(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
12 October 2006 (12.10.2006)

PCT

(10) International Publication Number
WO 2006/106461 A2

(51) International Patent Classification: Not classified

(21) International Application Number:
PCT/IB2006/050989

(22) International Filing Date: 31 March 2006 (31.03.2006)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/668,000 4 April 2005 (04.04.2005) US
11/205,559 17 August 2005 (17.08.2005) US

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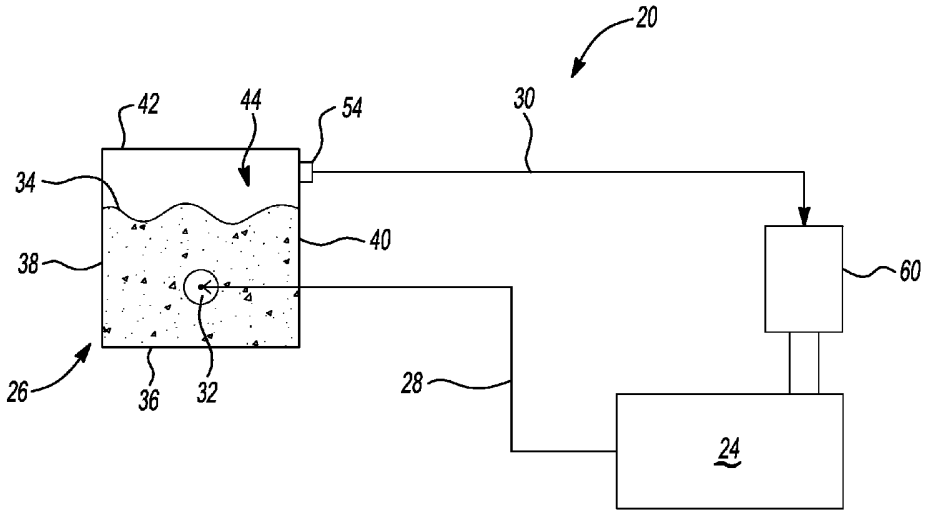
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT,

[Continued on next page]

(54) **Title:** CIRCULATING FLUID SYSTEM FOR POWDER FLUIDIZATION AND METHOD OF PERFORMING SAME



(57) **Abstract:** An aeration system for circulating an aerating fluid through a chemical composition within a container. The aeration system is closed-loop such that the aeration fluid is supplied by a fluid supply system to the interior of a container to aerate the chemical composition therein. The aeration fluid is returned to the fluid supply system for subsequent redelivery to the container. A filtering mechanism may be employed to remove large particulate matter from the aeration fluid prior to flowing back to the fluid supply system. The aeration process improves the flowability of the chemical composition thus facilitating the transferring and/or discharging of the chemical composition from the container. The aeration process may occur during transport, prior to discharging, and/or during a discharging or transferring operation.

WO 2006/106461 A2

RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

CIRCULATING FLUID SYSTEM FOR POWDER FLUIDIZATION AND METHOD OF PERFORMING SAME

FIELD OF THE INVENTION

[0001] The present invention relates to the preparation of subterranean formation treatment compositions, and more particularly, but not by way of limitation, an apparatus and method for circulating a fluid through a chemical composition within a container in the preparation and/or delivery of these compositions.

BACKGROUND OF THE INVENTION

[0002] In the oil drilling and production industry, chemical compositions, typically in the form of viscous aqueous fluids, are used in subterranean operations for such purposes as the development and completion of wellbores that penetrate subterranean formations, and the production of gaseous and liquid hydrocarbons from natural reservoirs. Viscous aqueous fluids are also used as carrier fluids. These viscous aqueous fluids can be used in operations that include perforating subterranean formations, fracturing subterranean formations, modifying the permeability of subterranean formations, or even controlling the production of sand or water from subterranean formations. Some compositions employed in these oilfield operations are commonly known as drilling compositions, completion compositions, work-over compositions, packer compositions, fracturing compositions, stimulation compositions, conformance or permeability control compositions, consolidation compositions, and the like.

Such viscous aqueous fluids may be used as fracturing fluids, acidizing fluids, cementing mixture, and high-density completion fluids. Often such chemical compositions are additives, crosslinkers, or polymer compositions, and in the case of viscosifying agents, may be agents such as guar, guar-derived polymer compositions, cellulose, or cellulose-derived polymer compositions. These viscous fluids are often an aqueous solution of these chemical compositions. For example, the viscous aqueous fluid can be an aqueous solution of a dry powder polymer material.

[0003] The chemical compositions are typically transported by bulk transporters, bins and reservoirs to the field district or field location in order to be discharged, stored and/or pumped into a well. When the chemical composition is in a powder or dry form, the discharging process or transfer process of the powdered chemical composition requires the use of a transfer or discharge device, such as a transfer pump or a feeder, and may include the use of a metering device. The powdered chemical composition is also commonly discharged by gravity. In many of these discharge and transfer processes, the powdered chemical composition is aerated to facilitate removal from the bulk transporters, bins or reservoirs to another container, or a processing system (i.e., mixing system, conditioning system, storing system, etc.).

[0004] In order to aerate the powdered chemical compositions, a dry fluid, such as air having a moisture content less than a predetermined value, is often required to avoid solidification or agglomeration of the powdered chemical composition during the aeration process. The injected dry fluid for aeration is exhausted from the container and released into the

atmosphere. The releasing of the exhausted aeration fluid into the atmosphere, however, may require filtering in order to remove particulates within the released fluid, such as for health or environmental reasons. The filtering of the fluid released from the container to health and environmental safe levels, can be very costly, especially for fine particles. Additionally, the releasing of the fluid into the atmosphere requires the use of an external source of the dry fluid to replace the fluid that is being released so that the aeration process can continue.

[0005] Prior art on the aeration of powders includes devices to inject the fluid inside the container. Patents dealing with the aeration devices themselves include U.S. Patent No. 4,172,539 to Botkin for "AERATOR NOZZLE," issued October 30, 1979; U.S. Patent No. 4,530,173 to Pausch et al. for "BIN FLUIDIZER," issued December 3, 1985; U.S. Patent No. 4,662,543 to Solimar for "AERATION DEVICE FOR ASSISTING IN AERATION OF MATERIAL FROM CONTAINERS," issued May 5, 1987; and U.S. Patent No. 6,170,976 to Sisk for "PREASSEMBLED FLUIDIZING DEVICE HAVING EXPANSIVE AIR PASSAGE STIMULATING ENHANCED FLOW OF GRANULAR MATERIALS IN TANK TRAILERS AND CONTAINERS," issued January 9, 2001. These prior art patents assume dry fluid is readily available from an external source and are not concerned with limited supply of the dry fluid. These patents also do not teach the concern of exhausting the aerating fluid, other than going through an external filter and exhausting the cleaned fluid to the atmosphere. This implies a filter cleaning the fluid to health and environmental safe levels. As stated above, such filtering may be costly.

[0006] Thus, it would be advantageous to provide an apparatus for and a method of aerating the powdered chemical composition while avoiding or minimizing one or more of the drawbacks stated above. That is, it would be advantageous to avoid the necessity of providing costly filtering equipment to filter the aerating fluid. Furthermore, it would be advantageous to avoid and/or minimize the necessity of using an external source of a dry fluid to aerate the powdered chemical composition.

SUMMARY OF THE INVENTION

[0007] To alleviate one or more disadvantages associated with the venting of the fluid to the atmosphere and/or the requirement for a continuous supply of dry fluid with which to aerate, the invention is directed toward use of a closed-loop circulating fluid system for aerating the chemical composition in a substantially dry form (e.g., in powder form) for subterranean treatment operations. The inventors have discovered that some chemical compositions, such as viscosifying polymer compositions, crosslinkers, additives, chelants, surfactant, delay agents, proppants, breakers, and the like, in powder form can become compacted for various reasons and particularly tend to become compacted due to vibrations which occur during transport. The compaction can hinder the transferring of the chemical compositions from the bulk transporters, bins or reservoirs to another container or a processing system (i.e., mixing system, conditioning system, storing system, etc.). To improve the flowability of the powdered chemical composition, a closed-loop aeration system is utilized to recirculate a dry fluid through the powdered chemical composition. Such recirculation provides a fluid flow to aerate the powdered

chemical composition while avoiding the filtering requirements associated with venting of the fluid to the atmosphere. Additionally, the recirculation of the dry fluid advantageously minimizes the quantity of dry fluid necessary to aerate and improve the flowability of the powdered chemical composition within the container.

[0008] In one aspect of the invention, a method of aerating a powdered chemical composition is disclosed. The method includes the steps of (1) supplying a fluid flow to a container having a powdered chemical composition therein, the fluid flow being supplied by a fluid supply device; (2) aerating at least a portion of the powdered chemical composition by selectively introducing the fluid flow into the powdered chemical composition within the container; (3) routing the fluid flow from the container back to the fluid supply device after being introduced into the powdered chemical composition; and (4) recirculating the fluid flow through the powdered chemical composition within the container and through the fluid supply device by performing steps (1) – (3), as desired, whereby a discharging of the powdered chemical composition is improved.

[0009] In another aspect of the invention, a method of transferring a powdered chemical composition is disclosed. The method includes the steps of: (1) selectively introducing a fluid flow into a powdered chemical composition within a first container, the fluid flow being supplied by a fluid supply apparatus; (2) returning the fluid flow to the fluid supply apparatus; (3) recirculating the fluid flow through the powdered chemical composition within the first container and through the fluid supply apparatus, whereby a flowability of the powdered chemical composition is improved; and (4)

transferring the powdered chemical composition from the first container to a second container.

[0010] In yet another aspect of the present invention, an aeration system for aerating in a chemical composition is disclosed. The aeration system includes a fluid-tight container operable to hold a chemical composition therein. There is at least one fluid delivery device operable to introduce a fluid flow into a chemical composition within the container. A fluid supply system is operable to selectively supply a fluid flow to the fluid delivery device. There is a supply flow path through which the fluid supply system supplies the fluid flow to the fluid delivery device. There is also a return flow path extending between the container and the fluid supply system through which the fluid flow returns to the fluid supply system. The fluid flow is recirculated through the container and the fluid supply system thereby forming a closed-loop flow path for the fluid flow.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0012] **FIG. 1** is a general schematic view of an aeration system for circulating fluid through a powdered chemical composition in a container according to the principles of the present invention;

[0013] **FIG. 2** is a schematic representation of a control system for use with the aeration system of **FIG. 1** according to the principles of the present invention;

[0014] **FIG. 3** is a schematic cross-sectional representation of a transport container with which the aeration system of **FIG. 1** can be employed;

[0015] **FIG. 4** is a flowchart of a method of transferring a powdered chemical composition with the aeration system of **FIG. 1**, according to the principles of the present invention; and

[0016] **FIG. 5** is a flowchart of a method of aerating a powdered chemical composition with the aeration system of **FIG. 1**, according to the principles of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0017] The following description of the preferred embodiments is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses. Illustrative embodiments of the invention are described below. In the interest of clarity, not all features of an actual implementation are described in this specification. It will, of course, be appreciated that in the development of any such actual embodiment, numerous implementation specific decisions must be made to achieve the developer's specific goals, such as compliance with system related and business related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time consuming but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure.

[0018] The present invention relates to the preparation of subterranean formation treatment compositions, and more particularly, but not by way of limitation, an apparatus and method for transferring and conditioning dry polymer materials in the preparation and/or delivery of treatment compositions.

[0019] Aeration of powdered chemical compositions, such as viscosifying polymer compositions, crosslinkers, additives, chelants, surfactants, delay agents, proppants, breakers, and the like, can be utilized to improve the flowability of the powdered chemical compositions. As flowability is improved, metering of the powdered chemical compositions may also be improved. As used herein, the term "viscosifying polymer compositions"

means any suitable polymer composition for treating a subterranean formation, such as, by non-limiting example, guar, guar-derived polymers, cellulose, cellulose-derived polymers, xanthan gum, or synthetic polymers such as polyacrylamides and polyacrylamide copolymers, and the like.

[0020] Embodiments of the invention provide at least two main advantages over the prior art. First, a conditioned fluid, such as dried air having a relative humidity less than a predetermined value, is circulated without the addition of a conditioning device. This provides cost, energy, and/or volume savings, especially for high volume low pressure delivery systems. Second, embodiments of the invention avoid the need or necessity for a filtering/cleaning system required for cleaning the exhausted fluid before it is released into the environment.

[0021] Some embodiments of the invention may be useful for transferring a powdered material, such as a chemical composition, in a conditioned environment, by adding a fluid to aerate the powder. Also, the invention may be used for aerating liquids as well. Further, the embodiments are not limited to only transferring material, but may also be useful for metering, energizing, or even changing the density of materials.

[0022] Some embodiments of the invention use recirculation of a fluid in a closed-loop system between the container holding the dry particulate material and the fluid-supplying system, such as an air-blower system. Referring to **FIG. 1**, a schematic of a closed-loop aerating system **20** for aerating a powdered chemical composition within a container is shown. Aerating system **20** includes a fluid supply system **24** such as, for example, a compressor, blower, injector or pump, operable to selectively supply an

aerating fluid to a container **26** via appropriate supply plumbing **28** and to collect the aerating fluid from container **26** via appropriate return plumbing **30**. In one embodiment, fluid supply system **24** is a blower system operable to supply a flow of dry air (air having a relative humidity below a predetermined value) to container **26** and to receive the dry air from container **26**. It should be appreciated, however, that the aeration fluid is not limited to dry air. For example, the aeration fluid can include other fluids, such as inert gases, such as, by way of non-limiting example, carbon dioxide, nitrogen, argon and the like, as well as the above-mentioned air.

[0023] Fluid supply system **24** can be operated to selectively supply a flow of the aeration fluid to container **26**. By the phrase "selectively supply," it is meant that the fluid flow can be a steady steam of fluid, pulsed flows of the fluid or a combination thereof, in patterned or random order.

[0024] Fluid supply system **24** is interconnected with container **26** via appropriate supply plumbing **28**. Supply plumbing **28** communicates with one or more fluid-injecting devices **32**. Injecting devices **32** are located at various locations along container **26**, as described in more detail below. Injecting devices **32** can take a variety of forms. For example, injecting devices **32** can include simple holes, one or more nozzles, one or more elastomeric cups attached to the interior of container **26** in which the fluid is injected under the cups, and one or more permeable membranes, such as a felt cloth or finely divided, consolidated metal particles (porous metal) or a finely perforated pad through which the fluid can be injected into container **26**. Other examples of possible injecting devices include those disclosed in U.S.

Patent Nos. 6,170,976; 4,662,543; 4,530,173; and 4,172,539, mentioned above.

[0025] Container **26** is operable to hold or store a powdered chemical composition **34** therein. Container **26** can take a variety of forms. Suitable examples include, but are not limited to, a bin, can, silo or tank. Additionally, container **26** can also be a static or stationary container that is not moved or can be a mobile container such that it is capable of being transported from one location to another. For example, container **26** can be attached to or contained on the bed of a vehicle, a railcar, and the like.

[0026] Container **26** generally includes a bottom **36**, sidewalls **38**, **40** and a top or lid **42**. Bottom **36**, sidewalls **38**, **40** and top **42** form an interior cavity **44** within which powdered chemical composition **34** may be disposed. Cavity **44** is selectively sealed such that aeration fluid flowing into and exiting cavity **44** can be controlled and only flows through designated entry and exit points or locations. By the phrase "selectively sealed," it is meant that interior cavity **44** of container **26** can be sealed, when desired, to provide limited entry and exit points for fluid flowing therein and can be opened such that there are multiple points for entering and exiting of fluid flowing therein and/or the adding and removal of the powdered chemical composition to/from interior cavity **44**.

[0027] An outlet **54** communicates with interior cavity **44** and is operable to route the aeration fluid supplied by fluid supply system **24** back to fluid supply system **24**. Appropriate return plumbing **30** interconnects outlet **54** with an inlet to fluid supply system **24**. Outlet **54** can be a single outlet or multiple outlets. Additionally, outlet **54** can be disposed on a sidewall **38**, **40**

or top **42** of container **26**. At least one outlet **54** is located on container **26** in a position that resides above the level of the powdered chemical composition **34** disposed therein.

[0028] In some embodiments, an optional filtering mechanism **60** may be placed along return plumbing **30** such that the aeration fluid flows through filtering mechanism **60** prior to flowing back into fluid supply system **24**. Such filtering mechanism **60** may be used to remove the larger-sized powder particles that are contained within the fluid flow and would prevent fluid supply system **24** from working correctly. It should be appreciated that filtering mechanism **60** is not comparable to a filtering mechanism that would be required to clean the aeration fluid from any particles deteriorating the air quality in order to meet health or environmentally safe levels. That is, filtering mechanism **60** is not sufficient to allow the venting of the aeration fluid directly into the environment. A suitable type of filtering mechanism **60** includes but not limited to cartridge type, media type, bag type and cyclone filtration systems.

[0029] In one embodiment, a control system, such as that shown in **FIG. 2**, is utilized to control the operation of aerating system **20**. Control system **70** may include a selectively operable controller **72** that controls the operation of fluid supply system **24** and/or each injecting device **32**. Controller **72** can take a variety of forms. For example, controller **72** can be as simple as one or more manually operable open/close or proportional valve(s). Alternatively, if greater control is desired, controller **72** can be an electrical or pneumatic controller that can automatically individually control fluid supply system **24** and/or each injecting device (1^{st} to the N^{th}) **32** via the

appropriate connections **74**, **76**, respectively, therebetween. Regardless of the type of controller utilized, control system **70** is operable to selectively supply a fluid flow to injecting devices **32** as needed.

[0030] In one embodiment, container **26** may take the form of that shown in **FIG. 3**. In this embodiment, container **26** has an interior cavity **44** with a lower discharging/feeder portion **80**. Cavity **44** is defined by longitudinally-extending sidewalls **38**, **40** and a bottom surface **36**. Each sidewall **38**, **40** has a tapering portion **38a**, **40a** that taper toward each other as they extend toward discharge portion **80** and bottom surface **36**. Tapering portions **38a**, **40a** facilitate the flow of the powdered chemical composition **34** within cavity **44** toward discharge portion **80**. A metering device/apparatus **84** is disposed within discharge portion **80** of cavity **44**. Metering device **84** controls the quantity and rate at which powdered chemical composition **34** is discharged from container **26**. Metering device **84** includes a longitudinally-extending metering screw **86** and a pair of longitudinally-extending agitators **88**, **90** that help feed the powdered chemical composition **34** into metering screw **86**.

[0031] Container **26** has a plurality of injecting devices **32** each connected to supply plumbing **28** for receiving a fluid flow from fluid supply system **24**. As illustrated, injecting devices **32** are preferably located along sidewalls **38**, **40** and in proximity to discharge portion **80**. The introduction of the aerating fluid, such as by non-limiting example, air, nitrogen, carbon dioxide and the like in gaseous form into powdered chemical composition **34** reduces the bulk density of the powdered chemical composition **34** within

container **26** and increases the flowability of the composition at the time of discharge.

[0032] Container **26** also includes a top **42** that is sealed to sidewalls **38**, **40**. Top **42** may include one or more access ports or inlets (not shown) that enable powdered chemical composition **34** to be added thereto. Outlet **54** communicates with interior cavity **44** and with return plumbing **30**. Outlet **54** is positioned on sidewall **40** in a location that is above the level of powdered chemical composition **34**. It should be appreciated, however, that outlet **54** could also be disposed on top **42**, if desired.

[0033] The methods of the present invention are applicable to a variety of powdered chemical compositions, such as viscosifying polymers and others discussed above. The viscosifying polymer in substantially dry form (powder) is typically ground to very small dimensions. Preferably, the median particle size of the viscosifying polymer is in the range of from about 40 to about 60 microns (but could be of any particle size). This small particle size aids in the rapid hydration and viscosification of the well treatment fluid, and facilitates continuously mixing a fluid. The bulk density of the viscosifying polymer is generally in the range of from about 340 to about 700 kilograms per cubic meter (but could be of any density).

[0034] Referring to **FIG. 4**, a method of transporting and discharging/transferring a powdered chemical composition is shown. The powdered chemical composition **34** is packed into container **26**, as indicated in block **100**, which may be a bulk transporter, a storage bin, silo or a reservoir. Container **26**, in the case of a mobile container, is then transported from the supply site to a destination site, such as by non-limiting example, a

field district or a field location, as indicated in block **102**, in order to be discharged, transferred, stored and/or pumped into a well. Container **26** can be transported over the roadway and/or railways or other suitable means of transport. Optionally, as indicated in block **104**, the powdered chemical composition can be aerated during transport, as described in more detail below. When the powdered chemical composition is aerated during transport, an appropriate fluid supply system **24** is included either with container **26** and/or the vehicle transporting container **26** so that aerating system **20** can be realized.

[0035] Upon arriving at the destination site, the powdered chemical composition may be aerated, as indicated in block **106**, and as described below. If needed, a local fluid supply system **24** can be connected to container **26** to aerate the powdered chemical composition. The aeration process is described in more detail below. The aeration of the powdered chemical composition decreases the bulk density and thereby conditions the powdered chemical composition to an improved flowable state. The aeration process may also energize and/or fluidize the powdered chemical composition.

[0036] With the powdered chemical composition flowable, the chemical composition can be discharged from container **26** at the destination site, as indicated in block **108**. The discharging process may use a discharging device, such as a transfer pump or a feeder. The discharging can also be accomplished via gravity. If desired, metering device **84** can be operated to discharge the powdered chemical composition from container **26**.

Optionally, as indicated in block **110**, the aeration process can continue during the discharging of the powdered chemical composition.

[0037] Referring now to **FIG. 5**, the method of aerating the powdered chemical composition with aeration system **20** is shown. To aerate the powdered chemical composition within container **26**, supply plumbing **28** and return plumbing **30** are connected to container **26** and/or fluid supply system **24**, if necessary, as indicated in block **120**. Container **26** may already have supply plumbing **28** and return plumbing **30** attached to the respective injecting devices **32** and outlet **54**. In this case, supply plumbing **28** is connected to the appropriate connectors on fluid supply system **24** and return plumbing **30** is attached to the appropriate connectors on fluid supply system **24** or, optionally, to the appropriate connectors on filtering mechanism **60** which is connected to fluid supply system **24**. Alternatively, fluid supply system **24** may include supply plumbing **28** and return plumbing **30** such that supply and return plumbing **28**, **30** are attached to the respective injecting devices **32** and outlet **54** of container **26**. Regardless of whether supply plumbing **28** and return plumbing **30** are attached to container **26** or fluid supply system **24**, the appropriate connections, if necessary, are made to form aerating system **20**.

[0038] To begin the aeration process, a fluid flow is supplied to injecting devices **32**, as indicated in block **122**, with fluid supply system **24**. To accomplish this, controller **72** is operated to cause fluid supply system **24** to supply a conditioned fluid flow (fluid flow having desired properties, such as a desired moisture level) to injecting devices **32**. The fluid flow to injecting devices **32** is injected into the interior cavity **44** of container **26** and through

powdered chemical composition **34** therein, as indicated in block **124**. Controller **70**, if so designed, can command each injecting device **32** individually or in a group to selectively inject the fluid flow into the powdered chemical composition **34** within container **26**, as desired. The injected fluid flows through powdered chemical composition **34** thereby aerating the powdered chemical composition and decreasing the bulk density. This operation conditions the powdered chemical composition **34** to an improved flowable state and facilitates the discharging operation. The aeration may also energize and/or fluidize the powdered chemical composition. The aerating fluid may be the fluid that currently exists within container **26** and/or fluid supply system **24**. Alternatively, if needed, fluid supply system **24** may include a limited supply of aerating fluid having the desired physical properties. It should be appreciated, however, that such a limited supply would not be sufficient to enable fluid supply system **24** to adequately aerate the powdered chemical composition within container **26** absent the recirculation of the aerating fluid. This limited supply could also serve to back flush the filtration system.

[0039] The fluid injected into the interior cavity **44** of container **26** is returned to fluid supply system **24** via return plumbing **30**, as indicated in block **126**. Optionally, as indicated in block **128**, the returning fluid flow can be routed through filtering mechanism **60** prior to returning to fluid supply system **24**. In this case, filtering mechanism **60** removes particulate matter from the fluid flow that would be damaging to fluid supply system **24**. If the aeration process is to continue, as indicated in decision block **130**, the fluid flow is recirculated to the injecting devices **32** with fluid supply system **24**, as

indicated in block **132**. The recirculated fluid flow is then injected into the powdered chemical composition again and returned to the fluid supply system **24**, as indicated in blocks **124**, **126**. Again, optionally, the recirculated fluid flow can be filtered prior to returning to fluid supply system **24**, as indicated in block **128**. The recirculation of this fluid flow continues until it is desired to end the aeration process, as indicated by decision block **130**. When it is desired to discontinue the aeration process, controller **72** is operated to cause fluid supply system **24** to stop supplying the fluid flow to injecting devices **32**, as indicated in block **134**.

[0040] Accordingly, the present invention facilitates the aeration of a chemical composition in dry form (i.e., powdered) within a container. The aeration of the chemical composition enhances the flowability and facilitates the discharge of the chemical composition. The aeration system advantageously recirculates the conditioned aerating fluid thereby avoiding the necessity of including a conditioning device to supply additional conditioned fluid. The avoidance of this conditioning device provides costs, energy and/or volume savings. Additionally, the recirculation of the aerating fluid avoids the need for a filtering/cleaning system necessary for cleaning the aerating fluid to health and environmental safe levels associated with exhausting the aerating fluid into the environment. The aerating system is also useful for transferring a powdered material in a conditioned environment, by adding a fluid flow to aerate the powder. Also, the present invention may be used for aerating liquids as well. Further, the embodiments are not limited to only transferring material, but may also be useful for metering, energizing, or even changing the density of the materials being aerated.

[0041] The methods of the invention are useful in subsurface operations, including such operations as fracturing subterranean formations, modifying the permeability of subterranean formations, fracture or wellbore cleanup, acid fracturing, matrix acidizing, gravel packing or sand control, and the like. Another application includes the placement of a chemical plug to isolate zones or to assist an isolating operation.

[0042] When used in fracturing operations, techniques for hydraulically fracturing a subterranean formation will be known to persons of ordinary skill in the art, and will involve pumping a fracturing composition, often including a powdered chemical composition, into the borehole and out into the surrounding formation. The fluid pressure is above the minimum in situ rock stress, thus creating or extending fractures in the formation. See Stimulation Engineering Handbook, John W. Ely, Pennwell Publishing Co., Tulsa, Okla. (1994), U.S. Patent No. 5,551,516 (Normal et al.), "Oilfield Applications", Encyclopedia of Polymer Science and Engineering, vol. 10, pp. 328-366 (John Wiley & Sons, Inc. New York, New York, 1987). In the fracturing treatment, the compositions delivered by methods of the invention fluids may be delivered in the pad treatment stage, the proppant stage, or both. The fracturing materials are preferably mixed on the surface. Alternatively, the materials may be mixed downhole. The invention may also be useful when gravel packing a wellbore.While the presently preferred embodiments of the invention have been described herein with reference to specific components, functionality and operation, it should be appreciated that changes and deviations from that disclosed can be employed without departing from the spirit and scope of the present invention. For example,

additional components (not shown) may be included within aeration system **20** to enable, facilitate and/or enhance the operation of aeration system **20**. Such components may include, by non-limiting example, valves employed along the various flow paths to aid in the controlling of the fluid flow therethrough, check valves, vacuum breakers and/or pressure relief valves to facilitate the operation of aeration system **20**. Thus, the description of the invention is merely exemplary in nature and variations that do not depart from the gist of the invention are intended to be within the scope of the invention. Such variations are not to be regarded as a departure from the spirit and scope of the invention.

CLAIMS

What is claimed is:

1. A method of aerating a powdered chemical composition comprising:

(a) supplying a fluid flow to a container having a powdered chemical composition therein, the fluid flow being supplied by a fluid supply device;

(b) aerating at least a portion of the powdered chemical composition by selectively introducing the fluid flow into the powdered chemical composition within the container;

(c) routing the fluid flow from the container back to the fluid supply device after being introduced into the powdered chemical composition; and

(d) recirculating the fluid flow through the powdered chemical composition within the container and through the fluid supply device by performing steps (a) – (c), as desired,

whereby a discharging of the powered chemical composition is improved.

2. The method of claim 1, wherein step (c) includes routing the fluid flow through a filtering device prior to reaching the fluid supply device.

3. The method of claim 2, further comprising removing large particulate matter from the fluid flow with the filtering device, the filtering

device being unsuitable for venting the fluid flow to the atmosphere after having flowed therethrough.

4. The method of claim 1, wherein step (c) includes routing the fluid flow through an outlet on the container that is above a level of the powdered chemical composition and through a flow path extending between the outlet and the fluid supply device.

5. The method of claim 1, wherein the fluid flow is an air flow and step (a) includes supplying a flow of conditioned air having a moisture content less than a predetermined level.

6. The method of claim 1, wherein step (b) includes introducing a plurality of gas flows into the powdered chemical composition at a plurality of discrete locations within the container.

7. The method of claim 1, wherein step (b) includes introducing a steady gas flow into the powered chemical composition.

8. The method of claim 1, wherein step (b) includes introducing pulses of gas flow into the powered chemical composition.

9. The method of claim 1, further comprising discharging the powdered chemical composition from the container and wherein step (b) is performed during the discharging operation.

10. The method of claim 1, wherein step (a) includes supplying a gaseous fluid flow, step (b) includes introducing the gaseous fluid flow, step (c) includes routing the gaseous fluid flow and step (d) includes recirculating the gaseous fluid flow.

11. The method of claim 1, whereby step (b) fluidizes the powdered chemical composition.

12. The method of claim 1, whereby step (b) energizes the powdered chemical composition.

13. The method of claim 1, whereby step (b) changes a density of the powdered chemical composition.

14. A method of transferring a powdered chemical composition comprising:

(a) selectively introducing a fluid flow into a powdered chemical composition within a first container, the fluid flow being supplied by a fluid supply apparatus;

(b) returning the fluid flow to the fluid supply apparatus;

(c) recirculating the fluid flow through the powdered chemical composition within the first container and through the fluid supply apparatus, whereby a flowability of the powdered chemical composition is improved; and

(d) transferring the powdered chemical composition from the first container to a second container.

15. The method of claim 14, wherein step (b) includes routing the fluid flow through a filtering device prior to reaching the fluid supply apparatus.

16. The method of claim 15, further comprising removing large particulate matter from the fluid flow with the filtering device, the fluid flow being unsuitable for venting to the atmosphere after having flowed though the filtering device.

17. The method of claim 14, wherein step (c) is performed while at least a portion of the transferring process of step (d) is being performed.

18. The method of claim 14, wherein step (a) includes supplying a flow of air, step (b) includes returning the flow of air, and step (c) includes recirculating the flow of air.

19. The method of claim 14, wherein step (d) includes metering the powdered chemical composition.

20. The method of claim 14, wherein step (a) includes introducing a plurality of gas flows into the powdered chemical composition at a plurality of discrete locations within the first container.

21. An aeration system for aerating a chemical composition, the aeration system comprising:

a fluid-tight container operable to hold a chemical composition therein;

at least one fluid delivery device operable to introduce a fluid flow into a chemical composition within the container;

a fluid supply system operable to selectively supply a fluid flow to the fluid delivery device;

a supply flow path through which the fluid supply system supplies the fluid flow to the fluid delivery device; and

a return flow path extending between the container and the fluid supply system and through which the fluid flow returns to the fluid supply system,

wherein the fluid flow is recirculated through the container and the fluid supply system thereby forming a closed-loop flow path for the fluid flow.

22. The aeration system of claim 21, further comprising a metering device operable to meter a quantity of the chemical composition during discharging of the chemical composition from the container.

23. The aeration system of claim 22, further comprising at least one agitator operable to agitate the chemical composition within the container.

24. The aeration system of claim 21, further comprising a filtering device operable to remove particulate matter from the fluid flow, the filtering device forming a portion of the return flow path such that the fluid flow passes through the filtering device prior to returning to the fluid supply system.

25. The aeration system of claim 21, wherein the fluid supply system includes a blower and the fluid flow is an air flow.

26. The aeration system of claim 21, wherein the at least one fluid delivery device is one of a plurality of fluid delivery devices disposed at a plurality of discrete locations along the container.

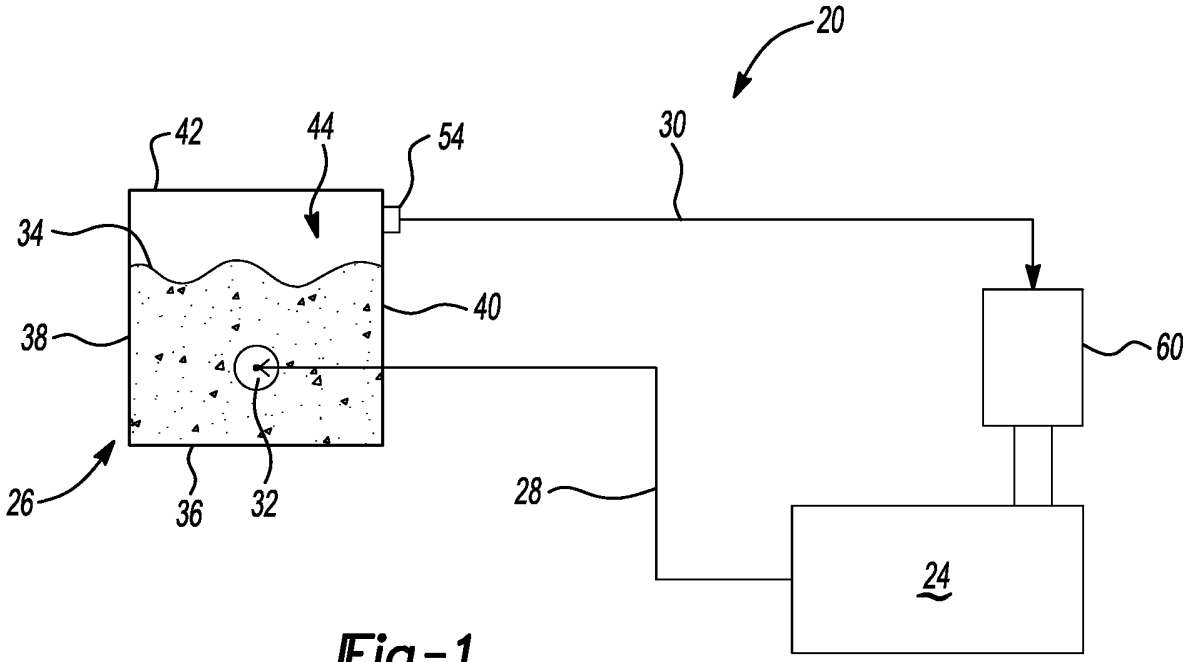
27. The aeration system of claim 21, wherein the chemical composition is a powdered chemical composition.

28. The aeration system of claim 21, wherein the chemical composition is a liquid.

29. The aeration system of claim 21, further comprising a controller operable to control operation of the fluid supply system.

30. The aeration system of claim 21, wherein the fluid flow is introduced into the chemical composition as a continuous fluid flow.

31. The aeration system of claim 21, wherein the fluid flow is introduced into the chemical composition in pulses of fluid flow.


20
42
44
54
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34
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28
24

Fig-1

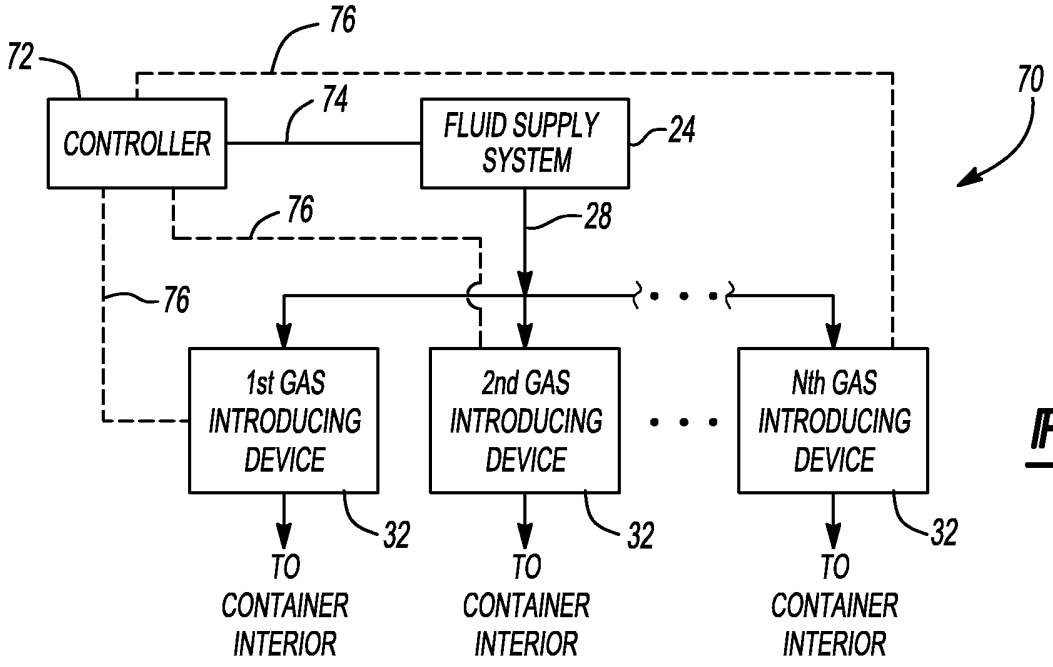
76
72
70
CONTROLLER
74
FLUID SUPPLY SYSTEM
24
28
76
76
1st GAS INTRODUCING DEVICE
2nd GAS INTRODUCING DEVICE
Nth GAS INTRODUCING DEVICE
32
32
32
TO CONTAINER INTERIOR
TO CONTAINER INTERIOR
TO CONTAINER INTERIOR

Fig-2

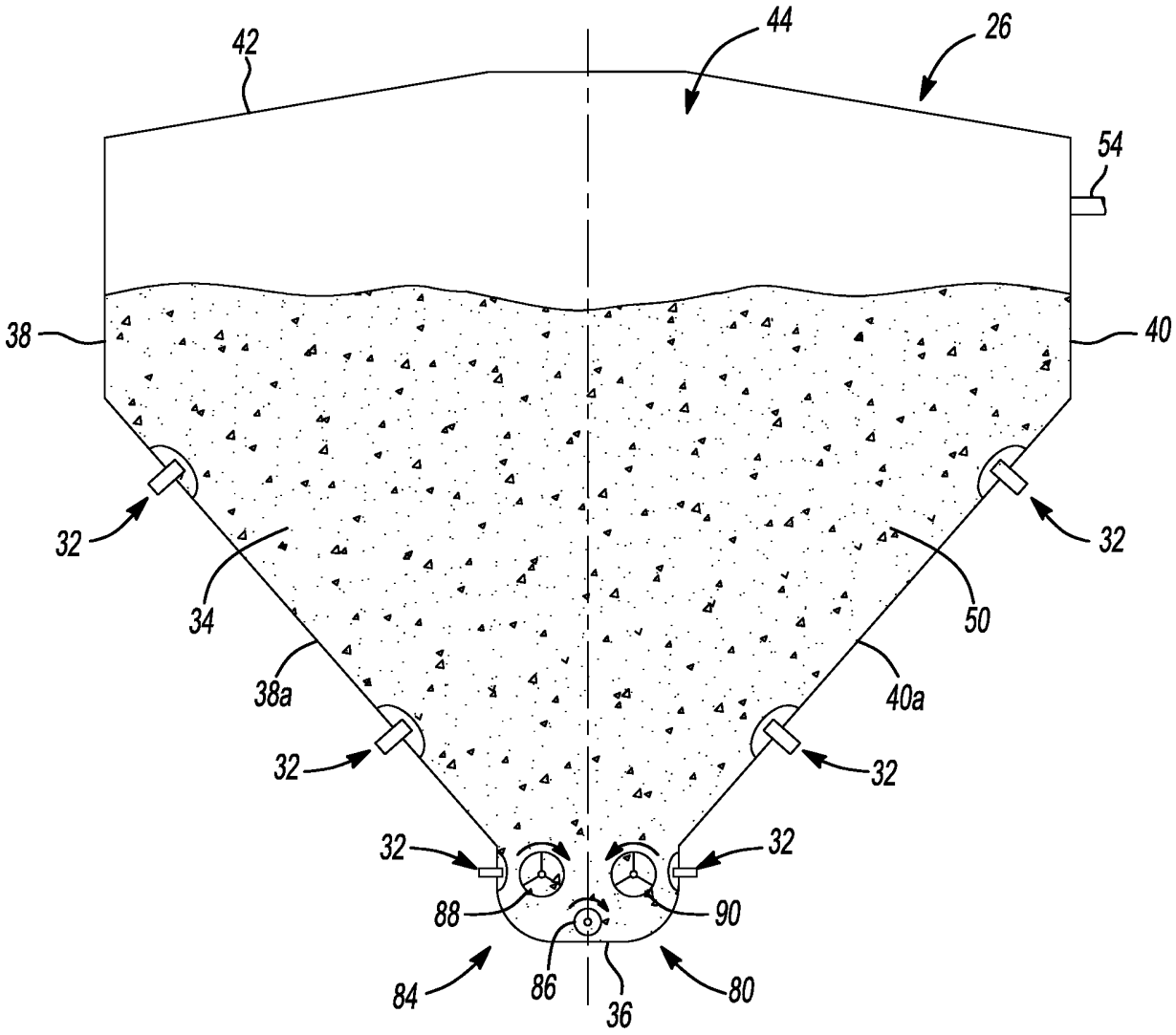

Fig-3

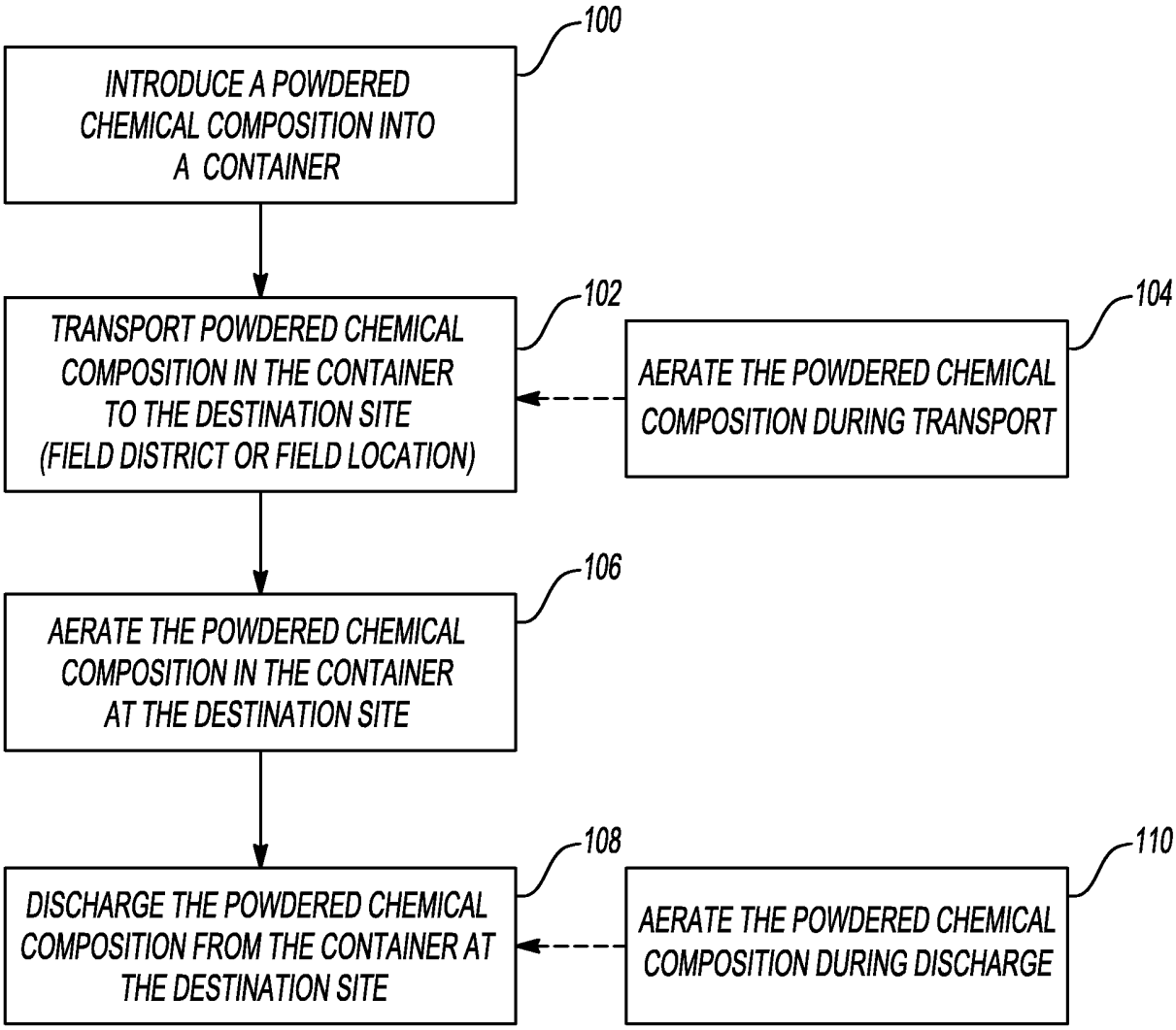
100
INTRODUCE A POWDERED CHEMICAL COMPOSITION INTO A CONTAINER
102
TRANSPORT POWDERED CHEMICAL COMPOSITION IN THE CONTAINER TO THE DESTINATION SITE (FIELD DISTRICT OR FIELD LOCATION)
104
AERATE THE POWDERED CHEMICAL COMPOSITION DURING TRANSPORT
106
AERATE THE POWDERED CHEMICAL COMPOSITION IN THE CONTAINER AT THE DESTINATION SITE
108
DISCHARGE THE POWDERED CHEMICAL COMPOSITION FROM THE CONTAINER AT THE DESTINATION SITE
110
AERATE THE POWDERED CHEMICAL COMPOSITION DURING DISCHARGE

Fig-4

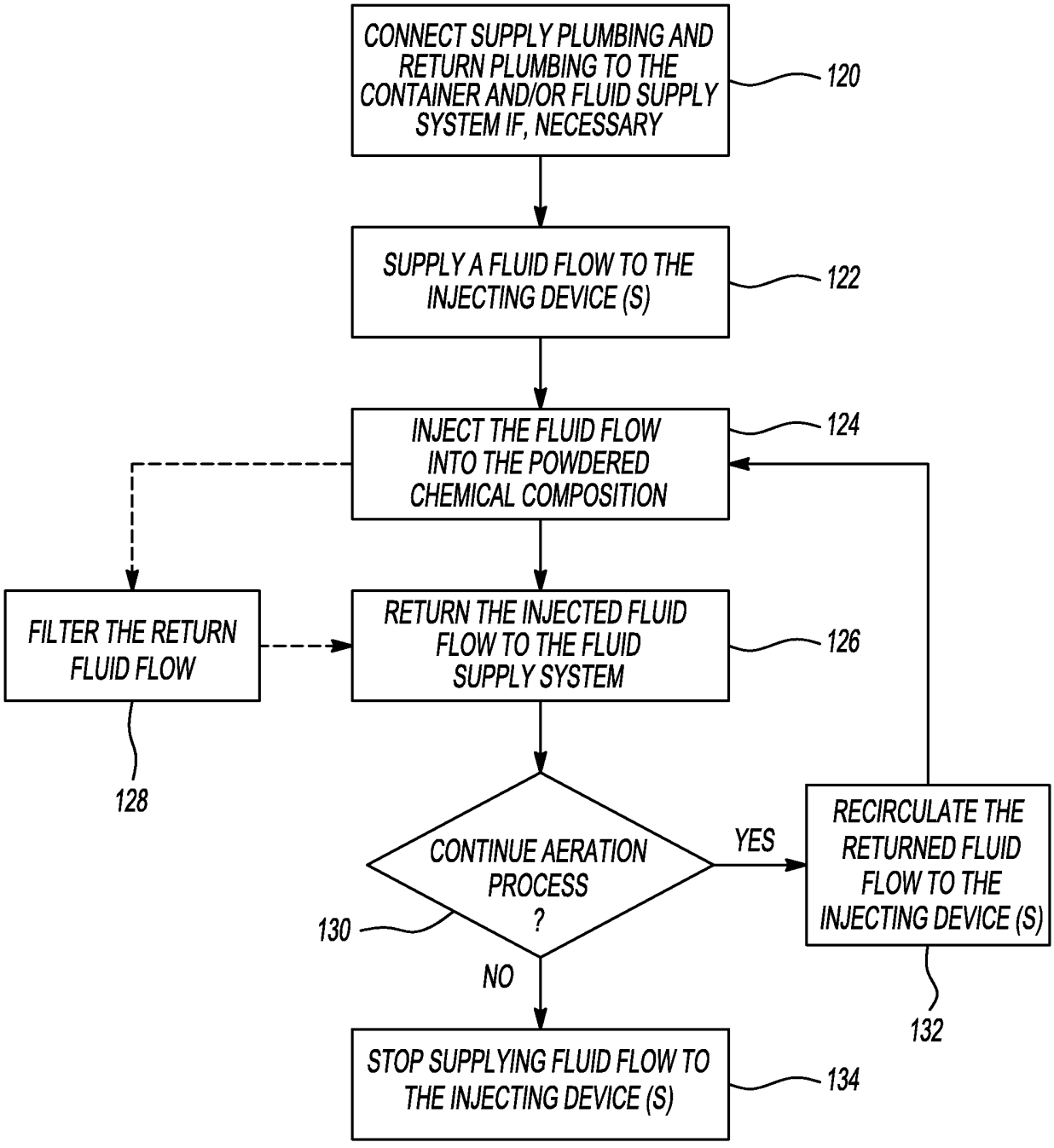
CONNECT SUPPLY PLUMBING AND RETURN PLUMBING TO THE CONTAINER AND/OR FLUID SUPPLY SYSTEM IF, NECESSARY
120
SUPPLY A FLUID FLOW TO THE INJECTING DEVICE (S)
122
INJECT THE FLUID FLOW INTO THE POWDERED CHEMICAL COMPOSITION
124
FILTER THE RETURN FLUID FLOW
128
RETURN THE INJECTED FLUID FLOW TO THE FLUID SUPPLY SYSTEM
126
CONTINUE AERATION PROCESS ?
130
YES
NO
RECIRCULATE THE RETURNED FLUID FLOW TO THE INJECTING DEVICE (S)
132
STOP SUPPLYING FLUID FLOW TO THE INJECTING DEVICE (S)
134

Fig-5