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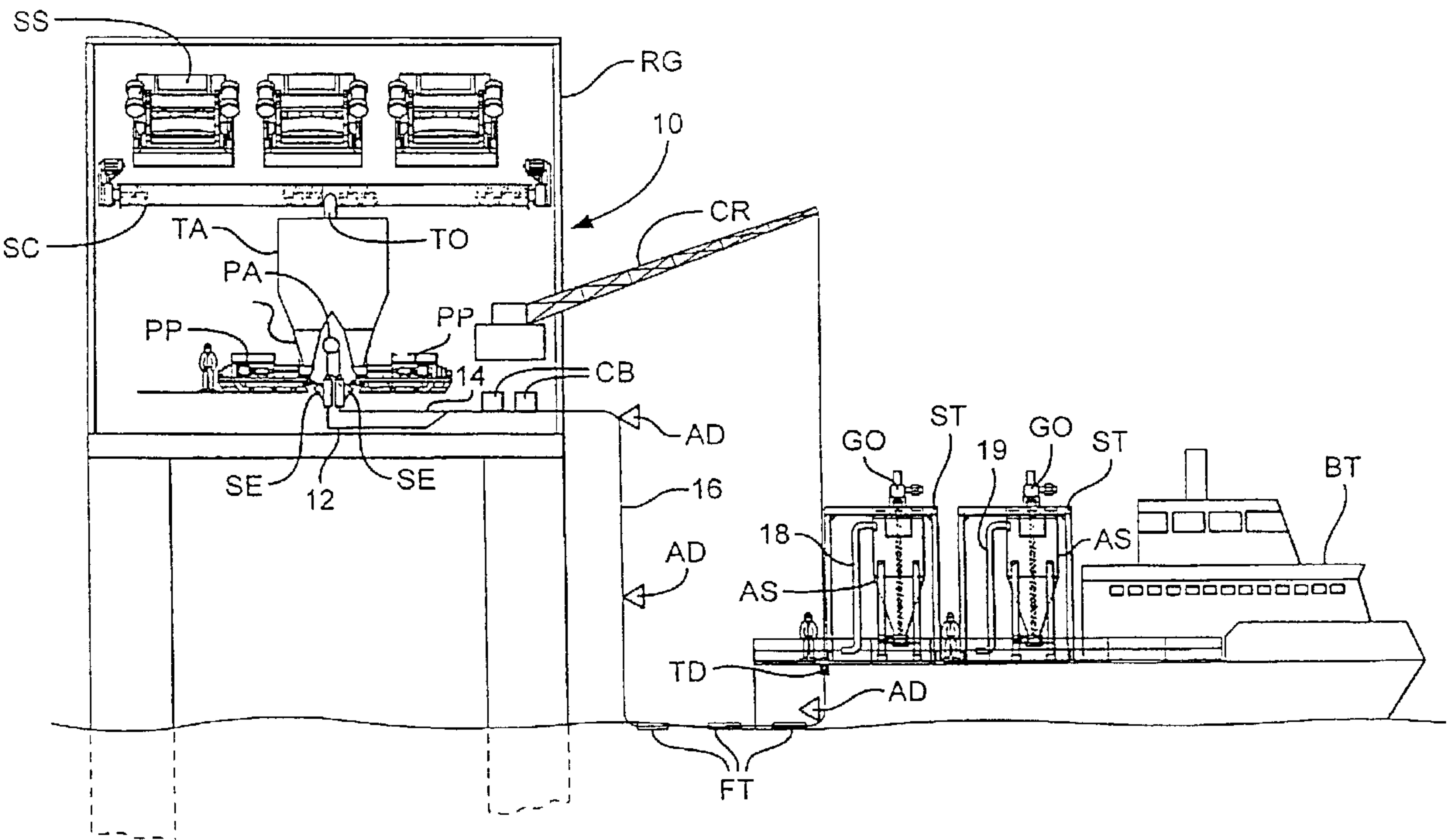

(57) Abrégé/Abstract:
A method for moving drilled cuttings comprising the step of receiving wet drilled cuttings from shale shakers, centrifuges and hydrocyclones, characterised in that the method comprises the step of drying the wet drilled cuttings to produce dry drilled cuttings, and moving the dried drilled cuttings using positive pressure through a tube to a tertiary apparatus.

ABSTRACT

APPARATUS AND METHOD FOR MOVING DRILLED CUTTINGS

A method for moving drilled cuttings comprising the step of receiving wet drilled cuttings from shale shakers, centrifuges and hydrocyclones, characterised in that the method comprises the step of drying the wet drilled cuttings to produce dry drilled cuttings, and moving the dried drilled cuttings using positive pressure through a tube to a tertiary apparatus.

APPARATUS AND METHOD FOR MOVING DRILLED CUTTINGS

This application is a division of copending Canadian Application Serial No. 2,505,628 filed February 26, 2004.

The present invention relates to an apparatus and method for moving drilled cuttings and particularly, but not exclusively, for moving wet cuttings and solids produced in the construction of an oil or gas well.

In the drilling of a borehole in the construction of an oil or gas well, a drill bit is arranged on the end of a drill string and is rotated to bore the borehole. A drilling fluid known as "drilling mud" is pumped through the drill string to the drill bit to lubricate the drill bit. The drilling mud is also used to carry the cuttings produced by the drill bit and other solids to the surface through an annulus formed between the drill string and the borehole. The drilling mud contains expensive synthetic oil-based lubricants and it is normal therefore to recover and re-use the used drilling mud, but this requires the solids to be removed from the drilling mud. This is achieved by processing the drilling fluid. The first part of the process is to separate the solids from the solids laden drilling mud. This is at least partly achieved with a vibratory separator, such as those shale shakers disclosed in US 5,265,730, WO 96/33792 and WO 98/16328. Further processing equipment such as centrifuges and hydrocyclones may be used to further clean the mud of solids. The solids are covered in contaminates and residues.

The resultant solids are further processed to remove substantially all of the residues and contaminates from the solids. The solids can then be disposed of in a landfill site or by dumping at sea in the environment from which the solids came. Alternatively, the solids may be used as a material in the construction industry or have other industrial uses. The solids are usually processed on land using methods disclosed, for example in our co-pending PCT Application, Publication No. WO 03/062591. This processing equipment may be arranged near to an oil or gas rig. Alternatively, the processing equipment may be situated on land away from a marine based oil platform or distant from a land based rig. Therefore, the solids have to be conveyed from the exit point of the shakers, centrifuges and hydrocyclones to the solids processing equipment. This may be carried out by using a ditch provided with a driven screw to convey the wet solids to storage vessels, such a system is disclosed in our co-pending PCT Application, Publication No. WO 03/021074. The solids may have a fluid, such as water, added to them to form a slurry. The slurry may be pumped into ships, lorries, skips or bags to be moved to the processing site. Alternatively or additionally, the wet solids from the storage vessels may be moved using a compressed gas, as disclosed in PCT Publication No. WO 00/76889 through pipes.

The prior art discloses various methods for transporting low slurry density and low particle density dry solids and non-continuous high slurry density transport of high particle density wet material using continuous positive pneumatic pressure. Many low density slurries typically have particles mixed with air with a specific gravity less than 1.0. The prior art discloses various methods that employ the vacuum transport of high particle and low particle density solids.

However, none have tackled the problem of transporting low slurry density, high particle density material, and particularly, but not exclusively, oilfield drilled cuttings or other oily/wet waste material using continuous positive pneumatic pressure.

In accordance with the present invention, there is provided a method for moving drilled cuttings material, the method comprising the step of applying pneumatic fluid under positive pressure to the drilled cuttings to continuously move the drilled cuttings material through a conduit to a separation apparatus, and continuously separating drilled cuttings from a substantial portion of the pneumatic fluid.

The positive pressure is above atmospheric pressure. Continuous movement may be continuous as they are produced, or continuously from a storage bin, tank or vessel. The drilled cuttings material may be in a slurry transported through conduit(s), for example, at about 200 mph, 250 mph, or higher to the separator apparatus that separates solids in the slurry from the air. In one such method about thirty-five tons per hour of solids are processed. In one aspect a slurry is, by volume, about fifty percent cuttings (plus wet fluid) and about fifty percent pneumatic fluid. In other aspects the cuttings (plus wet fluid) range between two percent to sixty percent of the slurry by volume.

In one particular aspect the drilled cuttings material is a slurry that includes drilled cuttings from a wellbore, well drilling fluids, drilling muds, water, oil, and/or emulsions with the cuttings present as varying weight percents of the slurry. "Slurry density" refers to material from a well in an air flow and "particle density" refers to the material prior to its inclusion in an air flow.

In certain aspects systems and methods in accordance with the present invention provide the continuous or almost-continuous transport of material.

Preferably, the drilled cuttings are included in a low density slurry with drilling fluid. The slurry can be formed by adding water to the solids in a tank or pipeline or in the ditch. The drilled cuttings material are moved continuously or almost-continuously with a low slurry density, high particle density material

Advantageously, the separation apparatus is a cyclone separator. The drilled cuttings entering the cyclone separator may be wet. Preferably, the method further comprises the step of drying said wet drilled cuttings in a drying apparatus. Advantageously, the drying apparatus is a vortex dryer. Preferably, the wet drilled cuttings pass between said cyclone separator and said drying apparatus through a flow line. Preferably, the wet drilled cuttings are pumped through said flow line, advantageously, with a cement pump or like. In one aspect the present invention provides apparatus for reduces the density of a slurry of material. Such apparatus includes decelerator/separator apparatus.

Preferably, the method comprises the step of expanding the drilled cuttings material in an expansion chamber before the drilled cutting material enters the conduit. Preferably, in order to reduce the density of the drilled cuttings. Advantageously, the drilled cuttings are fed at a predetermined rate into said expansion chamber, whereupon said expanded drilled cuttings material is subjected to pneumatic fluid under positive pressure. Advantageously, the expansion chamber is joined to said conduit. Preferably, the expansion chamber has substantially the same cross-sectional area as the cross-sectional area of said conduit. Advantageously, the positive pressure pneumatic fluid flows into said expansion chamber through a nozzle. Preferably, the method further comprises the step of pumping, by gravity or otherwise supplying said drilled cuttings material from a tank apparatus into said expansion chamber. Advantageously, the tank apparatus includes a valve, the method comprising the step of selectively controlling flow of said material into the expansion chamber by operating said valve.

Preferably, the conduit is provided with at least one pneumatic fluid movement assistance device at an intermediate point along said conduit, the method further comprising the step of using the at least one pneumatic fluid movement assistance device to facilitate movement of the drilled cuttings material through the conduit and/or to inhibit blockages from forming in said conduit. Advantageously, the method comprises the step of moving separated drilled cuttings from the separation apparatus to a collection apparatus from the group consisting of cuttings box, tank, skip, bag, storage device, container, and receptacle on a boat or barge. In one aspect the velocity of moving solids is reduced using, for example, a separator apparatus, and then the solids are collected in collection apparatus (for example, tanks, boxes, storage containers). In certain aspects self-unloading tanks are used that have a positive pressure solids removal system. Such tanks may have systems for measuring the amount of solids in the tanks and providing an indication of this amount.

When the method of the invention is carried out in the sea from a floating platform to another sea vessel preferably, the conduit is provided with float apparatus and at least a portion of the conduit is in or on water.

Advantageously, the drilled cuttings material is included within a slurry of material, wherein the slurry has a low slurry density, and wherein upon mixing of the slurry with the fluid under positive pressure a resultant slurry is produced, the resultant slurry having a high particle density.

Preferably, the slurry has a specific gravity between 2.3 and 4.0 and the particle density of the resultant slurry is between 240 Kg/cu.metre and 479 Kg/cu.metre (2 pounds/gallon and 4 pounds/gallon).

Advantageously, the pneumatic fluid is air. The air may be normal ambient air or may have a larger component of inert gas, or be steam.

Preferably, the gas under positive pressure is applied substantially in line with said conduit and preferably substantially concentrically therewith.

The invention also provides an apparatus for moving drilled cuttings material, the apparatus comprising a conduit, a supply of pressurised gas and a separation apparatus, wherein gas under positive pressure is applied to the drilled cuttings to continuously move the drilled cuttings material through said conduit to move the drilled cuttings to a separation apparatus, whereupon the drilled cuttings are continuously separated from gas.

Preferably, the drilled cuttings are wet and the apparatus further comprises drying apparatus for drying the drilled cuttings.

The inventors have observed that it is unnecessary to move the moisture which resides in the drilled cuttings after processing in shale shakers, hydrocyclones and centrifuges. The inventors have observed that this moisture can be reprocessed.

The present invention also provides a method for moving drilled cuttings, the method comprising the step of receiving wet drilled cuttings from shale shakers, centrifuges and hydrocyclones, characterised in that the method comprises the step of drying the wet drilled cuttings to produce dry drilled cuttings, and moving the dried drilled cuttings using positive pressure through a tube to a tertiary apparatus.

Drying the drilled cuttings improves the movement of drilled cuttings along tubes, as well as reducing the weight to be moved.

Advantageously, the dry drilled cuttings has less drilling fluid therein by weight than the wet drilled cuttings.

Preferably, the wet drilled cuttings comprise solids and moisture and are 15% to 20% moisture to solids by weight.

Advantageously, the dried drilled cuttings comprise solids and moisture and are 1% to 3% moisture to solids by weight.

Preferably, fluid content of said dry drilled cuttings is at least 500% less by weight than fluid content of the wet drilled cuttings.

Preferably, the step of drying reduces the weight of drilled cuttings processed by removing drilling fluid from said drilled cuttings, said removed drilling fluid not moved through said tube. The reduced load on the positive pressure and reducing the size of the storage vessel or increasing its effective capacity.

The method may also comprise the steps of receiving the wet drilled cuttings from the shale shakers, centrifuges and hydrocyclones using a screw auger in a ditch. Alternatively or additionally with a conveyor belt.

Advantageously, the step of drying is performed by a cuttings processor. Preferably, the cuttings processor comprises a rotating conical screen. Preferably, the cuttings processor vibrates. Preferably, the cuttings processor is located on an oil rig, oil platform or drilling vessel, advantageously in close proximity to the shale shakers, centrifuges and/or hydrocyclones. Advantageously, less than 100m. Advantageously, the tertiary apparatus is located on a boat or transporter. Preferably, the tertiary apparatus is a storage vessel such as a cuttings box, tank, container, receptacle on a boat. Alternatively, the tertiary apparatus comprises a further cuttings processor or decanting centrifuge. Preferably, the tertiary apparatus comprises a secondary positive pressure blow tank apparatus for facilitating movement of drilled cuttings from the storage apparatus. Preferably, the tertiary apparatus further comprises a storage vessel, which may be pressurised and a pipe connection means, such that a pipe is connected to the pipe connection means and upon pressurisation, drilled cuttings flow from the storage vessel through said pipe.

Advantageously, the dried drilled cuttings are transferred in clumps or slugs using positive pressure. Preferably, the slugs are transferred at low speed. 30 to 200Kph. Preferably, the drilled cuttings are fed into a blow tank. Advantageously, the cuttings pass from a feed hopper into said blow tank. Preferably, a valve is located between the hopper and the blow tank, to selectively allow drilled cuttings into the blow tank and to provide a gas tight seal to the blow tank. Preferably, there is also at least one pneumatic fluid movement assistance device to facilitate movement of the drilled cuttings material through the conduit and/or to inhibit blockages from forming in said conduit.

Alternatively, the dried drilled cuttings are reduced in density using an expansion chamber and transferred using a positive pressure gas at high speed. Preferably, the gas is separated from the dry drilled cuttings in a separator.

Preferably, further comprising a decanting centrifuge, the fluid small particles resulting from the step of drying processed in the decanting centrifuge producing secondary drilled cuttings and secondary drilling mud. Preferably, the secondary drilling fluid is recycled for reuse in a drilling operation. Advantageously, the secondary drilled cuttings is sent to a mill apparatus for breaking up agglomerations of said secondary drilled cuttings, and moving said secondary drilled cuttings with said drilled cuttings using the method of the invention.

Preferably, the drilled cuttings are sent to a mill apparatus for breaking up agglomerations of before the drilled cuttings are moved through said tube. Advantageously, after the cuttings processor and before entering the blow tank.

Preferably, the dry drilled cuttings is a free-flowing paste. Advantageously, the dry drilled cuttings is a non-free-flowing paste.

The invention is primary concerned with moving drilled cuttings from shale shakers. Although drilled cuttings may come from hydrocylones and centrifuges.

The invention also provides an apparatus for moving drilled cuttings, the apparatus comprising a cuttings processor for drying wet drilled cuttings from shale shakers, centrifuges and hydrocyclones, to produced dry drilled cuttings, a blow tank for receiving dried drill cuttings, and a means for supplying a gas to move the dried drill cuttings along a tube under positive pressure to a tertiary apparatus.

In one such method about thirty-five tons per hour of solids are processed.

For a better understanding of the present invention, reference will now be made, by way of example, to the accompanying drawings, in which:

Figures 1 to 5 are schematic representations showing an apparatus and steps in a method in accordance with the present invention in use;

Figure 6A is a top view of an air/solids separator in accordance with the present invention;

Figure 6B is a view in cross-section taken along line 6B-6B of Figure 6D;

Figure 6C is a side view of the separator of Figure 6A;

Figure 6D is a front view of the separator of Figure 6A;

Figures 7 and 8 are side views in cross-section of a slurry expansion chamber apparatus in accordance with the present invention;

Figure 9 is a side schematic view of a separator in accordance with the present invention;

Figures 10 and 11 are schematic views of systems in accordance with another aspect of the present invention; and

Figure 12 is a cross-sectional view of a prior art cuttings processor.

Figure 1 shows an apparatus 10 in accordance with the present invention in use. Three shale shakers SS are shown mounted on an offshore rig RG. However, any number of shale shakers may be on the rig RG and linked to the apparatus of the invention. The shale shakers SS process drilling fluid having drilling solids, drilled cuttings, debris, etc. entrained therein. Separated solids and/or cuttings (with minimal liquid) exit the shale shakers SS and are fed to a "ditch" having a screw conveyor SC (or to any other suitable cuttings movement apparatus or device) which moves the separated solids to a feed opening TO of a tank TA.

Solids from the tank TA are pumped, optionally, by one or more pumps PP (two shown) in a line 16 and, optionally, to and through collection devices; for example, optional cuttings boxes CB are shown in Figure 1. Pressurized air from a pressurized air source flows to slurry expansion chambers SE in which the density of the solids pumped from the tank TA is reduced. In one particular embodiment air is provided at about 1,420 litres per second to 2,830 litres per second (3000 cubic feet per minute to 6000 cubic feet per minute) or about 189 actual litres per second to 378 actual litres per second (400 to 800 ACFM (actual cubic feet per minute at 689 Kpa (100 p.s.i.))) air pressure in a line 16 ranges between 1 bar to 2.8 bar (15 and 40 p.s.i.); and, preferably, the solids density is relatively low, for example, between 125 grams per litre to 250 grams per litre (1 and 2 pounds per gallon) of fluid flowing in the line 16. The solids are impelled from the slurry expansion chambers SE by the pressurized air into lines 12 and 14 that flow into the line 16. Desirably, one such system will process 20 to 40 tons of material per hour. Preferably solids, cuttings, etc. flow continuously in the line 16 to storage tanks on a boat BT.

Floats FT may be used with the line 16 and tether/disconnect apparatus TD provides selective and releasable connection of the line 16 to corresponding flow lines 18 and 19 of the storage tank systems ST. Optionally, air/solids separators AS may be used to remove air from the incoming fluid and/or to concentrate the solids therein. Air escapes from the systems ST via gas outlets GO and solids exiting the systems ST flow directly to a dock/shipping facility or are collected in containers on the boat BT. The line 16 and/or tether/disconnect apparatus TD may be supported by a crane CR on the rig RG. It is also within the scope of this invention for its systems and methods to be used on land.

In one particular aspect the systems ST employ self-unloading storage tanks which have one or more air inlets on their sides with pressurized air flow lines connected thereto to prevent wet solids build upon the tanks internal walls and interior surfaces and to facilitate solids movement from the tanks. Optional air assist devices AD through which air under pressure is introduced into the line 16 may be used on the line 16 to facilitate solids flow therethrough.

Figure 2 shows a system 20 in accordance with the present invention, like the system 10 (like numerals and letters indicate like parts), but with tanks TK receiving solids from the tank TA. The solids flow by gravity into the tanks TK. Alternatively, or in addition to gravity flow, the solids may be moved by suitable conveyor apparatus, screw conveyor(s), belt movement apparatus, etc. Valves VL selectively control flow into the tanks TK and valves VV selectively control flow from the tanks TK into flow lines 21, 22. Pressurized air from a pressurized air source PS forces the solids from lines 21, 22 into a line 23 (like the line 16, Figure 1).

Figure 3 shows a system 30 in accordance with the present invention, in which some parts and apparatuses are like those of the systems 10 and 20 (like numerals and letters indicate like apparatuses and items). Material flows in the line 23 to a separator SR from which solids flow to a tank TC of a system TN. Gas (primarily if not wholly air) flows out from an opening OP of the separator SR. Pumps PM (one, two, or more) (for example, cement pumps or progressive cavity pumps) pump solids from the tank TC in lines 31, 32 and 33 to a vortex dryer VD. In certain aspects only one of the pumps PM is operational at any given time. One, two or more tanks TC may be used. Separated solids exit from the bottom of the vortex dryer VD. In one particular aspect the cuttings coming out of the bottom of the vortex dryer are about 95% dry, i.e., 5% by weight of the solids exit stream is oil, drilling fluid, etc. In certain aspects the systems 20 and 30 achieve continuous flow of 20 to 40 tons of solids per hour. An ultrasonic meter UM indicates the depth of solids in the tank TC and tank sensors TS measure the weight of solids therein.

Figure 4 shows a system 40 in accordance with the present invention which has some apparatuses and items like the systems 10, 20 and 30 (and like numerals and letters indicate like apparatuses and items). The separator SR separates solids from air in the line and feeds them primarily via gravity (optionally with a pressurized air assist) to one or more cuttings boxes CT. Air may be vented from opening(s) in the box CT. In accordance with the present invention a separator SR can be a separate apparatus interconnected with a tank or box in fluid communication therewith or it can be built into a tank or box as are integral part thereof. In one particular aspect the cuttings box CT is a commercially available Brandt FD-25 (Trademark) Cuttings Box. Figure 4A illustrates that the separator SR can be replaced with a cuttings processor CP (like the cuttings processor 110, Fig. 10, described below) that feeds processed cuttings to the box CT and that any separator SR in any system herein can be so replaced.

Fig. 4B illustrates that any tank TA in any system herein can be fed with cuttings from a cuttings processor CQ (like the cuttings processor 110, Fig. 10, described above).

Figure 5 shows a system 50, like the system 20 (like numerals and letters indicate like apparatuses and items), but with material fed in the line 23 to a separator SR on a cuttings box CT.

Figs 6A to 6D show one embodiment of a separator 60 in accordance with the present invention which may be used as the separator SR, above. A top 64a, mid section 64b, and lower section 64c are bolted together to form a housing 64. Material is fed into the top section 64a through a feed inlet 61 that is, preferably, tangent to the diameter. Gas flows out through a top opening 62. Mounted within the housing 64 is a generally cylindircal hollow vortex finder 65. In one particular aspect the diameter of the vortex finder 65 and the diameter of a solids exit opening 66 of the lower section 64c are sized so that the flow from the opening 66 is primarily solids (for example, between about 80% to 99% solids by weight) and the flow of gas out of the top opening 62 is primarily (99% or more) air; for example, with a housing 64 that is about 1.2m (48 inches) in height, with a mid section 64b about 0.6m (24 inches) in diameter, the top opening 62 is about 0.3m (12 inches) in diameter and the bottom opening 66 is about 0.25m (10 inches) in diameter. It is within the scope of this invention to provide such an apparatus with dimensions of any desired size.

Mounts 67 facilitate mounting of the separator SR on a tank, rig, boat, or other structure. Any suitable support, for example, one or more posts 68, may be used.

Figure 7 shows a slurry expansion chamber apparatus 70 in accordance with the present invention which has a main hollow body 71 with an opening 72. Material M flows through a feed tube 73 (for example, cuttings, fluid, and material from a wellbore) through the opening 72 into the main hollow body 71. Air under pressure from any suitable pressurized air source is introduced into a feed conduit 74 and then into a nozzle 75. A converging nozzle 75 is shown. The air mixes with the material M, reduces its density, and propels the reduced-density material R out through an exit opening 76. Optionally the nozzle 75 is deleted and the air flow and/or movement into the expansion chamber reduces the density of the material.

Figure 8 shows a slurry expansion chamber apparatus 80 in accordance with the present invention which has a main hollow body 81 with an opening 82. Material L flows through a feed tube 83 (for example, cuttings, fluid and material from a wellbore) through the opening 82 into the body 81. Air under pressure from a pressurized air source is introduced into a feed conduit 84 and then into a nozzle 85. The air mixes with the material L, reduces its density, and propels the reduced-density material T out through an exit opening 86. The apparatus in Figures 7 and 8 may be used as the slurry expansion chamber apparatuses in the systems of Figures 1 to 5.

Figure 9 shows an air/solids separator 90 usable as the separators AS, Figure 1, mounted on a base 99. A mixture of air and solids is introduced into a tank 91 through a feed conduit 92. Solids flow by gravity to an exit opening 93.

Optionally, a slurry expansion chamber apparatus SE receives the solids and propels them through a pipe 98 to storage, to a collection tank or tanks, or to a cuttings box, on shore, on a rig, or on a boat or barge. Air flows out from a top opening 94.

Optionally the separator 90 may be provided with a motor apparatus 95 (for example, a gear-box/air-motor-apparatus device) that rotates a screw 97 that inhibits or prevents the bridging of solids within the tank 91. Alternatively or in addition to such motor apparatus, devices like the air assist devices AD described above may be used to inhibit such bridging.

A valve 96 (for example, an air-operated valve) selectively closes off the opening 93 as desired.

Figure 10 shows a system 100 according to the present invention which has shale shakers SS (e.g. as in Figure 1) the processed solids, drilled cuttings, etc. from which are fed by a conveyor SC (as in Figure 1) to a cuttings processor 110. The conveyor may be any know conveyor, such as a screw conveyor arranged in a ditch, a belt conveyor or the cuttings mixed into a slurry and pumped in a pipe. The cuttings processor 110 is a rotating annular screen apparatus, which, optionally is formed in a conical shape, for example, as disclosed in GB-A-2,297,702 published Aug. 14, 1996. Commercially available embodiments of such annular screen apparatus are available from Don Valley Engineering Company Limited, including, but not limited to, its models MUD 8 and MUD 10. A method using one such annular screen apparatus includes applying a mixture of wet drilled cuttings (drill cuttings and drilling fluid) obtained from the shale shakers, hydrocyclones, centrifuges, to the inner surface of an annular filter screen, rotating the annular filter screen, the annular screen having a plurality of apertures, the apertures being of a size such that the drilling fluid can pass through the apertures but drill cuttings with oil are substantially prevented from passing through the apertures. The cuttings processor 110 significantly reduces the amount of fluid in the drilled cuttings; for example, in one particular embodiment from about 15% to 20% fluid by weight in the drilled cuttings reduces to about 1% to 3% therein. In one particular aspect the cuttings processor 110 and others herein like it fit within a 1 meter cube; hence they take up minimal space on a rig, platform or on a boat.

The treated drilled cuttings are then introduced into a hopper 112 from which they flow into a blow tank 120. A valve 113 selectively controls flow from the hopper 112 to the blow tank 120. Air under pressure, for example, at least 75 psi (5 bars) (in one aspect between 75 and 150 psi (5 and 10 bars) and in one aspect about 125 psi (8.6 bars)), flows into the blow tank 120 in a line 114 from a positive pressure air source 115. In one aspect, all of the items SS, SC, 110, 112, 120, 114 and 115 and their associated lines, valves and controls are all located on a drilling rig in one aspect an offshore drilling rig. The blow tank 120 may be like the tanks TK and their associated apparatus, Figure 2 or Figure 3.

In the offshore drilling rig situation, as shown in Figure 10, processed drill cuttings are fed from the blow tank 120 (with the valve 135 open), with a valve 123 closed, and a valve 122 and 136 open, and with a valve 142 closed, in a line 121 to a cuttings box CB (like those described above) on a ship 116 in the water adjacent the offshore rig. Optionally with valve 136 closed and valve 124 open, the drilled cuttings are fed to a blow tank 127 from which they can be fed to any suitable on-ship or off-ship storage device or processing apparatus. A pressurized air source 141 on the ship provides air under pressure to the blow tank 127.

Optionally either or both of the cuttings box CB or the blow tank 127 can be fed with drilled cuttings processed by a cuttings processor 130 or 140, respectively, as indicated by the dotted lines in Figure 10. In one aspect with the valve 122 closed and a valve 142 open, drilled cuttings are fed from the blow tank 120 in a line 125 to a cuttings processor 130 (like the cuttings processor 110) and processed cuttings are fed in a line 126 to the cuttings box CB. In one aspect with the appropriate valves open and the appropriate valves closed, including a valve 124 closed, drilled cuttings are fed in a line from the blow tank 120 to a cuttings processor 140 (like the cuttings processor 110) and processed cuttings are fed in a line 129 to the blow tank 127. A valve 132 selectively controls the flow of drilled cuttings from the blow tank 127. In one aspect drilled cuttings from the blow tank 127 are fed in a line 131 to a cuttings processor 150 (like the cuttings processor 110) and processed cuttings flow in a line 133 from the cuttings processor 150 (e.g. to a cuttings box, to other storage apparatus, or to off-ship storage or processing.

In one particular embodiment of a system as described in Figure 10 above, drilled cuttings conveyed to the cuttings processor 110 have 15% to 20% fluid by weight and drilled cuttings fed from the cuttings processor 110 to the hopper 112 have 1% to 3% fluid by weight. As desired any number of positive pressure air assist devices 146 can be used on the line 121. In one particular embodiment for about 1 cubic meter of total material fed to the cuttings processor 110, about 0.5 cubic meter is received by the blow tank 120.

It is to be understood that the cuttings processors used in certain embodiments of the present invention (like the processor 110 and those like it) receive material that includes drilled cuttings and recoverable drilling fluid. The cuttings processor produces primary drilled cuttings whose drilling fluid component is much less by weight than the fluid-laden material in the initial feed. As shown in Figure 3B primary drilled cuttings from the processor 110 are, in one particular embodiment, fed to mill apparatus 170 to break up agglomerated masses of drilled cuttings. The mill apparatus, in one aspect, is a pug mill. The mill apparatus 170 produces drilled cuttings with some fluid therein which are fed in a line 171 to the blow tank 120. The processor 110 also produces a secondary stream 172 that contains drilling fluid and some drilled cuttings. The stream 172, in one aspect, is fed to further processing apparatus which, in one aspect, is one or more decanting centrifuges, e.g. decanting centrifuge apparatus 173, which produces recyclable drilling fluid that exits in a line 174 and drilled cuttings 175 with some drilling fluid therein. The drilling fluid 174 is fed back into a rig mud system for re-use in a drilling operation. The drilled cuttings 175, which may be in the form of a paste, are, in one aspect, fed to the mill apparatus 170; or are fed to the blow tank 120 without milling (shown by dotted line, Figure 3B). Any system herein may employ mill apparatus 170 and/or further processing apparatus like the apparatus 173.

As shown in Figure 3B, to measure the amount of material within the blow tank 120 and the amount fed to and within the cuttings box CB, load cell apparatus 180 is used on the blow tank 120 and the cuttings box CB which can provide continuous monitoring of the weight of material in these apparatuses; and, optionally, ultrasonic level probes 177 monitor the level of material in these apparatuses. Optionally, timer apparatus 178 monitors the time of flow into the blow tank 120.

Figure 11 shows a system 200 according to the present invention which is an improvement of systems disclosed in European Patent EP 1,187,783 B1 granted Sept. 24, 2003. An offshore oil rig 201 has located on a platform 203 a pressure vessel 205 into which is loaded screened drill cuttings arising from a drilling process. The pressure vessel 205 includes an upper material inlet and a lower material outlet as well as apparatus for supplying compressed air to the interior of the vessel. The material inlet includes a valve assembly and the entire vessel may be similar to that manufactured and sold by Clyde Materials Handling Limited. The pressure vessel may hold between 0.25 cubic metre to 20 cubic metres or more of drill cuttings. In one embodiment the pressure vessel holds 0.3 to 1 cubic metres of drill cuttings. Initially, drilled cuttings are fed to a cuttings processor 210 (like the processor 110, Figure 10) and the cuttings processed by the cuttings processor 210 are fed to the pressure vessel 205. The material from the processor 210 may be a free-flowing or a non-free flowing paste depending on how much fluid the cuttings processor 210 removes.

The pneumatic conveying system, including the pressure vessel 205, follows a cycle of filling and discharging material from the pressure vessel. At the start of the cycle, the material inlet valve is closed. A vent valve is opened to equalize vessel pressure to ambient air. The inlet valve is opened and the oil cuttings/oil mixture is fed into the pressurized vessel. The vent valve is opened to vent displaced air from the vessel. When the pressurized vessel if full, the inlet valve closes. The vent valve also closes and the vessel is now sealed. An air inlet valve is opened and the material is conveyed along a pipe 207 which extends from a position below pressurized vessel 205 to an elevated position above a container assembly 209. Assembly 209 can include three ISO container sized vessels 211 located within a support framework 214. (In other embodiments, the container assembly may include a number of vessels 211 other than three.) Pipe 207 extends above the top of container assembly 209 and has downwardly extending branches leading into the inlets of each of the containers 211.

Each container 211 has a lower conical shaped hopper portion 215 and at the lowermost point of this portion there is a valve inlet 217 whereby the material within the containers 211 may be discharged via pipe 219 to a hose connection pipe 221. Optionally using positive pressure to push the dried drill cuttings along the pipe 227, 229 in slugs at a slow rate or by dropping the cuttings into an expansion chamber and moving the low density cuttings at high speed.

A supply boat 223, fitted with a further container assembly 225, may be brought close to the oil rig 201. A flexible hose 227 is connected to pipe 219 at hose connection pipe 221. At its other end hose 227 is connected to a filling pipe 229 located on boat 223. Filling pipe 229 leads from the rear of boat 223 to a position above container assembly 225 and branch pipes extends downwardly from pipe 229 to the inlets of each of the containers 231 forming part of the containers assembly 225.

Optionally, using appropriate valving and controls (not shown) material in the flexible hose 227 is fed to a cuttings processor 250 (like the cuttings processor 110,

Figure 10) on the boat 223 which then provides processed cuttings to the container assembly 225. The cuttings processor 250 may not be required, the cuttings passing directly into the container assembly 225. Optionally, cuttings from the container assembly 225 are fed to a cuttings processor 252 (like the cuttings processor 110, Figure 10) from which processed cuttings may be provided to storage or further processing on the boat 223 and/or on shore. Positive pressure is applied to containers 225 in order to push the drilled cuttings through a pipe on to shore at a dock. Again, either using positive pressure to push the dried drill cuttings along the pipes in slugs at a slow rate or by dropping the cuttings into an expansion chamber and moving the low density cuttings at high speed.

Figure 12 illustrates a prior art rotating annular screen apparatus as disclosed in U.K. Patent Application GB 2,297,702 A published Aug. 14, 1996, which e.g., in certain aspects, can serve as the cuttings processor 110, Figure 10, and the like cuttings processors mentioned above. The cuttings processor 301 in Figure 12 is a vibrating centrifuge for use with the present invention, consisting of an outer body 303, a conical screen 305 having a small radius end 306 and a large radius end 308, a drive shaft 307 for rotating the conical screen 305 and a feed tube 209. The conical screen 305 is rotated by the drive shaft 307 with a centrifugal force acting on the conical screen 305, e.g. a force of between 10g and 200g. A linear motion is applied along the longitudinal axis of the drive shaft 307, e.g. with a force per unit mass of up to 5g and an amplitude of up to 10mm. As the conical screen 305 is directly coupled to the drive shaft

307, this linear motion is imparted onto the conical screen 305. The angle of the conical screen 305 is critical to the efficiency of the process and can range from 10 degrees to 110 degrees depending on the efficiency required. A mixture of drilling cuttings and oil, e.g., oil in oil based drilling mud, is conveyed into the input port 311, falls down the feed tube 309 and is guided onto the small radius and 306 of the conical screen 305 by a feed tube guide 313. The vibrating centrifuge separates the drilling mud from the drilling cuttings by the combination of the centrifugal force supplied by the rotating conical screen 305, the linear motion imparted on the conical screen 305 and the angle of the conical screen 305. As the mixture of drilling mud and drilling cuttings are conveyed onto the rotating conical screen 305, the centrifugal force forces the drilling mud to migrate through apertures in the conical screen 305. However, the apertures are of a size such that the drilling cuttings are too large to migrate through the apertures in the conical screen 305, and hence are retained on an inside surface 315 of the conical screen 301. The linear motion, which is produced by the drive assembly of the vibrating centrifuge, conveys the retained drilling cuttings towards the large radius end 308 of the conical screen 305. Because of the conical form of the screen 305, as the drilling cuttings are conveyed towards the large radius end 308 of the conical screen 305, the force per unit mass acting on the drilling cuttings increases and so further removing any remaining residual oil based drilling mud from the drilling cuttings. The recovered drilling mud flows off the outside surface 317 of the conical screen 305 and exits the outer body 303 through recovered mud exit pipe 319. After the drilling cuttings have been conveyed along the length of the conical screen 305 and passed through the large radius end 308, the drilling cuttings exit the outer body 303 through dry drilling cutting exit ports 321, 323. In one particular aspect, the level of oil retained on the drilling cuttings after the cuttings have been ejected from the vibration centrifuge is reduced to between 0.015 kg and 0.04 kg of oil per kilogram of drilling cuttings.

CLAIMS:

1. A method for moving drilled cuttings, the method comprising the step of receiving wet drilled cuttings from at least one of a shale shaker, centrifuge and hydrocyclone, characterised in that the method comprises the further steps of drying the wet drilled cuttings to produce dry drilled cuttings comprising 1% to 3% moisture to solids by weight, and moving the dried drilled cuttings using positive pneumatic pressure through a tube to a tertiary apparatus comprising a storage vessel and means for supplying positive pressure for facilitating movement of drilled cuttings from the storage vessel through a conduit.

2. The method in accordance with Claim 1, wherein the wet drilled cuttings comprise solids and moisture and are 15% to 20% moisture to solids by weight.

3. The method in accordance with Claim 1 or 2, wherein the storage vessel comprises a lower conical shaped hopper portion.

4. The method in accordance with Claim 1, 2 or 3, wherein the method further comprises the step of receiving the wet drilled cuttings from at least one of the shale shaker, centrifuge and hydrocyclone using a screw auger in a ditch.

5. The method in accordance with any one of Claims 1 to 4, wherein the method further comprises the step of receiving the wet drilled cuttings from the shale shakers, centrifuges and hydrocyclones using with a conveyor belt.

6. The method in accordance with any one of Claims 1 to 5, wherein the step of drying is performed by a cuttings processor.

7. The method in accordance with Claim 6, wherein the cuttings processor comprises a rotating conical screen.
8. The method in accordance with Claim 6 or 7, wherein the cuttings processor vibrates.
9. The method in accordance with Claim 7 or 8, wherein the cuttings processor is located on an oil rig, oil platform or drilling vessel.
10. The method in accordance with any one of Claims 1 to 9, wherein the tertiary apparatus is located on a boat or transporter.
11. The method in accordance with any one of Claims 1 to 10, wherein the storage vessel is taken from the group: cuttings box, tank, container, or a receptacle on a boat.
12. The method in accordance with any one of Claims 1 to 11, wherein the tertiary apparatus comprises a further cuttings processor or decanting centrifuge.
13. The method in accordance with any one of claims 1 to 12, wherein the storage vessel further comprises a pressure vessel and a pipe connection means, such that a pipe is connected to the pipe connection means and upon pressurisation of the pressure vessel, dry drilled cuttings flow from the storage vessel through said pipe.
14. The method in accordance with any one of Claims 1 to 13, wherein said tube comprises at least one pneumatic fluid movement assistance device.
15. The method in accordance with any one of Claims 1 to 14, wherein the dried drilled cuttings are fed into said tube with a blow tank.
16. The method in accordance with Claim 15, wherein the dried drilled cuttings pass from a feed hopper into said blow tank.
17. The method in accordance with Claim 16, wherein a

valve is located between the hopper and the blow tank, the method further comprising the step of selectively allowing dried drilled cuttings into the blow tank.

18. The method in accordance with any one of Claims 1 to 17, wherein, the dried drilled cuttings are transferred in slugs using said positive pressure pneumatic fluid.

19. The method in accordance with Claim 18, wherein the slugs are transferred at low speed.

20. The method in accordance with Claim 18 or 19, wherein the conduit comprises at least one pneumatic fluid movement assistance device to facilitate movement of the drilled cuttings material therethrough or to inhibit blockages from forming therein.

21. The method in accordance with Claim 20, wherein the at least one pneumatic fluid movement assistance device is located at an intermediate point along said conduit, the method further comprising the step of using the at least one pneumatic fluid movement assistance device to facilitate movement of the drilled cuttings material through the conduit or to inhibit blockages from forming in said conduit.

22. The method in accordance with any one of Claims 1 to 17, wherein the dried drilled cuttings are reduced in density using an expansion chamber with a gas and transferred using a positive pressure pneumatic fluid at high speed.

23. The method in accordance with Claim 22, wherein the gas is separated from the dry drilled cuttings in a separator at the tertiary apparatus.

24. The method in accordance with any one of Claims 1 to 23, further comprising the step of obtaining secondary drilling fluid and secondary small cuttings resulting

from the step of drying in the cuttings processor.

25. The method in accordance with Claim 24, wherein the secondary drilling fluid and secondary small cuttings is recycled for reuse in a drilling operation.

26. The method in accordance with Claim 24 or 25, wherein the secondary small drilled cuttings are sent to a mill apparatus for breaking up agglomerations of said secondary small drilled cuttings, and said secondary small drilled cuttings are moved with said drilled cuttings using the method.

27. The method in accordance with any one of claims 1 to 26, wherein the pneumatic fluid is air.

28. An oil rig comprising an apparatus for moving drilled cuttings material which has been separated from a drilled cuttings laden drilling mud using at least one of a shale shaker, a hydrocyclone and a centrifuge, the apparatus comprising a cuttings processor for drying wet drilled cuttings from a shale shaker, centrifuge or hydrocyclone, to produced dry drilled cuttings, a blow tank for receiving dried drill cuttings, and a means for supplying a gas to move the dried drill cuttings along a tube under positive pressure to a tertiary apparatus comprising a storage vessel having means for supplying positive pressure for facilitating movement of drilled cuttings from the storage vessel.

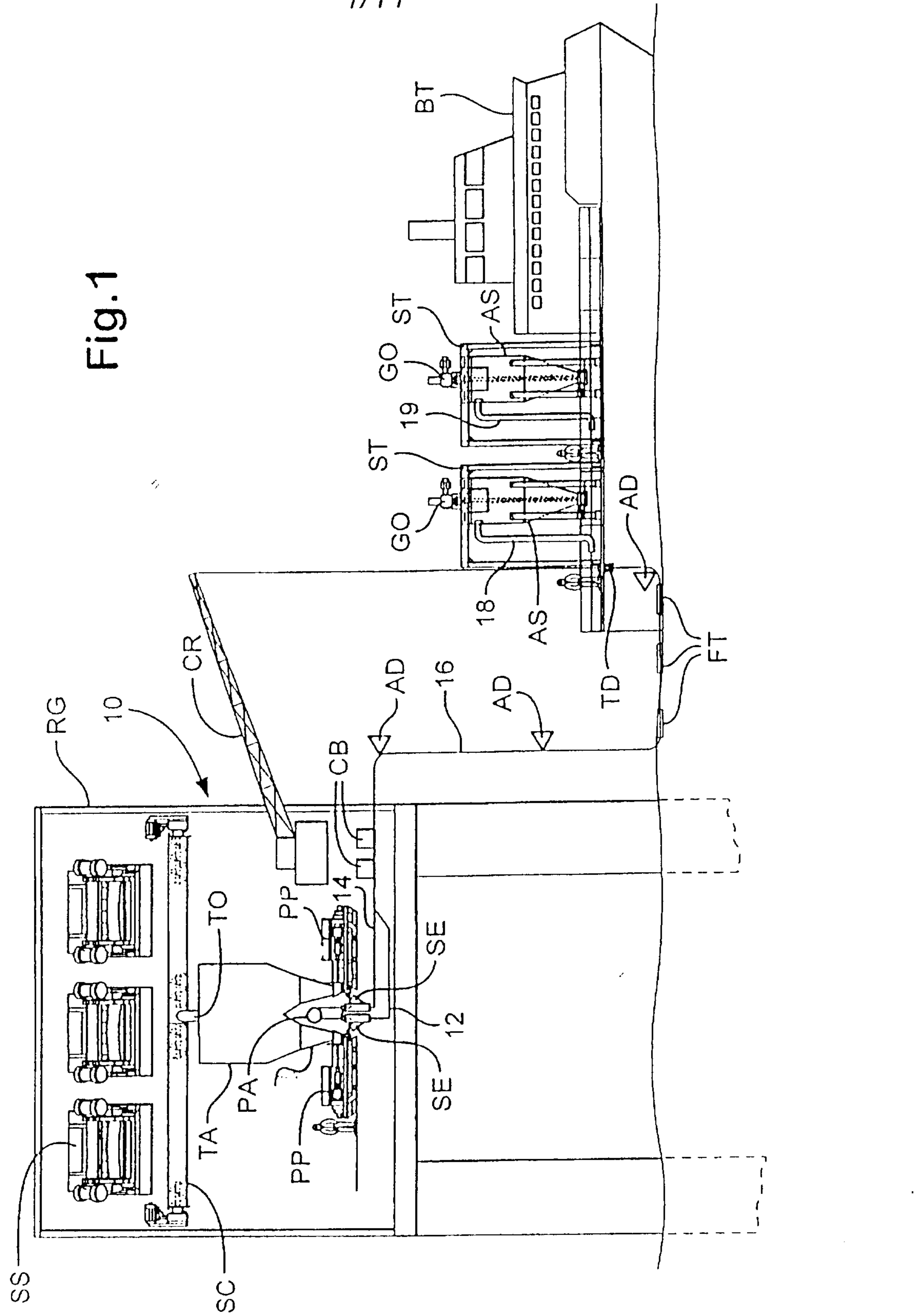
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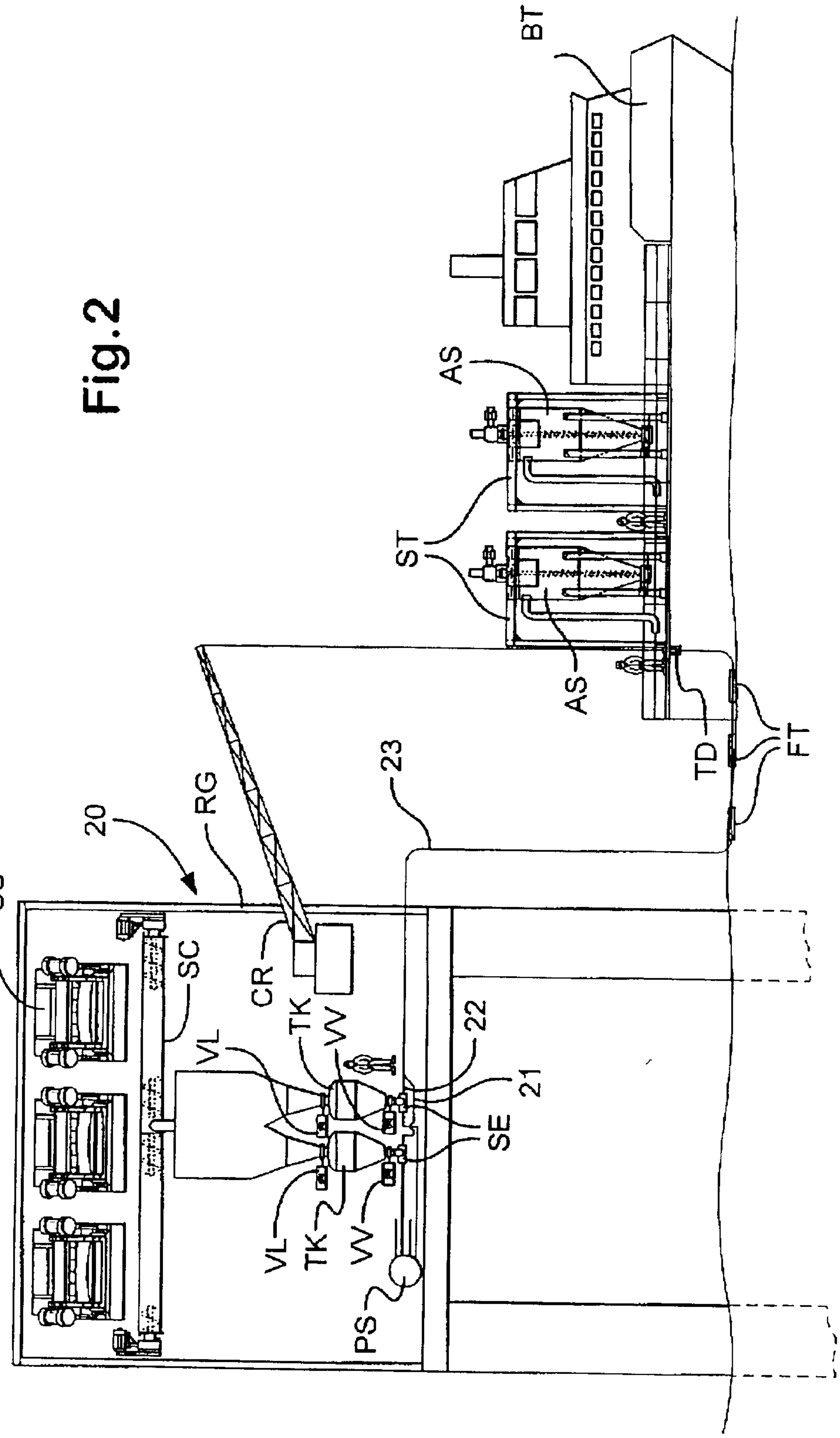
Fig.1

Fig.2



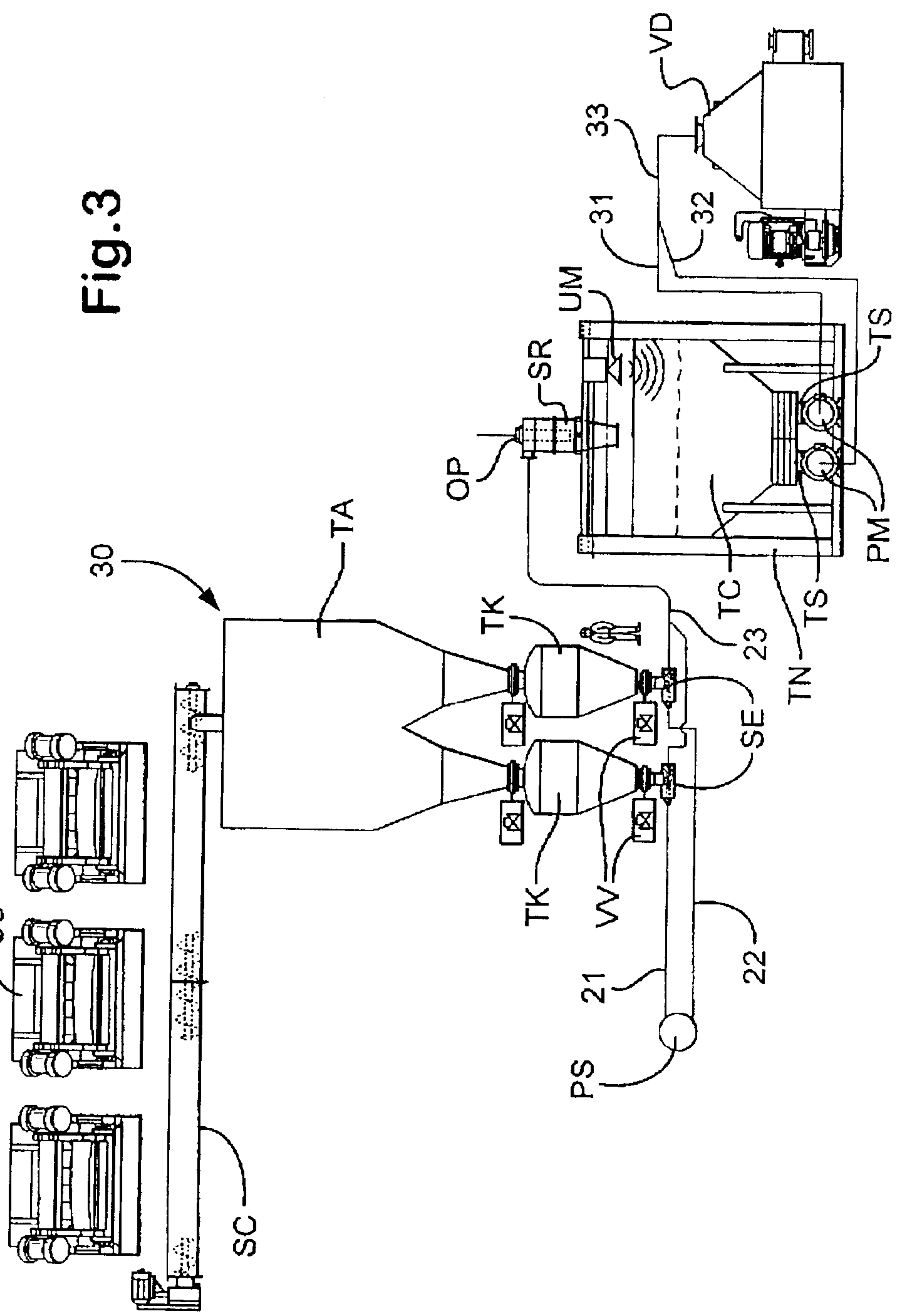

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Fig.3

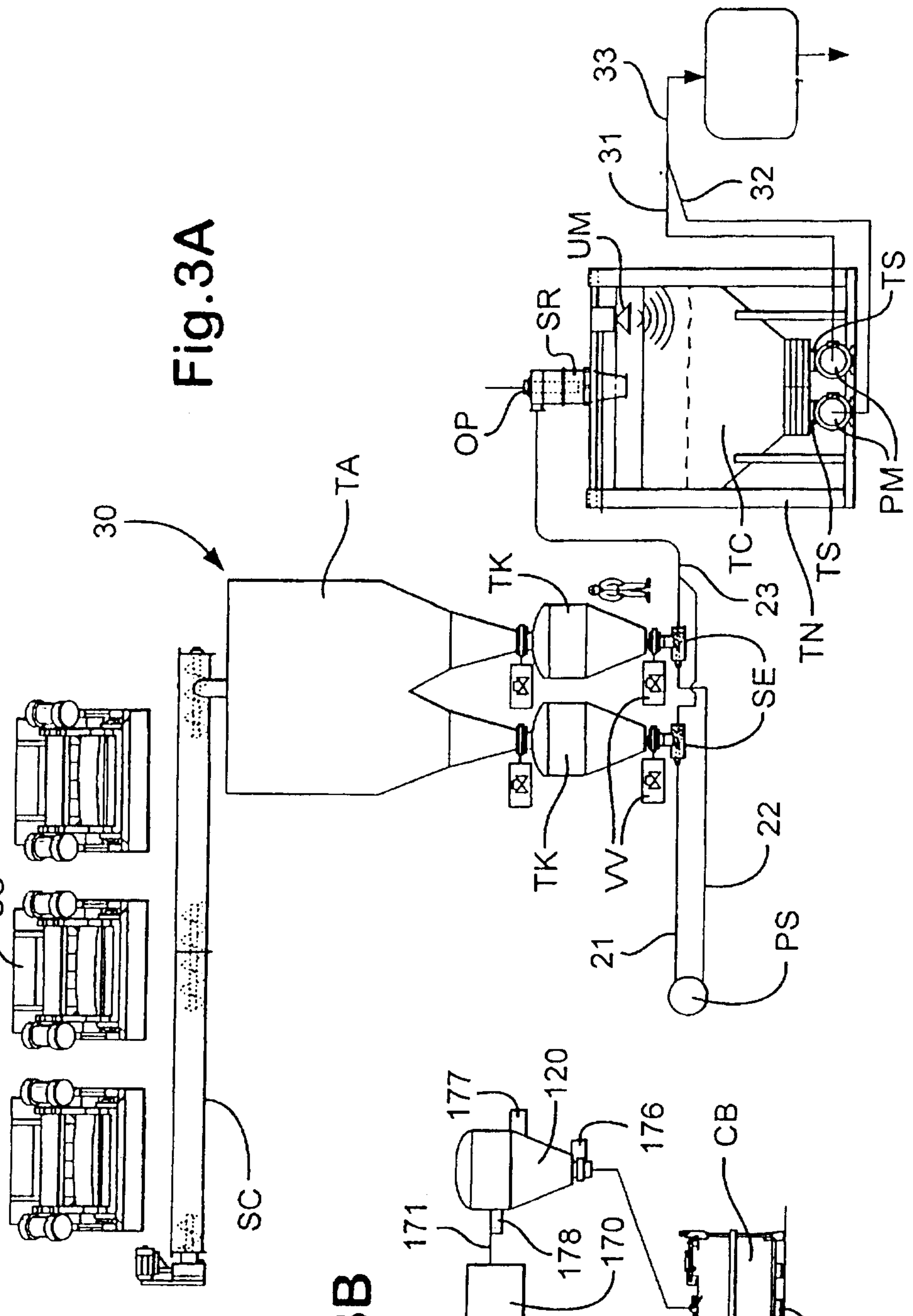
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Fig.3A

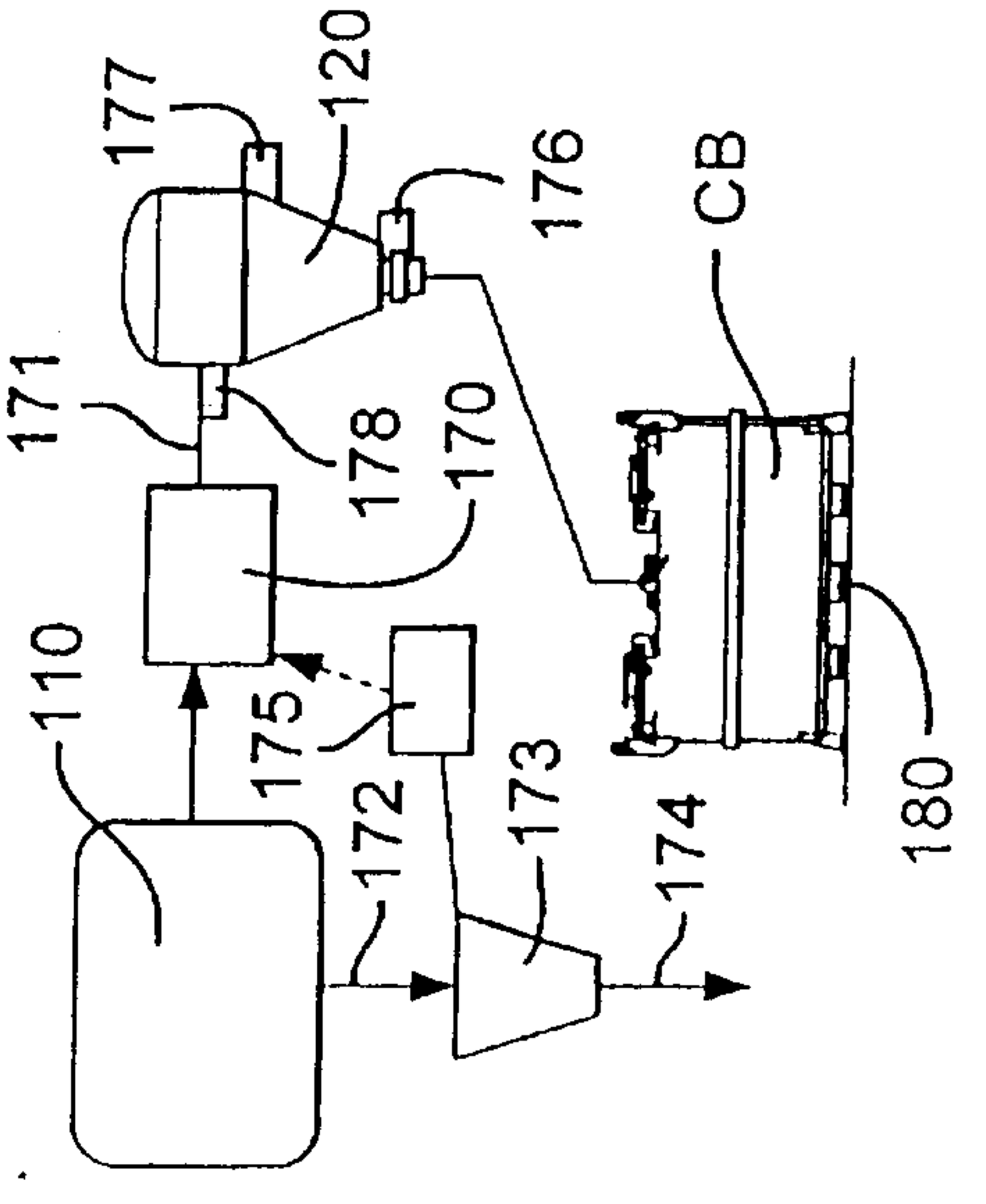
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Fig.3B

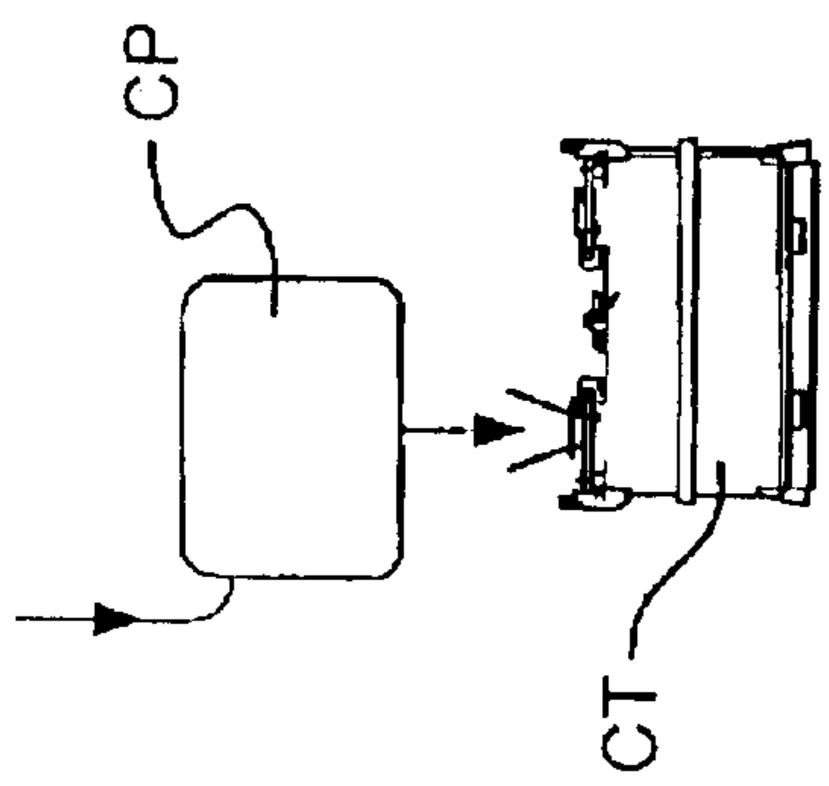


Fig.4A

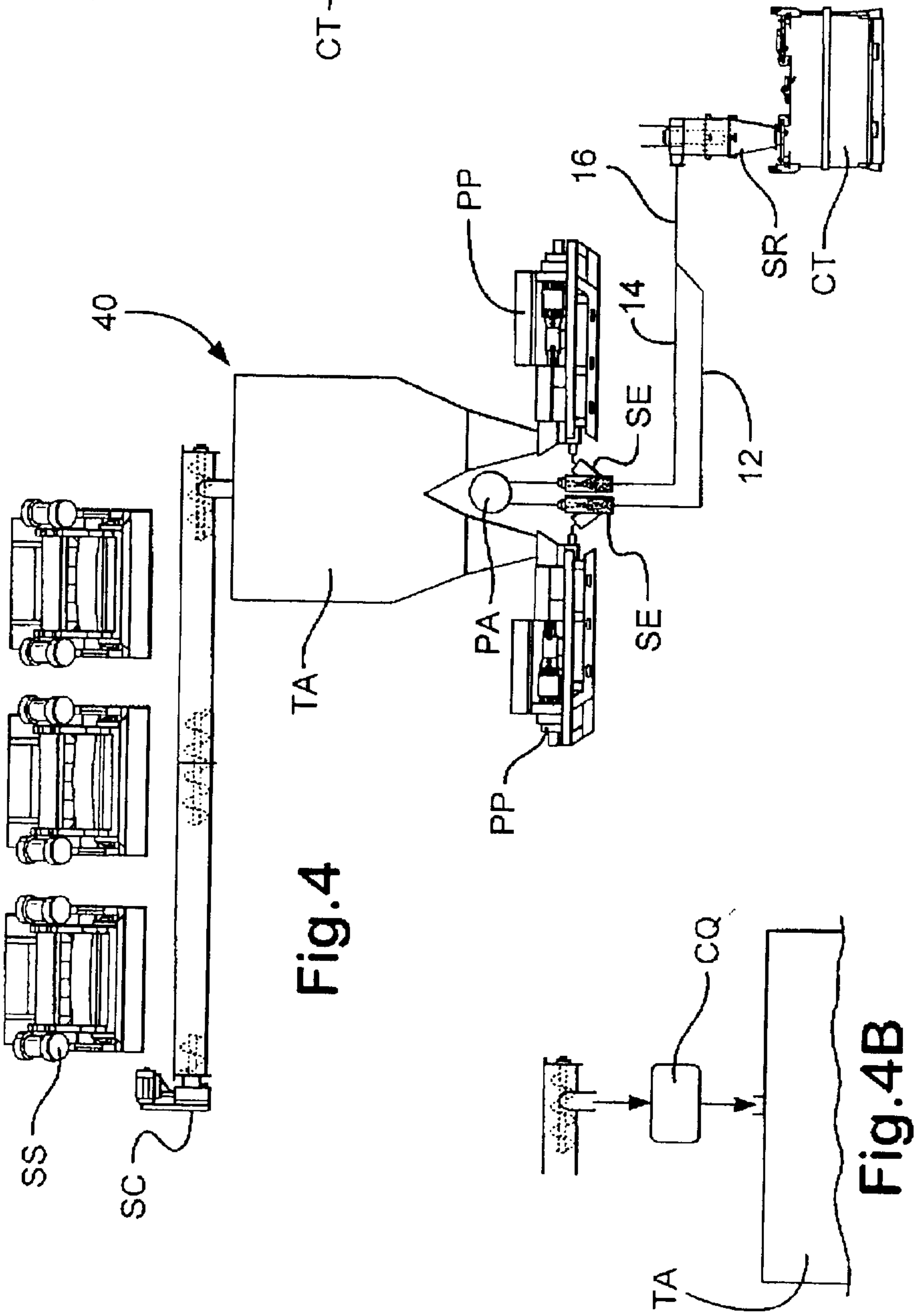
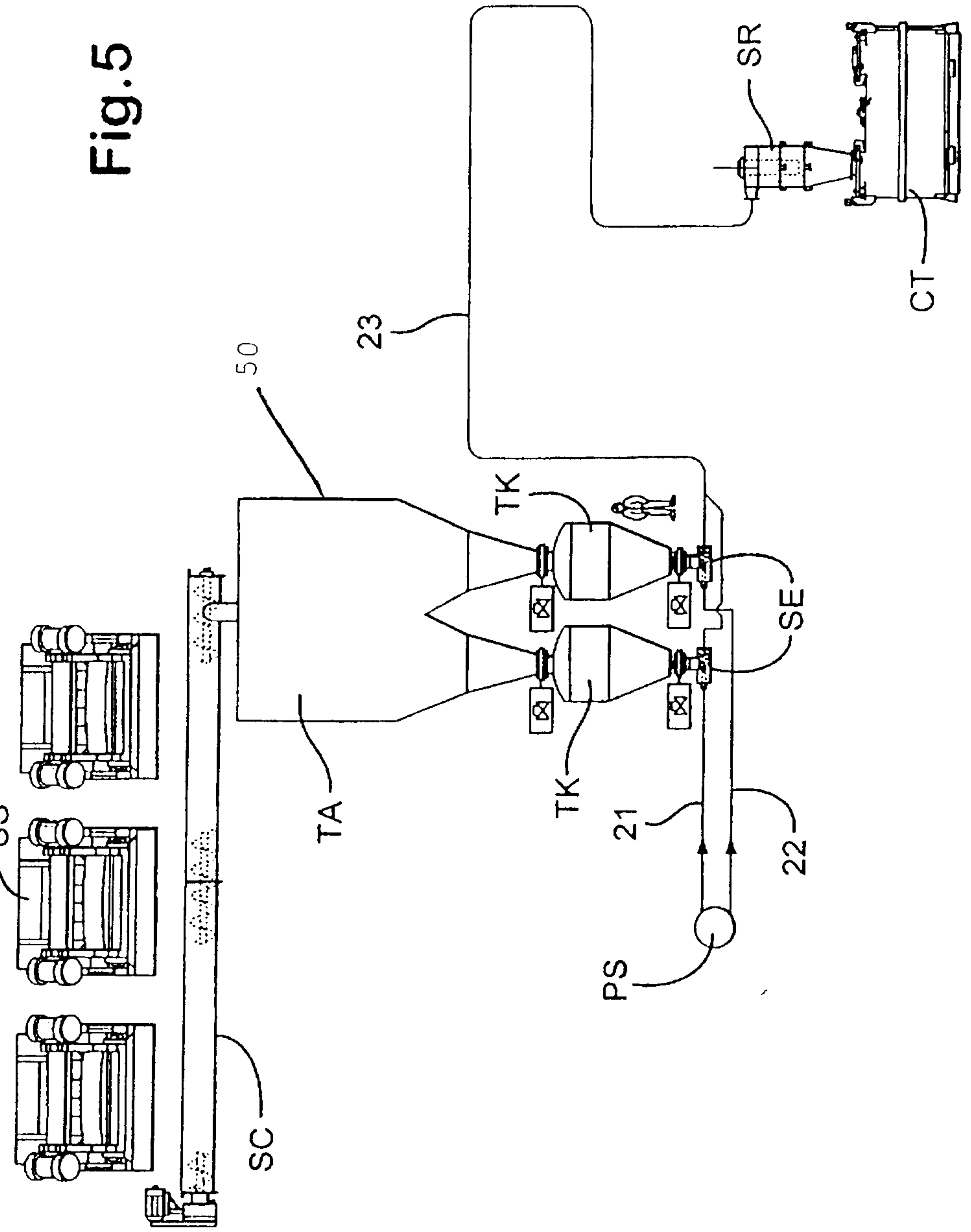


Fig.4

Fig.4B

Fig.5



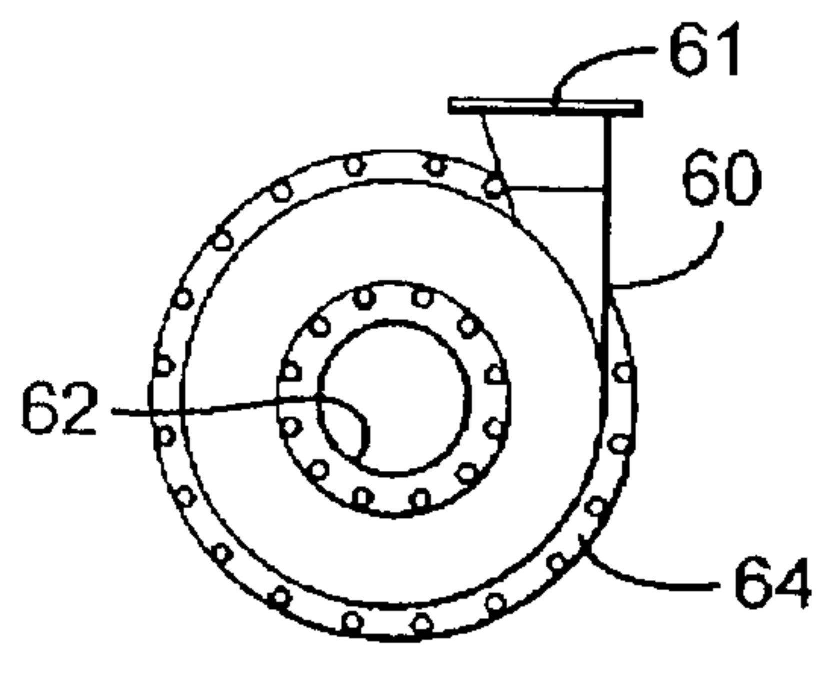


Fig.6A

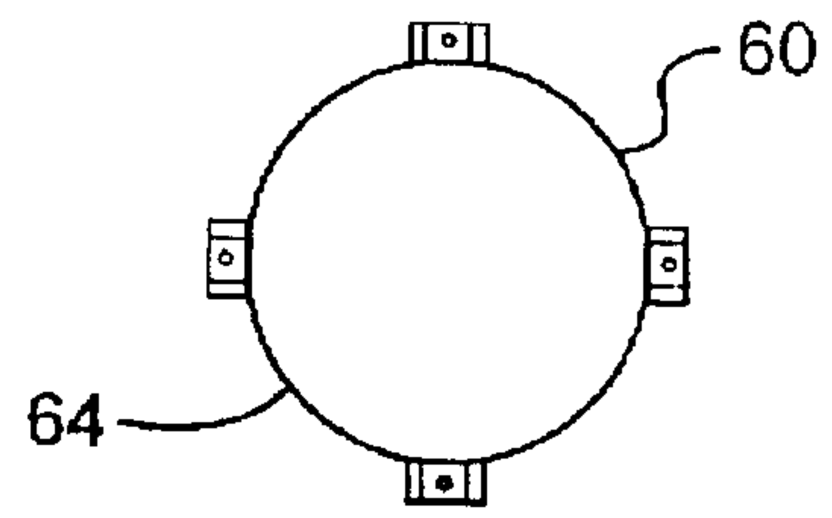


Fig.6B

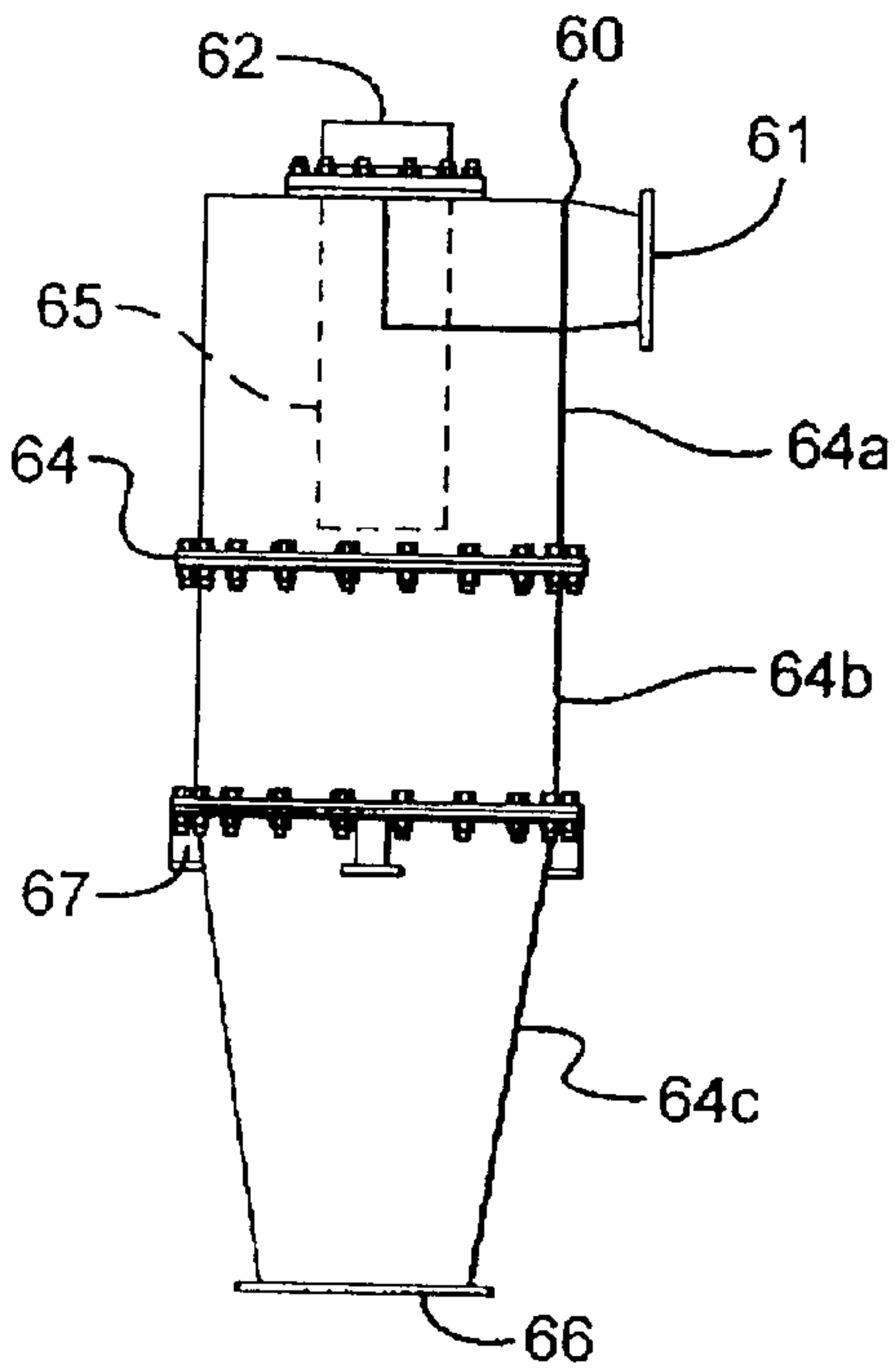


Fig.6C

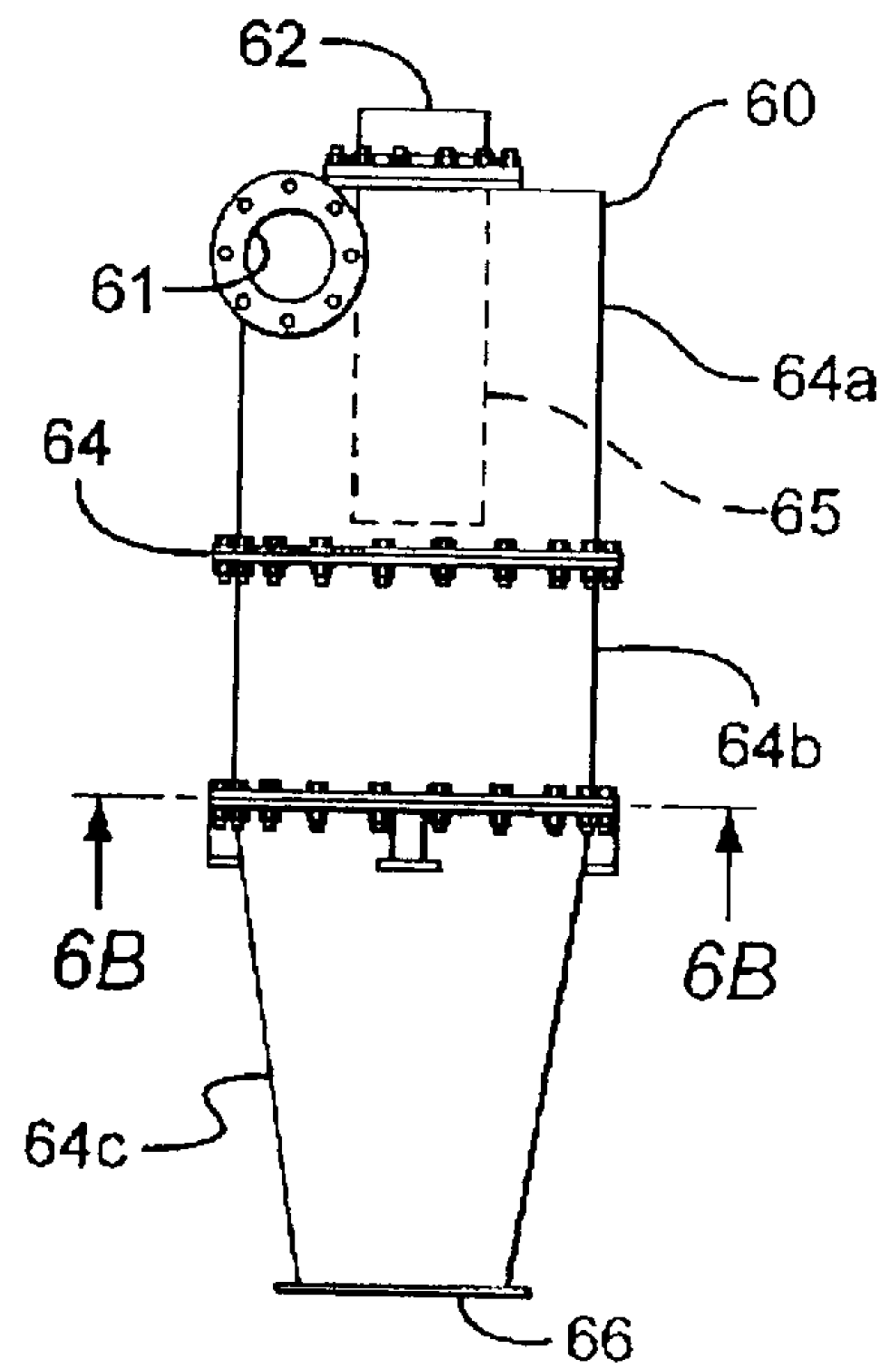


Fig.6D

Fig.7

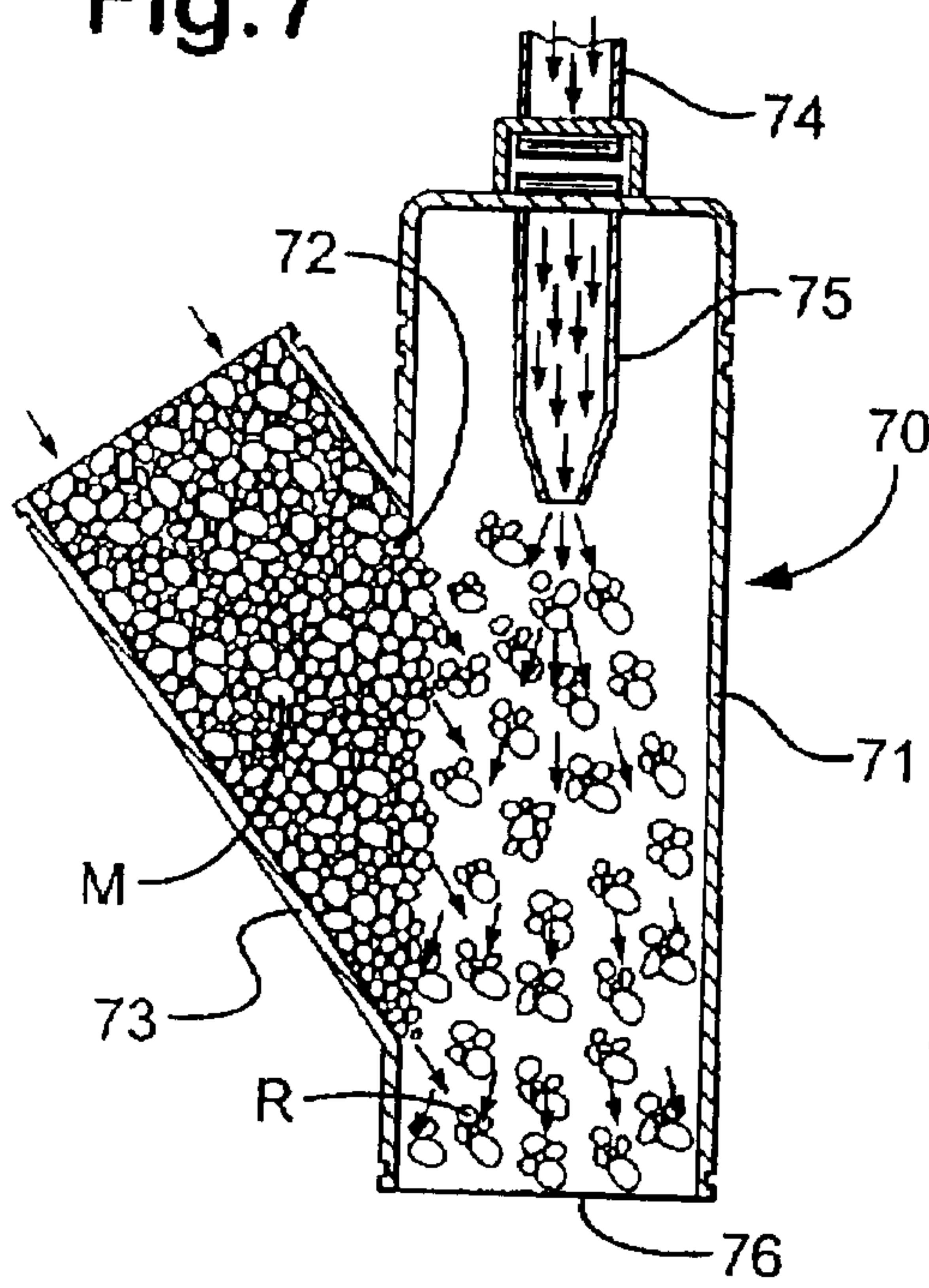


Fig.9

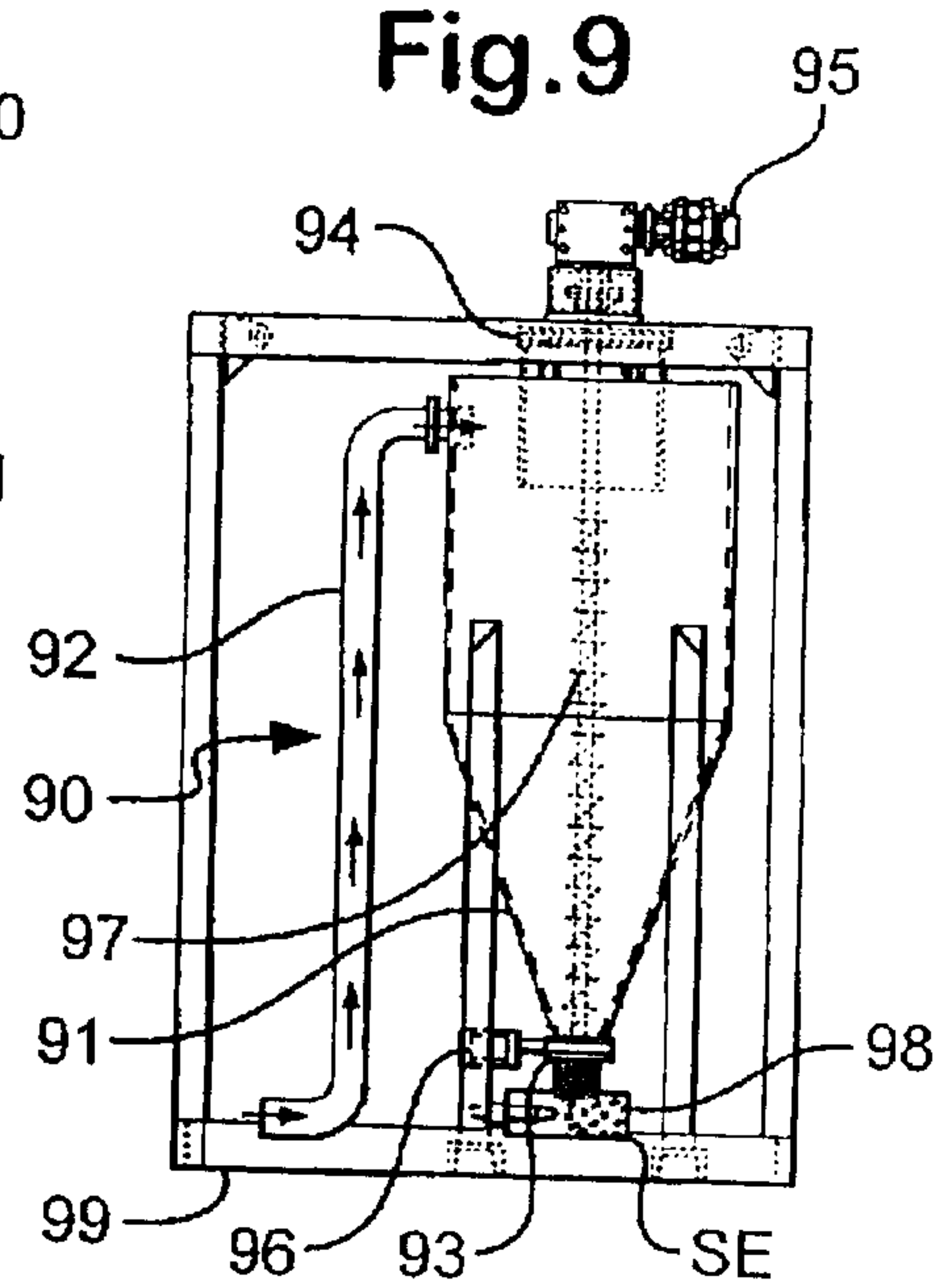
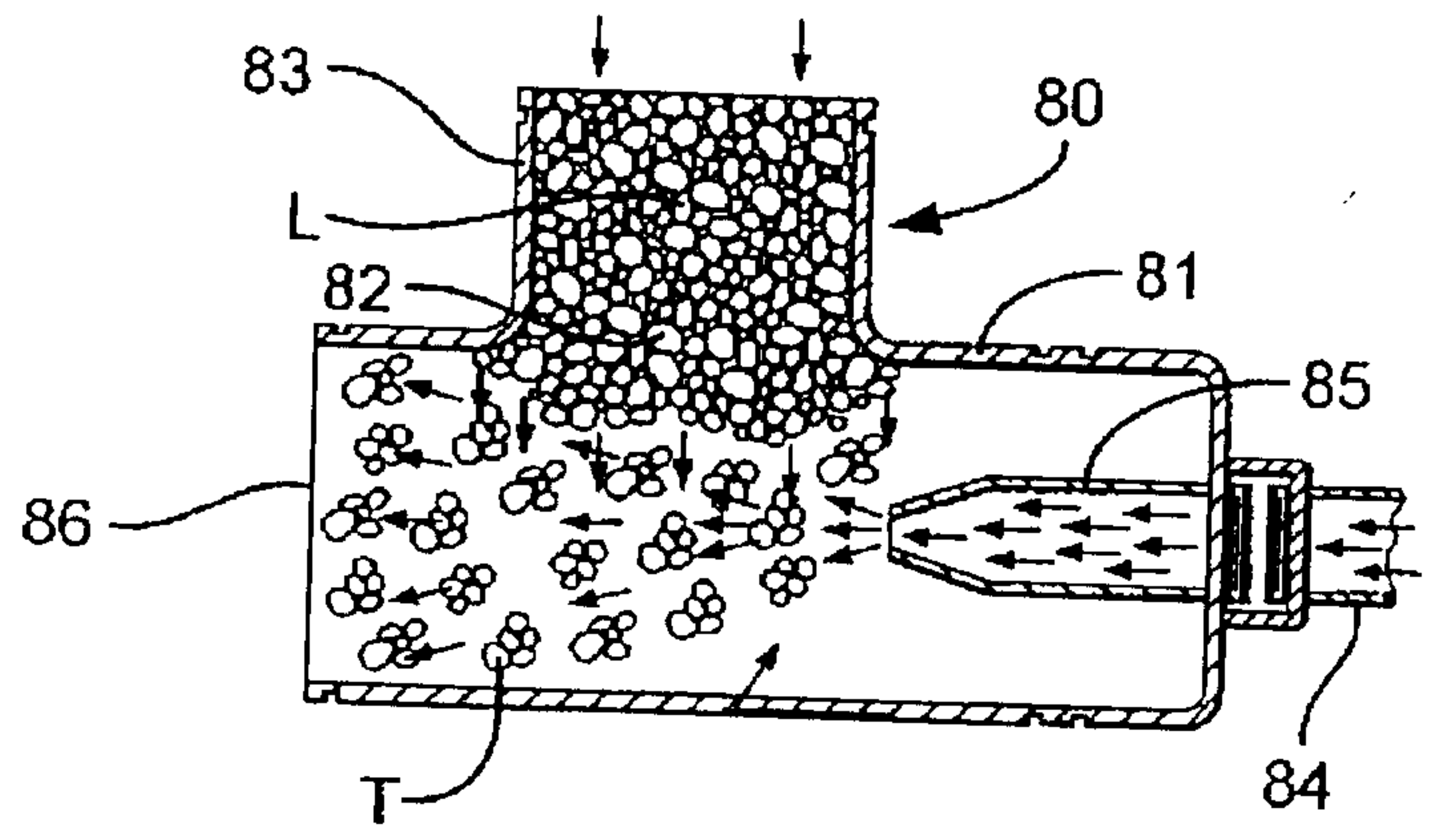


Fig.8



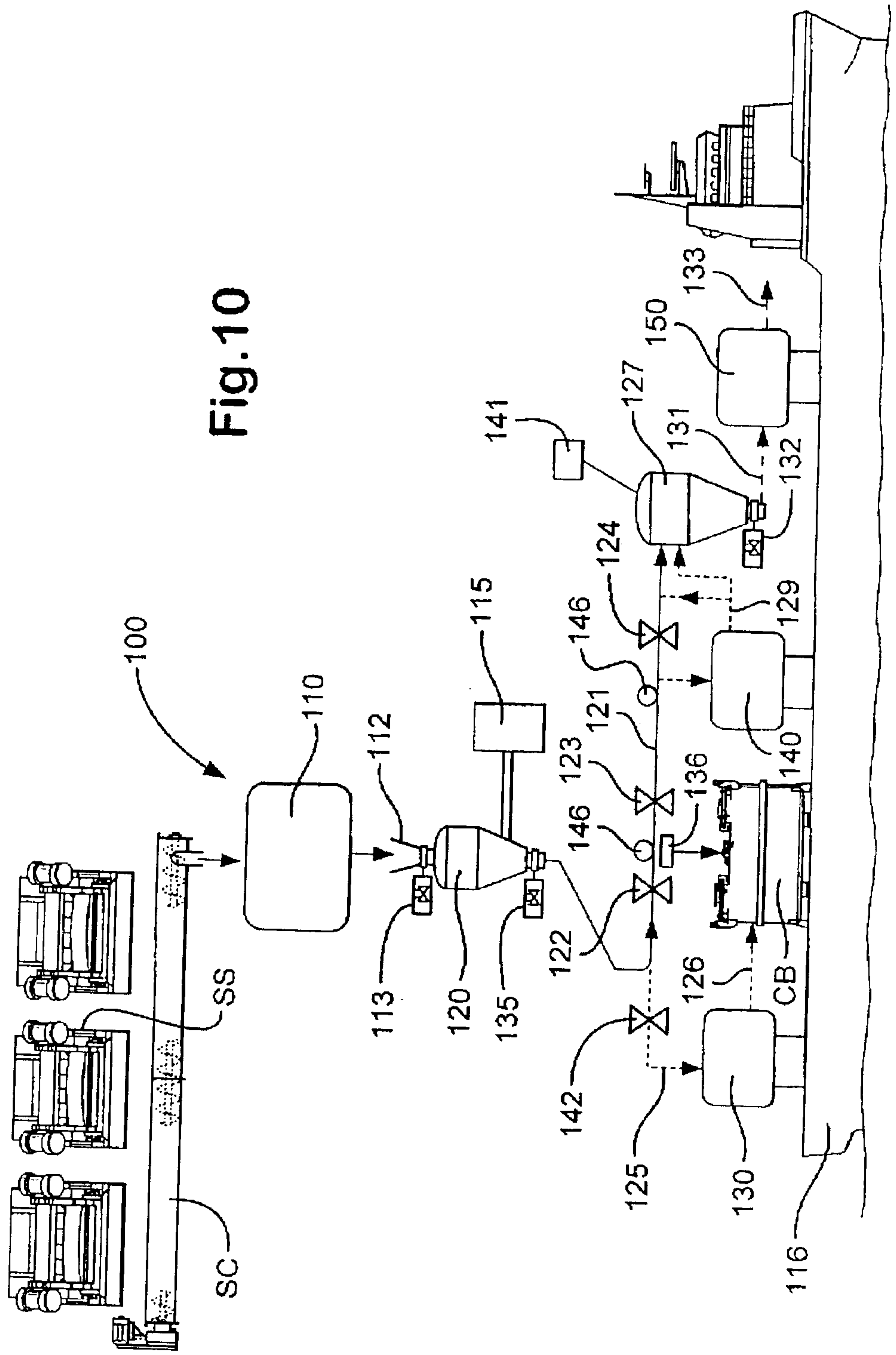

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Fig.10

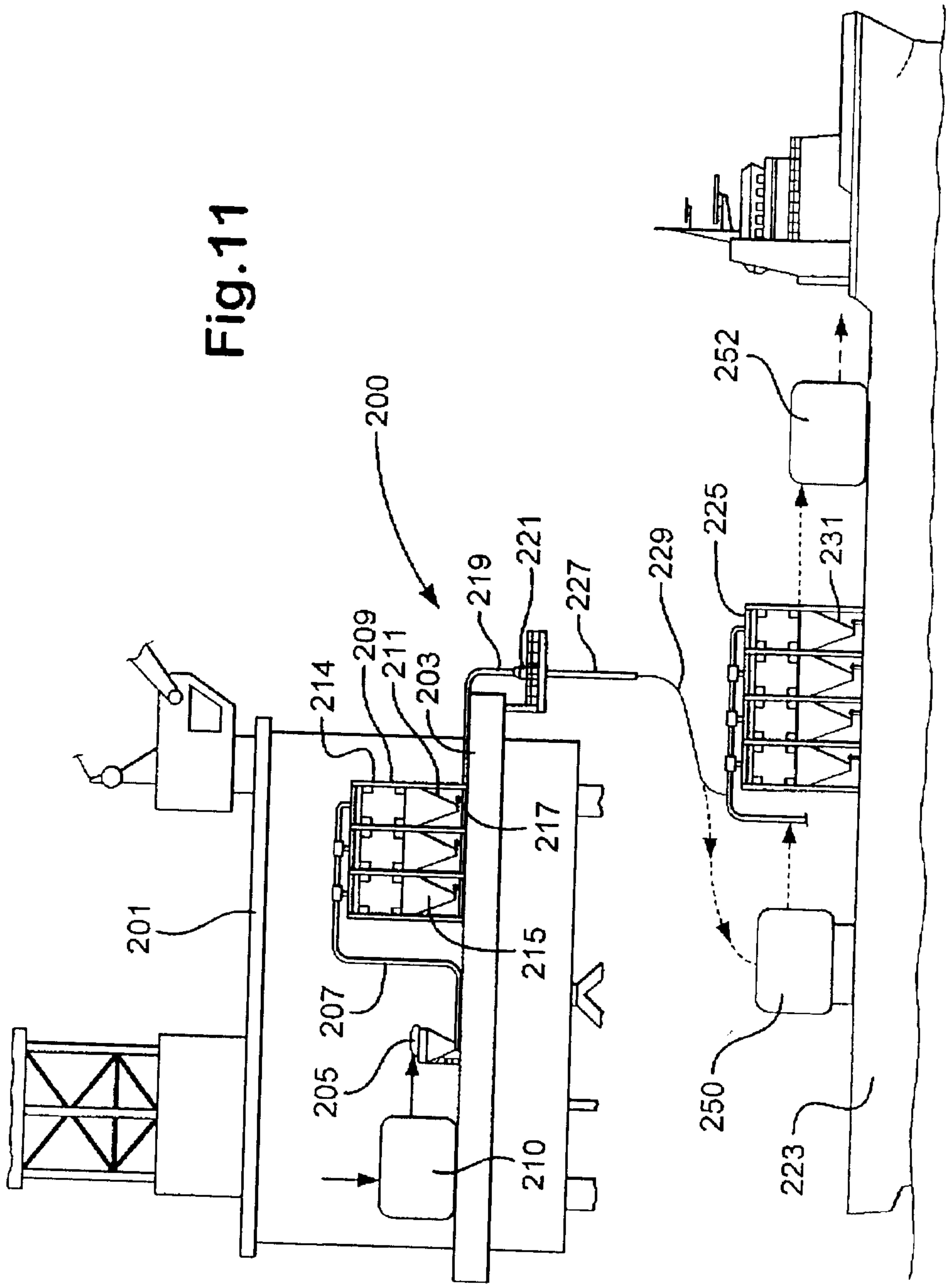
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Fig.11

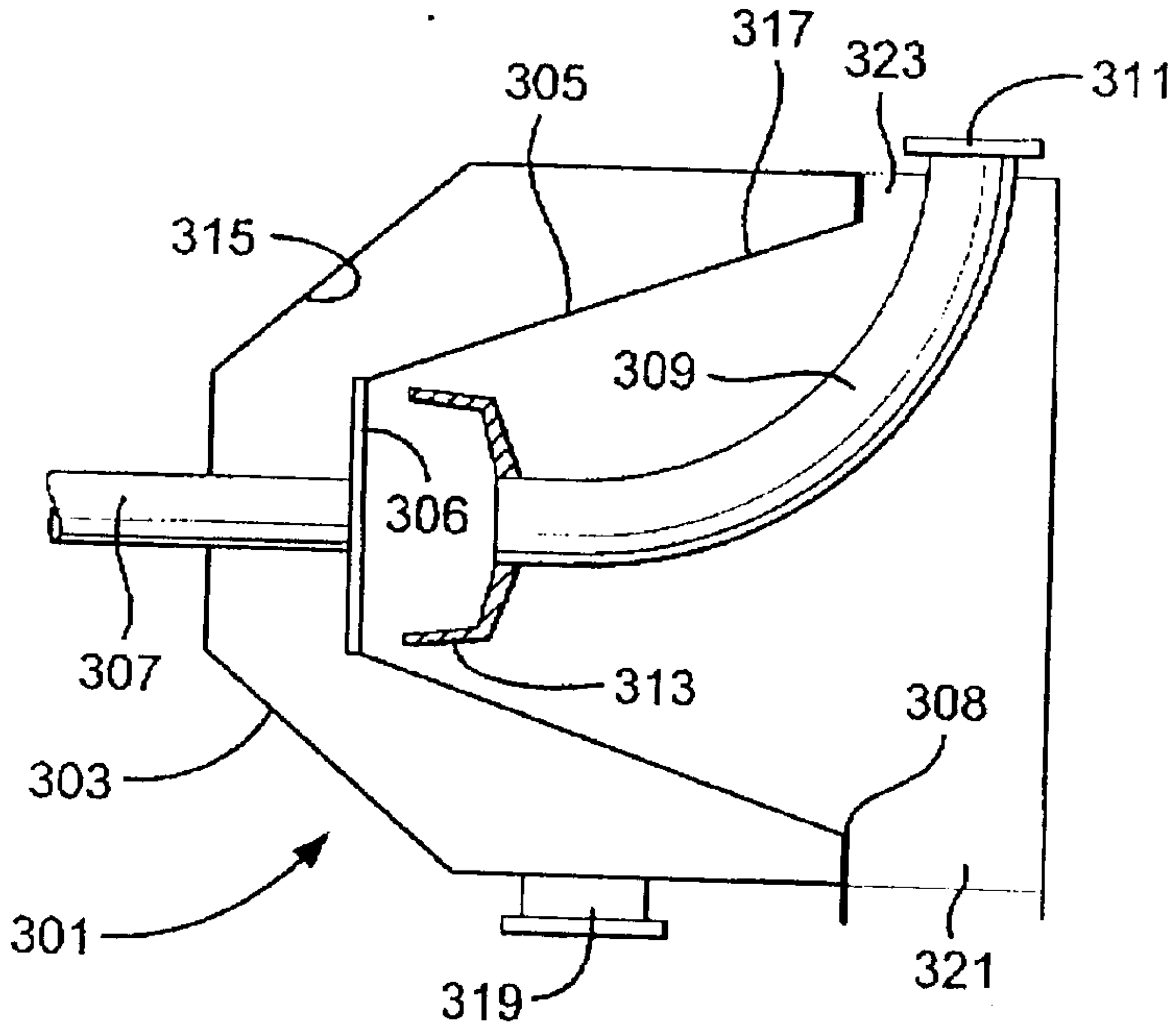
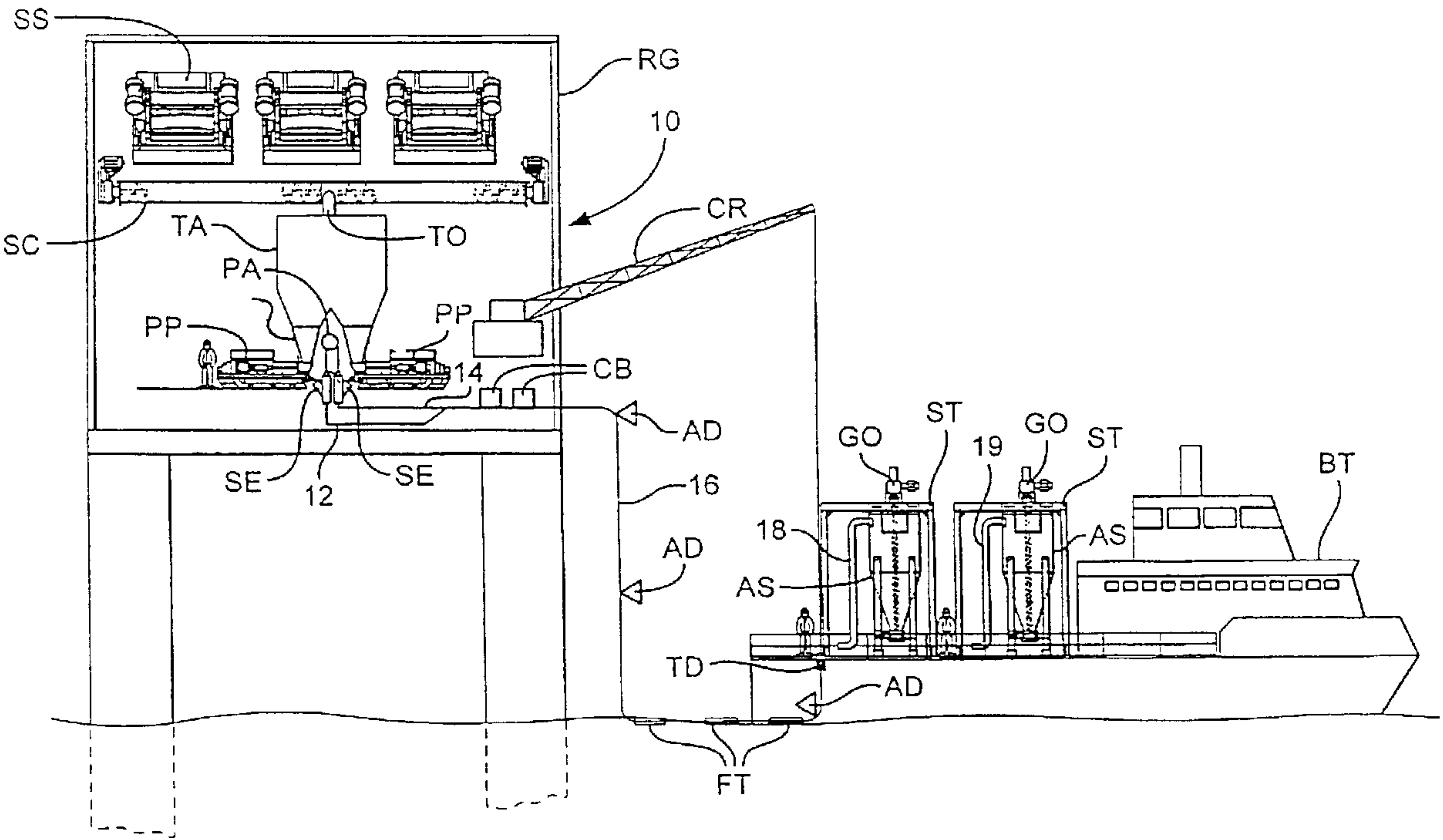


Fig.12
Prior Art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