspirées au fond de l'eau en utilisant ladite tête d'aspiration (4) et rejetées dans une cale (2) d'un navire (1), dans lequel on sépare l'effluent desdites boues, dans lequel on renvoie l'effluent vers ladite tête d'aspiration où il est refoulé, l'effluent étant refoulé :

- par des sorties (31) vers au moins un coté latéral de la chambre d'aspiration (24) et dans lequel les sorties sont proches d'un bord de ladite tête d'aspiration près du fond de l'eau, de sorte que pendant l'aspiration desdites boues (3) dans et/ou à travers la chambre d'aspiration, l'effluent renvoyé est aspiré dans ladite chambre ; et/ou
- par des sorties débouchant (18) dans la chambre d'aspiration (24), près de l'extrémité postérieure (19) de la tête d'aspiration (4), de sorte que l'effluent renvoyé est injecté dans la chambre d'aspiration, selon un angle et/ou dans une direction incluant un angle avec une direction de projection dans laquelle ladite eau est projetée dans la chambre d'aspiration.

15. Procédé selon la revendication 14, dans lequel au moins 90 % environ du volume d'effluent renvoyé vers la tête d'aspiration (4) est aspiré dans la chambre d'aspiration, de préférence au moins 95 % et mieux encore environ 97 % et/ou dans lequel il n'y a substantiellement pas d'aspiration d'eau dans la chambre d'aspiration (24) provenant de la masse d'eau qui entoure directement la tête d'aspiration (4).

16. Procédé selon la revendication 14 ou 15, dans lequel l'effluent renvoyé est refoulé au moins en partie sur deux côtés opposés de la tête d'aspiration (4), de préférence avec une pression qui est sensiblement égale ou légèrement supérieure à la pression de l'eau qui entoure la tête d'aspiration.

17. Procédé selon l'une quelconque des revendications 14 à 16, dans lequel l'effluent renvoyé est au moins en partie injecté sur un côté arrière de la tête d'aspiration, vue dans une direction de déplacement de la tête d'aspiration (4), dans lequel l'effluent renvoyé est de préférence injecté à une pression suffisante pour heurter un flux de boues résultant au moins de la projection d'eau en jets, afin de modifier une direction d'écoulement de celui-ci, dans lequel de préférence l'eau est projetée dans la chambre d'aspiration (24) près d'une extrémité antérieure de la tête d'aspiration (4), vers le fond, et l'effluent renvoyé est injecté dans ladite chambre d'aspiration près d'une extrémité postérieure, dans une direction substantiellement orientée vers l'extrémité antérieure.

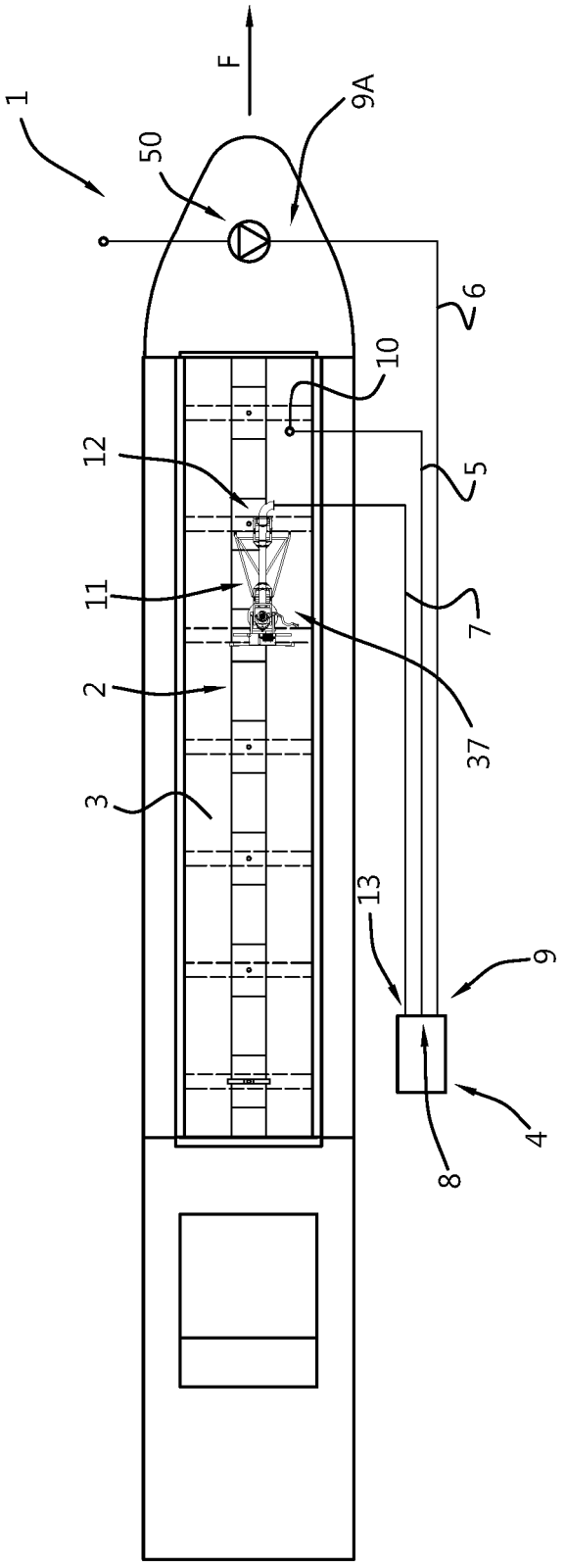


Fig. 1

Fig. 1A

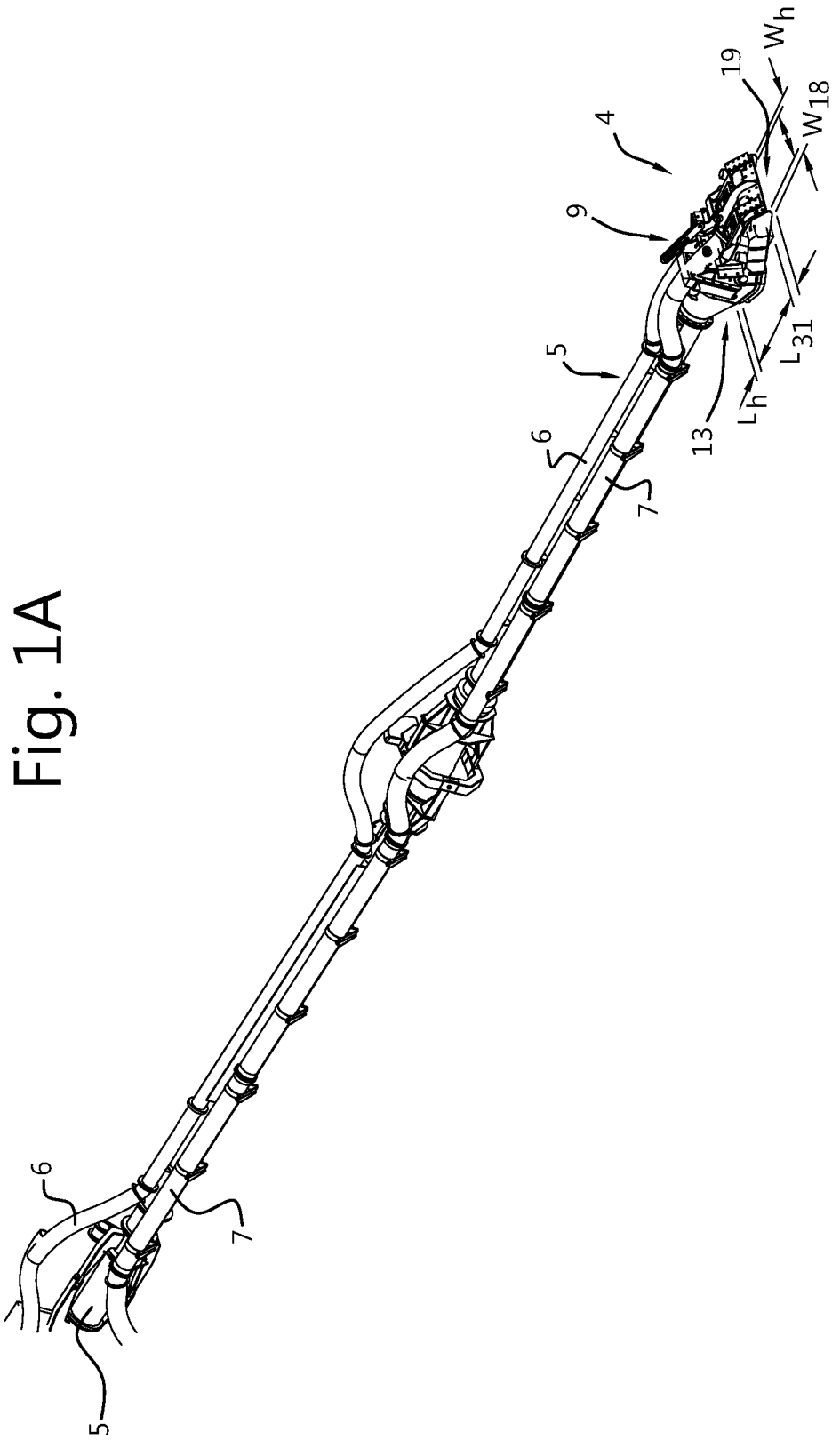


Fig. 2A

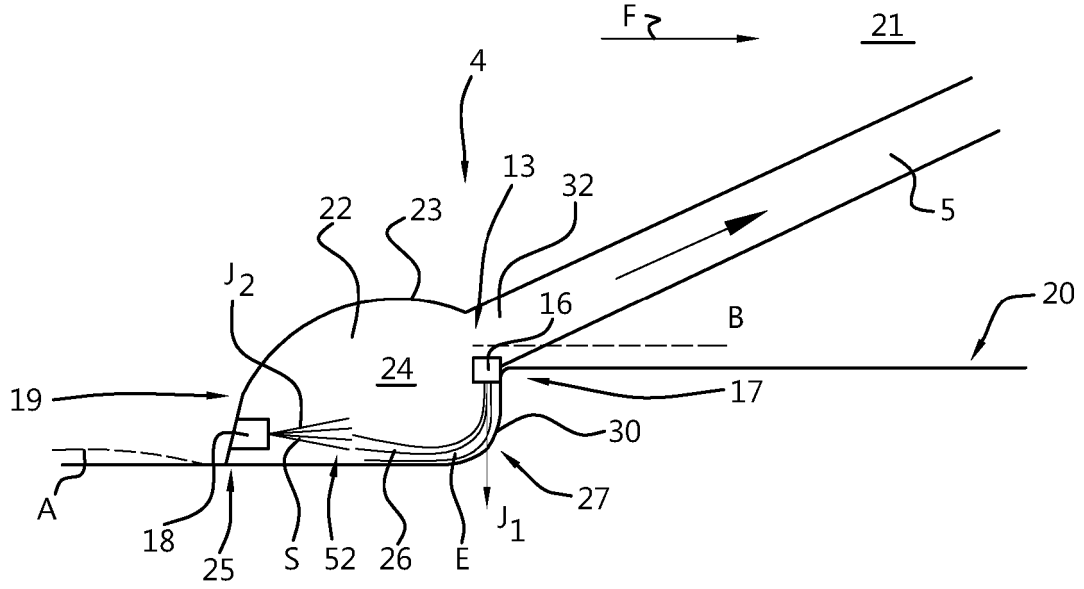
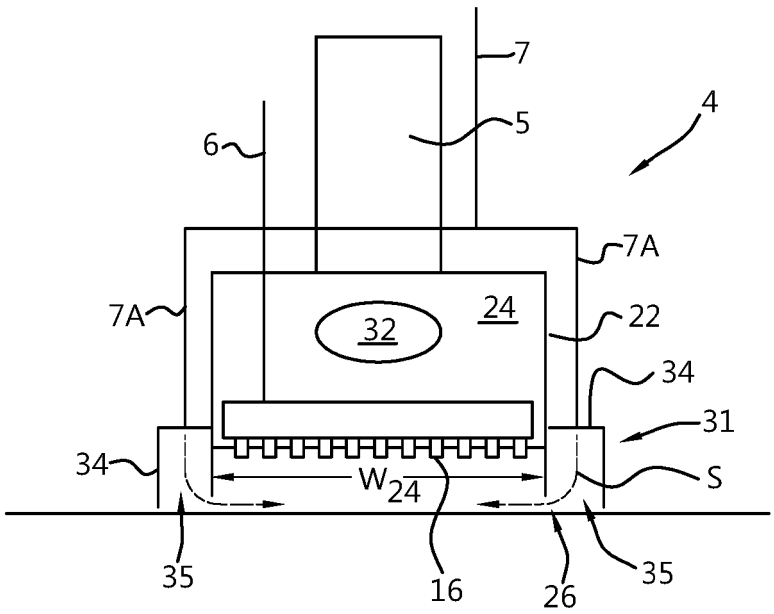

F
21
4
13
32
5
22
23
J2
16
B
20
24
19
17
30
A
27
18
25
S
52
26
E
J1

Fig. 2B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5
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7A
24
22
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34
31
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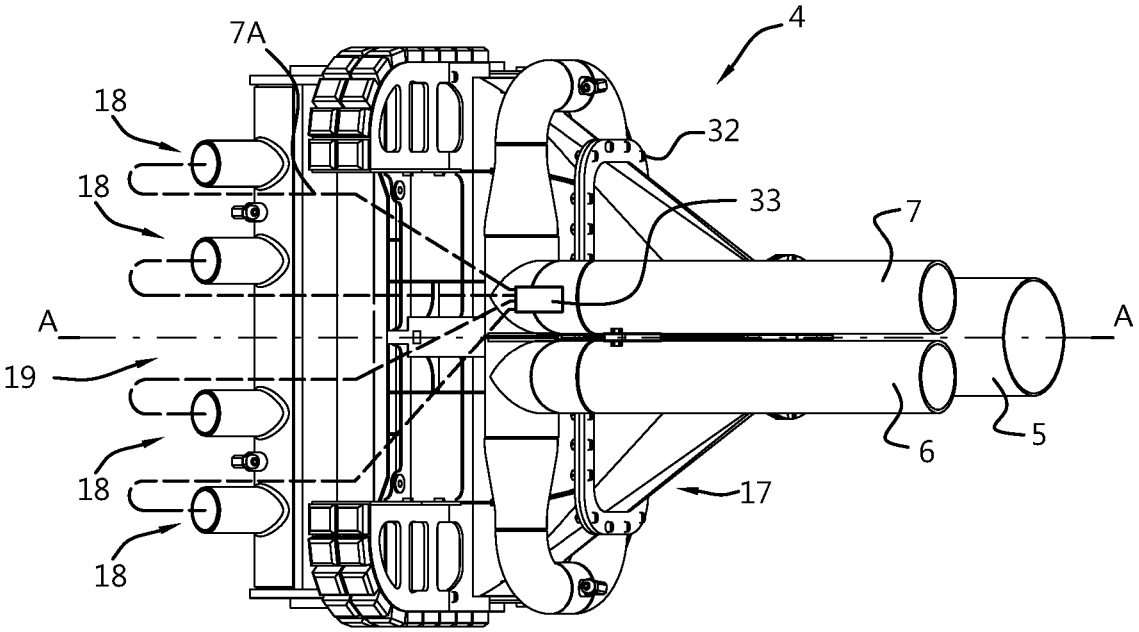
W24
S
35
16
26
35

Fig. 3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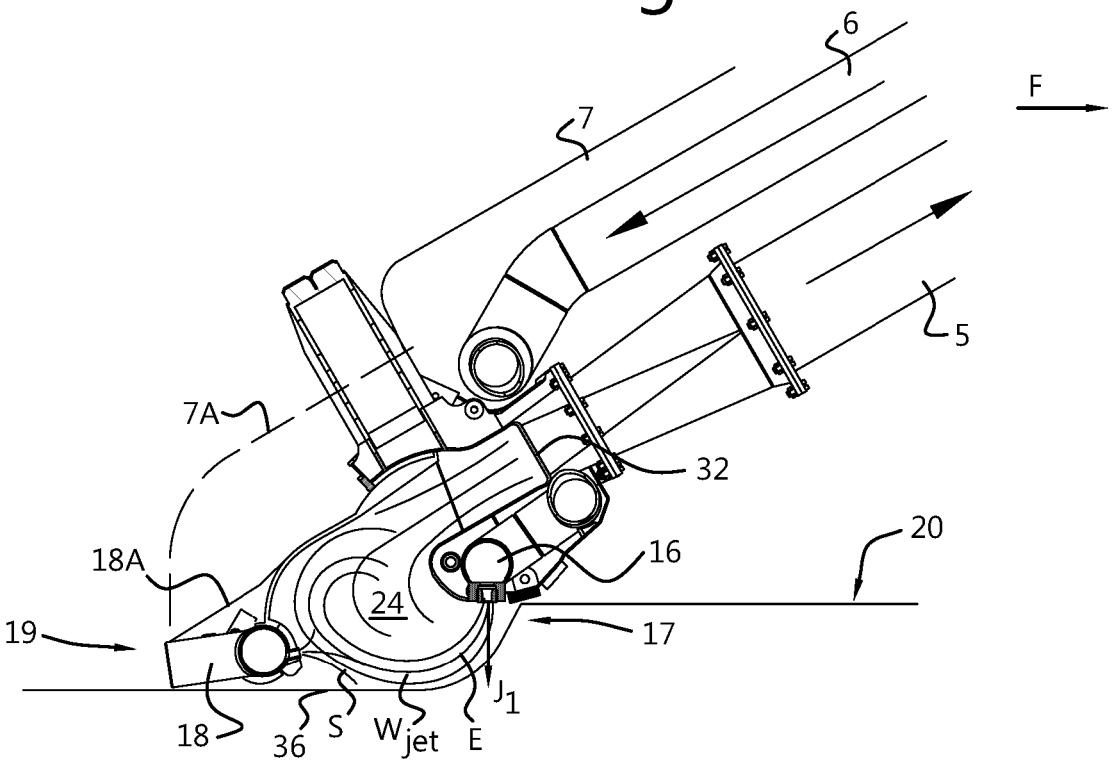
4
18
18
32
33
7
A
A
19
18
18
6
5
17

Fig. 3A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24
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17
J1
18
36
S
Wjet
E

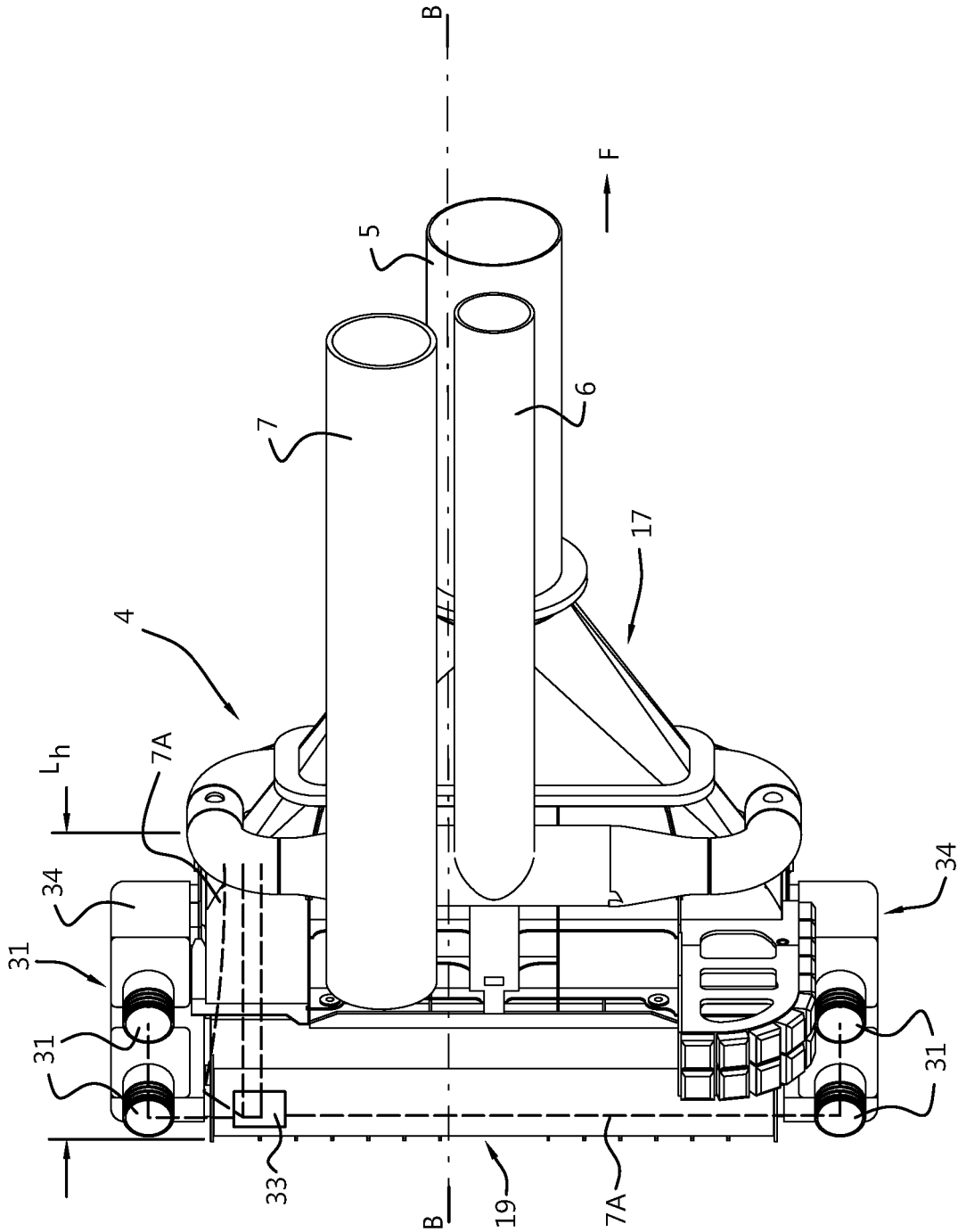


Fig. 4

Fig. 4B

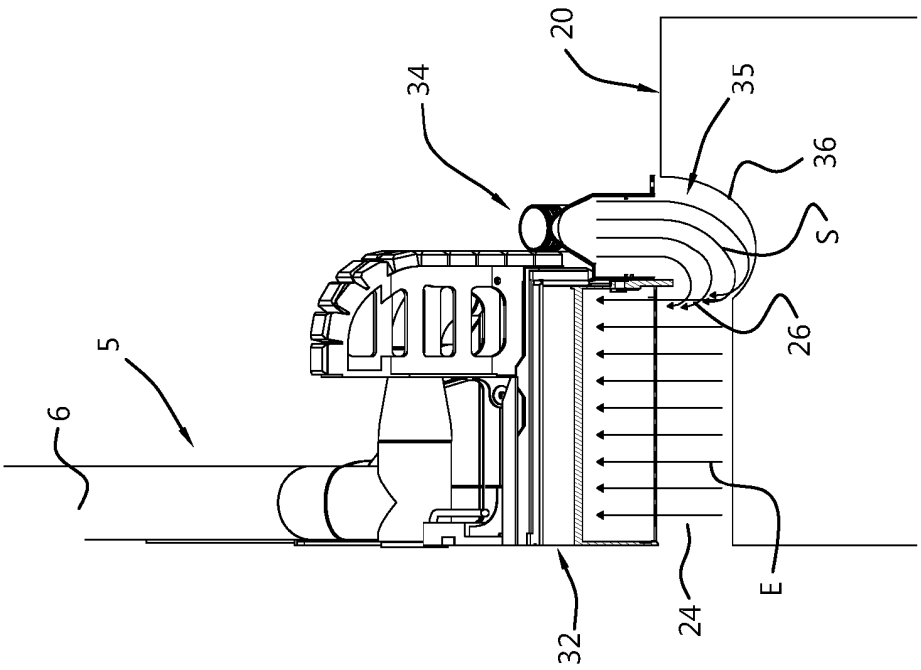


Fig. 4A

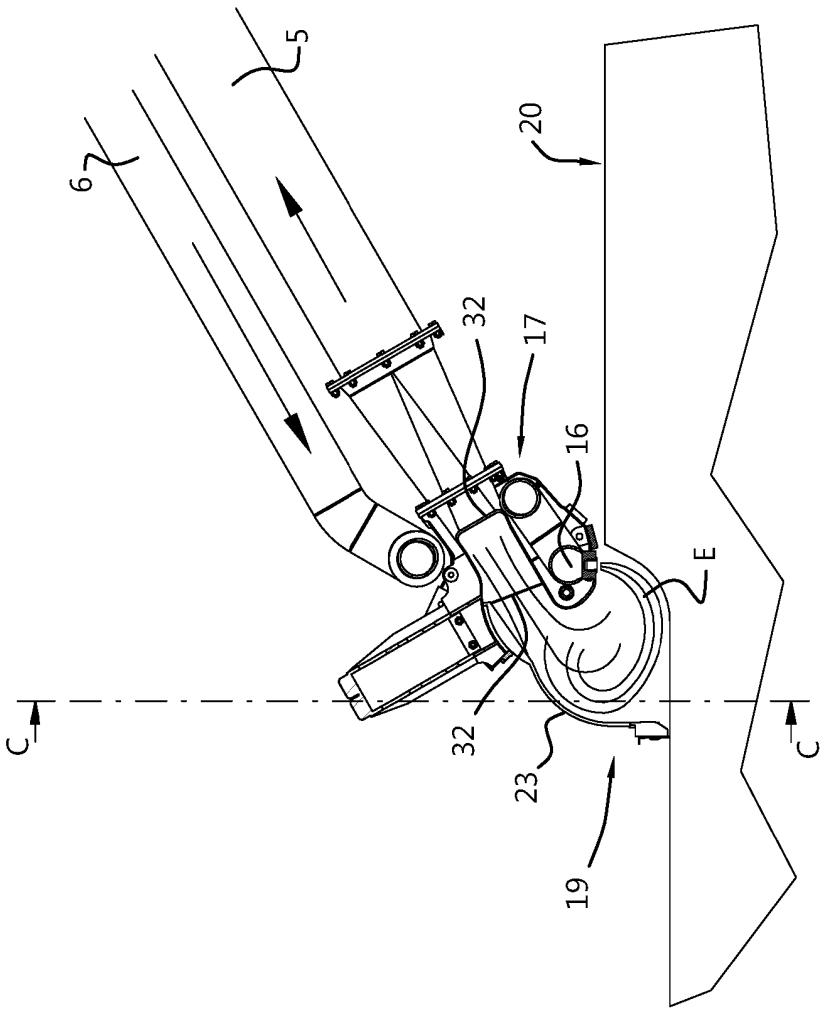


Fig. 4C

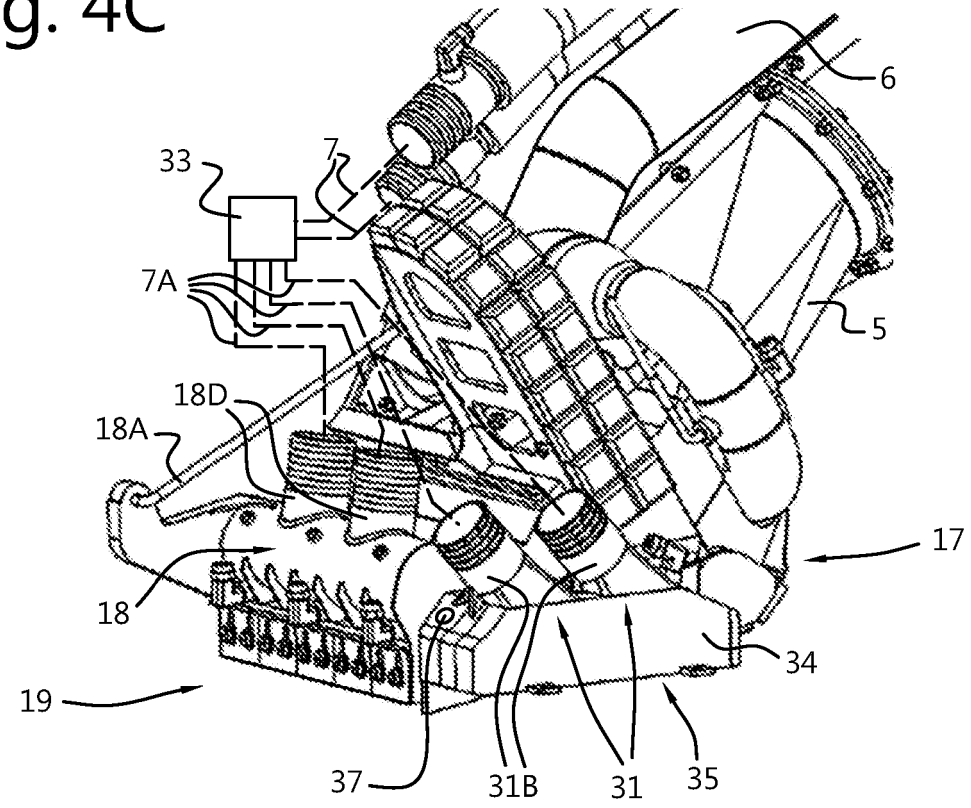


Fig. 5A

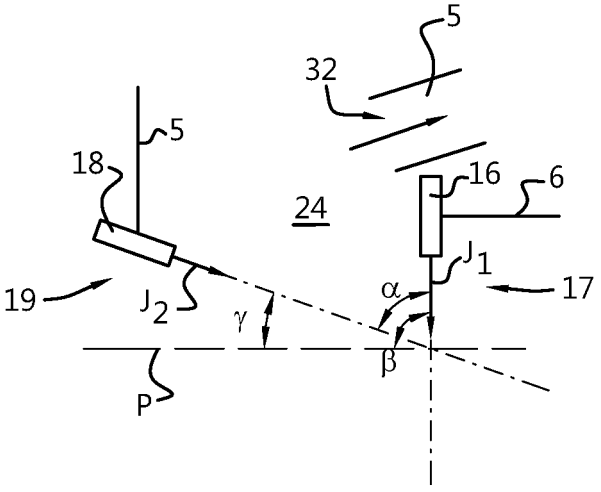


Fig. 5B

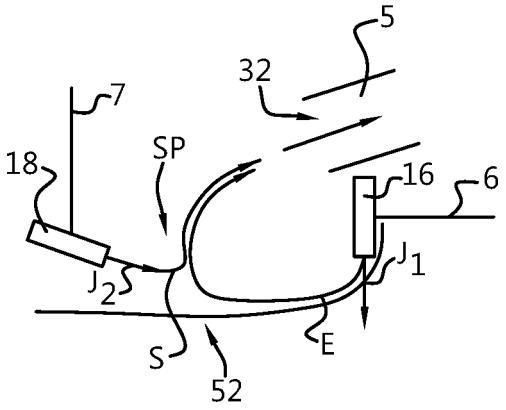
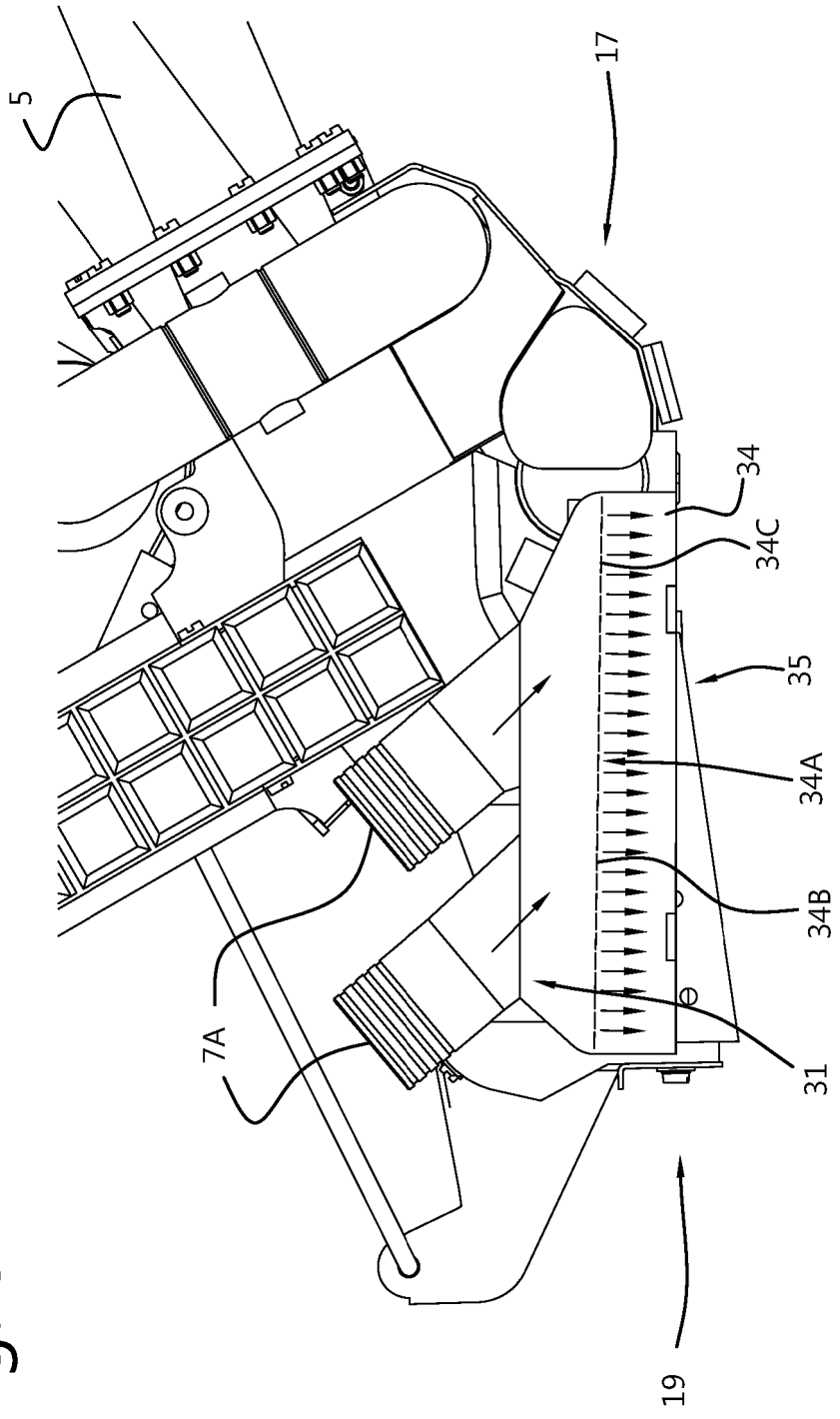


Fig. 6



REFERENCES CITED IN THE DESCRIPTION

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- WO 2010112640 A **[0003]**
- US 5603171 A **[0003]**