



- (51) **International Patent Classification:**
B01F 15/02 (2006.01) *B65G 65/46* (2006.01)
B01F 7/02 (2006.01) *B65G 43/00* (2006.01)
- (21) **International Application Number:**
PCT/US2016/029949
- (22) **International Filing Date:**
29 April 2016 (29.04.2016)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
62/155,670 1 May 2015 (01.05.2015) US
- (71) **Applicant (for US only):** **SCHLUMBERGER TECHNOLOGY CORPORATION** [US/US]; 300 Schlumberger Drive, Sugar Land, Texas 77478 (US).
- (71) **Applicant (for CA only):** **SCHLUMBERGER CANADA LIMITED** [CA/CA]; 125 - 9 Avenue SE, Calgary, Alberta T2G 0P6 (CA).
- (71) **Applicant (for FR only):** **SERVICES PETROLIERS SCHLUMBERGER** [FR/FR]; 42 rue Saint Dominique, 75007 Paris (FR).
- (71) **Applicant (for all designated States except CA, FR, US):** **SCHLUMBERGER TECHNOLOGY B.V.** [NL/NL]; Parkstraat 83-89m, NL-2514 JG The Hague (NL).
- (72) **Inventors:** **HODGSON, Kim**; 3423 Stillwater Lane, Sugar Land, Texas 77479 (US). **LESKO, Timothy**; 715 Tyler Run, Sugar Land, Texas 77479 (US). **LEUGEMORS, Edward Kent**; 22719 Piper Road, Needville, Texas 77461 (US). **YANG, Tiffany Lynn**; 767 W. Van Gogh Place, Fayetteville, Arkansas 72703 (US).
- (74) **Agents:** **GREENE, Rachel** et al.; 10001 Richmond Avenue, IP Administration Center of Excellence, Room 4720, Houston, Texas 77042 (US).
- (81) **Designated States (unless otherwise indicated, for every kind of national protection available):** AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

[Continued on next page]

(54) **Title:** FIBER BLOWER

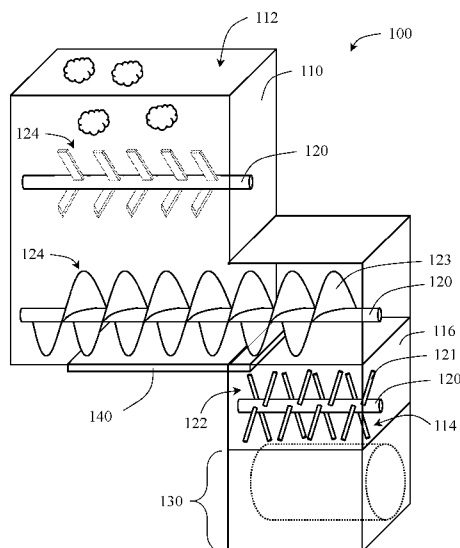


FIG. 1

(57) **Abstract:** A fiber blower includes a hopper, a plurality of rods disposed in the hopper, each rod having a longitudinal axis extending there through and each rod rotatable about the longitudinal axis with a motor, a variable frequency drive operatively connected to each motor to control rotational speed of the rods, and a rotating air lock disposed at an outlet of the hopper. The plurality of rods includes at least one picker rod and at least one bladed rod.



(84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE,

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

Published:

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

FIBER BLOWER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This Application claims priority for Application 62/155,670 filed on May 1, 2015 in the United States.

BACKGROUND

[0002] Solids, such as fibers, may be introduced into a flow that is pumped into a well for a number of different reasons. For example, fibers may be mixed with a proppant and a carrier fluid in a hydraulic fracturing operation for purposes of preventing settling of the proppant. Moreover, the fibers may create a more uniform distribution of the proppant over the fractures.

[0003] Fibers may be used in other oilfield applications, such as applications in which the fibers are mixed with cement or as lost-circulation material. For example, in a well cementing operation, the fibers may contribute to the strength of the cement and enhance the rigidity and stress tolerance of the cement.

[0004] Fibers may also be combined with a gelling agent with or without other solids for purposes of fluid diversion. In this regard, a combined fiber and gelling agent mixture may be used to treat selected regions of a well to prevent/control fluid loss in the regions.

[0005] Fibers may be used in other oilfield applications, such as applications in which the fibers are selectively mixed with a carrier fluid and proppant to create different proppant-bearing zones in a well. In this regard, the fibers may be used to establish one or more segregated regions of the well, so that some regions contain proppant, whereas other regions do not.

[0006] Some materials are packed and do not flow easily. A fiber feeder conditions material by breaking up chunks and moving it toward an outlet which then conveys the material. FIG. 17 shows an example of a previously used fiber feeder used for metering and conveying the conditioned fibers through an outlet. As shown, the fiber feeder 10 includes a hopper 12, in which fibers 15 may be fed. A control panel 13

may be provided with the hopper 12, for example, to control entry of fibers 15 into the hopper 12 and/or display weight parameters of the fibers 15 being fed through the hopper, among other functions. Augers 14 driven by motor 16 are provided in a lower chamber of the hopper 12, which may collect and section the fibers 15 to meter them towards an outlet 18 of the fiber blower 10. Fibers exiting the outlet 18 of the fiber feeder 10 may fall into a delivery point as smaller pieces of fiber than were fed into the inlet of the hopper 12.

SUMMARY

[0007] This summary is provided to introduce a selection of concepts that are further described below in the detailed description. This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid in limiting the scope of the claimed subject matter.

[0008] In one aspect, embodiments of the present disclosure relate to an apparatus that includes a hopper, a plurality of rods disposed in the hopper, each rod having a longitudinal axis extending there through and each rod rotatable about the longitudinal axis with a motor, wherein the plurality of rods include at least one picker rod and at least one bladed rod, a variable frequency drive operatively connected to each motor to control rotational speed of the rods, and a rotating air lock disposed at an outlet of the hopper.

[0009] In another aspect, embodiments of the present disclosure relate to a method of controlling a delivery rate of fibers that includes controlling a first speed of a first motor with a first variable frequency drive to control rotational speed of at least one picker rod disposed in a hopper, controlling a second speed of a second motor with a second variable frequency drive to control rotational speed of at least one bladed rod disposed in the hopper, and delivering the fibers through the hopper to an air lock and through the air lock to a pneumatic stream, wherein the delivery rate of the fibers to the pneumatic stream may be varied by varying the second speed of the second motor.

[0010] In yet another aspect, embodiments of the present disclosure relate to a method that includes pouring fibers into a hopper having at least one bladed rod and

at least one picker rod, the at least one bladed rod having an auger portion including an auger blade extending helically around a rod, metering the fibers through a gate in the hopper to an outlet chamber of the hopper using the auger portion, and conveying the fibers through an air lock disposed at an outlet of the hopper to discharge the fibers through a discharge tube.

[0011] Other aspects of the invention will be apparent from the following description and the appended claims.

BRIEF DESCRIPTION OF DRAWINGS

[0012] FIG. 1 is a cut out view of a fiber blower according to embodiments of the present disclosure showing internal components of the fiber blower.

[0013] FIG. 2 is a diagram of a fiber blower hopper according to embodiments of the present disclosure.

[0014] FIG. 3 is a diagram of rotatable rods disposed in a hopper according to embodiments of the present disclosure.

[0015] FIG. 4 is an image of rotatable rods disposed in a hopper according to embodiments of the present disclosure.

[0016] FIG. 5 is a diagram of a hopper according to embodiments of the present disclosure.

[0017] FIGS. 6-8 are profiles of hoppers according to embodiments of the present disclosure.

[0018] FIGS. 9 and 10 are front and back views of fiber blowers according to embodiments of the present disclosure.

[0019] FIG. 11 is a partially cut-out view of a fiber blower according to embodiments of the present disclosure.

[0020] FIG. 12 shows a diagram of fiber flow through a fiber blower according to embodiments of the present disclosure.

[0021] FIG. 13 shows a front and side profile view of a discharge tube according to embodiments of the present disclosure.

[0022] FIG. 14 shows a blender assembly according to embodiments of the present disclosure.

[0023] FIG. 15 shows top view of an oilfield operation using a fiber blower according to embodiments of the present disclosure.

[0024] FIG. 16 shows performance of fiber flow rates using fiber delivery methods according to embodiments of the present disclosure.

[0025] FIG. 17 shows a conventional fiber blower.

DETAILED DESCRIPTION

[0026] Embodiments disclosed herein relate generally to methods and apparatuses for metering and conveying fibers. Apparatuses according to embodiments of the present disclosure may include an insulation blower having different sections or areas for metering and conveying fibers. Methods and apparatuses disclosed herein may be used for oilfield operations.

[0027] Fibers may include, for example, polylactic acid (PLA), polyglycolic acid (PGA), polyethylene terephthalate (PET), polyester, polyamide, polycaprolactam and polylactone, poly(butylene) succinate, polydioxanone, glass, ceramics, carbon (including carbon-based compounds), elements in metallic form, metal alloys, basalt, acrylic, polyethylene, polypropylene, novoloid resin, polyphenylene sulfide, polyvinyl chloride, polyvinylidene chloride, polyurethane, polyvinyl alcohol, polybenzimidazole, polyhydroquinone-diimidazopyridine, poly(p-phenylene-2,6-benzobisoxazole), rayon, cotton, wool, linen, hemp (or other natural fiber materials), rubber, sticky fiber, or a combination of two or more of the aforementioned materials.

[0028] Apparatuses according to embodiments of the present disclosure may be used for metering and conveying fibers to deliver such fibers at a selected delivery rate. Apparatuses according to embodiments of the present disclosure may include fiber blowers having a hopper, a plurality of rods disposed in the hopper, each rod having a longitudinal axis extending there through and each rod rotatable about the

longitudinal axis with a motor, and an air lock disposed at an outlet of the hopper. At least one parameter of feeding, metering and conveying fibers through fiber blowers of the present disclosure may be selected and/or designed to deliver the fibers at a selected delivery rate. For example, rotational speed of different rods may be altered or designed to vary the delivery rate of fibers from a fiber blower of the present disclosure. As discussed in more detail below, other parameters, e.g., the size of a gate opening between different chambers or areas of a fiber blower housing different types of rotating rods, may be altered to vary the deliver rate of fibers from a fiber blower of the present disclosure.

[0029] FIG. 1 shows an example of a fiber blower 100 according to embodiments of the present disclosure. The fiber blower 100 includes a hopper 110 having an inlet 112 and an outlet 114. A plurality of rods 120 is disposed in the hopper 110, each rod 120 having a longitudinal axis extending there through and each rod 120 rotatable about the longitudinal axis with a motor (not shown). The rods 120 include at least one picker rod 122 and at least one bladed rod 124. As used herein, a picker rod may refer to a rotatable rod having a central rod or shaft and a plurality of extensions extending outwardly therefrom, where the extensions have a generally uniform radial thickness measured from a central longitudinal axis of the extension to an outer perimeter of the extension. For example, extensions of a picker rod may have a circular cross sectional geometry (when sectioned transversely through the central longitudinal axis of the extension), in some embodiments, the cross sectional geometry may be elliptical having a major to minor axis ratio, for example, of less than 3:2 or less than 4:3, or in some embodiments, the cross sectional geometry may be a polygonal shape, for example, having more than five sides. In contrast, a bladed rod may refer to a rotatable rod having a central rod or shaft and one or more blades extending outwardly therefrom, where the blade(s) has a generally flattened profile. For example, a blade cross sectional profile may have an aspect ratio (of perpendicular dimensions, e.g., width and length, of the cross sectional profile) ranging from, for example, greater than 2:1, greater than 4:1 or greater than 6:1.

[0030] In the embodiment shown, the picker rod 122 includes a plurality of extensions 121 (e.g., spikes or rods) extending radially outward from the rod 120.

The bladed rod 124 includes an auger blade 123 extending helically around the rod 120. In some embodiments, a bladed rod may include a plurality of separated blades (e.g., paddle shaped blades or other shape of blade having a generally flattened profile) extending radially outward from a rod. In some embodiments, a bladed rod may include a combination of different types of blades extending outwardly from a rod (e.g., an auger portion of a bladed rod having an auger extending helically around the auger portion of the bladed rod and an agitator portion having a plurality of separated blades extending outwardly from the agitator portion of the bladed rod). In some embodiments, a bladed rod may have a blade spaced apart from and extending parallel to a central rotatable rod, where the blade may rotate around the central rod. Other configurations of bladed rods may be used in a hopper according to embodiments of the present disclosure.

[0031] The hopper 110 may have a geometry defining a chamber or section for housing different types of bladed rods. For example, as shown in FIG. 1, the hopper 110 may have an outlet chamber 116 at the outlet 114 housing at least one picker rod 122 and a main chamber housing the bladed rods 124. In the embodiment shown, the main chamber may have an extended portion adjacent to and above the outlet chamber 116, where the auger bladed rod 124 extends through the main chamber and extended portion of the main chamber, such that an auger portion of a bladed rod 124 is positioned above the picker rod 122. In other words, at least a portion of the picker rod 122 is axially positioned between an auger portion of the bladed rod 124 and the outlet 114. According to embodiments of the present disclosure, other configurations of a hopper may be provided having an auger portion of a bladed rod, at least a portion of a picker rod, and an air lock axially aligned with an outlet of the hopper.

[0032] A gate 140 may be positioned along the hopper 110 to open or close off an opening between the main chamber and the outlet chamber 116. The size of the opening left by the position of the gate 140 may affect the amount of fiber that may be metered from the bladed rods 124 and distributed to the picker rod 122. For example, a flow rate of fiber through the hopper 110 may be reduced as the gate 140 is moved to reduce the size of the opening to the outlet chamber 116, and the flow rate of fiber through the hopper 110 may be increases as the gate 140 is moved to increase the size

of the opening to the outlet chamber 116. According to embodiments of the present disclosure, the gate may be automatically or manually positioned to provide an opening to a hopper outlet chamber with a selected size.

[0033] Referring still to FIG. 1, an air lock 130 is disposed at the outlet 114 of the hopper 110, opposite the side of the outlet chamber opening to the hopper main chamber. The air lock 130 may include a housing having a plurality of vanes rotatable within the housing about a rotor shaft. When fibers are received into an air lock opening, a pressure or vacuum driven pneumatic conveying system generated by the air lock may convey the fibers from an outlet of an adjacent hopper to a discharge tube.

[0034] Rotatable rods may be arranged in fiber blowers according to embodiments of the present disclosure to meter fiber within a hopper towards an air lock disposed at the hopper outlet, where the air lock may convey the metered fiber to a discharge tube. For example, rotatable rods may be arranged in rows substantially covering a cross sectional area of a hopper, such that fibers falling into the hopper may be contacted by at least one rotatable rod and metered in a direction toward the hopper outlet. Further, rotatable rods may be arranged at different heights along the height of a hopper. For example, in some embodiments, different types of rotatable rods may be positioned at different heights to process fibers in different ways as the fibers flow through the hopper.

[0035] FIG. 2 shows an example of an arrangement of rotatable rods disposed within a hopper of a fiber blower according to embodiments of the present disclosure. As shown, a fiber blower 200 may have a hopper 210 with a height 215 measured between an inlet 212 of the hopper to an outlet 214 of the hopper and a width 216 extending between two opposite side walls 217 of the hopper 210. Rotatable rods 220 may be arranged in rows 232, 234, 236 extending across the width 216 of the hopper, where each row is at a different height along the height 215 of the hopper 210. In the embodiment shown, each row 232, 234, 236 of rotatable rods has a different type of rotatable rod 220. For example, a first row 232 of rotatable rods may include picker rods having a plurality of extensions (e.g., spikes or rods) extending radially outward from a central rod, where the longitudinal axis of each picker rod extends along a

length of the hopper at a first height. A second row 234 of rotatable rods may include bladed rods having an auger blade extending helically around a central rod, where the longitudinal axis of each bladed rod extends along a length of the hopper at a second height, farther away from the outlet 214 than the first height. A third row 236 of rotatable rods may include bladed rods having a plurality of spaced apart blades extending radially outward from a central rod, where the longitudinal axis of each bladed rod extends along a length of the hopper at a third height, the third height being farther away from the outlet 214 than the second and first heights.

[0036] A row of rotatable rods 220 may have a collective profile that covers less than or the substantial width 216 of the hopper 210. In other words, the widths of each rotatable rod 220 in a row may add together to extend substantially the entire width 216 of the hopper 210 (e.g., as shown in first row 232), or the widths of each rotatable rod 220 in a row may add together to cover less than the width 216 of the hopper 210 (e.g., as shown in second row 234). A row of rotatable rods may have rotatable rods 220 spaced apart (evenly or unevenly) across the entire width 216, such as shown in FIG. 2, or a row of rotatable rods may have the rotatable rods spaced apart across a partial width of a hopper. In some embodiments, rotatable rods having blades extending outwardly from a central rotating rod or shaft may be positioned in a hopper to have overlapping profiles (where a portion of a blade of a first rotatable rod extends partially into the profile of a second rotatable rod), such as shown with the first row 232 of rotatable rods in FIG. 2.

[0037] Further, as shown in FIG. 2, a row 232 of picker rods may be positioned in a bottom or lower position along the height 215 of the hopper, near the outlet 214 of the hopper 210, to grab fibers and introduce them into an air lock (not shown) disposed adjacent the outlet 214 of the hopper 210. The first row 232 of picker rods may be disposed in an outlet chamber or section of the hopper 210, where an outlet chamber may be a section of the hopper 210 having a smaller width than the width at the inlet 212 side of the hopper 210. The second row 234 of bladed rods may be disposed at a second height above the first row 232 of picker rods (i.e., the second row 234 at the second height is farther away from the outlet 214 than the first row 232 at the first height), where at least a portion of the bladed rods in the second row have an auger

blade extending helically around a central rotating rod or shaft, which meters and delivers fibers to the picker rods in the first row 232. The third row 236 of bladed rods may be disposed at a third height above the second row 234 of bladed rods (i.e., the third row 236 at the third height is farther away from the outlet 214 than the first and second rows 232, 234), where the third row of bladed rods may have a plurality of separated blades extending radially outward from a central rotatable rod or shaft, which may condition (e.g., help separate and/or evenly distribute) fibers as they fall toward the second row 234 of bladed rods.

[0038] FIGS. 3 and 4 show different examples of rotatable rods according to embodiments of the present disclosure. For example, FIG. 3 shows a bladed rod 310 having a plurality of separated blades 312 extending outwardly from a central rotatable rod 314, a second type of bladed rod 320 having a blade 322 spaced apart from and extending parallel to a central rotatable rod 324, and a third type of bladed rod 330 having an auger blade 332 extending helically around a central rotatable rod 334, which is positioned below the first and second types of bladed rods (closer to an outlet of the hopper in which the rotatable rods are disposed).

[0039] FIG. 4 shows a view of rotatable rods disposed in a hopper from an inlet side of the hopper 400 looking into an outlet chamber of the hopper 400. The rotatable rods include bladed rods 410 having a plurality of separated blades 412 extending outwardly from a central rotatable rod and picker rods 420 having a plurality of extensions extending outwardly from a rotatable rod. The picker rods 420 are disposed in the outlet chamber of the hopper 400, below the bladed rods 410. A gate (not shown) between the outlet chamber and an adjacent air lock is open, such that the vanes 430 of the air lock can be seen.

[0040] In some embodiments, a rotatable rod may have different blade configurations along its longitudinal axis, where the different portions of the rotatable rod may be arranged in a hopper to perform different functions. For example, a hopper may include at least one rotatable rod having an auger portion and an agitator portion. The auger portion may include an auger blade extending helically around the auger portion of the rod, and the agitator portion may include a plurality of blades extending radially outward from the agitator portion of the rod. The auger portion may cover or overlap

with the outlet of the hopper. Further, at least a portion of one or more picker rods may be positioned between the auger portion of one or more bladed rods and an air lock, such that fibers may be metered by the auger portion(s) to the picker rods, and the picker rods may selectively pass through the fibers to the air lock.

[0041] Further, the blades of a bladed rod may be oriented to push or direct fiber in a certain direction. For example, as shown in FIG. 3, the auger blade 332 may be oriented to direct fibers in a first direction, the first direction extending parallel with the central rod 334 longitudinal axis and towards an outlet of the hopper. As shown in FIG. 4, the blades 412 extending from bladed rod 410 may be oriented to direct fibers in a first direction toward the outlet of the hopper. Particularly, the blades 412 may be angled at an acute angle from the central rod of the bladed rod 410 in the first direction (toward the outlet of the hopper), and/or, the blades 412 may be rotationally angled about the blade longitudinal axis.

[0042] FIG. 5 shows a top view of another example of rotatable rods positioned in a hopper. As shown, the hopper 500 may include a row of rotatable rods 510 extending the length 502 and substantially across the width 504 of the hopper 500. The row of rotatable rods includes an auger bladed rod 512 having an auger blade extending helically around a rotatable rod and bladed rods 514 having spaced apart blades extending outwardly from a rotatable rod. In the embodiment shown, the auger blade of the auger bladed rod 512 is oriented in a left handed screw configuration to direct fiber in a first direction 520 toward an outlet chamber or section of the hopper. In other embodiments, one or more auger bladed rods may be oriented in a right handed screw configuration. Fiber may be poured into the hopper, where it may be conditioned and moved by the bladed rods 514 to the auger bladed rod 512, and then metered and directed by the auger bladed rod 512 in the first direction 520 to the outlet chamber. As shown, the outlet chamber may have a cover 530 covering the outlet chamber and a portion of the auger bladed rod 512. The outlet chamber may have at least one picker rod 516 disposed therein, where fiber metered from the auger bladed rod 512 may be directed into the outlet chamber and to the picker rod 516. The picker rod 516 may digest the fibers delivered by the auger bladed rod 512 and output

the fibers at a hopper output rate. The fibers may be outputted from the hopper outlet to an air lock (not shown).

[0043] Hoppers according to embodiments of the present disclosure may have various geometries. For example, the cross sectional shape of the hopper 210 shown in FIG. 2 includes rectangular compartments or sections. However, other geometries may be used, for example, geometries having one or more curved or sloped walls for directing fibers toward an outlet of the hopper. FIGS. 6-8 show additional examples of hopper geometries having one or more sloped walls sloping inwardly toward an outlet of the hopper.

[0044] FIG. 6 is a side schematic view of a hopper 600 along its width according to embodiments of the present disclosure. As shown in FIG. 6, a hopper 600 may include two opposite side walls 612, 614 sloping inwardly from a hopper inlet 616 to a hopper outlet 618. Bladed rod 624 (having an auger blade extending helically around a rotatable rod) may be disposed in a row along the width of the hopper 600 at a first height, and bladed rods 622 (having a plurality of spaced apart blades extending outwardly from a rotatable rod) may be disposed in a row along the width of the hopper 600 at a second height, such that the auger bladed rod 624 is relatively closer to the hopper outlet 618, and the bladed rods 622 are relatively closer to the hopper inlet 616.

[0045] FIG. 7 is a side schematic view of a hopper 700 along its width according to embodiments of the present disclosure. As shown in FIG. 7, a hopper 700 may include two opposite side walls 712, 714, where side wall 714 extends substantially parallel with the hopper height, and side wall 712 slopes inwardly from a hopper inlet 716 to a hopper outlet 718. Bladed rod 724 (having an auger blade extending helically around a rotatable rod) may be disposed in a row along the width of the hopper 700 at a first height, and bladed rod 722 (having a plurality of spaced apart blades extending outwardly from a rotatable rod) may be disposed in a row along the width of the hopper 700 at a second height, such that the auger bladed rod 724 is relatively closer to the hopper outlet 718, and the bladed rod 722 is relatively closer to the hopper inlet 716.

[0046] FIG. 8 shows a side schematic view of a hopper 800 along its length according to embodiments of the present disclosure. As shown in FIG. 8, a hopper 800 may include a front wall 811 and a back wall 813 opposite the front wall 811, where the length of the hopper 800 may be measured between the front and back walls 811, 813. The height of the hopper 800 may be measured between a hopper inlet 816 to a hopper outlet 818. Bladed rod(s) 824 (having an auger blade extending helically around a rotatable rod) may be disposed in a row along the width of the hopper 800 at a first height, and bladed rod(s) 822 (having a plurality of spaced apart blades extending outwardly from a rotatable rod) may be disposed in a row along the width of the hopper 800 at a second height, such that the auger bladed rod(s) 824 is relatively closer to the hopper outlet 818, and the bladed rod(s) 822 are relatively closer to the hopper inlet 816.

[0047] Hoppers according to embodiments of the present disclosure may have different sizes, depending on, for example, the amount of fiber to be processed and the desired time between reloadings. For example, a hopper may have a volume ranging up to 100 cubic feet or more. When a hopper is attached to various components used for operation of a fiber blower, the fiber blower may have a size ranging up to greater than several feet in length, width and/or height. In embodiments using fiber blowers having a relatively large size, a fiber blower may be transported by, and in some embodiments operated from, the trailer of a commercial truck.

[0048] For example, FIGS. 9-11 show an example of a fiber blower 900 according to embodiments of the present disclosure, which may be transported by and operated from the trailer of a commercial truck 905. As shown, one or more fiber blowers 900 may be disposed in the trailer of the commercial truck 905. FIG. 9 shows a view from a rear of the truck 905 having the fiber blowers 900 loaded into the trailer with connections for a discharge tube facing outward. FIG. 10 shows a view from the inside of the truck 905 trailer, where the back of the fiber blowers 900 are seen. In the embodiment shown, a loading ramp 907 may be used to load fibers into the hoppers 910 of the fiber blowers. FIG. 11 shows partial cutaway view of a diagram the fiber blower 900. The fiber blower 900 includes a hopper 910 having at least one rotatable bladed rod 920 and picker rod 930 disposed therein, where the picker rod(s) 930 may

be disposed in an outlet chamber of the hopper and the bladed rod(s) 920 may be disposed in a main chamber of the hopper. An air lock 940 is disposed at an outlet of the hopper 910, below the outlet chamber, and a positive displacement blower 950 is disposed near the air lock 940 for providing a pneumatic stream into which fibers from the air lock 940 may be conveyed. Motors driving each of the rotatable rods 920, 930 may be housed in motor compartment 960, adjacent the hopper 910. Variable frequency drives 970 may be mounted on the fiber blower 900 proximate to the motors 960 for driving one or more of the motors at a variable speed. In some embodiments, variable frequency drives 970 may be remotely controlled. In some embodiments, variable frequency drives 970 may be controlled at the fiber blower 900.

[0049] Fiber blowers according to embodiments of the present disclosure may utilize a variable frequency drive to control the rotational speed of rotatable rods disposed within the fiber blower. For example, a variable frequency drive may be operatively connected to a motor that is operatively connected to a rotatable rod disposed in the hopper of a fiber blower. The variable frequency drive may be used to control and set the speed of the motor, and the motor may drive rotation of the rotatable rod at the set rotational speed. A fiber blower according to embodiments of the present disclosure may have multiple rotatable rods disposed in a hopper, each rotatable rod rotated by a motor, and each motor operatively connected to and controlled by a variable frequency drive.

[0050] Referring now to FIG. 12, a diagram showing operation of a fiber blower 1000 according to embodiments of the present disclosure is shown. The fiber blower 1000 includes a hopper 1010 having a plurality of bladed rods 1020 disposed therein and extending along a length of the hopper 1010. A plurality of picker rods 1030 may be disposed in an outlet chamber of the hopper 1010, along an axial height of the hopper closer to the outlet than the axial height at which bladed rods 1020 are disposed. A rotary air lock 1050 may be removably attached to the outlet of the hopper 1010, which may be removed, for example, for maintenance and/or cleaning. A rotatable component (e.g., a rotor assembly having a plurality of vanes extending from a rotor shaft) within the rotary air lock 1050 may be rotated in an air lock rotation direction

1052 to meter fiber into a pneumatic stream while also forming an air seal within pockets of the rotatable component to control air flow through the air lock. The speed of rotation of the air lock rotatable component may be driven by an engine or an electric motor 1080, for example.

[0051] Each of the bladed rods 1020 and picker rods 1030 may be driven by a motor to rotate in either clockwise or counterclockwise directions. Each motor may be operatively connected to a variable frequency drive 1070, where the variable frequency drive(s) 1070 may control the speed of the motor, thereby controlling the rotational speed of each of the rods. A variable frequency drive may control motor speed and torque by changing the input frequency and voltage supplied to the motor. In some embodiments, the variable frequency drives may be housed together in a housing of the fiber blower. In some embodiments, variable frequency drives may be housed separately from the fiber blower housing and are wired to the motors in a fiber blower driving rotatable rods disposed in the hopper.

[0052] One or more variable frequency drives may be provided with a fiber blower according to embodiments of the present disclosure to independently control the motor speed of one or more motors rotating bladed and/or picker rods disposed in the hopper of the fiber blower. A variable frequency drive may control a motor to vary rotational speed of a connected rod (e.g., in response to changed conditions or as part of a predetermined plan for varying motor speed), or a variable frequency drive may control a motor to maintain a constant rotational speed of a connected rod (e.g., at an optimized speed). In some embodiments, one or more motors controlled by a variable frequency drive (thereby providing the motor with variable and controllable speeds) may be used to drive one or more bladed rods, and one or more motors having a set speed may be used to drive one or more picker rods in the fiber blower. In some embodiments, a motor controlled by a variable frequency drive may drive each rotatable rod disposed in a fiber blower hopper.

[0053] In the embodiment shown in FIG. 12, each of the bladed rods 1020 and picker rods 1030 may be driven with a motor that is controlled with a variable frequency drive 1070, while the rotary speed of the air lock 1050 may be driven with a motor 1080 set to a constant optimal speed. In some embodiments, the rotary speed of the

air lock 1050 may be set to an optimal speed, the rotational speed of the picker rods 1030 may then be optimized and set to run at a constant rotational speed using variable frequency drives 1070, and the rotational speed of the bladed rods 1020 may then be varied using variable frequency drives 1070, which may be varied to alter the rate of fiber flow through the hopper 1010. In some embodiments, the rotary speed of the air lock 1050 may be set to an optimal speed and the rotational speed of the picker rods 1030 and the bladed rods 1020 may be varied using variable frequency drives 1070. The speed of the bladed rods 1020 and/or picker rods 1030 may be varied using a variable frequency drive, for example, to alter the rate of fiber flow through the hopper 1010.

[0054] The embodiment shown in FIG. 12 further includes a sliding gate 1040 positioned along the hopper 1010 to vary an opening size between a main chamber of the hopper 1010 containing the bladed rods 1020 and an outlet chamber of the hopper 1010 containing the picker rods 1030. The gate 1040 may be partially disposed inside the hopper 1010 while also being accessible for control (e.g., by an operator to manually open or close the gate or by a control mechanism to mechanically open or close the gate) in order to control the size of the opening to an outlet chamber of the hopper 1010. The sliding gate 1040 may be positioned to close off a desired amount of the opening area, for example, more than 75 percent of the area of the opening, between 75 and 50 percent of the area of the opening, between 50 and 25 percent of the area of the opening, or less than 25 percent of the area of the opening between the main chamber and the outlet chamber.

[0055] The size of the opening formed between the main chamber, the outlet chamber and the gate 1040 may affect the amount of fiber 1090 that may be metered from the bladed rods 1020 and distributed to the picker rods 1030. For example, a flow rate of fiber through the hopper 1010 may be reduced as the gate 1040 is moved to reduce the size of the opening to the outlet chamber, and the flow rate of fiber through the hopper 1010 may be increased as the gate 1040 is moved to increase the size of the opening to the outlet chamber. According to embodiments of the present disclosure, a sliding gate may be used in combination with varying the rotational speed of rotating rods disposed in a fiber blower to design and/or alter the flow rate of fibers through

the fiber blower. In some embodiments, the rotational speed of rotating rods disposed in a fiber blower according to embodiments of the present disclosure may be varied, without use of a gate, to design and/or alter the flow rate of fibers through the fiber blower.

[0056] An example of the flow of fibers 1090 through a fiber blower 1000 according to embodiments of the present disclosure is shown in FIG. 12. Fiber 1090 may be poured into the hopper inlet, where rotating bladed rods 1020 may condition and/or meter fibers 1090, and direct the fibers 1090 to the picker rods 1030. The picker rods 1030 may then direct the fibers 1090 to the hopper outlet, where the fibers 1090 exit the hopper outlet to the air lock 1050 inlet port, and travel through the air lock 1050 and out the air lock 1050 outlet port. Fibers 1090 exiting the air lock 1050 may be conveyed by a pneumatic stream (e.g., using a positive displacement blower, such as shown in FIG. 11 at 950) through a hose 1060 to be delivered to a remote location.

[0057] While the embodiment shown in FIG. 12 includes one outlet chamber (housing picker rods 1030) provided between a hopper main chamber (housing bladed rods 1020) and an air lock 1050, other embodiments may include more than one outlet chamber. For example, in some embodiments, a hopper may include a main chamber (housing bladed rods) and two separated/spaced apart outlet chambers (each housing picker rods). Two air locks may be attached to the outlets at the outlet chambers, where each outlet chamber has an air lock attached at the outlet. Further, in such embodiments, two blowers (e.g., positive displacement blowers) may be provided with the fiber blower, where each blower may be configured to generate an air stream to convey fibers exiting each air lock.

[0058] According to embodiments of the present disclosure, a discharge tube may be directly or indirectly connected to an outlet of a fiber blower, where the discharge tube has an internal conduit extending through the length of the discharge tube, and through which fibers may be conveyed. For example, in some embodiments, a discharge tube may be directly connected to an outlet port of a fiber blower air lock. In some embodiments, a discharge tube may be connected to an outlet port of a fiber blower air lock via a hose, where one end of the hose is connected to the outlet port of

the fiber blower and an opposite end of the hose is connected to the discharge tube. A discharge tube may have a rigid or flexible structure.

[0059] In some embodiments, a discharge tube may be provided with a fluid nozzle, which may allow entry of a fluid into the internal conduit of the discharge tube. FIG. 13 shows a front profile and a side profile of an example of a discharge tube 1100 according to embodiments of the present disclosure. The discharge tube 1100 includes a tubular body 1102 having a connection end 1104 and an output end 1106 opposite the connection end 1104. The connection end 1104 may be connected to, for example, a hose or outlet port from a fiber blower. A fluid nozzle, such as a water spray nozzle 1108, may open into an internal conduit of the tubular body 1102 at a location along the length of the tubular body 1102. In the embodiment shown, the water spray nozzle 1108 may open at a location along the tubular body 1102 proximate to the output end 1106. Water or other fluid may be introduced into the internal conduit of the discharge tube 1100 when conveying fibers through the discharge tube, for example, to limit the amount of fiber flyaway or to discharge a fiber-fluid mixture.

[0060] Fibers may be delivered from a fiber blower through a discharge tube (or hose) according to embodiments of the present disclosure and introduced directly into a mixer or blender assembly, for example, a Precision Optimal Density (POD) blender assembly available from Schlumberger. A blender assembly may receive fiber delivered from a fiber blower according to embodiments of the present disclosure and mix the fibers with additional materials, such as a proppant (e.g., sand) and/or a liquid (e.g., a carrier fluid or other fluid used downhole).

[0061] FIG. 14 shows an example of a blender assembly 1200, into which fibers 1250 may be delivered from a fiber blower according to embodiments of the present disclosure. As shown, the blender assembly 1200 includes a blender hopper 1210 to receive a flow F of fibers delivered from a fiber blower, through a discharge tube 1220, and exiting an output end 1222 of the discharge tube 1220. The blender hopper 1210 may also receive a proppant delivered from an upper hopper 1214 and a carrier fluid, where the fibers 1250, proppant and carrier fluid may descend through a lower opening 1212 of the hopper to a vortex mixer 1230 including a shaft 1232 and a

mixing blade 1234. In some embodiments, carrier fluid may be introduced through a spray nozzle in the discharge tube, where the discharge tube may have a configuration similar to or the same as the discharge tube 1102 described above and shown in FIG. 13, and where a fluid-fiber mixture is directed into the blender hopper 1210 from the discharge tube and may be mixed with a proppant through the vortex mixer. In some embodiments, a discharge tube may be provided with a fluid nozzle for introducing a first fluid type or composition (e.g., water) with the fibers as the fibers are being blown through the discharge tube, and the first fluid-fiber mixture may then be directed into a blender hopper to be mixed with a second fluid type or composition (and optionally with a proppant) through a vortex mixer. In some embodiments, a discharge tube may be provided without a fluid nozzle, where fibers may be directed into a blender hopper through the discharge tube without adding a fluid through the discharge tube.

[0062] Using a discharge tube 1220 according to embodiments of the present disclosure or other delivery conduit providing an output end of a blow line that may deliver fibers directly into an eye of the vortex mixer may reduce the amount of lint or flyaways from fiber delivery. For example, as shown in FIG. 14, by delivering fibers 1250 into a blender assembly using the pneumatic stream generated from a fiber blower according to embodiments of the present disclosure and/or through a discharge tube according to embodiments of the present disclosure (e.g., such as shown in FIG. 13), the fibers 1250 may be relatively accurately delivered into a small space within the blender assembly 1200, such as through a gap 1236 between the edge of the hopper lower opening 1212 and the shaft 1232 of the mixer 1230. Other aspects that may help with reducing fiber lint may include, for example, providing dust collectors at the delivery points and/or using a blower (e.g., a blower rated up to 250 SCFM of air) in the fiber blower having a valve that may be opened to allow some of the air to re-circulate, which may reduce the delivery air, and where reducing air flow may help with the reduction of blowing fiber lint. However, introducing fluid (e.g., water spray) into the output end of a discharge tube, such as described above, may be more effective at suppressing fiber lint than other method(s) of reducing fiber lint.

[0063] When delivering fibers from a fiber blower and through a discharge tube according to embodiments of the present disclosure, the fiber blower may be positioned a distance away from the point of delivery (e.g., into a blender assembly), for example, ranging up to 150 ft or more away from the point of delivery. For example, FIG. 15 shows use of a fiber blower 1500 according to embodiments of the present disclosure in an oilfield operation. As shown, the fiber blower 1500 may be positioned a distance away from the point of delivery, thereby allowing for more room for other equipment used at the point of delivery. In the embodiment shown, the point of delivery is a blender assembly 1510, where fibers may be delivered from the fiber blower 1500 (e.g., through a discharge tube) to the blender assembly 1510 to be mixed with other materials, such as a proppant and a carrier fluid, in preparation to be sent downhole.

[0064] Fiber blowers according to embodiments of the present may allow for controlled delivery rate of fibers by controlling the rotational speed of individual rotatable rods disposed in the fiber blower. For example, according to embodiments of the present disclosure, a method of controlling the delivery rate of fibers may include controlling a first speed of a first motor with a first variable frequency drive to control the rotational speed of at least one picker rod disposed in a hopper of a fiber blower, controlling a second speed of a second motor with a second variable frequency drive to control the rotational speed of at least one bladed rod disposed in the hopper, and delivering the fibers through the hopper to an air lock, where the fibers may be distributed through the air lock to a pneumatic stream (e.g., using a blower mounted to the fiber blower, such as described above). The delivery rate of the fibers to the pneumatic stream may be varied by varying the second speed of the second motor, to thereby vary the rotational speed of the at least one bladed rod.

[0065] In some embodiments, the delivery rate of fibers through a fiber blower having at least one bladed rod, at least one picker rod, and an air lock may be varied by varying the rotational speed of one or more of the bladed rods while keeping the rotational speed of the picker rod(s) and air lock constant. In such embodiments, each motor driving each bladed rod having its rotational speed varied may be controlled by a variable frequency drive, whereas motors driving the picker rod(s) may be

controlled by a variable frequency drive or may be set to provide a constant speed, and the motor or engine driving rotation of the rotary air lock may be set to provide a constant speed.

[0066] For example, according to embodiments of the present disclosure, a rotary air lock disposed at the outlet of a fiber blower hopper is set to a constant speed (e.g., an optimized speed). The rotational speed of picker rods disposed near the outlet in the hopper of the fiber blower may then either be set to run at a constant rotational speed (e.g., an optimized rotational speed) or may be driven at variable rotational speeds with the use of one or more variable frequency drives operatively connected to the motor(s) driving rotation of the picker rods. The rotational speed of bladed rods disposed above (farther away from the outlet than) the picker rods may be driven at variable rotational speeds with the use of one or more variable frequency drives operatively connected to each of the motors driving rotation of the bladed rods.

[0067] A constant rotational speed of an air lock may be set to be faster than the variable rotational speeds of bladed rods used in a fiber blower. For example, when variable speed bladed rods are used in a fiber blower to help with metering fiber through the fiber blower, the rotational speed of the bladed rods may be made relatively slower than rotational speed of the air lock to help achieve desired sectioning and delivery rates of the fiber through the hopper, while the rotational speed of the air lock may be set to be relatively faster to deliver the sectioned and metered fibers quickly.

[0068] In some embodiments, the type of rotatable rod disposed in a fiber blower may be designed in combination with the design and control of rotational speed of the rotatable rods in order to deliver the fibers through the fiber blower at a selected delivery rate (or delivery rate range). For example, in some embodiments, a fiber blower may be designed to have multiple rows of rotatable rods disposed at different heights along the fiber blower hopper, where each row may have a different type of rotatable rod to perform a selected function of processing fiber through the hopper. A bottom row of rotatable rods closest to the outlet of the fiber blower hopper may be a row of one or more picker rods, and one or more rows above the picker rod row (farther from the outlet) may be made of bladed rods. Bladed rods may include those

described above, for example, an auger bladed rod having an auger blade extending helically around a central rod or shaft, a bladed rod having a plurality of paddle or other flattened-shape blades extending outwardly from the central rod, and a bladed rod having a blade spaced apart from and extending parallel to the central rod.

[0069] A row of auger bladed rods may be positioned above a row of picker rods to meter fibers from the hopper to the picker rods, and the picker rods may further meter the fibers to an air lock. In some embodiments, a bottom row of picker rod(s) may be set to run at a relatively faster constant speed to digest fiber that an above row of variable speed auger bladed rods brought. In some embodiments, a row of bladed rods may be positioned above both a row of auger bladed rods and a row of picker rods, where the row of bladed rods may agitate and break up fibers being fed through the hopper, the row of auger bladed rods may then meter the fibers to the row of picker rods, and the row of picker rods may then digest and introduce the fibers to an air lock.

[0070] According to some embodiments, a fiber blower may be designed to have multiple rows of rotatable rods disposed at different heights along the fiber blower hopper, where one or more rows may have a combination of different types of rotatable rods. For example, in some embodiments, a row of rotatable rods at a height closest to a hopper outlet may be made entirely of picker rods, while a row of rotatable rods at a height above the picker rod row (farther away from the hopper outlet) may be made of at least one rotatable rod having a bladed portion (with a plurality of spaced apart blades extending radially outwardly from the central rotating rod) and an auger portion (with an auger blade extending helically around the central rotating rod). The blades on the bladed rods may be oriented to direct fiber through the bladed portion, e.g., to condition and break up large chunks of fiber, then through the auger portion, e.g., to meter the fibers towards the picker rods, and then through the picker rods, e.g., to grab the fibers and introduce them into an air lock. In such embodiments, where a row of rotatable rods above a row of picker rods includes a metering configuration (e.g., an auger portion), the row of picker rods may be set to have a faster rotational speed than the above row of rotatable rods. For example, the rotational speeds of a rotary air lock and a bottom row of picker rods may be set to be

faster than the rotational speed of an above row of bladed rods having at least one auger portion. The rotational speed of the bladed rods may then be varied to vary the end delivery rate of the fibers out of the fiber blower.

[0071] In some embodiments, the size of an opening to an outlet chamber of a hopper may be designed in combination with the design and control of rotational speed of the rotatable rods in order to deliver the fibers through the fiber blower at a selected delivery rate (or delivery rate range). For example, as described above, a hopper may include a first chamber (or outlet chamber) having at least one picker rod disposed therein, a second chamber having at least one bladed rod disposed therein, and a gate assembled at least partially between the first and second chambers to selectively alter the size of the opening between the first and second chambers (e.g., by sliding the gate more or less through the opening). The size of the opening may be altered alone or in combination with varying the rotational speed of one or more bladed rods disposed in the hopper to alter the delivery rate of fibers being fed through the hopper.

[0072] Referring now to FIG. 16, performance graphs showing the delivery rate of fibers through a fiber blower according to embodiments of the present disclosure are provided to show the effects of altering an opening size to an outlet chamber of the fiber blower hopper (having picker rods disposed in the outlet chamber) and varying the rotational speed of the picker rods. In the graphs, motor speed (and thus the rotational speed of a rotatable rod being rotated by the motor) closely follows the frequency of the variable frequency drive driving the motor. Thus the relationship between variable frequency drive frequency and fiber rate may correspond to a relationship between rotational speed of a rotatable rod (rotated with a motor being driven from the frequency of the variable frequency drive) and fiber rate. The first graph shows the fiber delivery rate at different frequencies (from a variable frequency drive) driving the motor to a picker rod when a gate is positioned through an opening to the outlet chamber to leave an opening size of about 15 cm wide. The second graph shows the fiber delivery rate at different frequencies (from a variable frequency drive) driving the motor to a picker rod when a gate is positioned through an opening to the outlet chamber to leave an opening size of about 10 cm wide. As shown, the delivery rate is relatively insensitive to the frequency driving the motor of the picker

rod when the gate leaves the 15 cm wide opening to the outlet chamber, whereas when the gate was closed to leave the 10 cm wide opening, the delivery rate of the fiber changed more with the change in frequency and rotational speed.

[0073] By designing opening size to an outlet chamber in a hopper in combination with rotational speeds of rotational rods disposed in the hopper, the delivery rate of fiber through the hopper may be designed and selected for different applications.

[0074] In some embodiments, the size and/or spacing of blades and/or extensions may be altered to correspond with a size or size range of fiber tufts/bundles/tows that may be trapped or processed by the blades and/or extensions. For example, a row of picker rods may have a size and/or spacing between the extensions extending from the central rod that traps a certain fiber size or range of fiber sizes, where fibers greater than the fiber size or size range are inhibited from falling through the extensions. The picker rod extensions and the speed at which they rotate about the central rod may act as a fiber metering device, as well as the amount of cross sectional area of the picker rod extensions that are exposed through an outlet chamber opening, which may be controlled by a gate. Accordingly, some embodiments may benefit when interchangeable picker rods are provided in an outlet chamber of a hopper, where the interchangeable picker rods may be swapped for picker rods with different extension sizes and/or spacing. In some embodiments, picker rods may have the size of their extensions altered by attaching a sleeve to existing extensions that would make the extensions fatter and thus slightly close the gaps/spacing between the extensions.

[0075] According to embodiments of the present disclosure, a method of delivering fibers at a fiber delivery rate may include pouring fibers into a hopper having at least one auger bladed rod (or bladed rod with an auger portion) and at least one picker rod disposed therein, metering the fibers through a gate in the hopper to an outlet chamber of the hopper using the auger portion(s) of the bladed rods, and conveying the fibers through an air lock disposed at an outlet of the hopper to discharge the fibers through a discharge tube. The fiber delivery rate may be predesigned, e.g., by designing the gate opening size and rotational speeds of the bladed rods and/or picker rods as described above, and/or the fiber delivery rate may be altered during operation, e.g., in response to or in anticipation of a change in parameters.

[0076] Fibers exiting the air lock of a fiber blower according to embodiments of the present disclosure may be conveyed by a pneumatic stream generated from a blower mounted to the fiber blower, such as described above, and outputted at a distal delivery point, e.g., at least 10 feet away from the fiber blower. For example, a delivery point may be a blender assembly, where fibers may be conveyed by the pneumatic stream into the blender assembly at a delivery rate.

[0077] Using apparatuses and methods of the present disclosure, fibers may be metered and conveyed to evenly distribute the fibers into a flow. A fiber-containing flow may be introduced into a well for various purposes. For example, a fiber-containing flow may be introduced into a well for preventing proppant settling, creating a more uniform proppant distribution, and selectively diverting fluid. Fibers may be used in a well for a number of different purposes, which may not involve proppant, gravel packing or hydraulic fracturing. For example, fibers may be introduced into a cement flow for purposes of increasing the rigidity of the cement and distributing stresses in the cement. Moreover, fibers may be used in other downhole applications, as can be appreciated by the skilled artisan. Thus, many variations are contemplated.

[0078] The delivery rate of fibers through a fiber blower according to embodiments of the present disclosure may be varied using one or more methods described herein, for example, by varying the rotational speed of one or more bladed and/or picker rods disposed within the hopper of the fiber blower, by altering a size of an opening to a chamber in the hopper housing picker rods, by altering the size and/or spacing of bladed and/or picker rods disposed in the hopper, and/or by altering the type of bladed rods used in the hopper.

[0079] In some embodiments, altering the delivery rate of fibers through a fiber blower may be useful when the type of fiber being fed through the fiber blower is changed. For example, a fluffier fiber having a material density of about 20 pounds per cubic feet may be more easily trapped/not flow as easily as a fiber type having a material density of about 40 pounds per cubic feet, which may fall through the fiber blower in a less regulated manner. In some embodiments, altering the delivery rate of

different fibers may include using different bladed rod speeds and/or types for different fibers to account for the differences in material density and performance.

[0080] While the present disclosure has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments may be devised which do not depart from the scope of the disclosure as described herein. Accordingly, the scope of the disclosure should be limited only by the attached claims.

CLAIMS

What is claimed is:

1. An apparatus, comprising:
a hopper;
a plurality of rods disposed in the hopper, each rod having a longitudinal axis extending there through and each rod rotatable about the longitudinal axis with a motor, wherein the plurality of rods comprises at least one picker rod and at least one bladed rod;
a variable frequency drive operatively connected to each motor to control rotational speed of the rods; and
a rotating air lock disposed at an outlet of the hopper.
2. The apparatus of claim 1, wherein the at least one bladed rod comprises an auger blade extending helically around the rod.
3. The apparatus of claim 1, wherein the at least one bladed rod comprises a plurality of blades extending radially outward from the rod.
4. The apparatus of claim 1, wherein the at least one bladed rod comprises an auger blade extending helically around an auger portion of the rod and a plurality of blades extending radially outward from an agitator portion of the rod.
5. The apparatus of claim 1, wherein the at least one bladed rod comprises a blade extending parallel to and rotatable around the rod.
6. The apparatus of claim 1, wherein the longitudinal axis of each of the at least one picker rod extends along a first height of the hopper, and wherein the longitudinal axis of each of the at least one bladed rod extends along a second height of the hopper, the second height farther away from the air lock than the first height.

7. The apparatus of claim 1, wherein the at least one bladed rod comprises an auger blade extending helically around an auger portion of the rod, wherein at least a portion of the at least one picker rod is positioned between the auger portion and the air lock.
8. The apparatus of claim 1, further comprising a discharge tube connected to the outlet, the discharge tube comprising a conduit extending therethrough and a water spray nozzle opening at a location along the conduit.
9. A method of controlling delivery rate of fibers, comprising:
controlling a first speed of a first motor with a first variable frequency drive to control rotational speed of at least one picker rod disposed in a hopper;
controlling a second speed of a second motor with a second variable frequency drive to control rotational speed of at least one bladed rod disposed in the hopper; and
delivering the fibers through the hopper to an air lock and through the air lock to a pneumatic stream;
wherein the delivery rate of the fibers to the pneumatic stream may be varied by varying the second speed of the second motor.
10. The method of claim 9, further comprising setting a constant rotational speed of the air lock.
11. The method of claim 10, wherein the constant rotational speed of the air lock is faster than the rotational speed of the at least one bladed rod.
12. The method of claim 9, further comprising altering an opening size between a first chamber of the hopper comprising the at least one picker rod and a second chamber of the hopper comprising the at least one bladed rod to alter the delivery rate of the fibers.
13. The method of claim 9, wherein the at least one bladed rod comprises an auger blade extending helically around an auger portion of the rod.

14. The method of claim 13, wherein the at least one bladed rod further comprises a plurality of blades extending outwardly from an agitator portion of the rod.
15. A method, comprising:
pouring fibers into a hopper comprising at least one bladed rod and at least one picker rod, the at least one bladed rod having an auger portion comprising an auger blade extending helically around a rod;
metering the fibers through a gate in the hopper to an outlet chamber of the hopper using the auger portion; and
conveying the fibers through an air lock disposed at an outlet of the hopper to discharge the fibers through a discharge tube.
16. The method of claim 15, wherein the auger portion, at least a portion of the at least one picker rod, and the air lock are axially aligned with the outlet of the hopper.
17. The method of claim 15, further comprising flowing the fibers through at least one agitator portion of the at least one bladed rod to condition the fibers, the agitator portion comprising a plurality of blades extending radially outward from a rod.
18. The method of claim 15, further comprising adding water to the fibers during discharging the fibers from the discharge tube.
19. The method of claim 15, wherein the fibers are conveyed at least 10 feet away from the outlet of the hopper by a pneumatic stream generated from a blower.
20. The method of claim 19, further comprising:
introducing the fibers conveyed by the pneumatic stream into a blender assembly at a delivery rate; and
introducing a proppant into the blender assembly.

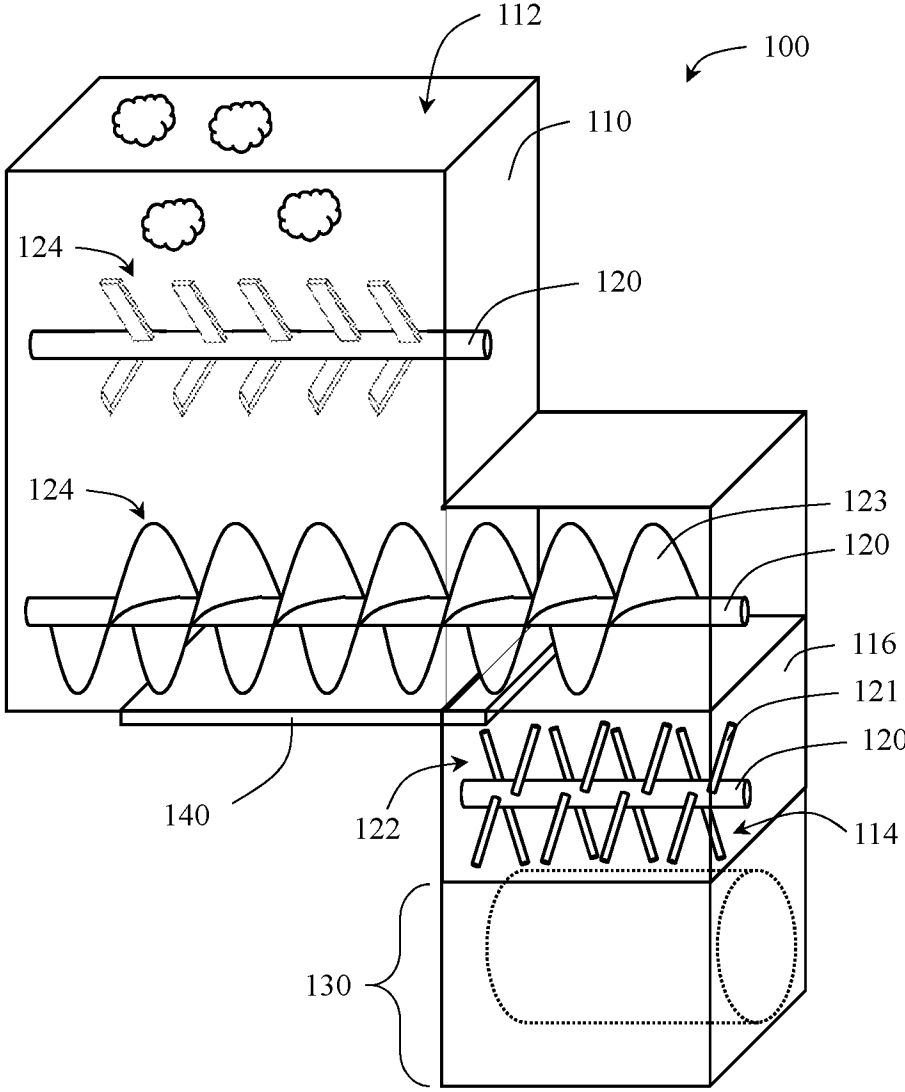


FIG. 1

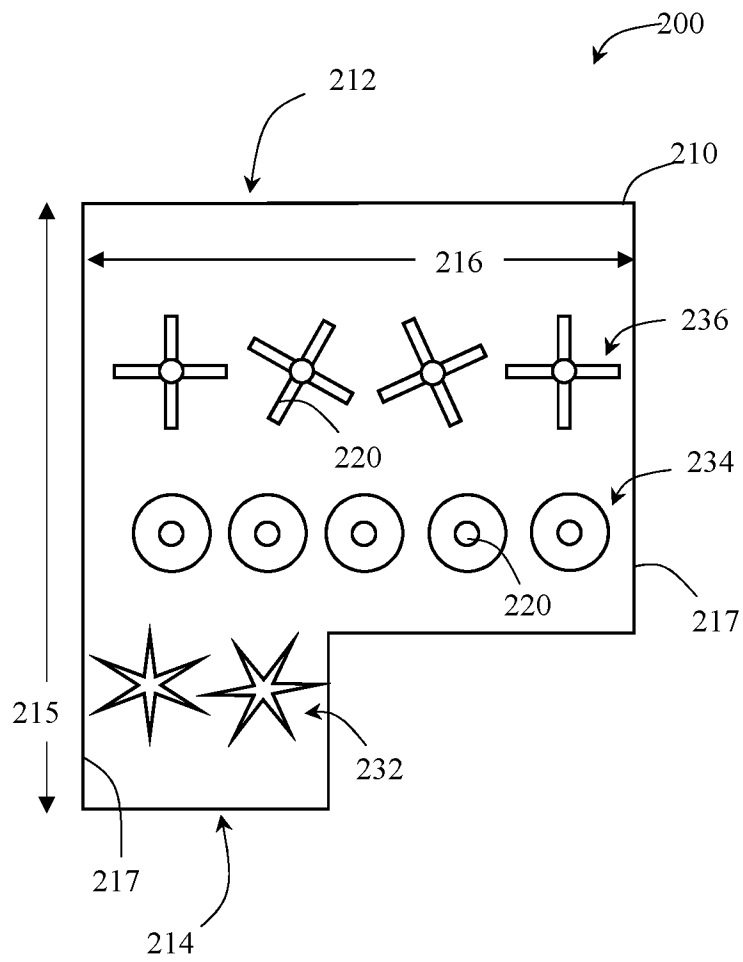


FIG. 2

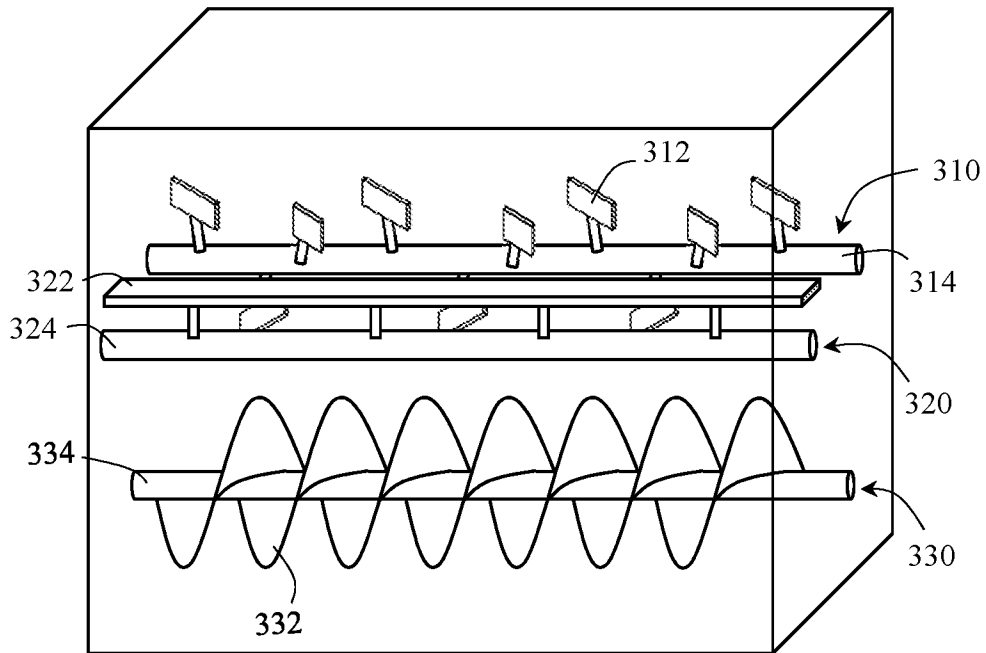


FIG. 3

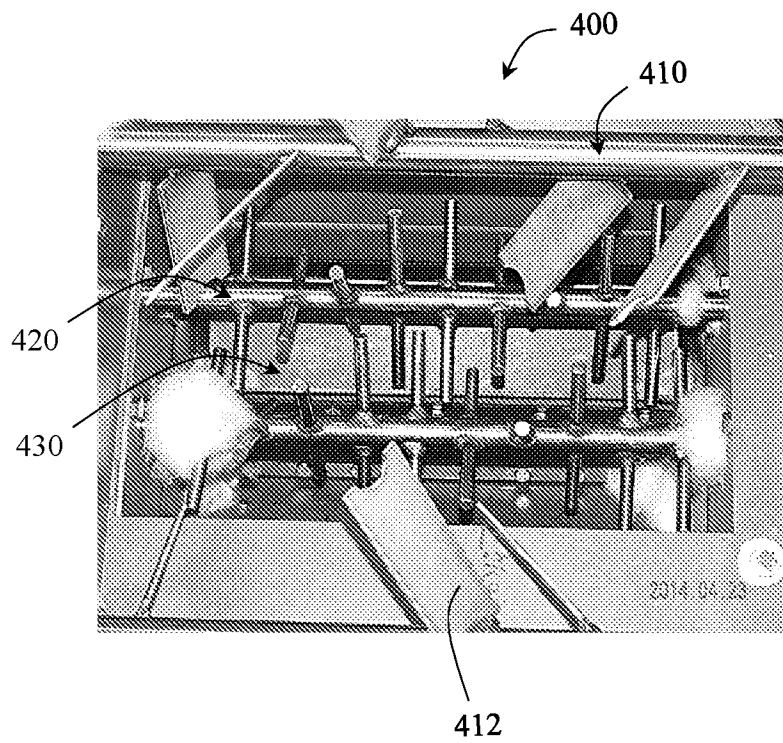


FIG. 4

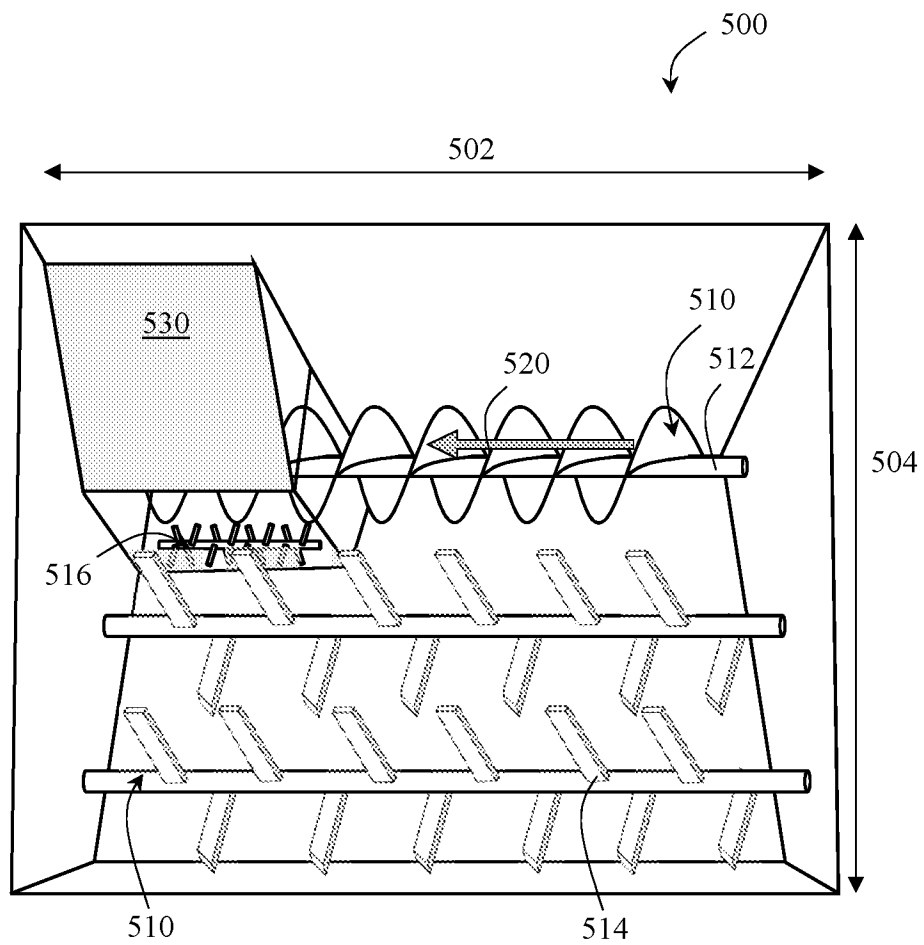


FIG. 5

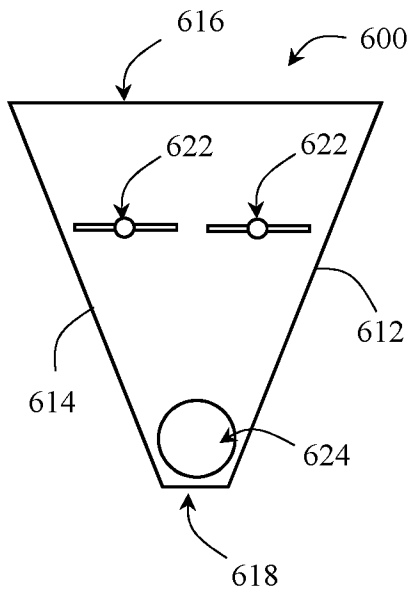


FIG. 6

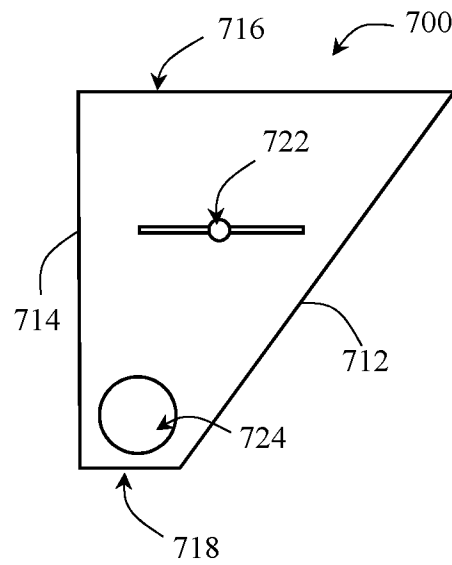


FIG. 7

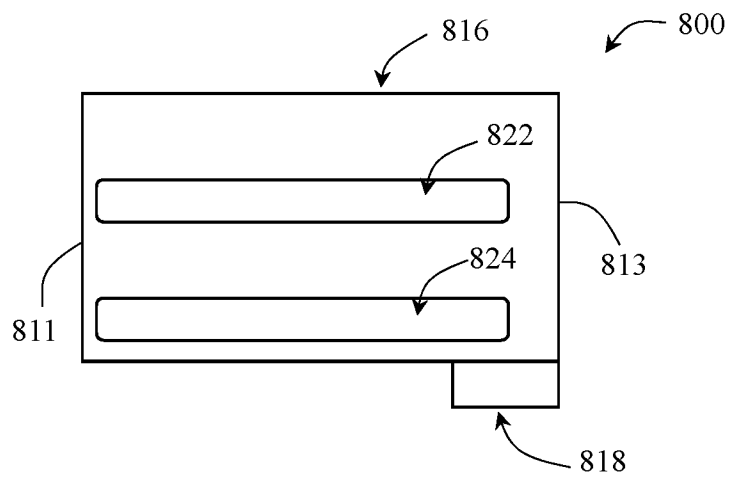


FIG. 8

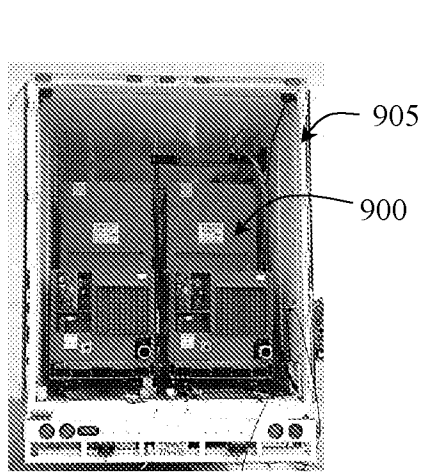


FIG. 9

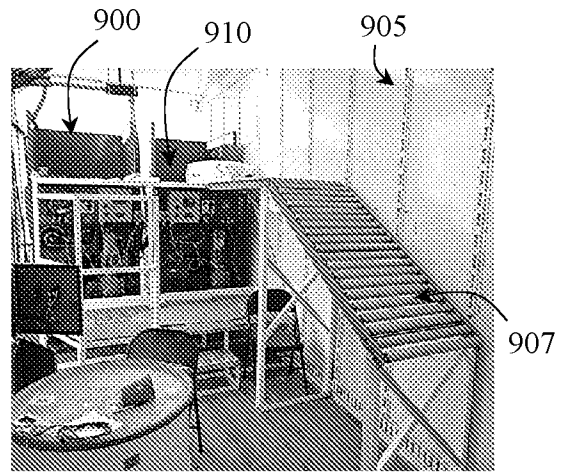


FIG. 10

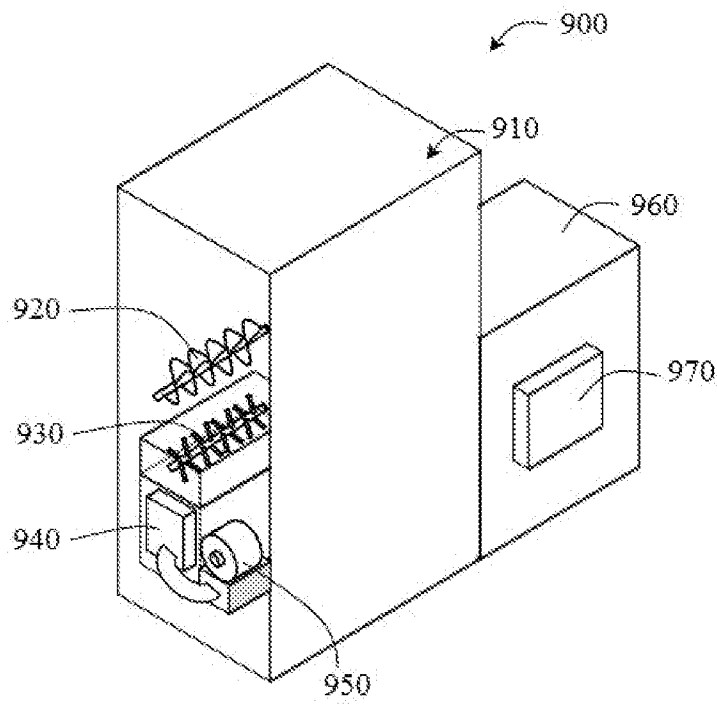


FIG. 11

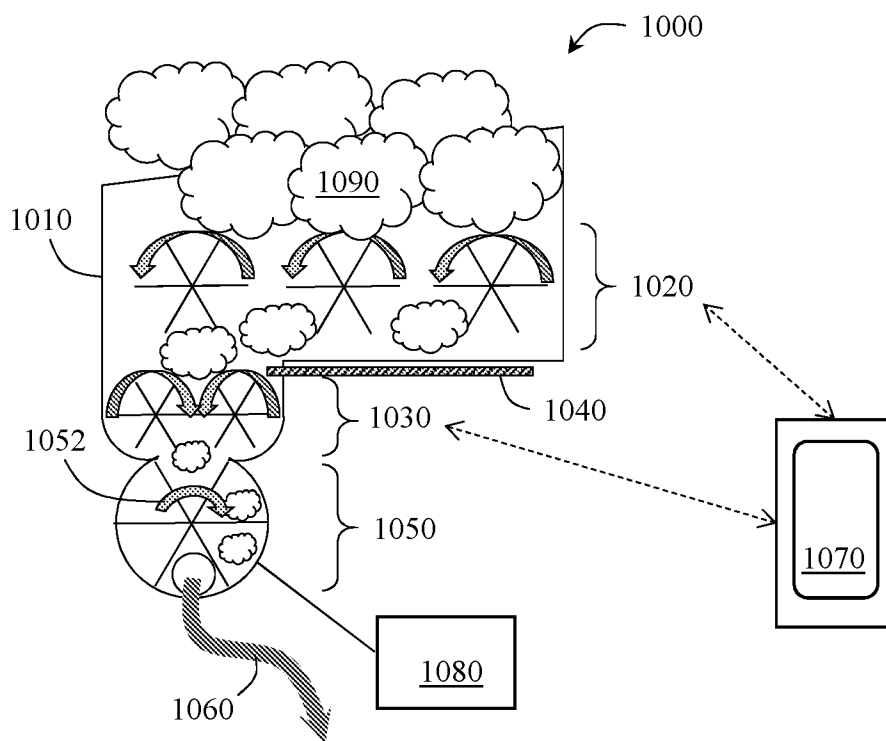


FIG. 12

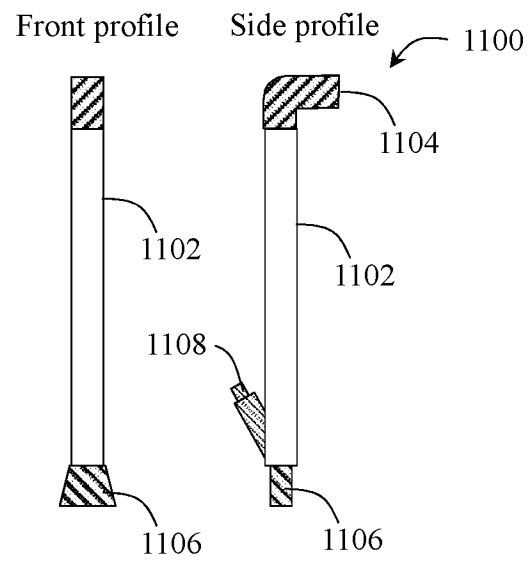


FIG. 13

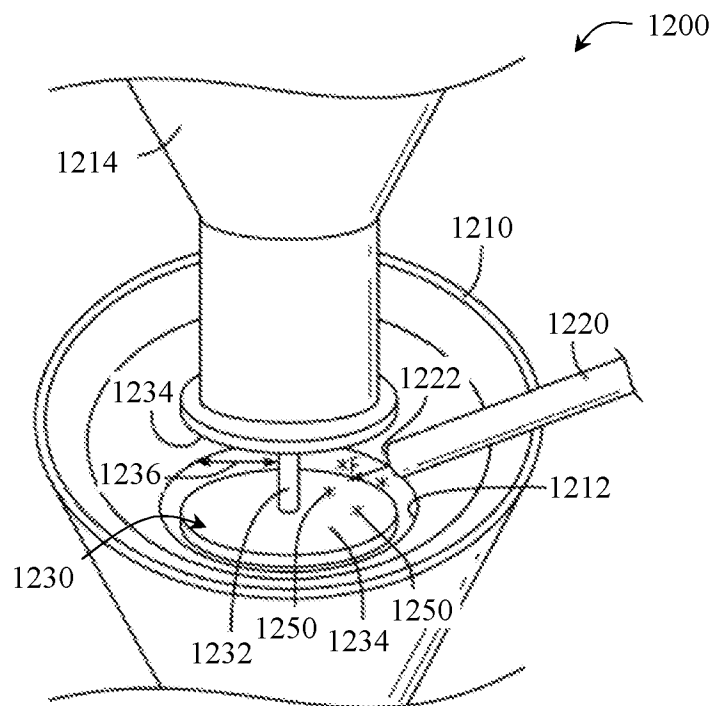


FIG. 14

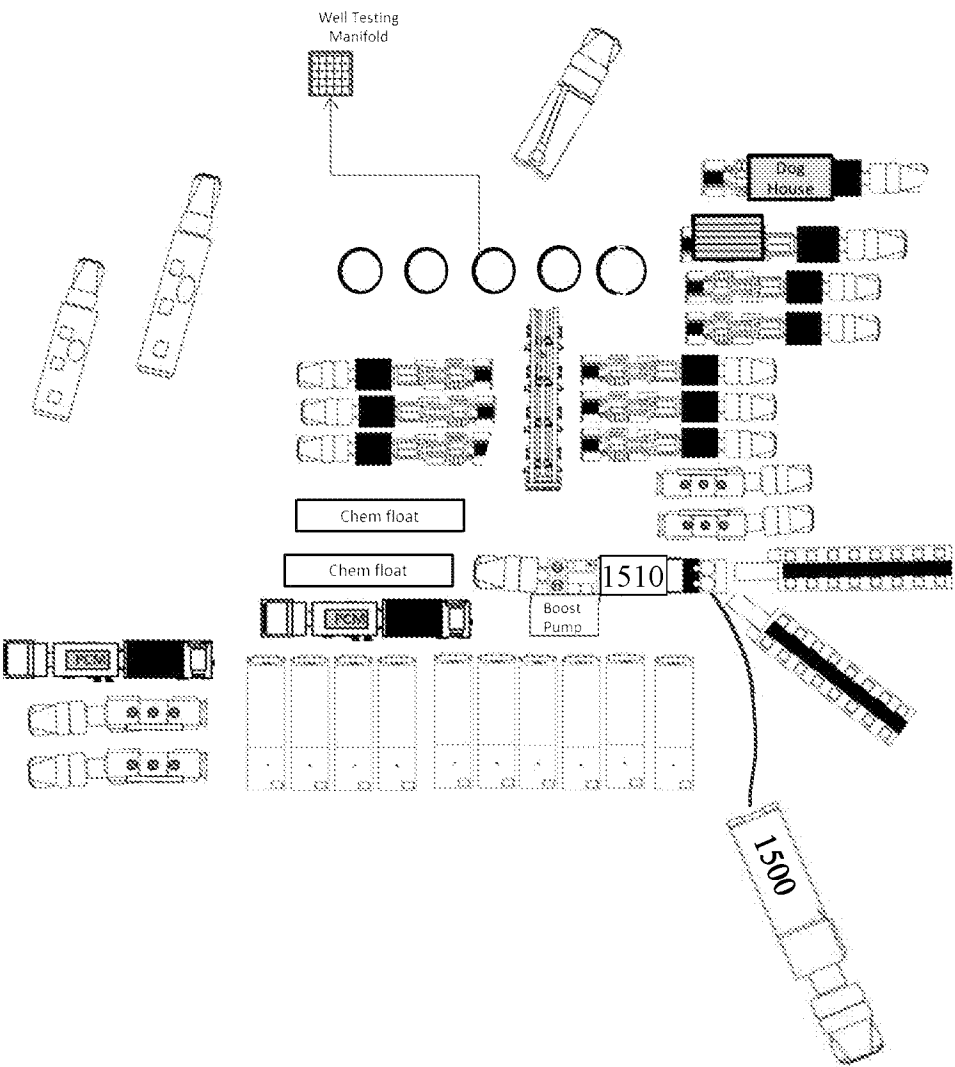


FIG. 15

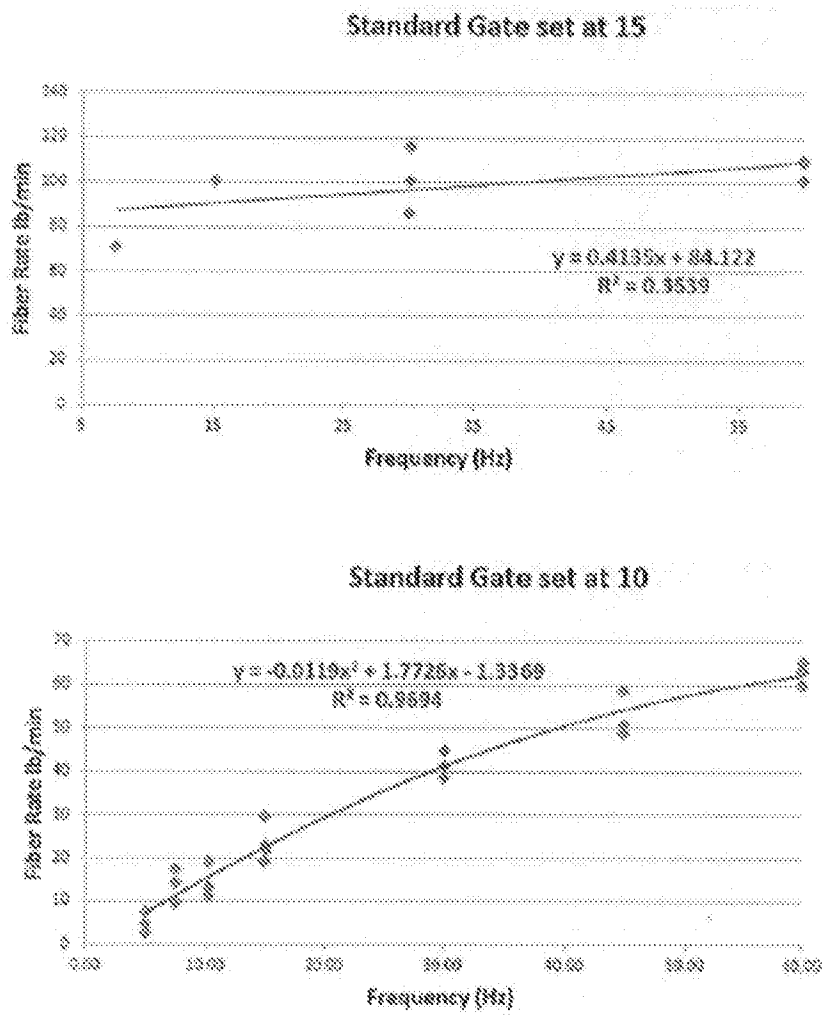


FIG. 16

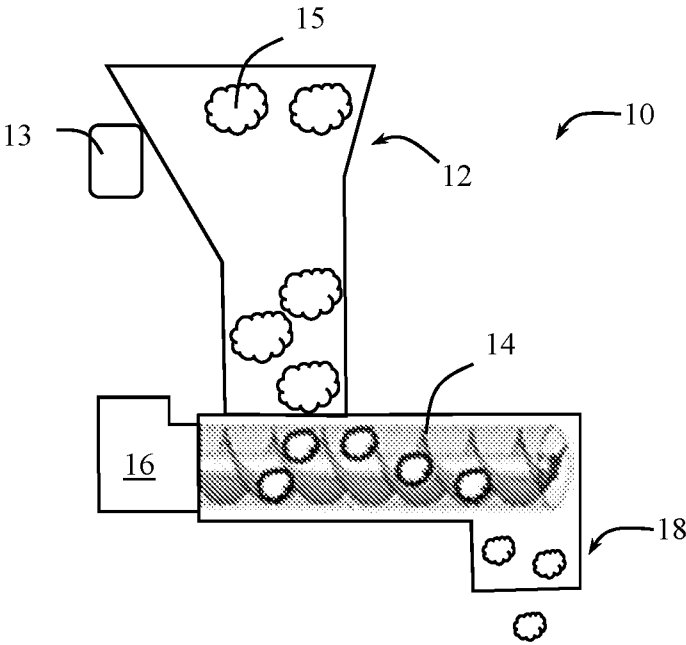


FIG. 17
(Prior Art)

A. CLASSIFICATION OF SUBJECT MATTER**B01F 15/02(2006.01)I, B01F 7/02(2006.01)I, B65G 65/46(2006.01)I, B65G 43/00(2006.01)I**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B01F 15/02; B02C 23/24; B02C 17/16; B65G 53/42; B65G 53/36; B65G 53/44; B65G 53/40; B65G 53/12; B01F 7/02; B65G 65/46; B65G 43/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & keywords: fiber, blower, hopper, rod, motor, air lock, blade

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5407139 A (MLECZEWSKI, T. L.) 18 April 1995 See abstract; columns 4-5; figures 2-4; and claims 1-15, 19.	1-20
Y	US 5829649 A (HORTON, P. H.) 3 November 1998 See abstract; figures 1-3; and claims 1-5.	1-20
Y	US 5947645 A (RIXOM, M. R. et al.) 7 September 1999 See abstract; and claims 1-3.	8, 18
A	US 5160222 A (NOLAND, R. D.) 3 November 1992 See abstract; and claims 1-8.	1-20
A	US 5590984 A (ASSARSSON, G.) 7 January 1997 See abstract; and claims 1-4.	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

18 August 2016 (18.08.2016)

Date of mailing of the international search report

19 August 2016 (19.08.2016)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

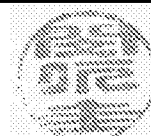
189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

Facsimile No. +82-42-481-8578

Authorized officer

MIN, In Gyou

Telephone No. +82-42-481-3326



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/029949

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5407139 A	18/04/1995	US 5529247 A	25/06/1996
US 5829649 A	03/11/1998	None	
US 5947645 A	07/09/1999	US 5931610 A WO 98-52852 A1	03/08/1999 26/11/1998
US 5160222 A	03/11/1992	None	
US 5590984 A	07/01/1997	CA 2130790 A1	26/02/1995