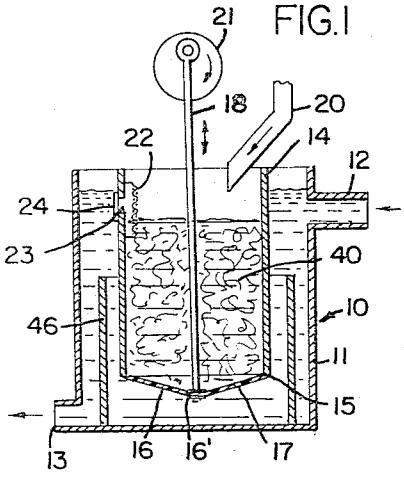
April 11, 1967 I. E. BENTOV 3,313,240

PUMP

Filed Jan. 8, 1965

FIG. 1



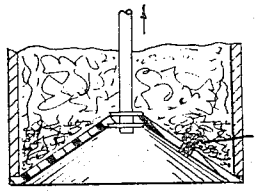


FIG. 2

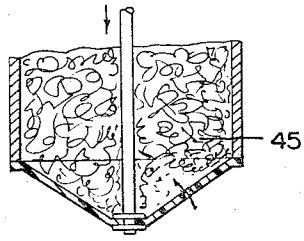


FIG. 3

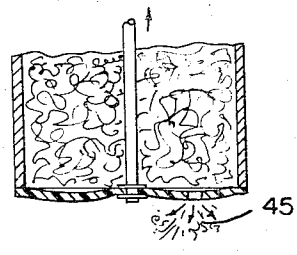
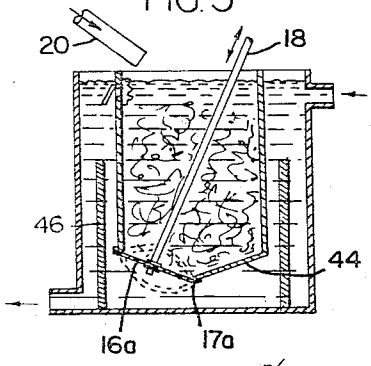


FIG. 4

FIG. 5



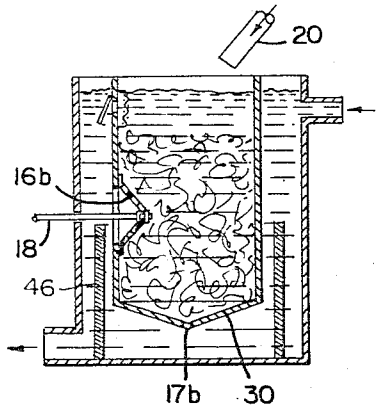


FIG. 6

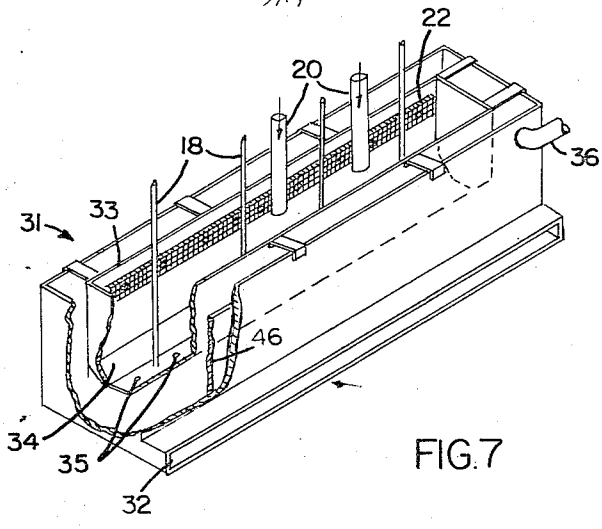


FIG. 7

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3,313,240

Patented Apr. 11, 1967

3,313,240

PUMP

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Filed Jan. 8, 1965, Ser. No. 424,253

6 Claims. (Cl. 103—151)

The present invention relates to a metering and mixing pump and more particularly to a pump which is particularly useful for forming a low concentration slurry mixture from a high concentration slurry mixture.

Pulp slurries comprising a mixture of cellulose fibers and water are frequently used in the paper industry and in other diverse commercial procedures such as pulp molding. Certain problems have arisen in the storage and handling of such fibers containing slurries. For example, it is frequently desirable to store highly concentrated slurry mixtures to minimize storage space needed. However, when highly concentrated slurries are stored, it is necessary to dilute the slurries to normally low concentrations for use as in paper making. Such dilutions have often resulted in nonuniform low concentration slurries being formed due, at least in part, to a tendency of fibers in the slurry to clump together or agglomerate. Such slurries can also present problems if conventional metering valves are used to meter predetermined amounts of high concentration slurry into an aqueous or other diluent. As a result of the nonuniformity of low concentration slurries often formed, it is not uncommon to find irregularities in final products such as streaks in paper sheets formed.

An object of this invention is to provide a pump for metering and mixing a high concentration slurry to form a low concentration slurry.

Another important object of this invention is to provide a pump in accordance with the preceding object which is relatively inexpensive yet may be operated continuously over long periods of time to form uniform low concentration slurries.

Still another object of this invention is to provide a pump in accordance with the preceding objects which avoids the use of complex and expensive valves and utilizes the high concentration slurry as a valve member in positively opening and closing an orifice to meter and uniformly mix fibers of the slurry with a diluent.

According to the invention the pump comprises a means defining a first chamber and a means defining a second chamber. A flexible resilient diaphragm is mounted between and separates the first and second chambers. A means is provided for reciprocally flexing the diaphragm into and out of the first and second chambers. An orifice is provided between the first and second chambers with the orifice permitting flow of fibrous materials in a slurry contained in the first chamber, through the orifice, in response to movement of the diaphragm in a first direction. Upon movement of the diaphragm further in the first direction, fibers of the concentrated slurry block the orifice and prevent interchange of materials between the first chamber and the second chamber. Movement of the diaphragm in a second direction opposed to the first direction clears the orifice automatically so that fiber interchange between the chambers is accomplished during reciprocal movement.

It is a feature of this invention that the fibers themselves acts as a valve member during movement of the diaphragm so that positive blockage of the orifice and opening of the orifice can be automatically accomplished simply and inexpensively. Preferably a fluid diluent such as water is continuously moved through the second chamber so that fibers entering the second chamber are automatically uniformly distributed in the moving stream of water forming a low concentration slurry which is ready for immediate use in paper making or other pulp forming procedures.

In the preferred embodiment of this invention, the first chamber comprises a tank positioned within a second tank. The bottom of the first rigid tank is made up of a flexible diaphragm having an eccentrically mounted push-pull rod attached to a central point of the diaphragm. A circular orifice is provided in the diaphragm which communicates with the interior of the first and second tank. The second tank is provided with a water inlet and outlet and water is constantly run through the tank at a uniform rate. When the push rod moves the diaphragm upwardly, a concentrated slurry in the first tank forms a fiber plug blocking the orifice. On downward movement of the diaphragm by the push-pull rod, the slurry is dispersed by inward flow of water to the inner tank and the orifice is opened. During the first portion of upwardly travel of the diaphragm fibers flow out of the orifice into the flowing water in the second tank forming a uniform low concentration slurry. At the extreme upper position a fiber block forms closing the opening. In this manner a low concentration slurry is continuously and uniformly formed which may be led from the second tank to a paper making or other pulp forming apparatus.

Other objects, features and advantages of this invention will become apparent from the following description and appended claims, reference being had to the accompanying drawings forming a part of this specification wherein like referenced characters designate corresponding parts in the various figures and in which:

FIG. 1 is a cross sectional view through the center of a pump in accordance with this invention;

FIGS. 2–4 are semi-diagrammatic views showing positions of operation thereof;

FIG. 5 is a cross sectional view showing an alternate embodiment of the pump of this invention;

FIG. 6 is a cross sectional view showing a second alternate embodiment thereof; and

FIG. 7 is a perspective view showing a third alternate embodiment thereof.

With reference now to the drawings and particularly FIG. 1 a preferred embodiment of the pump is illustrated at **10**. The pump **10** comprises an outer chamber or tank **11** having an open top and an inlet **12** with a bottom outlet **13**. The tank **11** is preferably a circular tank made of a sheet metal material although other materials and shapes can be used as will be obvious. Suspended within the outer tank **11** is an inner rigid tank or chamber **14** preferably having a cylindrical configuration although other shapes can be used. The tank **14** can be maintained in place by conventional rod legs on the bottom of tank **11** or other means not shown. At the lower peripheral edge **15** of the tank **14**, a flexible diaphragm **16** is attached.

The diaphragm **16** is a conventional rubber disc having its edge sealed or clamped to the peripheral rim **15** with a watertight joining means such as a series of bolts and clamping rings (not shown). The diaphragm **16** can be constructed of any resilient, flexible material and may even be made of thin metal materials in some cases, although elastomeric materials such as rubber or other plastics are preferred.

A hole **17** is provided in the diaphragm preferably at a point intermediate the center point of the diaphragm and the side wall provided by the tank **14**. The hole **17** is preferably a circular hole having a relatively small diameter but may vary in size and shape depending upon the particular slurry with which the pump is used.

A push-pull rod **18** is connected at a lower end to a central point on the diaphragm at **19** by conventional means such as two washers **16**[1] positioned on either side of the diaphragm by the rod **18** passing through the diaphragm. The upper end of the rod **18** is attached pivotably to a means for reciprocating the rod such as a driven disc **21**. The disc **21** preferably rotates at a constant speed causing reciprocal up and down motion of the push rod **18** and consequently of the diaphragm **16**. A conventional motor (not shown) may be attached to the disc **21** for rotation thereof about a fixed horizontal axis.

Preferably a screen **22** is provided on a side wall of the tank **14** adjacent an opening **23** which is closable by a conventional flap valve **24**. The flap valve **24** opens when the liquid level in tank **14** is level with and tends to rise above the liquid level in tank **11**. Thus when the diaphragm **16** is moved down as shown in FIG. 1 the flap valve is closed and the liquid level in tank **14** is below that of the liquid level in tank **11** causing an imbalance of liquid pressure in the pump **10**. The liquid head built up by lowering of diaphragm **16** tends to force liquid thru hole **17** to equalize the liquid level in both tanks. In all the cases the change in volume of tank **14** due to movement of the diaphragm causes fluid flow within the pump **10**. The screen **22** has a mesh size small enough to prevent passage of fibers of the slurry from the inner tank to the outer tank **11**.

Preferably a baffle is placed between the hole **17** and outlet **13** to assure uniform mixing of the slurry particles with the diluent stream in tank **11**. The baffle can have many forms and in the embodiment of FIG. 1 is preferably a cylindrical collar **46** welded to the bottom of tank **11** and extending upwardly between the upright walls of tanks **11** and **14**.

In use of the pump, water or other diluent is continuously pumped through tank **11** by means of inlet port **12** and outlet port **13**. The inner tank **14** is filled with a concentrated slurry stock solution **40** by a feeding pipe **20**. The slurry solution within the tank **14** is concentrated in the tank to a greater degree than when added since water or other diluent tends to flow past screen **22** out valve **24** into the outer tank **11** while solid materials **45** in the slurry are retained by the screen within the tank **14**. The eccentric **21** is constantly rotated to cause reciprocal movement of the diaphragm **16** as shown in FIGS. 2–4 and each movement of the diaphragm varies the effective volume of tank **14**.

The uppermost position of the diaphragm **16** is shown in FIG. 2 with fibrous material of the slurry bridging over hole **17** and binding together to provide a plug **41**. As the diaphragm is moved downwardly to the position shown in FIG. 4, water from the outer tank **11** tends to flow into the inner tank **14** through hole **17** breaking up the plug and diluting it as shown in FIGS. 3 and 4. This flow is due to the build up of water pressure in tank **11** as the slurry level drops and flap valve **24** automatically closes. As shown in FIG. 3, the diaphragm is in its lowermost position. Upon reciprocal movement of the diaphragm **16** upwardly to the position shown in FIG. 4, the diluted fibers tend to pass out of the tank **14** into the continuously flowing stream of water in the tank **11** and are uniformly mixed with the water to form a uniform low concentration slurry. In the final step of the cycle when the diaphragm reaches its uppermost position, as shown in FIG. 2, the plug **41** of fibrous material has again formed blocking the opening.

Excess water is filtered off from the concentrated slurry in tank **14** which is preferably supplied in batches from a source. This concentrates the slurry inside the tank **14** while providing low concentrate slurry leaving the outer tank by port or orifice **15**. The rate and amplitude of the reciprocating motion of the diaphragm **16** determines the quantity of the solids pumped in any specific system. The shape and size of the hole is also a controlling factor and may vary considerably depending upon the particular solid material in the slurry. For example, in paper pulp slurries, short fibrous cellulosic fibers give desired blockage with circular orifice size of from ⅛ to ½" diameter.

In a specific example of the preferred embodiment of this invention, tank **14** is filled as shown in FIG. 1 with one and one-half liter of a 2% by weight pulp to water slurry. Diaphragm **16** has a diameter of 2" and hole **17** a size of ¼" diameter. The diaphragm has a travel from its upper position to its lower position of one-half inch in a vertical direction. The diaphragm is fluctuated at a rate of 150 fluctuations per minute corresponding to 150 revolutions per minute of the eccentric **21** driven by a conventional electric motor. The resulting low concentration water pulp slurry leaving exit or orifice **13** has a concentration of $\frac{1}{100}\%$ by weight and is extremely uniform.

While one preferred embodiment of this invention has been described, it will be obvious that many variations thereof are possible. For example, in FIG. 5 there is shown a variation where the diaphragm **16*a*** is placed on a funnel shaped bottom wall of a sheet metal tank **14**. In this embodiment, the diaphragm is reciprocally moved by rod **18** as in the embodiment of FIG. 1, but, the rod is perpendicular to the relaxed position of the diaphragm shown and at an acute angle to the horizontal. Hole **17*a*** corresponding to hole **17** of the embodiment of FIG. 1, is formed in the metal funnel-shaped bottom **14** and acts as does hole **17** described above. A plug builds over the hole **17*a*** when the diaphragm is moved to its upper position while fibers flow into tank **11** until the plug is formed. During return of the diaphragm to its lowermost position the plug formed is dispersed by the influx of water through hole **17*a*** due to the build up of a head of water in tank **11**.

In the embodiment of FIG. 6, a generally funnel-shaped bottom **30** is used with a hole **17** formed in the bottom preferably at the lowermost tip. In this embodiment the diaphragm **16*b*** is positioned vertically in a side wall of the tank **14** with push rod **18** being positioned in a horizontal position and passing through a side wall of the outer tank **11**. Plug formation and dispersion occurs as in the embodiment of FIG. 5.

It will be obvious that many variations and positioning of the diaphragm and hole of the pump of this invention are possible. In all cases the hole **17**, **17*a*** or **17*b*** is unobstructed and the solid material of the slurry, which preferably comprises fibers, acts as a valve member in opening and closing the hole. This action of the fibers provides for mixing and metering of the fibrous material of the concentrated slurry to form a low concentrate slurry with the diluent passing from port **12** to port **13**.

In the embodiment of FIG. 7, provision is made for outflow of a uniform low concentration slurry over an elongated orifice which is particularly useful in providing a low concentration slurry on the web of a conventional paper making machine. In this embodiment, a header box **31** is provided, acting as an outer tank corresponding to tank **11**. A water inlet **36** in provided at a top edge of the box with the outlet **32** comprising an elongated slot equal in length to the width of the web of a paper

making machine with which the pump is used. An inner tank **33** is formed having a lowermost diaphragm **34** of a resilient flexible material and a screen **33** with its associated flap valve **24**. Push-pull rods **18** as described above are connected to the diaphragm for reciprocating into positions as shown in FIGS. 2–4. The diaphragm itself is provided with circular holes **35** evenly distributed along the width of the diaphragm or may be provided with an elongated slot or other configuration opening or openings. The operation of the diaphragm of this embodiment is the same as described with respect to the diaphragm **16** of FIG. 1; however, the plurality of holes **35** provide for continuous, uniform low slurry concentration formation over an elongated area which is fed directly to an elongated orifice opening **32**.

As has been described above, many variations of this invention are possible including variations in the size, dimensions and configuration of the inner and outer tanks and the means for reciprocating the diaphragm. In addition although only the use of fiber slurries has been described with relation to the pumps of FIGS. 1 and 5–7, it should be understood that the pump of this invention can be used to form low concentration slurries from high concentration slurries of any material slurry where the suspended material particles can interengage or interlock and bind together to block an orifice. For example, concentrated slurries of coal, gravel, plastic, sand and coke particles can be pumped in the pump of this invention to form low concentration slurries. Therefore, this invention is to be limited only by the spirit and scope of the appended claims.

What is claimed is:

1. A method of forming a low concentration uniform fiber slurry from a high concentration fiber slurry,

said method comprising placing said high concentration fiber slurry above a tank and separated from said tank by a wall defining an orifice,

alternately compacting and releasing fibers of said high concentration slurry to form a plug blocking said opening and alternately disperse said plug to pass fibers through said orifice to said tank,

said tank carrying a flowing stream of diluent in which said fibers are uniformly suspended to form said uniform slurry when said fibers pass through said orifice.

2. A method in accordance with the method of claim **1** wherein said wall comprises a flexible diaphragm which is reciprocated to compact and release said fibers.

3. A metering and mixing pump for forming uniform low concentration fiber slurries from high concentration fiber slurries, said pump comprising,

means defining a first chamber,

means defining a second chamber surrounding a portion of said first chamber,

means for concentrating a slurry in said first chamber comprising a screen aligned with a valve flap mounted on said means defining said first chamber which permits passage of a liquid from said first chamber to said second chamber,

a resilient diaphragm having a first side facing said first chamber and a second side facing said second chamber,

an unobstructed substantially constant size orifice defined by said first chamber and interconnecting said first chamber with second chamber,

means for reciprocating said diaphragm between said chambers when said first chamber carries a high concentration fiber slurry and said second chamber carries a diluent,

said orifice being constructed and arranged to be blocked by fibers of said slurry upon movement of said diaphragm into said first chamber and to be cleared upon movement of said diaphragm into said second chamber whereby fibers of said fibrous slurry are pumped into said second chamber during a first portion of travel of said diaphragm into said first chamber.

4. A metering and mixing pump for forming uniform low concentration fiber slurries from high concentration fiber slurries,

said pump comprising,

means defining a first chamber,

means defining a second chamber surrounding a portion of said first chamber,

a resilient diaphragm mounted on a side wall of said first chamber and having a first side facing said first chamber and a second side facing said second chamber,

an unobstructed substantially constant size orifice defined by a bottom wall of said first chamber and interconnecting said first chamber with said second chamber,

means for reciprocating said diaphragm between said chambers when said first chamber carries a high concentration fiber slurry and said second chamber carries a diluent,

said orifice being constructed and arranged to be blocked by fibers of said slurry upon movement of said diaphragm into said first chamber and to be cleared upon movement of said diaphragm into said second chamber whereby fibers of said fibrous slurry are pumped into said second chamber during a first portion of travel of said diaphragm into said first chamber.

5. A metering and mixing pump for forming uniform low concentration fiber slurries from high concentration fiber slurries.

said pump comprising,

means defining a first chamber,

means defining a second chamber surrounding a portion of said first chamber and having a diluent inlet port and outlet port,

a resilient diaphragm having a first side facing said first chamber and a second side facing said second chamber,

an unobstructed substantially constant size orifice defined by said first chamber and interconnecting said first chamber with said second chamber,

means for reciprocating said diaphragm between said chambers when said first chamber carries a high concentration fiber slurry and said second chamber carries a diluent,

said orifice being constructed and arranged to be blocked by fibers of said slurry upon movement of said diaphragm into said first chamber and to be cleared upon movement of said diaphragm into said second chamber whereby fibers of said fibrous slurry are pumped into said second chamber during a first portion of travel of said diaphragm into said first chamber.

6. A pump for forming a uniform low concentration slurry from a high concentration slurry, said pump comprising,

means forming a first chamber,

means forming a second chamber surrounding a portion of said first chamber,

a resilient diaphragm having a first side facing said first chamber and a second side facing said second chamber,

an unobstructed orifice defined by said first chamber and interconnecting said first chamber with said second chamber,

means for reciprocating said diaphragm between said chambers when said first chamber carries a high concentration slurry and said second chamber carries a diluent,

means for varying fluid pressure of said high concentration slurry and diluent with respect to each other responsive to movement of said diaphragm, said means for varying fluid pressure comprising a flap

valve interconnecting said first and second chambers,

said orifice being constructed and arranged to be blocked by solid material of said slurry upon movement of said diaphragm into said first chamber and to be cleared upon movement of said diaphragm into said second chamber whereby solid material of said slurry is pumped into said second chamber during a first portion of travel of said diaphragm into said first chamber.

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