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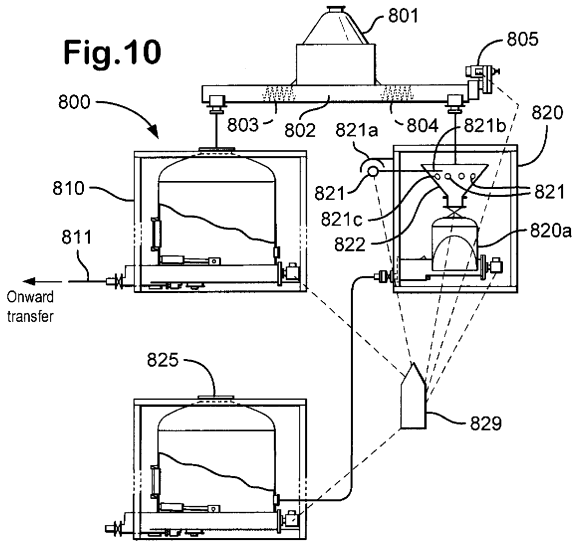
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(54) Apparatus and method for moving drill cuttings

(57) A method and apparatus for processing drill cuttings, the method comprising obtaining drill cuttings from at least one of a shale shaker, hydrocyclone, centrifuge or drill cuttings dryer (801), measuring the moisture content of the drill cuttings preferably with a moisture sensor (821) to obtain a moisture value, comparing the moisture value to a predetermined threshold and conveying the drill cuttings in a dry cuttings route (825) if the moisture value is below the predetermined threshold or conveying the drill cuttings in a wet cuttings route (810) if the moisture value is above the threshold.

Fig.10



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Description

[0001] The present invention relates to an apparatus and method for moving drill cuttings and particularly, but not exclusively, for moving wet drill cuttings produced in the construction of an oil or gas well or drying wet drill cuttings before the drill cuttings are moved a substantial distance and subsequently moving the dry drill cuttings.

[0002] For the US part of this application, the following should be noted: this application is a continuation-in-part of U.S. Application Ser. Nos. 10/392,285 filed 03/19/2003, and 10/764,825 filed 01/26/2004, which applications are incorporated fully herein for all purposes.

[0003] 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.

[0004] The resultant solids, known herein as "drill cuttings" are 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. In certain prior art systems oily drill cuttings are loaded into vessels, skips or cuttings boxes which are lifted by a crane onto a supply boat. Alternatively this may, in part, 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. Drill cuttings having processed by a shale shaker can contain approximately 10% to 20% moisture (oil, water) by weight.

[0005] It is now often desirable and/or legislatively required to transport recovered drill cuttings to a processing site on shore to remove substantially all of the oil and contaminates therein so that the drill cuttings can be disposed of or used in an environmentally safe and friendly way. Environmental agencies around the world are moving towards a "zero discharge" policy from offshore rigs. Continuous drilling on an offshore oil rig is common and drill cuttings are stored on the rigs until they can be transported by ships known as supply boats which collect the oily drill cuttings and take them to another site for further processing. There is a need to efficiently and effectively store the oily drill cuttings on the rig and also a need to efficiently and effectively store the cuttings on supply boats. 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.

[0006] 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.

[0007] Thus tackling the problem of transporting, buffering and storing low slurry density, high particle density material, and particularly, but not exclusively, oilfield drill cuttings or other oily/wet waste material using continuous positive pneumatic pressure.

[0008] WO 00/76889 discloses a system for transporting drill cuttings in the form of a non-free flowing paste, the system comprising a pressure vessel having a conical hopper discharge portion having a cone angle sufficient to induce mass flow. The drill cuttings are stored on a rig and supply boat in ISO sized storage vessels which have a conical hopper discharge portion, such that the ISO sized container vessels can be discharged between each other on the rig and ship and between the ship and port. These ISO containers are very tall and the quantity of drill cuttings stored in them is limited due to the lower converging portion of the vessels.

[0009] German Patent No. DE 40 10 676 discloses an apparatus for conveying sewage sludge or concrete. The apparatus comprises a pressure vessel having a feed opening and a screw conveyor therebelow. Paddles act as a stirrer and forcibly fill the screw conveyor through an opening in the pressure vessel. The sewage sludge or concrete is moved by the screw conveyor into a nozzle into which compressed air is applied to move the sewage sludge or concrete along a pipe in a continuous stream

[0010] United Kingdom Patent No. GB-A-2,330,600 discloses a system for transporting oil drill cuttings from

a rig to shore. The system comprises the steps of mixing the oily drill cuttings with a mud to form a slurry, storing the slurry in retention tanks on the rig and subsequently pumping the slurry to retention tanks on a ship for transportation to shore.

[0011] WO 03/021074 discloses *inter alia* an apparatus for transporting solid waste materials, the apparatus comprising: an upstream waste supply means; feed means to transport waste from the waste supply means to a pneumatic conveyancing means; which pneumatic conveyancing means comprises a tube within which waste material is transferred from the feed means to a downstream waste collector; wherein said tube is associated with at least one blockage sensing device, and electronic data processing means to process data output from the blockage sensing device.

[0012] WO 82/03066 discloses a method for unblocking conveying pipes for particulate material, comprising feeding air to the pipe at spaced-apart positions therealong in order to reduce the length of the blocking material.

[0013] In accordance with the present invention, there is provided an apparatus for selectively holding drill cuttings material, preferably in the process of moving drill cuttings the apparatus comprising a vessel having a first opening through which drill cuttings material is introducible into the vessel and a second opening through which the drill cuttings material is passable out from the vessel, characterised in that the apparatus further comprises movement apparatus, the movement apparatus comprising a movement member within the vessel and movable adjacent the second opening to facilitate passage of the drill cuttings material into the second opening. Preferably, the movement apparatus is mechanical movement apparatus.

[0014] Preferably, the apparatus further comprises a box for receiving the drill cuttings material passing through the second opening, the box having a cuttings outlet for connection to a conveying conduit. The box may be any space in which the drill cuttings can fall or be pushed into on their way into the conveying conduit. The box may form part of the conveying conduit. The conveying conduit may be a rigid pipe or a flexible hose, preferably between 50mm and 200mm in diameter, more preferably 100mm to 150mm and most preferably approximately 125mm in diameter.

[0015] Advantageously, the apparatus further comprises a compressed gas inlet for applying compressed gas to the drill cuttings to facilitate movement of the drill cuttings through the cuttings outlet. Preferably, the compressed gas inlet is substantially in line with the cuttings outlet. Preferably, the gas is air or an inert gas such as nitrogen. Advantageously, a balancing compressed air inlet is located in the vessel to provide a balancing pressure to inhibit drill cuttings from being blown back from the box into the vessel during discharge. The balancing pressure is preferably equal to the pressure in the box, but the balancing pressure may be slightly less than or greater than the pressure in the box.

[0016] Preferably, the vessel is a pressure vessel. Advantageously, the pressure vessel has been tested to withstand a working pressure of at least 2 Bar, more preferably, at least 4 Bar and most preferably, at least 7 Bar. Preferably, the apparatus further comprises a vent valve to prevent the vessel from being over pressurized.

[0017] A conveyor conduit is maintained substantially full thereby facilitating consistent feeding or dosing rates. The conveying conduit may, in certain aspects, be dosed with drill cuttings in such a way that the conveying conduit is full so that the drill cuttings move along the conveying conduit in one long slug. Alternatively, the drill cuttings may form a plurality of slugs along the conveying conduit separated by pockets of pneumatic fluid. This is controlled by the rate at which the drill cuttings are released or pushed into the conveying conduit, which is known as the "dosing rate". The dosing rate is dictated by, among other things, the consistency of the drill cuttings, the pneumatic pressure applied to the drill cuttings, and the diameter of the conveying conduit in order to achieve a predetermined conveying rate. In a preferred embodiment, a conveying rate of thirty metric tons of drill cuttings per hour are moved along from the storage vessel into the conveying conduit and on to a destination.

[0018] The drill cuttings stored in the storage vessel may be dry or may be wet. Wet cuttings contain water and/or oil. Wet drill cuttings may be free flowing, non-free flowing, or pasty. Drill cuttings are often wet after having been processed with shale shakers. The drill cuttings may be dried by a vortex dryer, as described herein to produce substantially dry drill cuttings which, in some aspects, may be free flowing solids which abide by the laws of Newtonian flow.

[0019] Advantageously, the movement apparatus further comprises power apparatus connected to the movement member for moving the movement member. Preferably, the second opening has a length and the movement member comprises an elongated member preferably, having a length substantially equal to or greater than the length of the second opening. Advantageously, the elongate member has an edge shaped for facilitating movement of the drill cuttings material to the second opening. Preferably, the elongate member has a leading edge, which is chamfered to facilitate movement of the elongate member under a pile of drill cuttings and an trailing edge designed to catch drill cuttings to move them towards the second opening, thus the trailing edge is preferably perpendicular to the direction of movement of the elongate member, may be stepped and/or may be concave advantageously a scooping edge for scooping the drill cuttings into the opening and most preferably is a sliding frame.

[0020] Preferably, the second opening has a width and the movement member is movable back and forth across the width. Advantageously, the movement member comprises a frame having a control shaft connected to at least one curved outer perimeter portion. Preferably, the

movement member comprises a frame having an outer perimeter portion generally eye-shaped. Alternatively, a rack and pinion system may be employed or a rotating disk having an arm located on the perimeter thereof to translate rotational motion into forwards and backwards motion, in a similar way to a crank in a car engine. Such a sliding member may be used in a variety of tanks, including, but not limited to, a mass flow hopper, core flow hopper, flat bottom hopper, a chisel plane flow-type tank, or a conical tank.

[0021] Preferably, the movement apparatus comprises or also comprises an auger. The auger may form part of a screw conveyor and may be any form of screw, which moves drill cuttings. Preferably, the auger is arranged beneath the second opening. Preferably, the auger is arranged in a ditch. The ditch may have a cover for inhibiting ingress of drill cuttings into the ditch when the apparatus is not being used for a long period of time. The cover may be movable with the movement member. The cover may be perforate or imperforate. Preferably, the box is located at the discharge end of the auger. Advantageously, the apparatus further comprises a motor for rotating the auger. Advantageously,

the apparatus further comprises fingers or which may be blade like located at the end of the auger for facilitating release of the drill cuttings from the auger and preferably facilitate breaking up clumps of drill cuttings. Preferably, the auger comprises at least one blade of constant pitch. Advantageously or alternatively, the auger comprises at least one blade having a variable pitch.

[0022] Advantageously, the apparatus as claimed in any preceding claim, further comprising a cover to selectively cover the second opening. Preferably, the cover pneumatically seals the second opening. Advantageously, the cover is made from a screen, and thus allows gas to pass therethrough. Preferably, the cover is connected to the movement apparatus and moves therewith.

[0023] Preferably, the apparatus further comprises a central stem and a plurality of fingers or bristles extending therefrom. Preferably, the stem is movable with a valve located in the first opening to selectively allow drill cuttings into the vessel.

Preferably, the vessel has a substantially planar internal base. The base of the vessel may be planar and/or substantially horizontal. By using a non-conical hopper or vessel in certain embodiments in accordance with the present invention, bridging is inhibited and reduces as compared to bridging that can occur in certain conical vessels. In one aspect, the sliding member(s) is/are substantially flat for sliding over a planar base. In certain aspects the sliding member is rigid. Preferably the planar base is circular and is between 1.5 and 4 meters in diameter, and in one particular embodiment is 2.7 meters in diameter. The planar base or the lower portion of the vessel may be provided with a plurality of small aeration ports to allow compressed sir therethrough to aerate the drill cuttings to facilitate conveying the drill cuttings through the second opening or into a ditch if provided.

[0024] Advantageously, the vessel has at least one substantially vertical wall. Preferably, the vessel has a domed top. Advantageously, the vessel is generally cylindrical with a generally circular base, the second opening extending through the generally circular base.

[0025] Advantageously, the first opening has a valve therein for controlling ingress of drill cuttings. The valve may be of the type disclosed in GB-A-1,539,079 or US-A-3,586,383.

[0026] Preferably, the first opening has a non return valve for inhibiting drill cuttings from exiting through the first opening.

[0027] Advantageously, the vessel has two sides which slope toward each other. The vessel may be of wedge, plane flow, transition, chisel, plane-flow, pyramid, square or any other suitable type.

[0028] Preferably, the vessel has a conical hopper portion. Advantageously, the conical hopper portion has a cone angle and forms a lower section of the vessel and the cone angle is below a critical value required to achieve mass flow of the drill cuttings material.

[0029] Advantageously, the vessel has a capacity of between 0.15 cubic metres and 1 cubic meter, such that preferably, the apparatus is not used for storing drill cuttings, but is used in the continuous conveying of drill cuttings. The apparatus may be as small as 0.05 and 0.2 cubic metre.

[0030] Preferably, the vessel has a capacity of at least three cubic metres, such that preferably, this is used for storing drill cuttings, either on a rig, on a barge, boat, lorry, train or in a storage area on shore. Most preferably, the vessel is between ten and thirty cubic metres and even more preferably between twelve and sixteen cubic metres.

[0031] Advantageously, the apparatus further comprises a moisture-content sensor for sensing moisture content of drill cuttings. Preferably, the apparatus further comprises a hopper wherein the moisture-content sensor is located in the hopper. Advantageously, the moisture-content sensor is located within the vessel. Preferably, the apparatus further comprises a controller for gathering data from the moisture-content sensor and means to divert the drill cuttings in response to the data. Preferably, the means comprises a diverter valve for diverting the drill cuttings. Advantageously, the means comprises a screw conveyor, which preferably has a motor driving the screw conveyor which can rotate the motor selectably in a clockwise and counter clockwise direction in order to reverse the conveying from a first direction to a second opposite direction.

[0032] Preferably, the apparatus further comprises a storage vessel for storing dry drill cuttings. Advantageously, the apparatus further comprises a storage vessel for storing wet drill cuttings. Advantageously, the storage vessel for storing dry cuttings is the internal bulk storage vessel of a drilling rig. Preferably, the storage vessel for storing dry cuttings is the internal hold of a boat or barge. Preferably, the storage vessel for storing dry

cuttings is a further apparatus of the invention. Advantageously, the storage vessel for storing wet cuttings is a further apparatus of the invention. Advantageously, the storage vessel in accordance with the present invention is fed using a blow tank. Alternatively, a pump, for example a positive displacement pump or a cement pump (or pumps) are used in addition to or in place of blow tank (s) to move the drill cuttings, for example from shakers or a ditch or vortex dryer to the storage vessels. The floor area and overall space around shale shakers is often limited and so the storage vessels or skips for containing the drill cuttings are often placed relatively far, for example a tens or hundreds of metres (a few hundred feet), from the shale shakers.

[0033] Preferably, the apparatus is skid mounted.

[0034] The invention also provide a method for conveying drill cuttings, the method comprising the steps of loading a conveying line with drill cuttings and applying a positive pressure to move the cuttings therealong, characterised in that the step of loading the conveying line is carried out by a mechanical movement apparatus. The drill cuttings may be free-flowing paste or a non free-flowing paste, dry clumps, dry free flowing particles, damp, a slurry or in any other form.

[0035] Preferably, the conveying line is provided with a compressed gas inlet, the method comprising the step of supply compressed gas through the compressed gas inlet to facilitate movement of the drill cuttings along the conveying line. Advantageously, the mechanical movement apparatus comprises an auger, the auger rotated to load the conveying line with drill cuttings. Preferably, the auger is located in a pressure vessel, the method further comprising the step of loading the pressure vessel with drill cuttings whereupon the auger is rotated to load the conveying line with drill cuttings from the pressure vessel. Advantageously, the step of pressurizing the pressure vessel to inhibit drill cuttings from passing from the auger or conveying line back into the pressure vessel.

[0036] Advantageously, the pressure vessel has an inlet opening and a valve located in the inlet, the method further comprising the step of activating the valve to selectively allow drill cuttings into the pressure vessel.

[0037] Preferably, the pressure vessel has an inlet opening and a non return valve located in the inlet, the method further comprising the step of allowing the drill cuttings into the pressure vessel, the gas under pressure and drill cuttings therein prevented from escaping through the non return valve.

[0038] Preferably, the method is accomplished on a boat, or on an offshore drilling rig.

[0039] Advantageously, all cuttings movement apparatus is in controlling communication with control apparatus, the method including controlling with the control apparatus the cuttings movement apparatus.

[0040] The invention also provides a method for storing drill cuttings in a storage vessel and discharging the drill cuttings therefrom into a pressurized conveying line, the method comprising the steps of loading the drill cuttings into a storage vessel, the method further comprising the steps of activating mechanical movement apparatus to move the drill cuttings toward an opening in the substantially in the storage vessel to facilitate discharge of the drill cuttings. Preferably, the storage vessel is pressurized, most preferably, with a pneumatic gas.

[0041] Advantageously, the storage vessel has a substantially planar base, the opening located in the substantially planar base. Preferably, the mechanical movement apparatus comprises a wiper, the method further comprising the step of moving the wiper to move at least some of the drill cuttings toward the opening. Advantageously, the wiper forms part of a frame, the method comprising the step of moving the frame to move at least some of the drill cuttings toward the opening. Preferably, the wiper comprises finger or bristles to move at least some of the drill cuttings toward the opening. Advantageously, the mechanical movement apparatus further comprises a piston and cylinder, the method further comprising the step of activating the piston and cylinder to move the wiper. The piston and cylinder may be activated by a hydraulic or pneumatic supply.

[0042] Prior art methods use a cuttings dryer which, when coupled with a pneumatic cuttings conveying system reduces waste volumes and liquid content, leading to an overall reduction in storage volume required and transportation and disposal costs are also reduced. Due to dried cuttings tending more towards lead phase when using a positive pressure pneumatic conveying system, it is important in certain aspects that any change in dryer output is acted upon at the earliest opportunity. It is known to be problematic to convey a product when its consistency is not uniform. To have a storage tank with a mixture of dried cuttings and wet cuttings can require a conveying system to alternate between various modes of flow, between continuous and discontinuous phase flow. The flow regime of cuttings within a pipe does not lend itself to this change as wet cuttings tend towards dense phase with either a shearing type or plug type flow whereby the slugs of cuttings act as a pulsatile regular/irregular moving bed which may fill the entire cross section of pipe; and dried cuttings tend towards suspended flow. The transfer rate is required to be substantially reduced should this "mixture" of modes of flow transfer be required. Reduced transfer rates are not desirable while a vessel is alongside a rig taking on a load. In order to maximize transfer rates, it is beneficial to maintain a cuttings consistency within the storage vessel.

[0043] The cuttings discharge from a dryer with a screen may be significantly altered should the screen "blind," hence not allowing the liquid to pass through resulting in a wet discharge. This is known to happen on occasions when a change in drilled formation results in a change of particle size generated at the drill bit.

[0044] In certain systems in accordance with the present invention a wetness meter is used to continuously monitor dryer discharge. The wetness meter may be based on the Near Infrared (NIR) principle, where it is

known that several molecular bonds absorb infrared light at well defined wavelengths. Common bonds are O-H in water, C-H in organics and oils and N-H in proteins. The light absorbance level at these specific wavelengths is proportional to the quantity of that constituent in the sample material. Infrared filters within the instrument sensor generate a sequence of light pulses, one of these pulses is selected to be at the specific absorbance wavelength for the constituent required to be measured while the other pulses are selected so as to determine the reflectance properties of the material. The light pulses illuminate the sample being measured with the reflected light being collected and focused onto a detector, the electrical signals from the detector are processed into a ratio to provide a value that is proportional to the constituent concentration - this being in percent or other engineering units, water content and oil based mud content can thereby be monitored. This technology is well defined and provides high accuracy and speed of response to facilitate on-line measurement and control of the dryer process.

[0045] Alternative methods in accordance with the present invention of obtaining a "wetness" value include passing the product through an open mesh and measuring the pressure drop generated. A rise in pressure drop indicates product adhering to the mesh most likely due to a rise in the "wetness" value. Dielectric constant based instrumentation or vibratory sensitive instrumentation may also be used to monitor change in consistency.

[0046] Use of information can minimize the "mixing" of cuttings with storage vessels. In one aspect a dedicated storage tank is used if a desired "wetness" value is exceeded. In one such system a bank of storage vessels are filled with drill cuttings of a satisfactory consistency and oily if the desired wetness value is exceeded, then the flow is diverted to a "wet" storage tank and an alarm raised such that the operator can then resolve the situation. In another system in accordance with the present invention a screw conveyor being used to feed the conveying system after the dryer may be immediately reversed in order to feed a dedicated "wet" tank. In another system in accordance with the present invention two dryers are used each fitted with a screen with a different mesh size. Should one dryer blind or malfunction resulting in a "wet" cuttings discharge, then the cuttings can be redirected by actuating an appropriate valve below the dryer feed conveyor in order to use the alternative dryer. In another system in accordance with the present invention overall height required is reduced through the use of screw conveyors.

[0047] The invention also provides a method for processing drill cuttings, the method comprising obtaining drill cuttings from at least one of a shale shaker, hydrocyclone, centrifuge or drill cuttings dryer, measuring the moisture content of the drill cuttings to obtain a moisture value, comparing the moisture value to a predetermined threshold and conveying the drill cuttings in a dry cuttings route if the moisture value is below the predetermined threshold or conveying the drill cuttings in a wet cuttings route if the moisture value is above the threshold.

[0048] Preferably, the dry cuttings route comprises a feeder apparatus and a pneumatic conveying line, the method further comprising the steps of loading the drill cuttings into the feeder apparatus, which feeder apparatus feeds the pneumatic conveying line with the drill cuttings. Advantageously, the pneumatic conveying line is a positive pressure pneumatic conveying line. The positive pneumatic pressure is applied to push the drill cuttings through the conveying line. Thus preferably, the pressure behind the drill cuttings is higher than the pressure in front of the drill cuttings in order to move the drill cuttings through the conveying line. The conveying line may be a rigid pipe or a flexible tube. Preferably, the pneumatic conveying line leads to a storage vessel, the method further comprising the step of conveying the drill cuttings through the pneumatic conveying line to the storage vessel. The storage vessel is preferably of the type disclosed and claimed herein. Advantageously, the pneumatic conveying line leads to a bulk storage tanks of an oil or gas rig, the method further comprising the step of conveying the drill cuttings through the pneumatic conveying line to the bulk storage tanks. Preferably, the pneumatic conveying line leads to a hold of an oil or gas rig, the method further comprising the step of conveying the drill cuttings through the pneumatic conveying line to the hold. The hold may be pressure tight and have its own positive pressure pneumatic conveying apparatus for removing the drill cuttings from the hold or the hold may not be pressure tight and may use a stand alone blow tank, apparatus of the invention as disclosed herein or vacuum apparatus, such as that manufactured and sold by The Fuller Company (now called FL Smidth) for sucking the drill cuttings from the hold and transferring them to other transportation means on the port, such as tanks or storage vessels on trains, barges or lorries. Preferably, the step of measuring the moisture content of the drill cuttings is carried out with a moisture sensor located in the feeder apparatus. Advantageously, the feeder apparatus comprises a hopper and a pressure vessel, the step of measuring the moisture content of the drill cuttings is carried out with a moisture sensor located in the hopper.

[0049] Preferably, the wet cuttings route comprises a feeder apparatus and a pneumatic conveying line, the method further comprising the steps of loading the drill cuttings into the feeder apparatus, which feeder apparatus feeds the pneumatic conveying line with the drill cuttings. Advantageously, the pneumatic conveying line is a positive pressure pneumatic conveying line. The positive pneumatic pressure is applied to push the drill cuttings through the conveying line. Thus preferably, the pressure behind the drill cuttings is higher than the pressure in front of the drill cuttings in order to move the drill cuttings through the conveying line. The conveying line may be a rigid pipe or a flexible tube. Preferably, the pneumatic conveying line leads to a storage vessel, the method further comprising the step of conveying the drill

cuttings through the pneumatic conveying line to the storage vessel. The storage vessel is preferably of the type disclosed and claimed herein. Advantageously, the pneumatic conveying line leads to a cuttings dryer for further drying, such as a vortex dryer or a dryer of the type disclosed in GB-A-2,297,702. Preferably, the drier drill cuttings are then returned in the method to have the moisture measured. Advantageously, if a mesh is used in the cuttings dryer, a mesh size different from the ones used in the apparatus from which the cuttings were previously processed i.e. shale shaker, hydrocyclone, centrifuge or drill cuttings dryer in case the high moisture content of the drill cuttings was caused by near particle blinding. Preferably, the step of measuring the moisture content of the drill cuttings is carried out with a moisture sensor located in the feeder apparatus. Advantageously, the feeder apparatus comprises a hopper and a pressure vessel, the step of measuring the moisture content of the drill cuttings is carried out with a moisture sensor located in the hopper.

[0050] Advantageously, the drill cuttings from the at least one of a shale shaker, hydrocyclone, centrifuge or drill cuttings dryer, are feed into a feeder apparatus whereupon moisture content of the drill cuttings is measured to obtain a moisture value with a moisture sensor located therein, the feeder apparatus feeding the drill cuttings into a pneumatic conveying line, the conveying line having a diverter valve therein, the method further comprising the steps of diverting the drill cuttings using the diverter valve into a dry cuttings route if the moisture value is below the predetermined threshold or conveying the drill cuttings in a wet cuttings route if the moisture value is above the threshold.

[0051] Preferably, a screw conveyor is located beneath the at least one of a shale shaker, hydrocyclone, centrifuge or drill cuttings dryer to receive the drill cuttings, the screw conveyor comprising a drive such that the screw conveyor is reversible to convey the drill cuttings in one direction for a dry cuttings route and in a second direction for a wet cuttings route.

[0052] Advantageously, the predetermined threshold is 1%, 3% or 5% moisture content. Moisture content is comprised water content and oil content. The ratio of oil to water on drill cuttings varies greatly, but is often found in the region of half water and half oil.

[0053] The invention also provides an apparatus for carrying out the above method. The apparatus preferably comprises a moisture sensor and means for directing the drill cuttings in a wet cuttings route or a dry cuttings route. Advantageously, the apparatus further comprises a controller for obtaining data from the moisture sensor and comparing the data to a predetermined value and activating the means according to the data.

[0054] The invention also provides a method for moving drill cuttings, the method comprising the steps of loading a conduit with drill cuttings, applying positive pneumatic pressure to the drill cuttings to push the drill cuttings through the conduit characterised in that the positive pressure is applied through inlets at spaced apart intervals along the conduit for facilitating movement of drill cuttings therethrough.

[0055] Preferably, the pneumatic pressure in the conduit is measured at spaced intervals therealong, the pressure measurements reported to a controller, the controller controlling the application of pneumatic pressure through said inlets at spaced apart intervals along the conduit. Advantageously, the controller switches each inlet at spaced apart intervals on or off in response to the pressure measurements. Preferably, the pressure applied at each subsequent inlet is less than the pressure of the previous inlet. Advantageously, the tubes to the inlets at spaced apart intervals along the conduit, wherein the tubes comprise non-return valves to inhibit ingress of drill cuttings into the inlets.

[0056] Preferably, the pressure to each inlet at spaced apart intervals is variable, the pressure applied thereto varied in accordance with the pneumatic pressure in the conduit is measured at spaced intervals.

[0057] Advantageously, the pressure to each inlet at spaced apart intervals is fixed. For example, the pressure at the first inlet is 4 bar, 3.5 at the second inlet, 3 bar at the third inlet, 2.5 bar at the fourth inlet, 2 bar at the fifth inlet and 1.5 bar at the sixth inlet. Each inlet may be spaced at a fixed distance along the conduit, for example every 25m. The distance may decrease to for example every ten metres across a bend in the conduit. The inlet may be placed at the elbow of the conduit.

[0058] The invention also provides a feeding apparatus for loading drill cuttings into a positive pressure conduit comprising a pressure vessel, an inlet, a valve for selectively allowing drill cuttings into the pressure vessel and an outlet leading into a conduit, the outlet comprising a bend therein beneath the pressure vessel characterised in that the bend has a compressed air inlet in the bend for supplying a positive pressure to push the drill cuttings therethrough. Preferably, the inlet is directed horizontally, advantageously in line with the conduit. Preferably, a further valve is located between the pressure vessel and the outlet. Advantageously, the outlet converges through the bend, for example a circular cross-section outlet converges from 150mm to 125mm diameter.

[0059] For a better understanding of the present invention, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1A is a top view of a storage vessel in accordance with the present invention taken along the line I-I of Figure 1B;

Figure 1B is a side view in cross-section of the storage vessel shown in Figure 1A;

Figure 1C is a view taken from a similar point to Figure 1A, of another embodiment of a storage vessel in accordance with the present invention;

Figure 1D is a top plan view of an alternative part for the storage vessel shown in Figure 1A;

Figure 2 is a schematic view of the apparatus of the invention in use;
Figure 3 is a schematic cross-section view of a prior art feeding vessel used in the apparatus shown in Figure 2;
Figure 3A is a side view in cross-section of a feeding vessel in accordance with the present invention which may be used in place of the feeding vessel shown in use in the apparatus shown in Figure 2;
Figure 3B is an end view and Figure 3C is a side view of the feeding vessel shown in Figure 3;
Figure 4 is a side schematic view of a feeding vessel in accordance with the present invention;
Figure 5A is a view in cross-section of taken along line VA-VA of a frame part shown in Figure 1A;
Figures 5B to 5D are alternative shapes for the cross-section of the frame part for the storage vessel shown in Figure 1A;
Figure 6 is a schematic view of a storage vessel arrangement in accordance with the present invention;
Figures 7A and 7B are top cutaway views of another embodiment of a storage vessel in accordance with the present invention, showing steps of operation thereof;
Figure 7C is a top cutaway view of another embodiment of a storage vessel in accordance with the present invention;
Figures 7D is a side view in cross-section of the storage vessel shown in Figure 7C with no drill cuttings therein;
Figures 7E is a side view in cross-section of the storage vessel shown in Figure 7A with drill cuttings therein;
Figure 8A is a side schematic view of an apparatus in accordance with the present invention;
Figure 8B is a top view of part of the apparatus shown in Figure 8A;
Figure 9A is a schematic view of a feeding apparatus in accordance with the present invention;
Figure 9B is an end view of part of the feeding apparatus shown in Figure 9A;
Figure 9C is a side view of part of the feeding apparatus shown in Figure 9A;
Figures 10 to 15 are schematic views of apparatus in accordance with the present invention.

[0060] Referring to Figures 1A and 1B, a storage vessel 1 in accordance with the present invention has a generally cylindrical pressure vessel 2 of circular cross-section with a substantially circular planar base 3 and a domed cap 4. The planar base 3 and the domed cap 4 may be formed integrally or be welded to the wall of the pressure vessel 2.

[0061] The pressure vessel 2 may be made of steel of the type defined by British Standard 1501 224-49B and may be designed to withstand a working pressure of between 1 and 20 Bar, and in one particular aspect 7 Bar. The domed cap 4 has, optionally, an inlet 5 with a supply hose 6 attached thereto, which in one particular aspect has a 52mm (two inch) diameter, for applying compressed gas such as air and/or nitrogen and/or another inert gas to the top of the drill cuttings DC in the vessel. The domed cap 4 is also provided with a cuttings inlet 7 provided with a valve 8, such as a gate valve or a full bore ball valve, which may be manually operable or operable remotely, for example using a stepper motor. Alternatively, cuttings may be introduced to the inlet 7 by any known system, for example but not limited to, a conveyor system.

[0062] The cuttings inlet 7, in one particular aspect, has an internal diameter of 125mm (5 inches). The planar base 3 has an opening 9. The opening 9 may be any suitable shape as viewed from above and, as shown, is generally rectangular. A tube 10 has an opening corresponding to and fixed to the perimeter of the opening 9 in the planar base 3 to form a pressure tight seal. The tube 10 may be welded or otherwise formed with the planar base 3. The tube 10 houses an optional auger which, in one aspect, is a screw conveyor 11 rotatably mounted in the tube 10 and driven by a variable speed hydraulic motor 12.

[0063] The motor 12 may alternatively be an electrical, petrol drive, pneumatic or otherwise powered motor. The screw conveyor 11 has a shaft 13 and a helical blade 14. The helical blade 14 has, in one aspect, a diameter of between 150mm and 600mm (6 and 24 inches), and in one particular aspect has a diameter of between 350mm and 400mm (fourteen and sixteen inches). The shaft 13 has a first end coupled to the variable speed hydraulic motor 12 and a second end rotatably arranged in a bearing 15 in an end wall 16 of the tube 10. The tube 10 extends beyond the perimeter of the planar base 3. The helical blade 14 extends along substantially the entire diameter of the planar base 3 and extends into a portion of the tube 10 which extends beyond the perimeter of the planar base 3, whereupon the helical blade ends. In certain aspects in which there is no auger apparatus or no conveyor 11, positive pressure gas in the vessel feeds the material in the vessel to the discharge opening.

[0064] Four, six or more radially projecting fingers 17 (two shown) extending from the shaft 13 (or which may be connected to the interior of the tube 10) are spaced from the end of the helical blade 14. The portion of the tube 10 which extends beyond the perimeter of the planar base 3 has a discharge box 18 with a lower chamber 18a, having a compressed gas supply inlet 19 arranged below the end of the helical blade 14. The discharge box 18 tapers from a top portion having a width substantially equal to the diameter of the tube 10 to a smaller width substantially equal to the diameter of an outlet 20. The air supply inlet 19 is directed into the lower chamber 18a of the discharge box 18 and in line with a cuttings outlet 20. The cuttings outlet 20 has, in one particular aspect, an internal diameter of 125mm (5 inches) and is attached to a cuttings conveying line (not shown) of the same or similar internal diameter, which may be a flexible hose

or a rigid pipe.

[0065] A sliding frame 21 is arranged inside the pressure vessel 2 on the planar base 3 about opening 9. The sliding frame 21 may be any desired shape as viewed from above which assists in moving drill cuttings to the opening 9. In one aspect as shown, the frame 21 has two symmetrical curved members 22 and 23 forming an eye shape which is arranged on four arms 24 joined to a central member 25. The curvature of the two symmetrical curved sections is slightly less than the curvature of the perimeter of the planar base 3. Outer edges 27 of the two symmetrical curved sections 22 and 23 and of the four arms 24 are, in one aspect, chamfered, whereas internal edges 28 (see Figure 5A) facing the opening 9 are at right angles to the plane of the planar base 3. The curved members 22 and 23 have flat bottoms 29. The angle of the chamfer in certain aspects is between 45 and 20 degrees from the flat bottom 29. This can be seen clearly in Figure 5A. It is within the scope of the present invention to have a frame or member sized and configured for movement across the opening 9 of any desired shape, for example, but not limited to, a member 402 as shown in Figure 1C or a generally circular frame, as shown with the frame 21a, Figure 1D. The opening 9 may be any desired shape with any desired width and length; and, as shown, may be about the same width as an auger apparatus located beneath the opening (or the auger apparatus may be slightly wider than the opening).

[0066] A hydraulically actuated piston and cylinder assembly 26 is joined at one end to the wall or planar base 3 of the pressure vessel 2 and the other to the sliding frame 21, to induce movement of the sliding frame 21 over the planar base 3 backwards and forwards as indicated by the arrow within the confines of the pressure vessel 2. Alternatively some of the frame movement apparatus may be positioned exteriorly of the vessel.

[0067] The curved members 22 and 23 may have various profiles to accomplish the function of sliding underneath the drill cuttings DC when moving away from the opening 9 and acting as a rake or scoop to scoop, dig, or move the drill cuttings into the discharge opening 9. In one aspect the space around the conveyor 11 in the tube 10 is maintained substantially full to facilitate maintenance of a consistent dosing rate dependent on the rpm's of the conveyor 11 while conveying drill cuttings from the storage vessel.

[0068] An exemplary, but not exclusive, list of alternatives for the curved members 22, 23 is shown in Figures 5A to 5D. Figure 5B shows a curved member 22 (the member 23 is similar) having a chamfered front face 31 and a concave rear face 30. Figure 5C shows a curved member 22 (or 23) having a chamfered front face 32 and a stepped rear face 33 having a shoulder 34. Figure 5D shows the curved member 22 (or 23) having a stepped front face 35 and a slightly angled rear face 36 such that an acute angle is formed in use between the angled rear face 36 and the planar base 3.

[0069] The storage vessel 1, in one aspect, is attached to a skid (not shown) to facilitate transport of the storage vessel 1 on lorries, supply boats, train cars and on offshore and onshore rigs. Te skid may also comprise a frame to surround the storage vessel 1, which may be a standard ISO size to facilitate transportation of boats, trains, lorries equipped with fixings at ISO spacings. The height of the storage vessel 1, in one particular aspect, when mounted on the skid is 3.26m, the length of the skid is 3.95m and the width of the skid is 2.9m. It should be noted that the height of the vessel is very small compared with the internal volume.

[0070] A pressure relief valve 8a is provided on the pressure vessel 2, which is set to between 10% and 20% above the normal working pressure of preferably 7 Bar. A removable and/or openable hatch 8b is, optionally, also provided in the wall of the pressure vessel 2 to allow access for inspection, servicing and cleaning.

[0071] Figure 1C illustrates a storage vessel similar to storage vessel 1, save that instead of a sliding frame 21, the storage vessel has a rake apparatus 100 and an associated movement apparatus. Like numerals indicate like parts. The rake apparatus 100 (or the sliding frame 21, etc.) can be used with any tank or vessel described herein. The rake apparatus 100 has a member 102 on a shaft 104 that is moved back and forth above the opening 9 by movement apparatus 110. A mover 112 (for example any suitable motor engine, or reciprocating mechanism, for example, but not limited to, a piston/cylinder assembly like that of Figure 1A) moves the shaft 104 back and forth to move the member 102 above the opening 9 to facilitate the movement of drill cuttings down into the opening 9. Optionally a vibratory apparatus 114 exterior to the vessel 2 vibrates the shaft 104 to vibrate the member 102 and/or to induce vibration through the vessel 2 in the drill cuttings. Optionally, a vibratory apparatus 106 is disposed within the vessel 2 on the shaft 104 to vibrate the shaft 104 and the member 102 to facilitate cuttings movement. Optionally a vibratory apparatus 108 on the member 102 facilitates cuttings movement.

[0072] Referring to Figure 2, wet drill cuttings are produced by a bank of shale shakers 50 on a drilling rig.

[0073] The screened wet drill cuttings fall from the screens of the shale shakers into a ditch 48. The wet drill cuttings are moved along the ditch 48 using a screw conveyor or belt conveyor or fall directly into a hopper. Wet drill cuttings are optionally fed into a dryer (not shown), such as a vortex dryer or a dryer of the type disclosed in GB-A-2,297,702, the disclosure of which is incorporated for all purposes herein, to remove a substantial amount of moisture. This is disclosed in more detail in co-pending PCT publication number WO2004/083597 (PCT application number PCT/GB2004/000762) and in co-pending US application number U.S. Ser. No. 10/764,825 filed by the applicant for the present patent, the disclosures of which are incorporated fully for all purposes herein. In some circumstances, the moisture content of the drill cuttings is reduced to between 1% and 5% moisture by weight and in other circumstances down to 1% moisture

by weight. Typically, "wet" cuttings contain 5% or more oil content and "dry" cuttings contain less than 5% oil content.

[0074] The wet or dry drill cuttings fall directly into a hopper 51 of a blow tank 52, shown in more detail in Figure 3. The blow tank 52 may be of the type disclosed in GB-A-1,564,311, the disclosure of which is incorporated fully herein for all purposes. A valve 53, which may be of the type disclosed in GB-A-1,539,079, the disclosure of which is incorporated fully herein for all purposes, is arranged between the hopper 51 and a small pressure vessel 54 having a capacity, in one aspect, of approximately 0.3 cubic meters, although the capacity in other aspects is between 0.1 and 1 cubic meter; or larger or smaller. The size of the small pressure vessel, in certain embodiments, is dependent on the space available near shale shakers, and/or the number of cycles needed to transfer material, for example at a rate of 30 metric tons per hour. The small pressure vessel 54 has a frusto-conical portion 55. An air inlet 56 is arranged in an upper part of a wall of the pressure vessel 54 and a cylindrical portion 57 of circular cross-section is arranged between the valve 53 and the wall of the frusto-conical portion 55, leaving a small annular gap 58 therebetween through which air under pressure can pass from the air inlet 56 into the frusto-conical portion 55. This aspect is also disclosed in US-A-3,586,383 in the name of William Trythall, the disclosure of which is incorporated fully herein for all purposes. A further valve 59 (which is optional) is arranged at the discharge end of the frusto-conical portion 55 between the small pressure vessel and a feed line 60. The further valve 59 may be of the same type as valve 53. The feed line 60 may be a flexible hose or a rigid pipe and, in one aspect, has an internal diameter of 125mm (5 inches). In one embodiment, the further valve 59 may be deleted.

[0075] In one aspect, the valve 53 and the further valve 59 cycle substantially out of phase, such that the valve 53 is open to allow the small pressure vessel 54 to be charged with drill cuttings under gravity from the hopper 51 while the valve 59 is closed to inhibit drill cuttings from entering the feed line 60. The valve 53 is closed so that a dose of drill cuttings is trapped in the small pressure vessel 54. The further valve 59 is opened. In one aspect air under pressure at between 1 and 8 Bar passes into the small pressure vessel 54 through gap 58 and applies a positive pressure to the top of the charge of drill cuttings to push a dose of drill cuttings out into the feed line 60. The further valve 59 may have a slight delay in opening to allow pressure to build up in the small pressure 54 vessel before being opened. The frusto-conical portion 55 may be at an angle to induce mass flow, as is well-known in the prior art, for example as disclosed in US-A-3,604,758, the disclosure of which is incorporated fully herein for all purposes. Alternatively the interior wall of the frusto-conical section is lined with a friction reducing material, such as plastic, fiberglass, PTFE or a paint or enamel. The frusto-conical portion 55 may alternatively be a chisel, pyramid, wedge, transition or square opening type. Substantially all of the dose is discharged into the feed line and then the cycle is repeated. Many cycles per minute may occur. The feed line 60 leads to the inlet 7 of the storage vessel 1, which is arranged on the offshore rig 49 or, if it is a land based rig, near the rig. for example within 100 - 300 meters, although it may be up to many (for example three or more) kilometers away.

[0076] In use, the storage vessel 1 is vented to atmosphere, either using a valve or by disconnecting the air supply line 6 from the air inlet 5. Doses of drill cuttings enter the storage vessel 1, through the feed line 60 from the blow tank 52 and gradually fill the storage vessel 1. The storage vessel 1 can, in one aspect, store up to twelve cubic meters of drill cuttings, cut may, in other aspects, be sized to store between five and twenty cubic meters. Once the storage tank 1 is full or near full, a valve (not shown) in the feed line is operated to divert the doses of drill cuttings to another storage vessel 61. Alternatively, the feed line is disconnected from cuttings inlet 7 and connected to the cuttings inlet on a further storage vessel 61. Several storage vessels may be arranged to form a bank 62 of storage vessels.

[0077] At a convenient time when the supply boat or vehicle to transport the drill cuttings is in close proximity to the bank of storage vessels 62, for example when a supply boat 64 is moored to or within three or four hundred meters of the offshore rig, one end of a flexible hose 63 is connected to one of the storage vessels 1, 61. The other end of the flexible hose 63 is connected to at least one storage vessel 65 in a bank of storage vessels 66 on the supply ship 64. The storage vessels 65 are, in one aspect of the type described with reference to Figures 1A to 1D. Floatation collars 67 may be provided on the flexible hose 63 to inhibit the hose from sinking into the sea.

[0078] An air supply provided by a compressor (not shown) under approximately 7 Bar and in another aspect 4 Bar is provided through air supply hose 6 through air inlet 5 into a space in the pressure vessel 2 provided above the surface of the drill cuttings. The variable speed hydraulic motor 12 is activated to drive the screw conveyor 11. A supply of air, for example under approximately 7 Bar or slightly less, is supplied through an air supply inlet 19 in the discharge box 18. The same or a slightly lower pressure in the lower chamber 18a of the discharge box 18 than the pressure applied above the drill cuttings inhibits movement of drill cuttings being pushed back from the screw conveyor 11 back into the pressure vessel 2. The hydraulic piston and cylinder 26 is activated to move the sliding frame 21 backwards and forwards to facilitate movement of the drill cuttings into opening 9. The chamfered edges on the sides of the members 22, 23, 24 of the sliding frame 21 ensure that upon movement away from the opening 9 the components of the sliding frame slide under the drill cuttings and upon movement towards the opening 9, the opposed right angle or scoop profile surfaces pull the drill cuttings towards the opening

9. The drill cuttings move through opening 9 into the screw conveyor 11 which moves the cuttings along towards the lower chamber 18a of the discharge box 18. Towards the end of the screw conveyor, a double helix blade may be arranged to facilitate break up of the drill cuttings. Fingers 17 may also be provided to facilitate break up of the drill cuttings which then fall into the discharge box 18 and are propelled through the opening 20 into flexible hose 63 into storage vessel 65 on the supply boat 64.

[0079] The supply boat then transports the loaded bank of storage vessels 66 to shore. The storage vessels may be lifted off the supply boat 64 and placed on train cars, flat bed lorries or directly into a processing plant. Alternatively, the drill cuttings can be discharged in the same way as described above in relation to moving the cuttings from an offshore rig to the supply boat 64.

[0080] An alternative feeding vessel 70 is shown in Figure 16 which may be used in place of the blow tank 52 shown in Figure 3A. The vessel 70 has a cuttings inlet 71 leading from a hopper or other vessel (not shown), into a pressure vessel 72 through a fill valve 73. The lower end of the pressure vessel 72 is provided with a frusto-conical portion 74 which leads to a discharge opening 75. The discharge opening is provided with a discharge valve 76 for selectively opening or closing the opening 75. The discharge valve 76 and the fill valve 73 are in a fixed relationship by a piston 77 which extends from the discharge valve 76 through the fill valve 73 to an actuating cylinder 78. The piston 77 may be actuated pneumatically, hydraulically or using a stepper motor to open and close the fill valve 73 and the discharge valve 76, which are arranged so that they operate substantially out of phase. An air supply inlet 81 is arranged in the top of the small pressure vessel 72 for supplying air under pressure, for example of approximately 7 Bars, although it may be supplied at a pressure between one and ten Bars. Aeration ports 79 are provided in the wall of the frusto-conical portion 74 to inhibit sticking of the drill cuttings to the walls and to inhibit bridging of the drill cuttings around the discharge opening. Fingers or bristles 80 extend radially from the piston 77 within the small pressure vessel 72, which are moved up and down in concert with the valves to brush any drill cuttings stuck to the walls or in the form of a bridge about the discharge opening (but for the bristles 80 the tank 70 is like a prior art tank).

[0081] In use, the fill valve 73 and the discharge valve 76 cycle substantially out of phase, such that the fill valve 73 is open to allow the small pressure vessel 72 to be charged with drill cuttings under gravity from the hopper 51 while the discharge valve 76 is closed to inhibit drill cuttings from entering feed line 60. The fill valve 73 is closed so that a dose of drill cuttings is trapped in the small pressure vessel 72. The discharge valve 76 is opened by actuation of the piston 77, which closes the fill valve 73. Air under pressure, for example at between 1 and 8 Bar, passes into the small pressure vessel 72 and applies a positive pressure to the top of the charge of drill cuttings to push a dose of drill cuttings out into the feed line 60. The valves may cycle several times per minute with a relatively small pressure vessel. With a pressure vessel of 0.3 cubic metres, the valves will cycle once or twice every minute or every two minutes. The feed line 60 (as in Figure 2) leads to the inlet 7 of the storage vessel 1, which is arranged on the offshore rig 49 or, if it is a land based rig, near the rig, for example within 300 meters although it may be up to three or four kilometers away. Venting is provided as needed via a vent line 82.

[0082] This type of feeding vessel 70 was manufactured by Klockner-Becroit and shown and described on pages 290-291 of the text book entitled "Pneumatic Conveying of Solids

- a theoretical and practical approach" by Klinzing and Marcus, published in 1997.

[0083] Figure 6 illustrates a system 150 which provides improvement to systems and apparatuses as disclosed herein, as well as with systems disclosed in: U.S. Patent 6,702,539 issued March 9, 2004; Great Britain Application No. 9913909 filed June 16, 1999; U.S. Application 10/018,124 filed as application PCT/GB00/02158 on June 14, 2000; and European Patent EP 1,187,783 B1, published Sept. 24, 2003.

[0084] Drill cuttings flow in a pipe 157 into containers 151. Each container 151 has a lower conical-shaped portion 155 with a lower opening 158. Adjacent each opening 158 is an apparatus 160 (which is like any apparatus or system disclosed herein to facilitate the movement of drill cuttings from a tank or vessel, for example, but not limited to, the apparatus disclosed in Figures 1A to 1D, for example with a movable frame 21 and/or a movable member 102 and the associated powered movement mechanisms. The apparatuses 160 move drill cuttings into a pipe 159 (for example like the pipe 19, U.S. Patent 6,702,539) from which the drill cuttings can be introduced into any suitable tank or container for transport, such as storage containers 1 or the containers 31 shown in US-A-6,702,539. The containers 31 of US-A-6,702,539 may have an apparatus like the apparatus 160 to facilitate cuttings movement.

[0085] Optionally, compressed gas (for example air and/or nitrogen or another inert gas) may be introduced into the vessels 151 with or after drill cuttings flow into the vessels 151 in the line 157. Optionally compressed gas is introduced in a line 161 into the vessels 151 for application to and/or above the drill cuttings as previously described and/or referred to for any embodiment described herein. Optionally compressed gas is applied in lines 162 to the apparatuses 160 as described above in the system of Figure 1A. Optionally, compressed gas may be applied to the interior of the line 159 with one or more apparatus 163 to facilitate the flow of the drill cuttings material through the line 159. Each apparatus 160 may, optionally, have a movement member (for example

like frame 21 or member 102) to facilitate movement of drill cuttings from the vessels 151.

[0086] Figures 3A to 3C illustrate a feeding apparatus 470 to feed cuttings (for example from shakers or dryers to storage vessels), which has a pressure vessel 472 with a non-conical lower portion 474 which has two sloping sides 475. In certain aspects the pressure vessel 472 has a capacity of between 0.15 cubic meter and 1 cubic meter, and in one particular aspect 0.33 cubic meter. Drill cuttings enter the pressure vessel 472 from an upper inlet hopper 476 through an opening 477. An inlet valve 478 (for example a dome valve) selectively controls the entry of drill cuttings into the pressure vessel 472 and, in one aspect, provides a pre-selected dose of drill cuttings, for example, in one aspect 0.15 cubic meter to 1 cubic meter, and in one particular aspect 0.3 cubic meter.

[0087] Optionally, a movement member 482 (for example, like the movement member 102 or frame 21 described above) is movable by movement apparatus 484 (shown schematically; for example any movement apparatus disclosed herein) to facilitate the movement of drill cuttings to and through the opening 479 and from the vessel. Optionally, an auger apparatus 480 (for example as any auger apparatus described herein and, in one aspect, like the conveyor 11, Figure 1A) may be used with the vessel 472.

[0088] Figures 7A, 7B and 7E show a storage vessel 200 in accordance with the present invention which has a pressure vessel 202 (for example, like the storage vessel 2, Figure 1A) with a domed top 204, a generally cylindrical wall 206, and a floor 208. Drill cuttings 220 are fed into the vessel 202 via an inlet 210 flow through which is controlled by a valve 212. Valve 212 may simply be a flapper non-return valve which allows drill cuttings into the pressure vessel 202 but does not allow drill cuttings or air under pressure from escaping the pressure vessel 202. Optionally, compressed gas is introduced through a gas inlet 214.

[0089] A frame 230 (for example similar to the frame 21, Figure 1A) slides over the floor 208. The frame 230 includes a solid closure portion 232, but which may be perforated or made of screen. The closure portion 232 selectively closes off an opening 234 in the floor 208 which is located above a screen conveyor 236 (like the conveyor 11, Figure 1A) which is rotatably mounted in a tube 240.

[0090] As shown in Figure 7A the closure portion 232 closes off flow, inhibits or reduces flow to the screw conveyor 236 when movement apparatus 250 is in the fully retracted position. This closed position is assumed when the storage vessel 200 has drill cuttings being stored therein, for inhibiting drill cuttings from sitting in the screw conveyor tube 240. It is possible if drill cuttings sit in the screw conveyor 236 for too long a period of time that the drill cuttings can set and inhibit or prevent the screw conveyor from rotating when discharging the drill cuttings commences. This closed position is also assumed when the storage vessel 200 is empty so that drill cuttings are inhibited from falling into the screw conveyor 236 and becoming compacted in the screw conveyor 236. As shown in Figure 7B, the frame 230 has been moved by the movement apparatus 250 (like any movement apparatus disclosed herein) and the opening 234 is no longer blocked and receives material flowing down from the vessel 202. Cuttings flow from the vessel 202 to a cuttings discharge end 242 of the tube 240 is facilitated by the screw conveyor 236.

[0091] As shown in Figure 7E by arrows 263, the conveyor 236 can be run in reverse to circulate cuttings within the vessel 202 to produce a more homogenized mass of cuttings. The arrows 264 indicate rotation of the conveyor 236 in the direction resulting in cuttings moving from the vessel 202.

[0092] Optionally, the tube 240 may have an inclined end plate 247 to facilitate cuttings movement toward the conveyor 236 and, when the conveyor is run in reverse, to facilitate cuttings movement into and within the vessel 202. Optionally, the tube 240 has an inclined end plate 248 near the tube's discharge end which urges material down into a discharge chamber 245 and out of the tube 240. Optionally, compressed gas is supplied to an inlet 243 to promote the movement of drill cuttings from the discharge chamber out the discharge end 242 of the tube 240.

[0093] As shown in Figures 7C and 7D a storage vessel 500 has a pressure vessel 502 (for example like the storage vessel 2, Figure 1A) with a domed top 504, a generally cylindrical side wall 506, and a floor 508, further including a plurality of aeration nozzles 561 through a floor 508 which inject gas under pressure into a vessel 502 (in certain aspects, upwardly and/or downwardly into the conveyor 536). The same compressed gas supply that provides gas to the inlet 514 may be used to provide gas to the nozzles 561 or a separate compressed gas source may be used. Air and drill cuttings inlets are not shown in Figure 7C or 7D. The pressurized fluid through the nozzles 561 may be at the same or higher pressure than the pressure used to convey the drill cuttings. By applying a pneumatic fluid through the air nozzles 562 the drill cuttings are aerated. This is important when dry drill cuttings are stored in the pressure vessel 502. The dry drill cuttings are aerated and moved out through the screw conveyor 536. When the drill cuttings are aerated, they act more like a fluid and, therefore, transportation of the drill cuttings is more predictable. This also can facilitate removal of blockages in the conveyor and may also be used to purge and clean the screw conveyor 536 at any convenient time, such as when the storage vessel 500 is empty. Optionally, the storage vessel 500 includes a plurality of aeration nozzles 562 which project into the tube 540 and provide gas under pressure into the tube 540 to promote cuttings movement, to inhibit cuttings consolidation and unwieldy slug formation. In one particular aspect there is a plurality of aeration nozzles along the full length of the tube 540. When the closure member 532 is in a closed position, air diffuses past the edges of

the closure member 532 (and, if it is perforated, through any perforations therein) and aerates the cuttings which are moving past the frame 530.

[0094] A sliding frame (for example like the frame 230, Figure 7A) in dealing with wet cuttings, dry cuttings, or cuttings which are moisture bearing, provides discharge rate control (from the discharge end 242) by controlling the amount of material that flows into the conveyor 236. Aerating dried cuttings, for example cuttings dried by a dryer facilitates cuttings movement by making the cuttings act more like a fluid and makes transportation of the cuttings more predictable.

[0095] Figure 8A shows an apparatus 600 in accordance with the present invention for storing and moving drill cuttings [which may be wet, dry, or moisture-bearing (damp)] which has an optional vortex dryer 610, feeder apparatus 620, and a conveying system 650. The vortex dryer 610 provides drill cuttings to the feeder apparatus 620. The feeder apparatus 620 has a pressure vessel 622 which provides drill cuttings to the conveying line 632. The feeder system 620 may be, in certain aspects, like the apparatus shown in Figures 3B or 4 or like any blow tank or storage vessel disclosed herein.

[0096] Referring to Figure 8A, compressed gas to facilitate cuttings conveyance is supplied from a compressed gas source 602 in a line 627 to a feeding vessel 622, which is identical to the feeding apparatus 470 shown in Figure 3A to 3C. Compressed gas from line 627 passes in a line 612 (with flow controlled by a valve 615) to a discharge box 624. A small amount of compressed gas is applied to the top of a pressure vessel 622 through valve 616 to inhibit cuttings from being blown back into the pressure vessel 622 from a screw feeder at the bottom of the pressure vessel 622, which feeds the discharge box 624. Cuttings discharged from the discharge box 624 are propelled by the compressed gas into and through a conveying line 632 from which the cuttings flow to further processing apparatus (for example another vortex dryer) or to storage vessel such as the storage vessel 1 shown in Figure 1A or to a prior art cuttings boxes located on a rig, on shore or on a boat.

[0097] A plurality of pressure monitors 640 are spaced-apart along the conveying line 632, each including a pressure gauge and in communication with a control system, for example a PLC control system 680. A plurality of gas injection apparatuses 690 are spaced-apart along the conveying line 632 for selectively injecting gas under pressure into the conveying line 632 as directed by the PLC controller 680. Gas is supplied in a line 613 to the apparatuses 690. A valve 614 controls flow in the line 613. The valves 614, 615, 616 are in communication with and controlled by the PLC controller 680. The motorised screw feeder of the apparatus 600 is in communication with and controlled by the PLC controller 680.

[0098] Each apparatus 690 includes a one way check valve 691 through which air flows into a conveying line 632, the one way check valves 691 inhibiting drill cuttings from entering and blocking pneumatic line 613; a controllable valve 692 that selectively controls flow of fluid into the conveying line 632; and a regulating valve 693 that selectively allows pneumatic fluid under pressure through and into the conveying line 632 when the pressure differential between the line 613 and the pressure at the point 640 is less than a predetermined difference in order to maintain a constant pressure drop along the conveying line.

[0099] The monitoring and control system maximizes throughput in a safe manner, i.e. avoiding plugging and pushing solids into a conveying line in an uncontrolled manner. The use of the apparatus 690 and 640, in one aspect, ensures that the cuttings are kept "live" and moving within the conduit 632. The pressures are monitored at strategic points along its full length. The pressures observed are maintained by modifying the cuttings feed rate and/or assist air flow for continuous (and, in some aspects, optional) performance. To minimize the overall pressure drop over the length of the conduit 632, the length and/or density of a conduit 632 is controlled which is in the dense phase mode of flow whereby it has filled the entire cross section of conduit

[0100] The denser the slug, the higher the wall friction, hence the higher the pressure required to propel the slug down the conduit 632. Also the relationship of slug-length-to-pressure required to propel a slug is exponential; i.e., the pressure required to convey a series of slugs separated by "cushions" of air is far less than that needed to convey a single slug whose length is equivalent to the sum of the lengths of the series of slugs.

[0101] The feeding apparatus 620 doses cuttings into the conduit 632 in slugs, the size of which are determined by the screw or auger outside diameter, shaft size and pitch. The feed rate is directly proportional to the rotational speed of the screw. Localized aeration within the conveying/discharge chamber of the screw ensures the cuttings are "life" and the speed control/stop/start facility of the screw controlled by the PLC controller 680 offers close control in the creation of the slugs. This control is based upon the pressure regime within the conduit 632 which is heavily dependant upon the mode of flow.

[0102] In one aspect nominal setpoints are used within the conduit 632 regarding the maximum pressure drop across the conduit 632, one set at a low value for dilute phase, for example 2 bar, which is used for dried drill cuttings and the other for non-dried cuttings which is higher, for example 4 bar. In one particular aspect, in dense phase, the drill cuttings move along the conveying line at approximately 10 m/s; and in lean or dilute phase, the drill cuttings move along the conveying line at approximately 30 m/s. The PLC controller 680 ramps up the screw speed to the speed necessary to feed the conveying line 632 so that pressure drop is maintained to a set level between the units 690. For example, with four units 690 spaced equidistant along the length of a straight conveying line 632, the conveying line 632 is dosed with a first dose of drill cuttings from the feeder 620. The air supply 602 is activated and the plug of drill cuttings moves

along the conveying line. The initial pressure is set to for example 4 bar and it is expected that the pressure at the end of the conveying line will be slightly above atmospheric when the plug reaches the end. The units 690 regulate the pressure in the line so that there is a reasonably constant pressure drop between the units 690. The pressure drop is, for example 0.5 bar between each unit, such that after the first unit 690 the pressure is regulated at 3.5 bar, after the second unit the pressure is regulated to 3 bar after the third unit the pressure is regulated to 2.5 bar and after the fourth unit the pressure is regulated to 2 bar so that it is expected that the pressure at the end of the conveying line 632 is approximately 1.5 bar and that there is a reasonable degree of certainty in knowing the plug will discharge from the end of the conveying line and into a storage vessel. If the pressure drop is within a certain percentage, for example 30%, and, in one aspect, 15%, and in one particular aspect, 10% of what was expected, the regulator opens the line 613 and allows air under pressure, regulated by regulator 693 to enter the conveying line at the correct pressure.

[0103] A standard PID loop "PID loop" (Proportional-Integral-Differential) is utilized such that should the pressure drop overshoot the desired setpoint, the screw feeder speed is reduced or stalled accordingly. Feedback from the pressure monitors 640 along the line which are located strategically slightly upstream of bends/vertical lifts or any other areas known to create turbulence within the conduit are used in order to actuate air assist valves in the apparatus 690 should it be necessary. An air assist valve is located at a turbulence point downstream of a pressure monitor and should the pressure at the monitor go below a given percentage value compared to the sensor immediately upstream of it, for example 80%, then air is fed direct from source 602 via the bypass line 613 which runs the full length of the conduit 632 into the associated assist point. The pressure setting for the air assist is set at for example 90% of the pressure value at the monitor 640 immediately upstream, and if this pressure is reached, then the assist air is also directed to the next injection point immediately downstream and so forth. Each valve 691 can feed an associated gas injection nozzle 699 (for example see Figure 8B).

[0104] Figures 9A to 9C illustrate a feeder apparatus 700 in accordance with the present invention, which is like the feeding apparatus 470 shown in Figure 3B, further incorporating a hopper 720 having a vibratory motor 725 for vibrating the buffer hopper portion 721 and a further air injector 772 and modified discharge box 753. A control system 701 is in communication with sensors in the hopper portion 721 and the pressure vessel portion 740. The hopper 720 comprises the buffer hopper 721; an optional vibratory motor 722 for vibrating the buffer hopper 721 and its contents; an expansion joint 722; and a valve 723 at an exit opening 724 to control the flow of drill cuttings from the hopper 721 to the storage vessel system 740. The conveying apparatus 700 is used, for example, to move drill cuttings from shakers to storage vessels, and, in one particular aspect, the pressure vessel 740 only has a storage capacity of about 0.3 cubic meter.

[0105] The pressure vessel portion 740 may be like the storage vessels shown in Figures 1A, 3B-D, 7A and 8A. The pressure vessel portion 740 has a vessel 742 which receives drill cuttings through an inlet 743. A vent valve 744 selectively vents the vessel 742 and a relief valve 745 relieves pressure in the vessel 742 at a preset level. A conveyor 750 conveys drill cuttings from the vessel 742 to a discharge box 751 and the cuttings exit a discharge end 752 of a tube 753 to flow into a conduit (not shown; for example like the conduit 632, Figure 8A). A motor/gear system 760 rotates the conveyor 750.

[0106] Compressed gas from a source 770 supplied gas under pressure in a line 771 to an inlet 772 on the discharge box 753; in a line 773 to an inlet 774 at the discharge end 752 of the discharge box 753; in a line 775 to an inlet 776 at the discharge box 751; and in a line 777 to an inlet 778 of the pressure vessel 742. The inlet 778 may be of very small diameter, as this is simply for balancing the pressure within the pressure vessel 742 with the pressur in the box 751 or in the discharge end 752. Each line has a one way check valve 779. Optionally the hopper 721 is mounted on isolation/non-vibration mounts 782.

[0107] All the operational components of the conveying apparatus 700 are in communication with (see dotted lines) a controller 701 (for example like the controller 680, Figure 8A).

[0108] Each line 771, 773, 777 has an on/off flow control valve 771a, 773a, 777a respectively (for example like the valves 692); a pressure regulator 771b, 773b, 777b, respectively (like the pressure units 690; pressure set manually or by the control system, the set pressure effectively sets the maximum working pressure of the system, for example, 2 BAR for dried cuttings or 4 BAR for wet cuttings from the shale shakers); and flow control valves 771c, 773c, and 777c, respectively, which control the rate of change in pressure (for example, may be needle valves, orifice plates, or similar devices).

[0109] Via the line 777 gas is provided to the vessel 742 at a pressure equal to the pressure of gas provided to the discharge box 753 in the line 771 and to the gas provided in the line 773 to the discharge box 751 so that the pressure drop across the conveyor (screw feeder) 750 is negligible. Therefore feed rate of cuttings from the system 700 is determined by the rpm's of the conveyor 750. In one aspect gas is input downstream of a discharge valve 752a in the line 773. With the discharge valve 752a closed, the vessel 742 can be vented to the atmosphere, permitting refilling of the vessel 742 while cuttings are being conveyed downstream of the discharge end 752.

[0110] The control system shown in Figures 9A to 9C may be used for any feeder apparatus or storage vessel disclosed herein.

[0111] Figure 10 shows a system 800 in accordance with the present invention, which has a cuttings dryer 801

which dries drill cuttings, such as a vortex dryer or a cuttings dryer of the type disclosed in GB-A-2,297,702. The vortex dryer 801 may be fed and located immediately below the discharge end of a shale shaker (not shown) or at the end of a ditch (not shown) fed by a plurality of shale shakers (not shown). However, the drill cuttings to be dried are dried in the cuttings dryer 801 for a set time or within a limited range of time. Accordingly, if the drill cuttings are very wet, for example if the shale shakers have suffered from "near sized particle blinding", in which case a substantial amount of drilling fluid would wash over the shaker into the cuttings dryer with the drill cuttings, some or all of the drill cuttings will not be sufficiently dry to transport with the pressure vessel or will simply require further drying, further processing or to be stored and conveyed in or from a special storage vessel. Thus, a conveyor system 802 with augers 803, 804 driven by a motor/gear system 805 provides drill cuttings selectively to a storage vessel 810 or to a pressurized feeding apparatus 820, based on measurements by a moisture sensor 821 (or sensors). Non-wet cuttings go to the pressurized feeding apparatus 820; if "wet" cuttings are sensed, the augers are reversed and cuttings are conveyed to the storage vessel 810 (which may be like the storage vessel 1). A sensor (or sensors) 821 sense moisture content of the drill cuttings. If the sensor 821 senses "wet" (for example greater than 1, 3 or 5% moisture content) then the auger is reversed and moves the cuttings to the "wet" cuttings storage vessel 810; and, if the cuttings are dry (for example less than 5% moisture or oil content), the auger is set in forward motion and the cuttings are supplied to the pressurized feeding apparatus 820, which blows the cuttings to a dry cuttings box 825, which may be like the cuttings storage vessel 1. In one particular arrangement, once cuttings have moved to the storage vessel 810, they can then be moved to the dry cuttings box 825. Optionally (as is the case for any moisture sensor or sensor apparatus in any system herein) the sensor 821 may have a protective canopy 821a for components outside a hopper and a protective canopy 821b for components 821c within a hopper 822. Such a canopy 821b protects sensor components 821c from drill cuttings falling downwardly in a hopper. Multiple sensors 821 may be used spaced apart around the hopper 822 (as is the case for any system in accordance with the present invention with moisture sensor apparatus). In certain aspects, such sensors are efficacious with a drill cuttings amount that is at least 2.5cm (one inch) thick and has an area of at least twenty to twenty six square cm (three to four square inches). Such sensors may produce continuous readings for more accurate use by a control system 829 which is in controlling communication with components of the system 800 as indicated by dotted lines.

[0112] The control system 829 can switch cuttings flow from the system 825 (for example for adequately dry cuttings) to the system 810 (for example for relatively wet cuttings). In any system herein a first storage apparatus or a "dry" storage apparatus can be a storage vessel, the hold of a ship, or a hold or reservoir on a rig or in legs of a rig. Such storage facility, in whatever form, may have, in accordance with the present invention, a positive pressure pneumatic system and a bottom aeration system for aerating drill cuttings material from underneath the material (for example through a perforated bottom plate or member) producing a dilute phase material which is more easily conveyed. In one particular aspect moisture content sensors are like Models MCT 300, MCT 600 and MCT 101-T sensors from Process Sensors Corporation, Milford, Massachusetts. As is the case with any pressurized vessel in any system herein, a cuttings vessel 820a of the system 800 may be, in volume, between 0.05 m^3 to 0.2 m^3.

[0113] Figure 11 shows a system 830 in accordance with the present invention in which a conveyor 831 powered by a motor/gear system 832 feeds drill cuttings to two vortex dryers 833. Cuttings processed by the vortex dryers 833 are fed by conveyor systems 834 to a hopper 835 of a feeder system 836 (like the system 820, Figure 10). One of the vortex dryers 833 has a screen which blinds if the drill cuttings are "near sized" ("near sized" means the size of cuttings generated by drilling which have a size distribution like that of the size of screen mesh apertures of screens in screening apparatus; near size particles can become lodged in screen apertures, clogging a screen), at which point wet drill cuttings flow out of the vortex dryer. This is noted by a moisture sensor 831 which sends a signal to the second vortex dryer, which kicks in, which has a screen with a screen size different from the first vortex dryer, and therefore can cope with this size of particle. The system 836 produces processed cuttings which exit in a conduit 837.

[0114] Figure 12 shows a system 850 in accordance with the present invention similar to the system of Figure 11 which has a conveyor system 851 powered by a motor/gear system 852 which conveys drill cuttings from shale shakers, hydrocyclones and/or centrifuges to vortex dryers 853 which in turn feed dried cuttings via a chute 854 to a feeding apparatus 856 (like the feeding apparatus 836) which feeds the cuttings into an exit conduit 857. The vortex dryers 853 have hoppers 854 beneath them which feed the feeding apparatus 856.

[0115] Figure 13 shows a system 900 in accordance with the present invention for a drilling rig R in which drill cuttings (for example from shale shakers, centrifuges) flow to an feeding apparatus 906 (like the feeding apparatus 820, 836, 856) with a vortex dryer 907. The feeding apparatus 906 processes the cuttings and feeds them to a storage vessel, which may be of the type shown in Figures 1A, 1C or 7A). If the reading from the moisture sensor in the feeding apparatus 906 indicates that the drill cuttings are dry, a controller (not shown) diverts the flow of drill cuttings from the feeding apparatus 906 to either the internal bulk handling storage units 910 built into the rig R or into the internal hold 911 in the supply boat B (if a supply boat is available). If the reading from

the moisture sensor indicates that the drill cuttings are wet, then the controller diverts the flow of drill cuttings to wet storage vessel 1 on the rig R or on the boat B. The internal bulk handling storage units built into the rig R and the internal hold in the supply boat B are able to handle dry bulk material but not wet bulk material. Thus by assessing the dryness of the drill cuttings, it is possible to store the drill cuttings in the internal bulk handling storage units 910 built into the rig R or into the internal hold 911 in the supply boat B. The wet drill cuttings can be loaded and stored in a storage vessel of the type shown in Figure 1 or reprocessed in a cuttings dryer, such as a vortex dryer or a cuttings dryer of the type disclosed in WO 2004/000762 and GB-A-2,297,702 and the moisture re-tested.

[0116] Figure 14 shows a system 920 in accordance with the present invention in which shale shakers 921 feed drill cuttings material on to a screw or belt conveyor 922 which feeds the material to a vortex dryer 923 which feeds dried material to a pressurized screw feeding apparatus 924 (like the screw feeder apparatus shown in Figures 8A, 9A and 10 to 12). Material processed through the pressurized screw feeding apparatus 924 exits for transfer in a line 925. Fluid recovered from the vortex dryer 923 flows in a line 926 to a holding tank 927 from which it is pumped by a pump 928 in a line 929 to a centrifuge 930. Solids from the centrifuge 930 are conducted in a line 931 for disposal and liquid is pumped in a line 932 to a holding tank 933. A pump 934 pumps liquid from the holding tank 933 either in a line 939 to a mud return system 935 (with a valve 936 closed and valve 938 open); or back to the vortex dryer 923 in a line 937 (with valve 936 open and a valve 938 closed).

[0117] Figure 15 shows a system 950 in accordance with the present invention in which a pressurized screw feeder apparatus 952 selectively feeds drill cuttings material to dried cuttings storage vessels 953 or to a "wet" tank storage vessel 954. A wetness meter 955 located in the hopper 968 senses moisture content of the drill cuttings material and controller 960 in communication with the wetness meter 955, controls a diverter valve 956 so that adequately dry cuttings go to the storage vessels 953 with flow to the "wet" tank system 954 shut off; and wet cuttings go to the wet tank system 954 with flow to the storage vessels 953 shut off. Optionally, each storage vessel 953 has its own associated diverter valve 957 so that flow to each box is selectively controlled by the controller 960.

[0118] In certain aspects the pressurized screw feeding apparatus 952 is like the apparatus in Figures 8A and 26; the wet storage vessel 954 is like the wet storage vessel in Figure 10; and the storage vessels 953 are like the storage vessels in Figures 1B, 3B and 10. The controller 960 controls the motors of each conveyor in the system 950.

[0119] In each of the systems of Figures 10 to 15 a suitable control system controls the various components and is in communication with the moisture sensors, valves, conveyors, and motors.

[0120] A method for moving drill cuttings from an offshore rig located in water to a boat in the water adjacent said offshore rig, said drill cuttings laden with drilling fluid, the method including feeding drill cuttings from a drilling operation to a cuttings processor, the cuttings processor comprising a rotating annular screen apparatus, processing the drill cuttings with the cuttings processor producing processed drill cuttings and secondary material, the secondary material including drill cuttings and drilling fluid, the processed drill cuttings including drilling fluid, feeding the processed drill cuttings from the cuttings processor to positive pressure blow tank apparatus, the positive pressure blow tank apparatus having a tank which receives the processed drill cuttings from the cuttings processor, feeding the secondary material from the cuttings processor to secondary apparatus, and supplying air under pressure to the tank of the positive pressure blow tank apparatus for expelling drill cuttings from the tank and propelling the drill cuttings to tertiary apparatus. In one particular aspect the secondary apparatus is decanting centrifuge apparatus, the method further including processing the secondary material with the decanting centrifuge apparatus, producing secondary drilling fluid and secondary drill cuttings. In one aspect, prior to feeding drill cuttings from the cuttings processor to the positive pressure blow tank apparatus, the drill cuttings are fed to mill apparatus to break up agglomerations of the drill cuttings and then feeding them from the mill apparatus to the positive pressure blow tank apparatus.

[0121] In one aspect, in methods wherein the secondary apparatus is decanting centrifuge apparatus, the methods include processing the secondary material with the centrifuge apparatus, producing secondary drilling fluid and secondary drill cuttings, recycling said secondary drilling fluid for reuse in a drilling operation, feeding said secondary drill cuttings to a mill apparatus for breaking up agglomerations of said secondary drill cuttings, feeding secondary drill cuttings from the mill apparatus to the positive pressure blow tank apparatus; and/or prior to feeding drill cuttings from the cuttings processor to the positive pressure blow tank apparatus, feeding said drill cuttings to mill apparatus to break up agglomerations of said drill cuttings and then feeding said drill cuttings from the mill apparatus to the positive pressure blow tank apparatus.

[0122] A method for moving drill cuttings material, the drill cuttings material including drill cuttings and drilling fluid, the method includes feeding the drill cuttings material to cuttings processor apparatus, the cuttings processor apparatus including rotating annular screen apparatus, processing the drill cuttings material with the cuttings processor producing processed drill cuttings and secondary material, the secondary material including drill cuttings and drilling fluid, said processed drill cuttings including drilling fluid, conveying with fluid under positive pressure processed drill cuttings from the cuttings processor to flow conduit apparatus, applying air under pos-

itive pressure to the flow conduit apparatus to continuously move the processed drill cuttings therethrough, continuously moving the processed drill cuttings with the air under pressure to separation apparatus, and with the separation apparatus continuously separating processed drill cuttings from the air.

[0123] A system for moving drill cuttings, the system having movement apparatus for moving drill cuttings, cuttings processor apparatus for processing the drill cuttings for feed to tank apparatus, the cuttings processor apparatus including rotating annular screen apparatus, tank apparatus for receiving drill cuttings from the cuttings processor apparatus, flow conduit apparatus for receiving drill cuttings from the tank apparatus, pressurized fluid apparatus for applying air under positive pressure to the drill cuttings and for continuously moving the drill cuttings through the flow conduit apparatus and to separation apparatus, and separation apparatus for continuously receiving the drill cuttings through the flow conduit apparatus, the separation apparatus for separating the drill cuttings from air.

[0124] A method of conveying a paste, the paste including drill cuttings laden with fluid, the method including feeding the paste to a cuttings processor, the cuttings processor comprising a rotating annular screen apparatus, reducing the weight of said paste with the cuttings processor by removing fluid from the paste, the cuttings processor producing produced material that includes drill cuttings and fluid, feeding the produced material from the cuttings processor into a vessel, applying a compressed gas to the vessel to cause the produced material to flow out of the vessel, the vessel including a conical hopper portion which, at least during discharge of the produced material, forms the lower section of the vessel and the cone angle is below a critical value required to achieve mass flow of the produced material.

[0125] Systems and methods for moving material that has a low slurry density, (for example with a specific gravity between 2.3 and 4.0 and, in one aspect, about 2.7 or lower) and a high particle density, (for example 2 lbs/gallon - 4 lbs/gallon or higher) with a positive pressure pneumatic fluid, for example air or steam. In other aspects the cuttings to be treated, for example from shale shakers, have a specific gravity of 1.8 (1800 kg/m3; 15 lbs/gallon) and certain high density cuttings have a specific gravity of 2.5 (21 lbs/gallon). In one particular aspect the material is a slurry that includes drill 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.

[0126] In certain aspects systems and methods provide the continuous or almost-continuous transport of material.

[0127] Systems with storage facilities for solids to be moved and apparatus for mixing heavy solids to be transported with a pneumatic fluid, for example, but not limited to, air or steam, at a positive pressure, i.e. above atmospheric pressure. 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.

[0128] In one aspect the apparatus reduces the density of a slurry of material. Such apparatus includes decelerator/separator apparatus.

Claims

1. A method for processing drill cuttings, the method comprising obtaining drill cuttings from at least one of a shale shaker, hydrocyclone, centrifuge or drill cuttings dryer, measuring the moisture content of the drill cuttings to obtain a moisture value, comparing the moisture value to a predetermined threshold and conveying the drill cuttings in a dry cuttings route if the moisture value is below the predetermined threshold or conveying the drill cuttings in a wet cuttings route if the moisture value is above the threshold.

2. A method in accordance with Claim 1, wherein the dry cuttings route comprises a feeder apparatus and a pneumatic conveying line, the method further comprising the steps of loading the drill cuttings into the feeder apparatus, which feeder apparatus feeds the pneumatic conveying line with the drill cuttings.

3. A method in accordance with Claim 2, wherein the pneumatic conveying line is a positive pressure pneumatic conveying line.

4. A method in accordance with Claim 2 or 3, wherein the pneumatic conveying line leads to one of: a storage vessel, a bulk storage tanks of an oil or gas rig, and a hold of an oil or gas rig, the method further comprising the step of conveying the drill cuttings through the pneumatic conveying line to one of the storage vessel, the bulk storage tanks of an oil or gas rig and the hold of an oil or gas rig.

5. A method in accordance with any of Claims 2 to 4 wherein the step of measuring the moisture content of the drill cuttings is carried out with a moisture sensor located in the feeder apparatus.

6. A method in accordance with any of Claims 2 to 5, wherein the feeder apparatus comprises a hopper and a pressure vessel, the step of measuring the moisture content of the drill cuttings is carried out

with a moisture sensor located in the hopper.

7. A method in accordance with any of Claims 1 to 6, wherein the wet cuttings route comprises a feeder apparatus and a pneumatic conveying line, the method further comprising the steps of loading the drill cuttings into the feeder apparatus, which feeder apparatus feeds the pneumatic conveying line with the drill cuttings.

8. A method in accordance with Claim 7, wherein the pneumatic conveying line is a positive pressure pneumatic conveying line.

9. A method in accordance with Claim 7 or 8, wherein the pneumatic conveying line leads to a storage vessel, the method further comprising the step of conveying the drill cuttings through the pneumatic conveying line to the storage vessel.

10. A method in accordance with Claim 7 or 8, wherein the pneumatic conveying line leads to a cuttings dryer for further drying.

11. A method in accordance with Claim 1, wherein the drill cuttings from the at least one of a shale shaker, hydrocyclone, centrifuge or drill cuttings dryer, are feed into a feeder apparatus whereupon moisture content of the drill cuttings is measured to obtain a moisture value with a moisture sensor located therein, the feeder apparatus feeding the drill cuttings into a pneumatic conveying line, the conveying line having a diverter valve therein, the method further comprising the steps of diverting the drill cuttings using the diverter valve into a dry cuttings route if the moisture value is below the predetermined threshold or conveying the drill cuttings in a wet cuttings route if the moisture value is above the threshold.

12. A method in accordance with any of Claims 1 to 11, wherein a screw conveyor is located beneath the at least one of a shale shaker, hydrocyclone, centrifuge or drill cuttings dryer to receive the drill cuttings, the screw conveyor comprising a drive such that the screw conveyor is reversible to convey the drill cuttings in one direction for a dry cuttings route and in a second direction for a wet cuttings route.

13. A method in accordance with any of Claims 1 to 12, wherein the predetermined threshold is one of: 5%, 3% and 1% moisture content.

14. An apparatus for carrying out the method as claimed in any of Claims 1 to 13, the apparatus comprising a moisture sensor (821,955) and means (802,956) for directing the drill cuttings in a wet cuttings route or a dry cuttings route.

15. An apparatus as claimed in Claims 20, the apparatus further comprising a controller (829,960) for obtaining data from the moisture sensor (821,955) and comparing the data to a predetermined value and activating said means according to the data.

Fig.1A

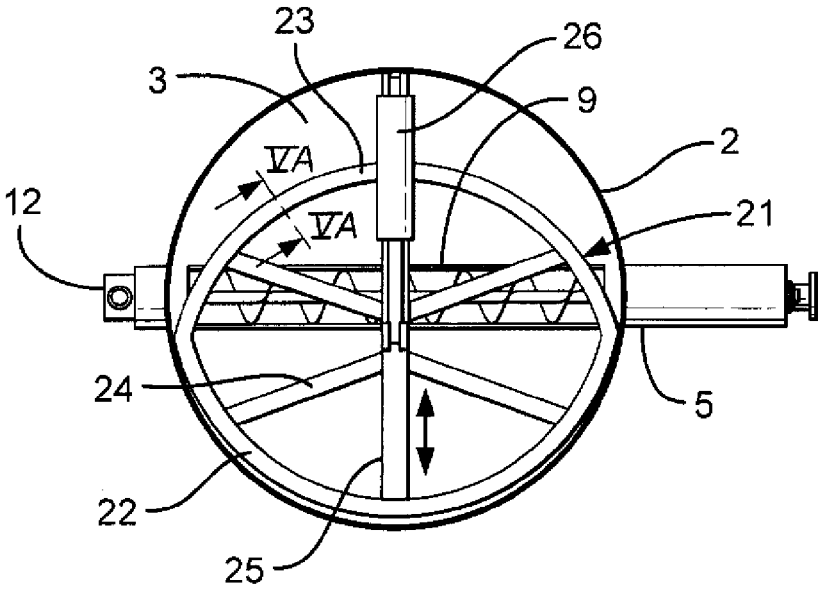
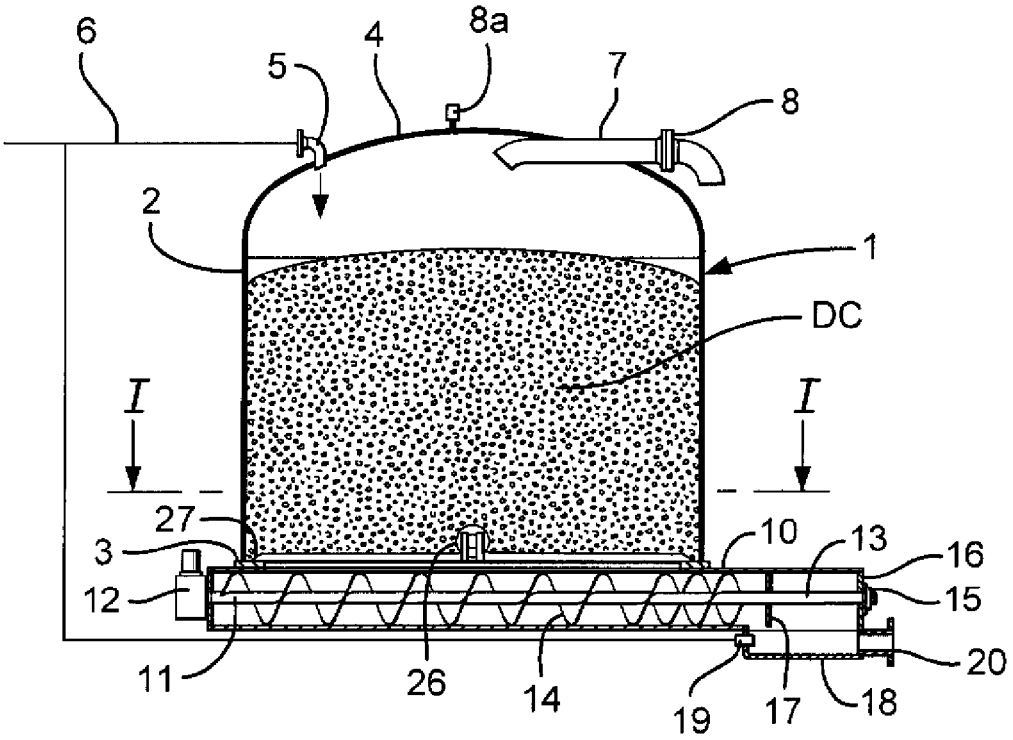

23
26
3
9
2
VA
VA
12
21
24
5
22
25

Fig.1B


6
5
4
8a
7
8
2
1
DC
I
I
27
3
10
13
16
12
15
11
26
14
19
17
18
20

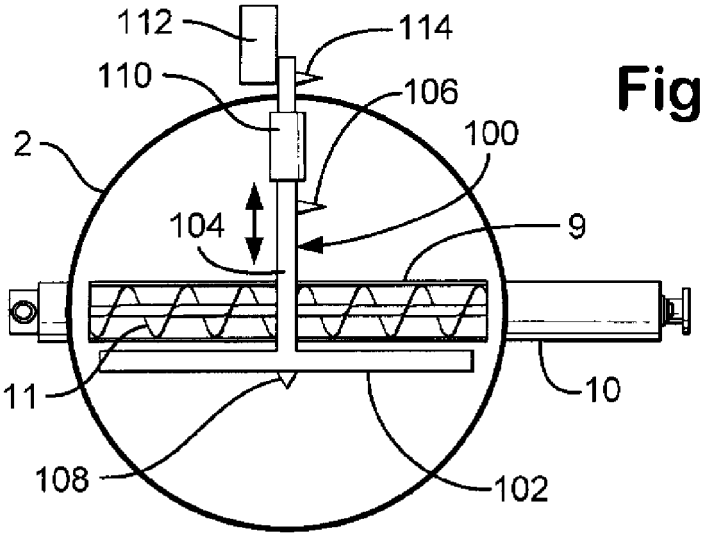


Fig.1C

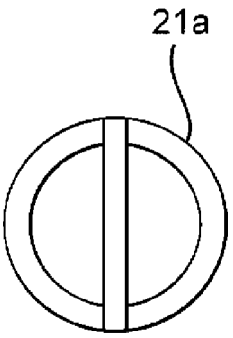


Fig.1D

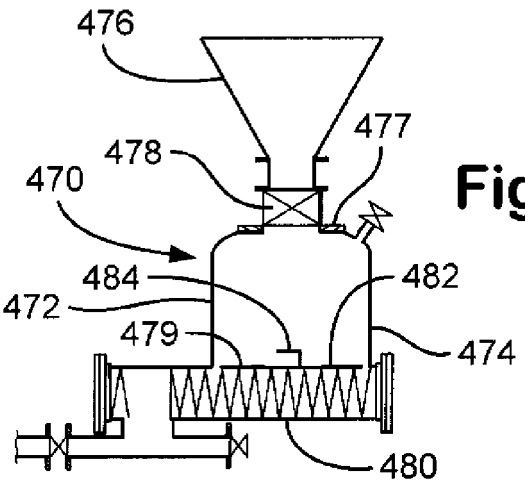


Fig.3A

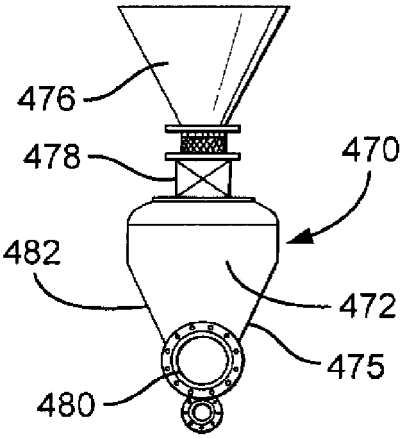


Fig.3B

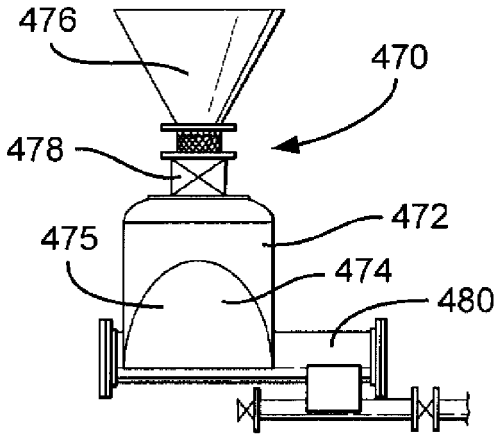


Fig.3C

Fig.2

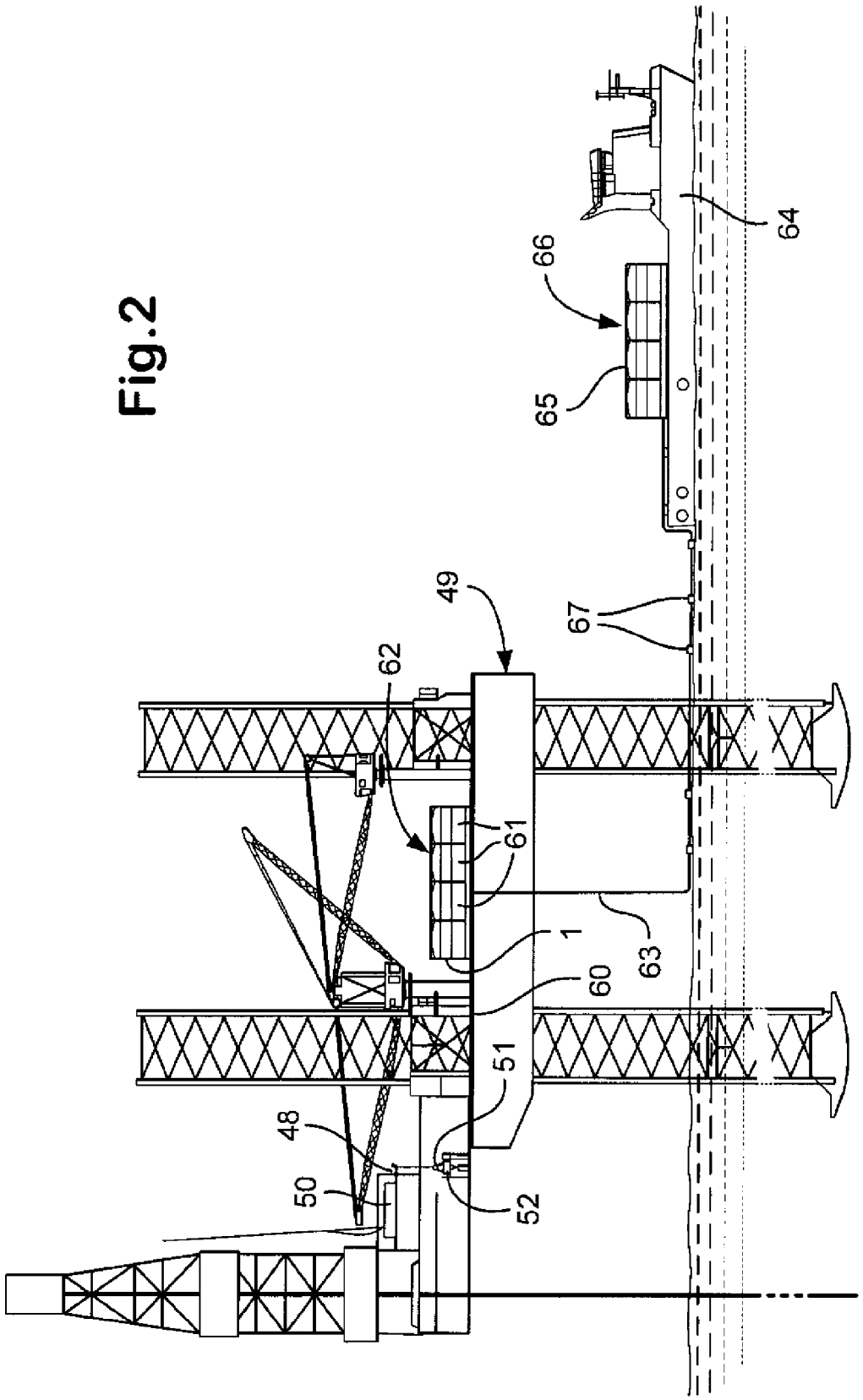


Fig.3

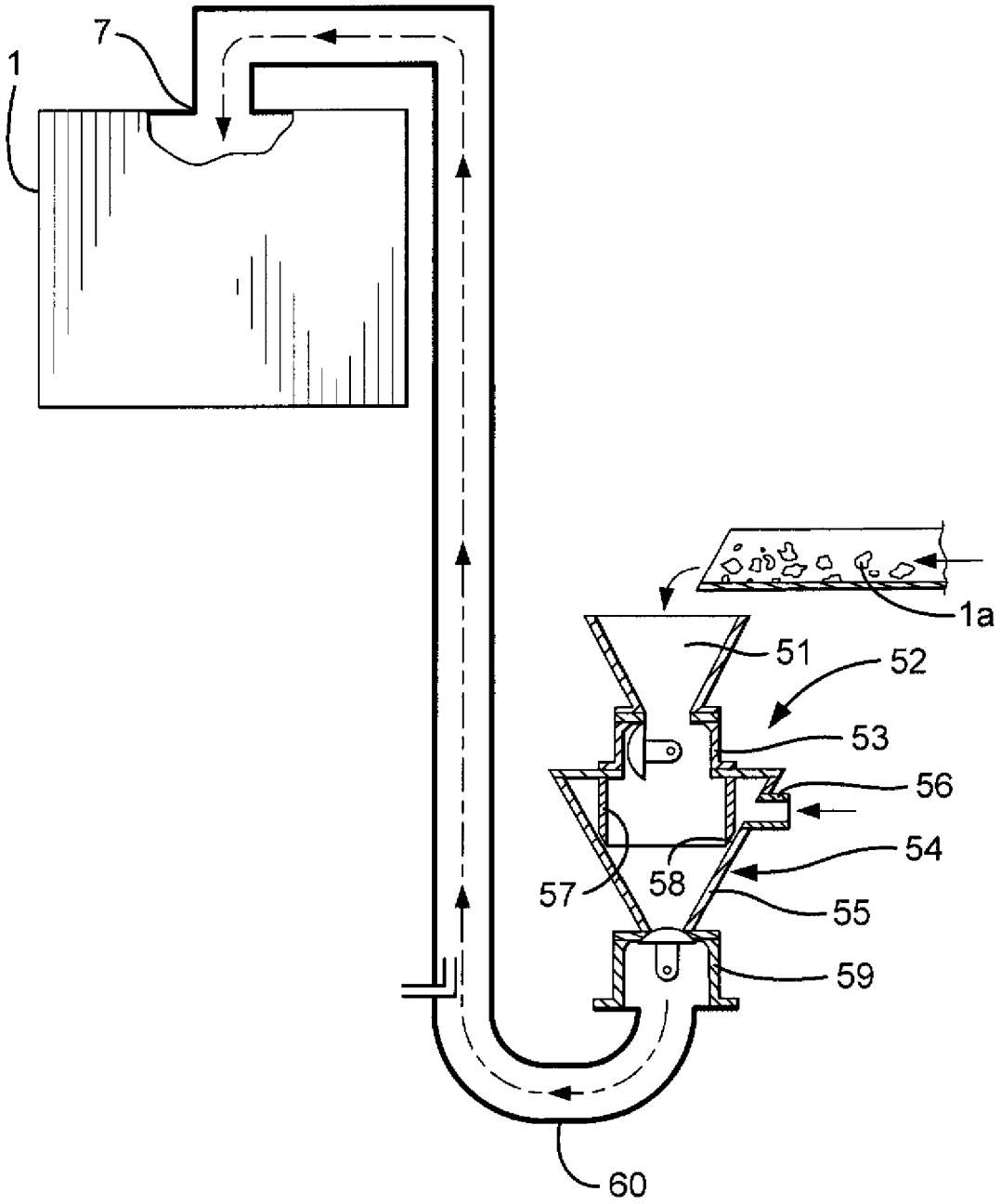


Fig.4

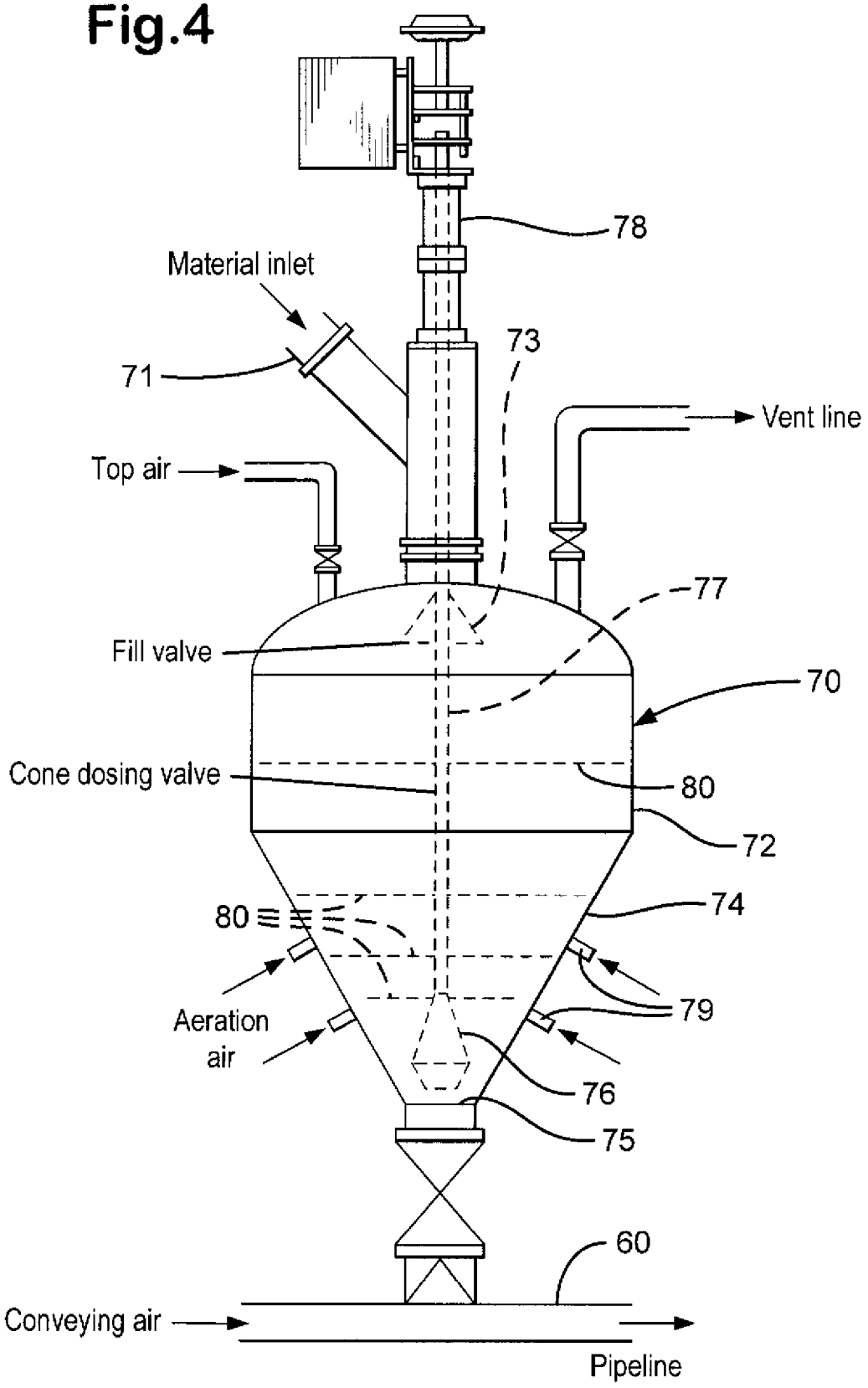

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Material inlet
73
71
Vent line
Top air
77
Fill valve
70
Cone dosing valve
80
72
74
80
79
Aeration
air
76
75
60
Conveying air
Pipeline

Fig.5A

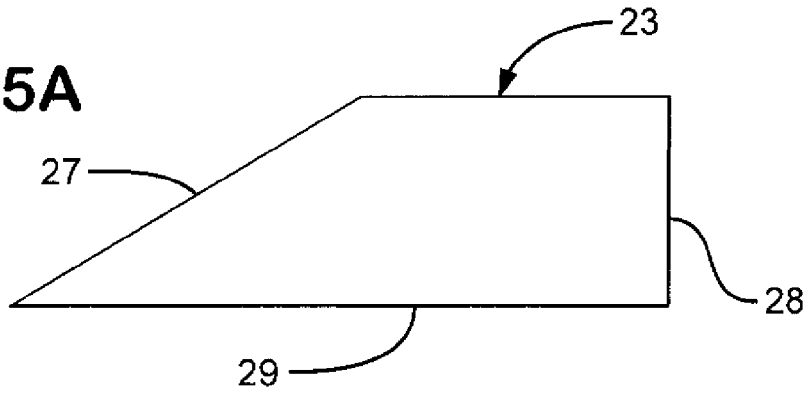


Fig.5B

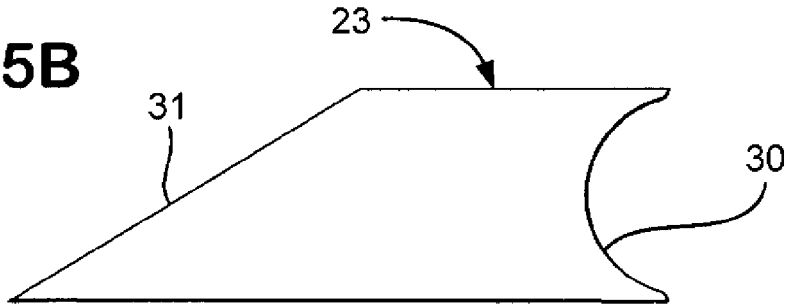


Fig.5C

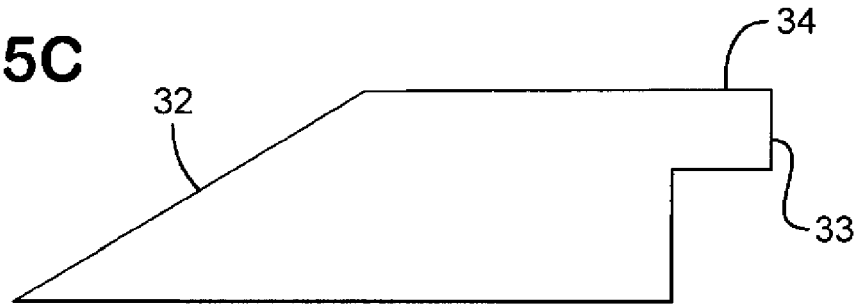


Fig.5D

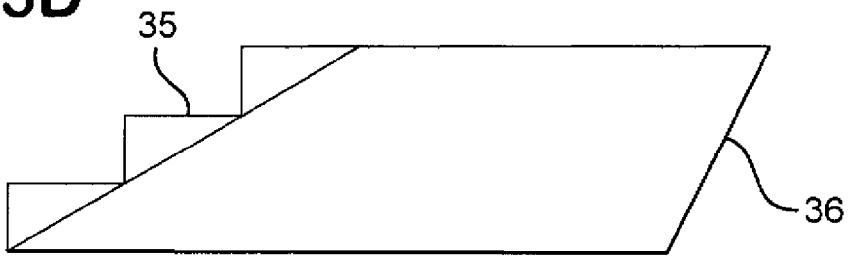
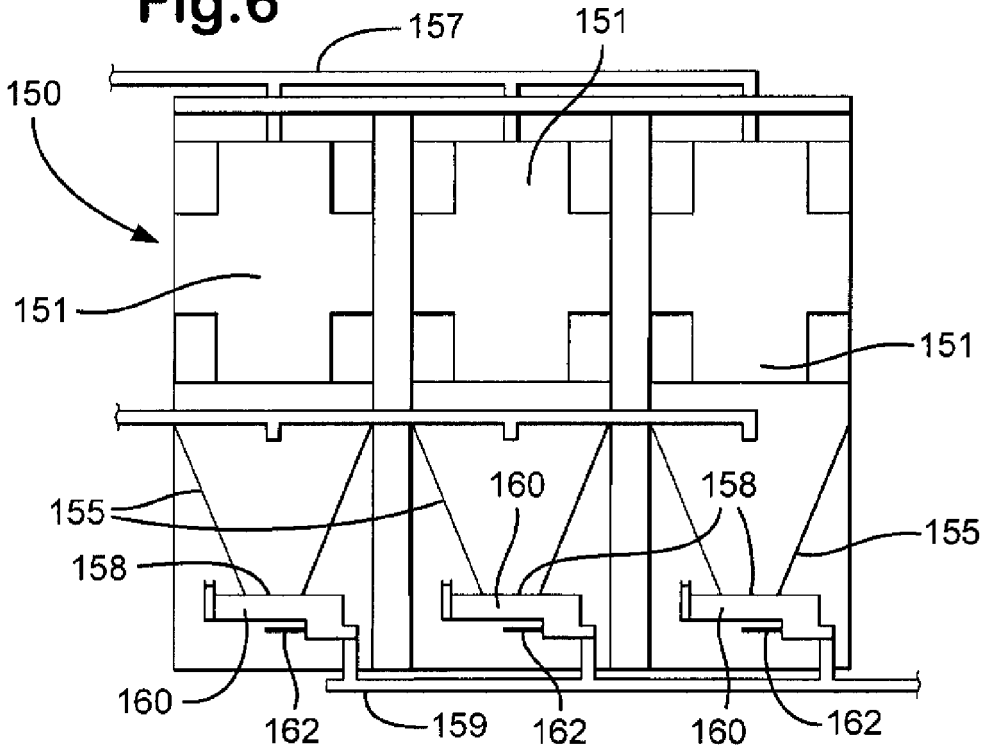


Fig.6



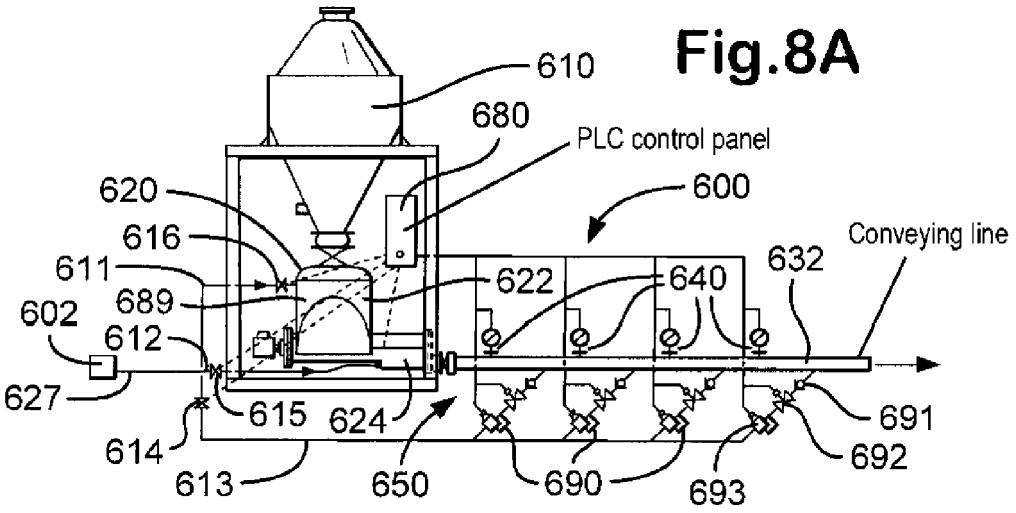


Fig.8A

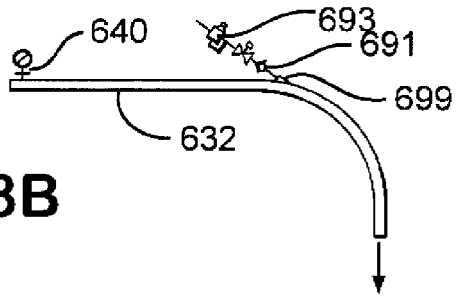


Fig.8B

Fig.7A

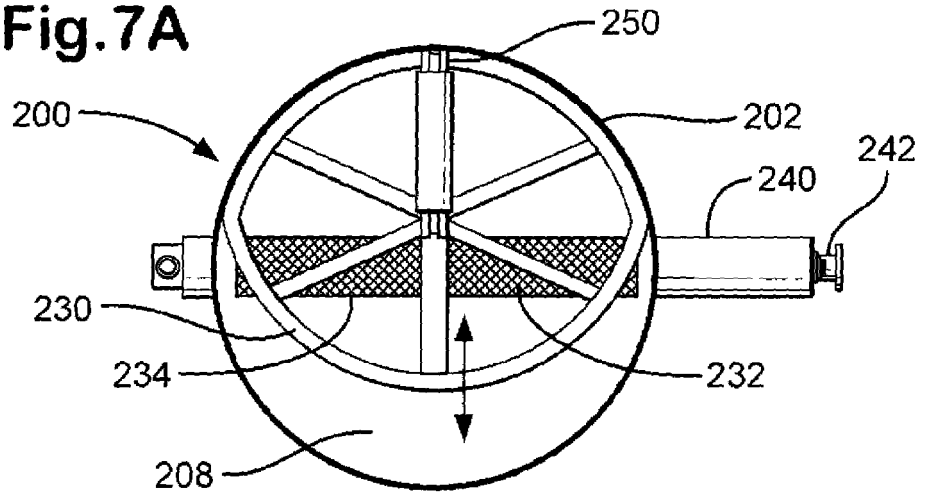


Fig.7B

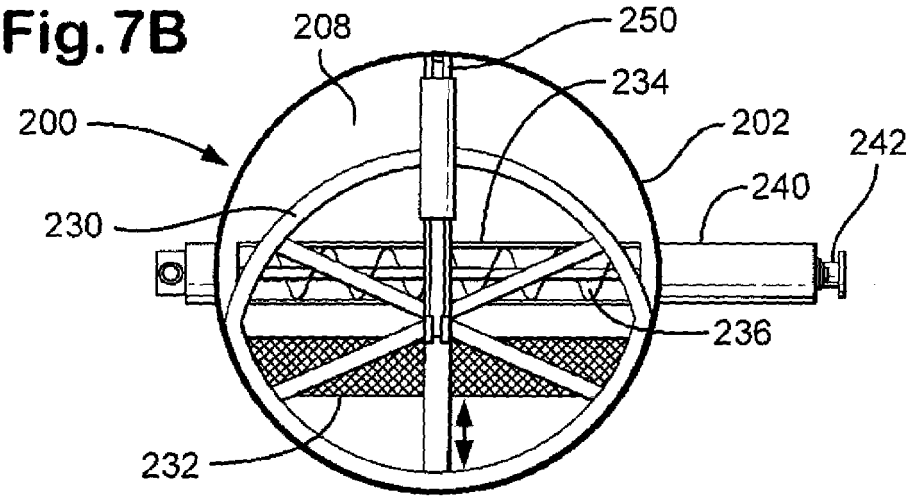


Fig.7C

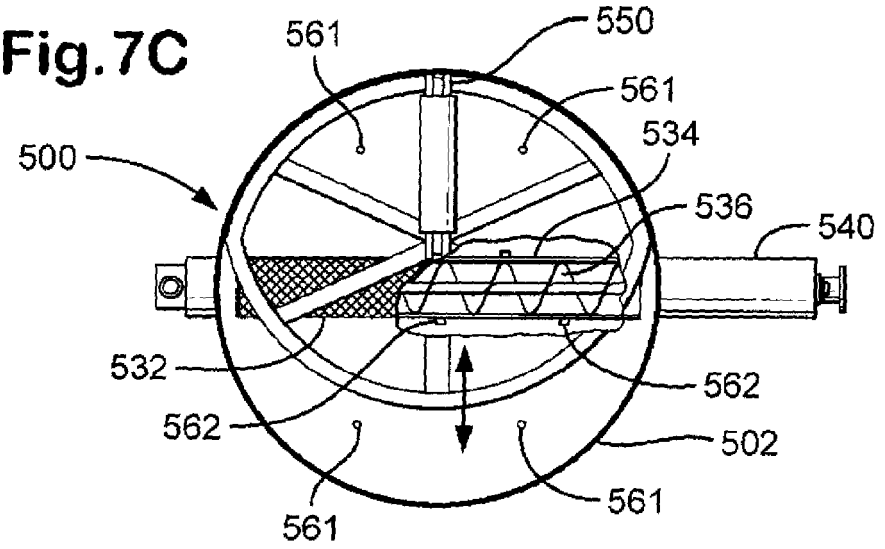


Fig.7D

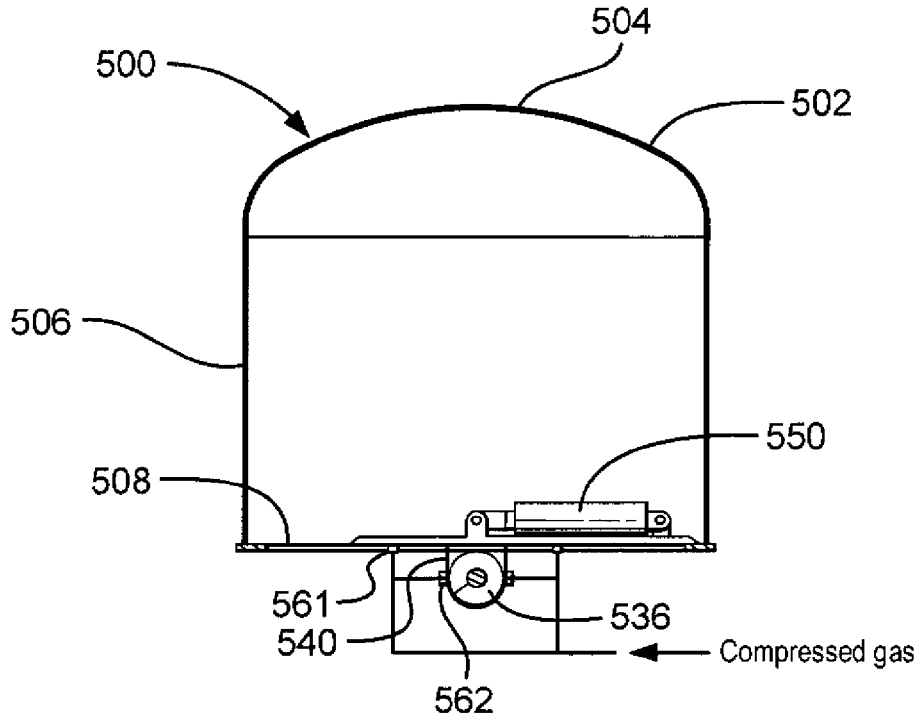

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Compressed gas
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Fig.7E

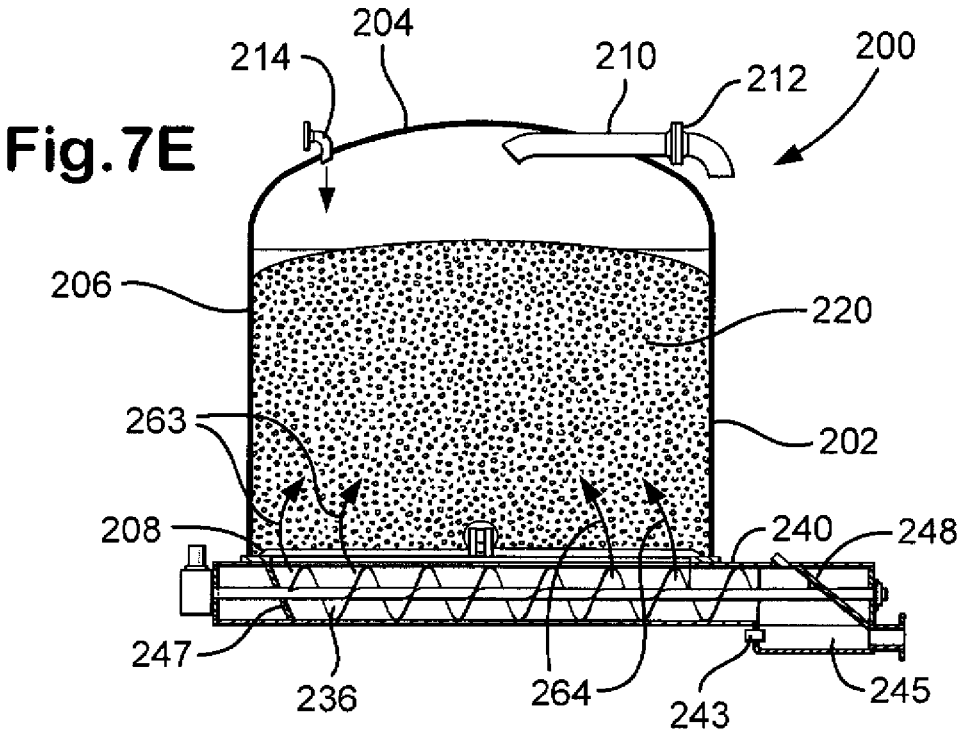

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Fig.9A

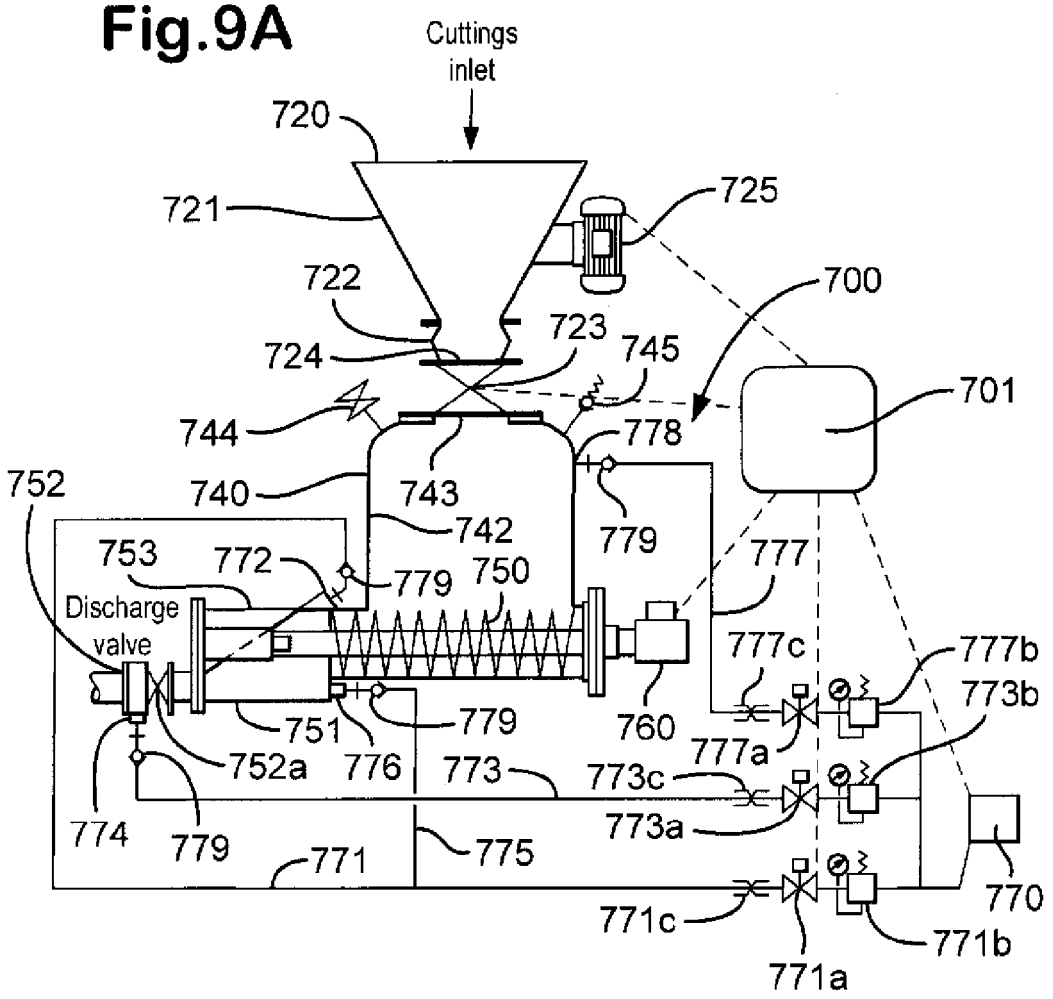


Fig.9B

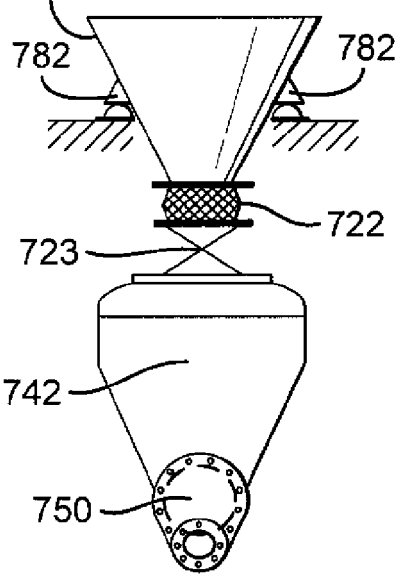


Fig.9C

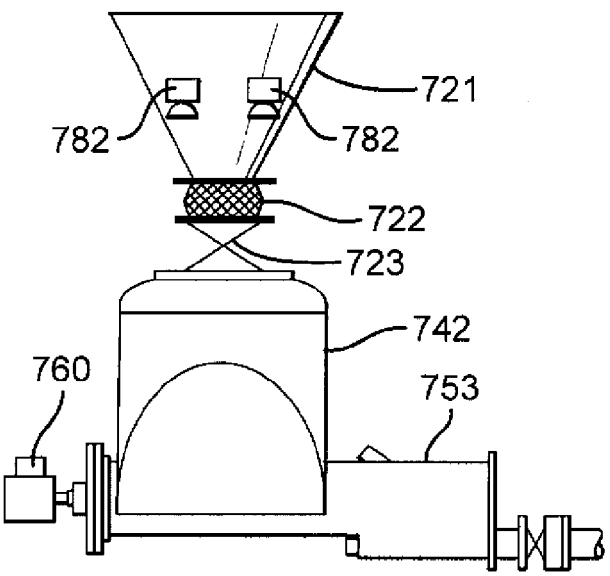
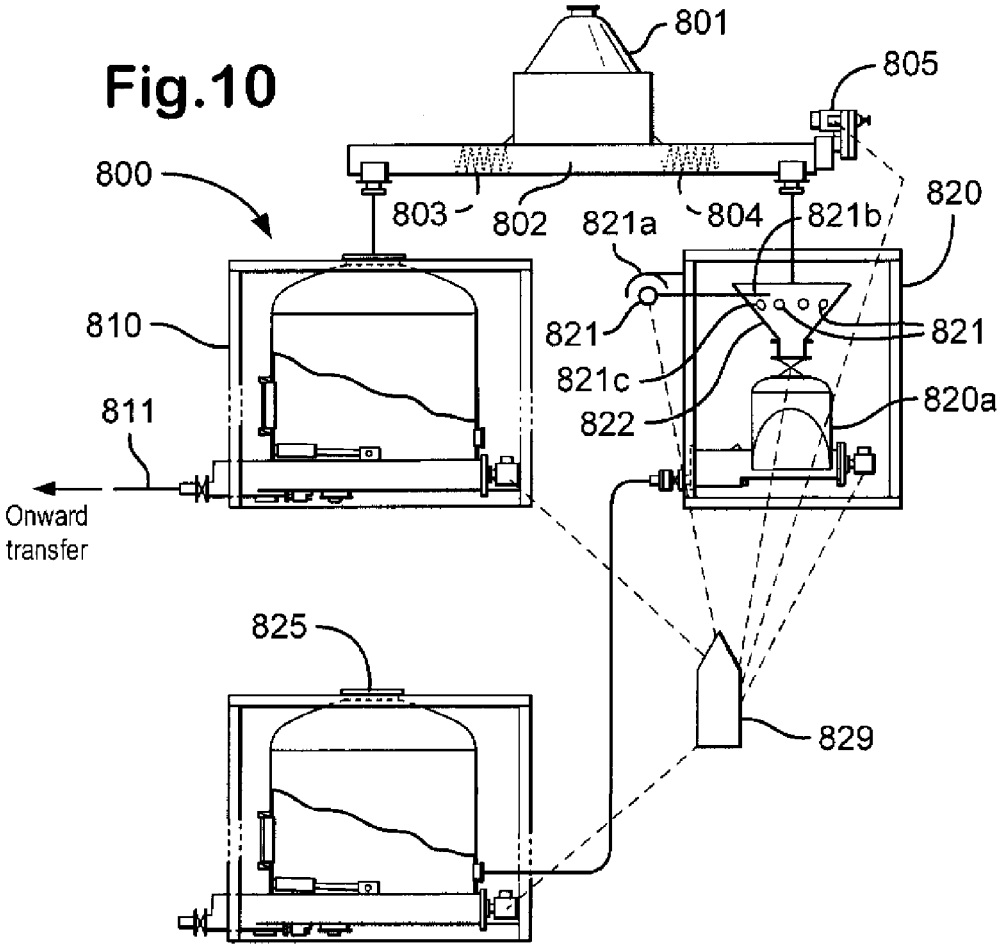


Fig.10


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805
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821b
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821a
810
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821
821c
820a
811
822
Onward
transfer
825
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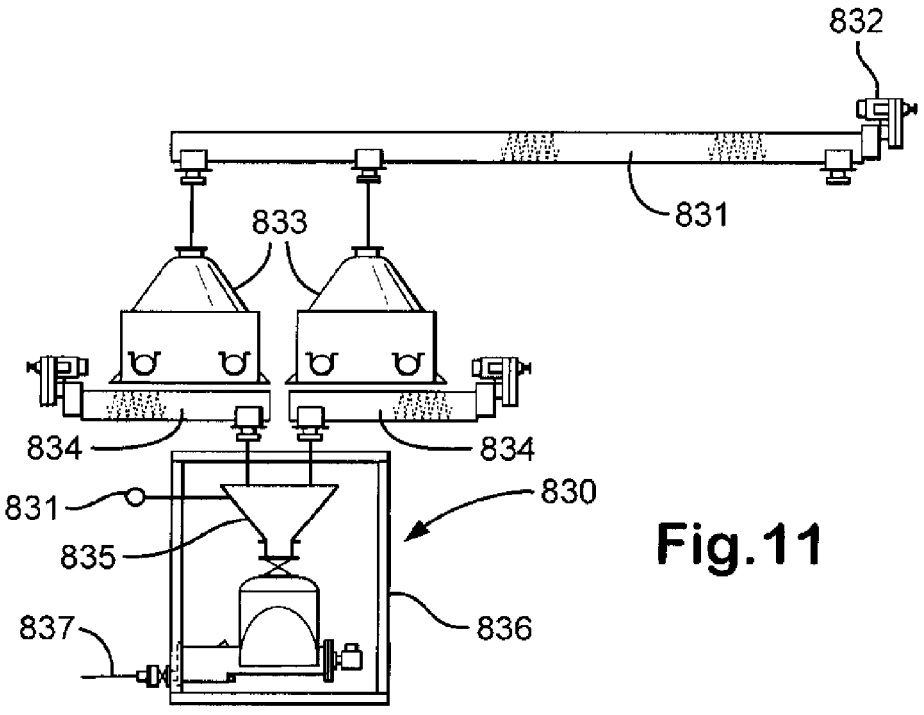

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Fig.11

Fig.12

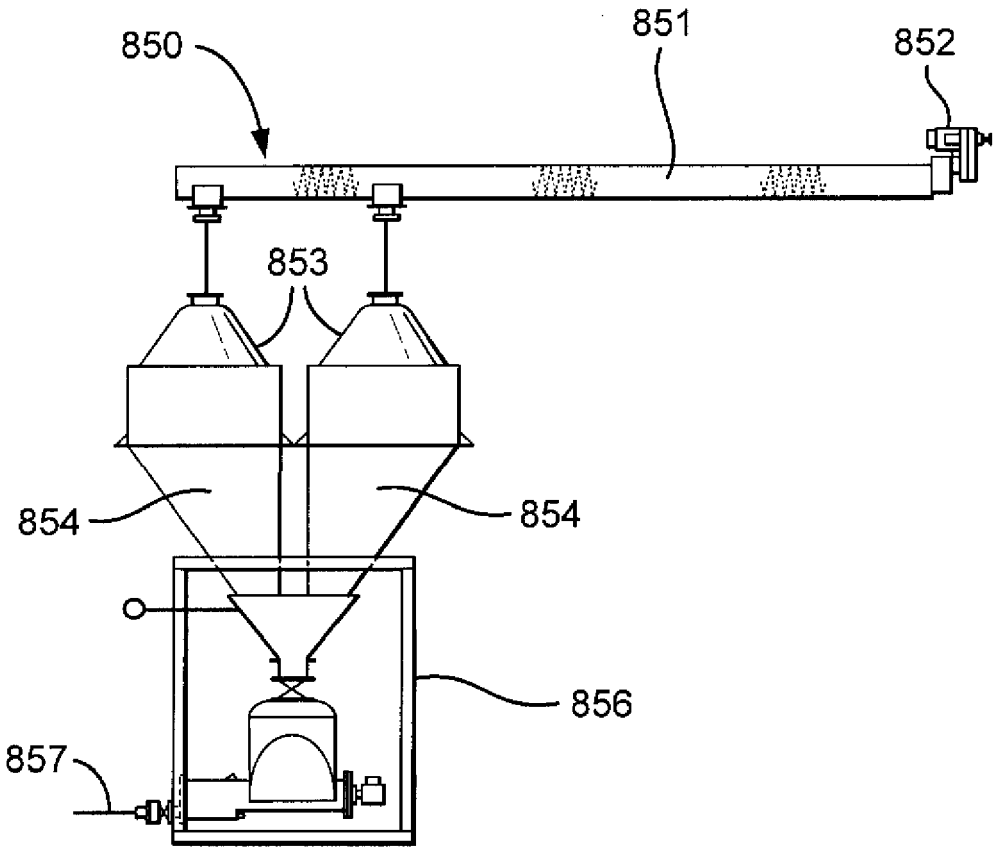
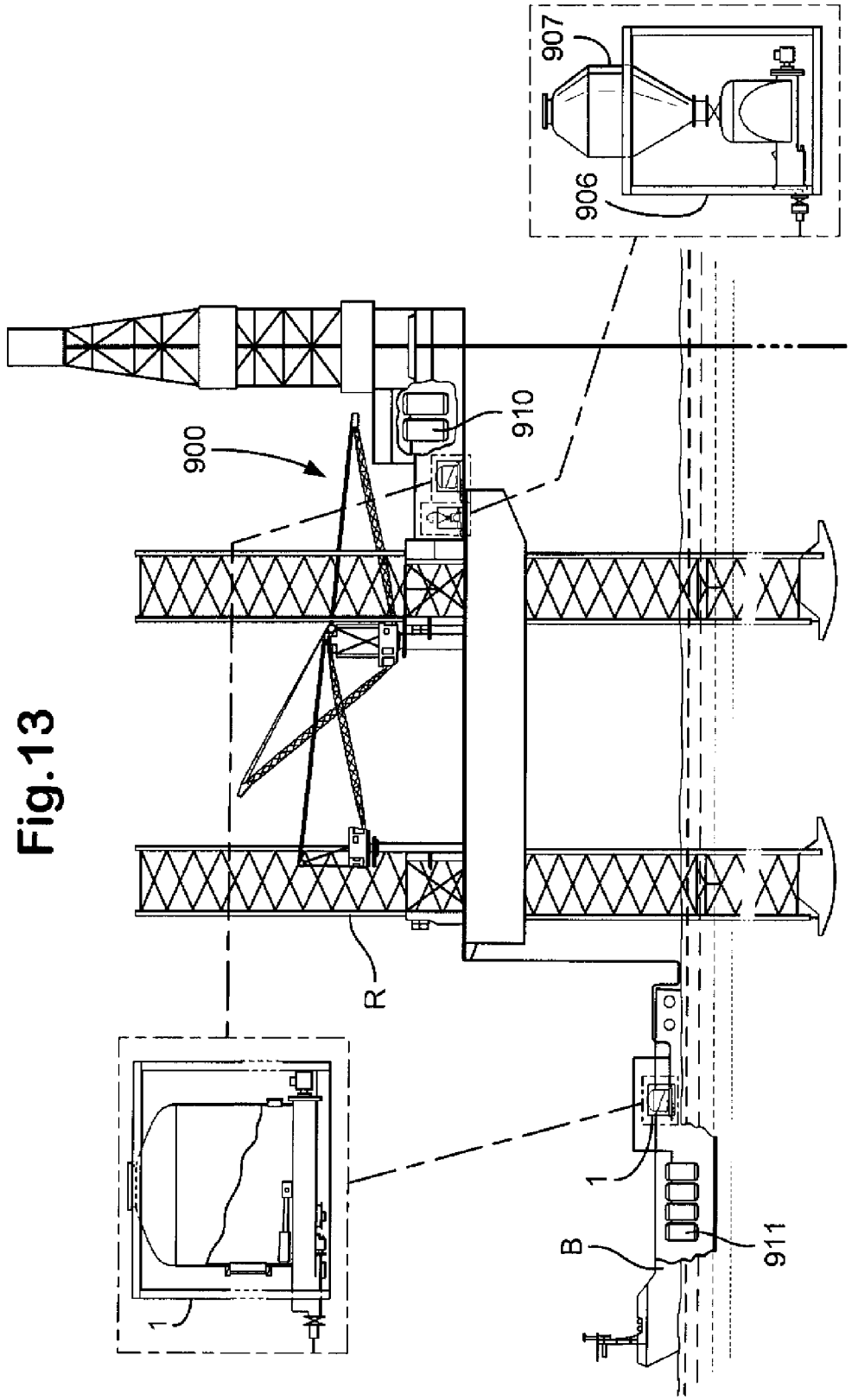


Fig.13



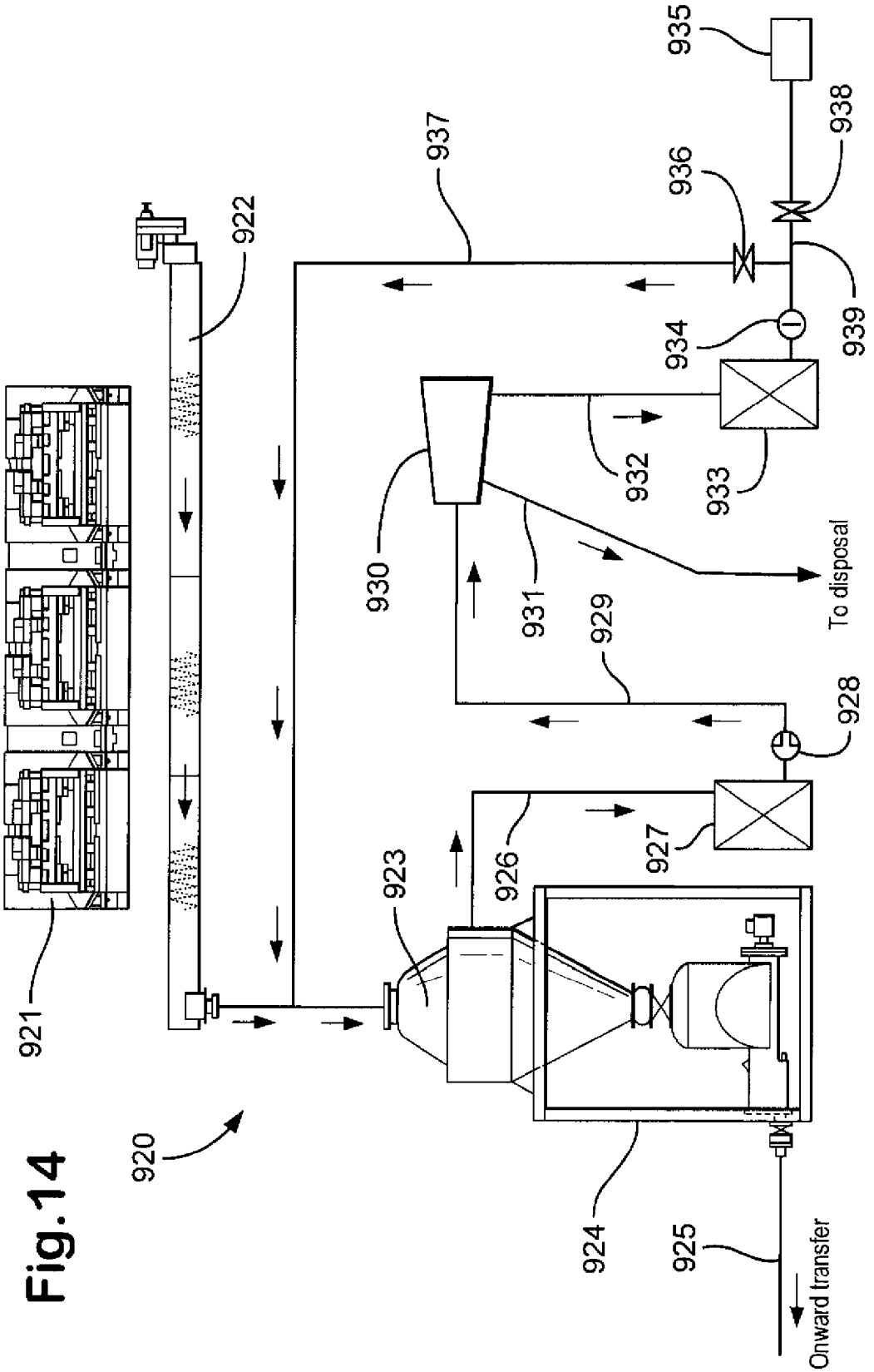
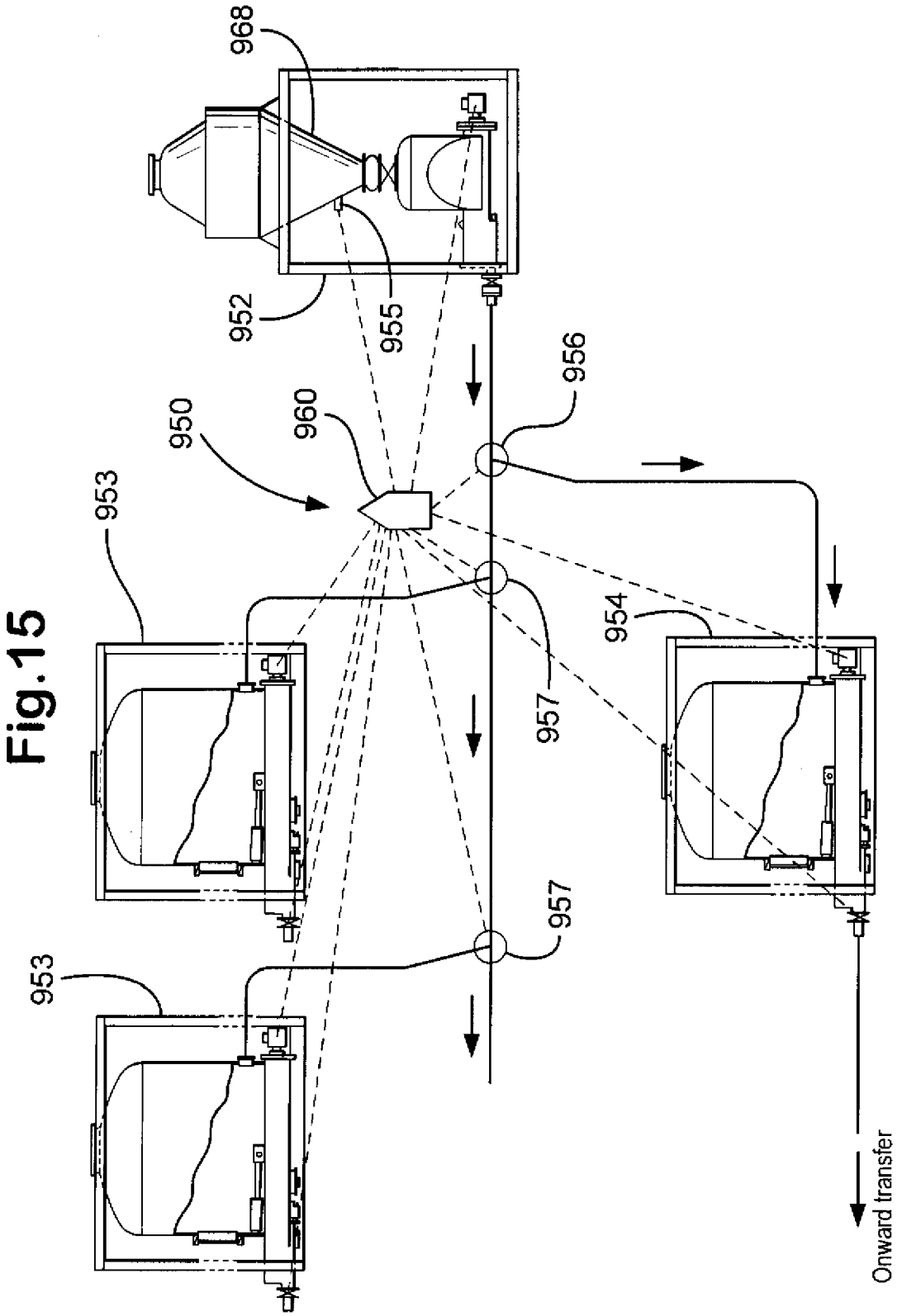

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Onward transfer
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To disposal
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Fig.14

Fig.15



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EUROPEAN SEARCH REPORT

Application Number
EP 08 17 0858

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 0 224 353 A (ATLANTIC RICHFIELD CO [US]) 3 June 1987 (1987-06-03) * page 13, paragraph 2; figure 1 * -----	1-7, 9-11, 13-15	INV. E21B21/06 E21B41/00
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TECHNICAL FIELDS SEARCHED (IPC)

E21B
B65G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	9 February 2009	Schneider, Marc

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