May 23, 1950 G. M. BOOTH 2,508,987

SLURRY FEEDING APPARATUS

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Fig. 3

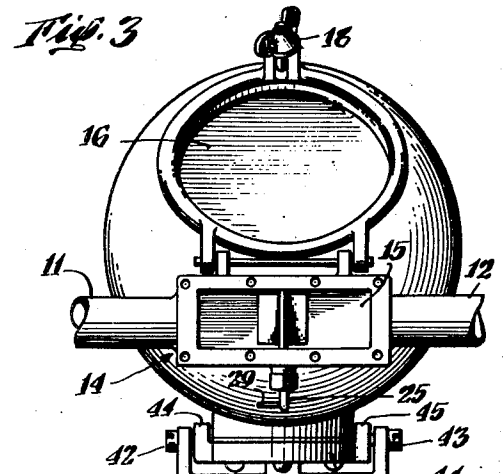


Fig. 2

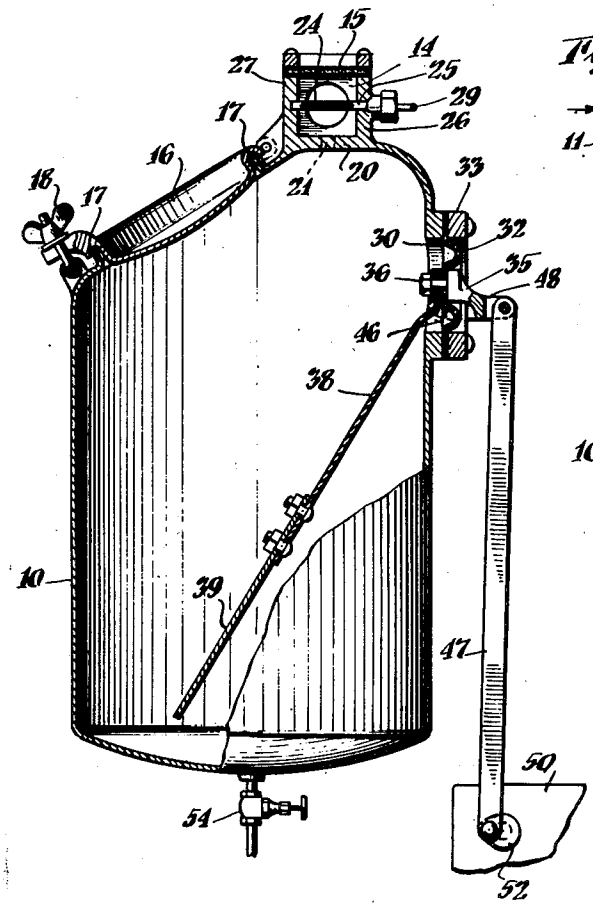
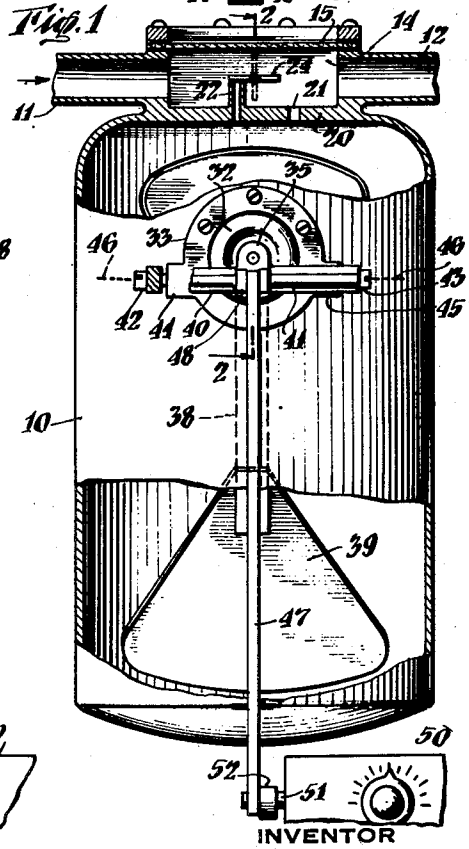


Fig. 1



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SLURRY FEEDING APPARATUS

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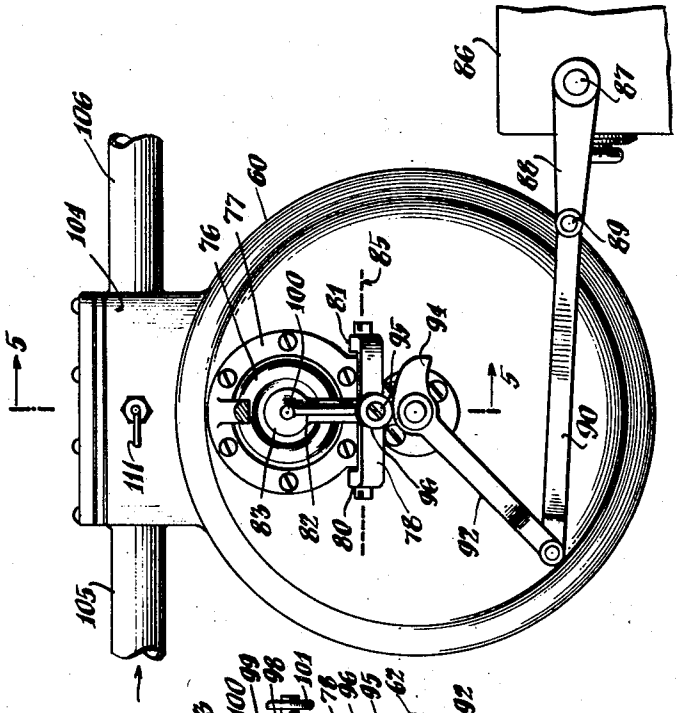


Fig. 4

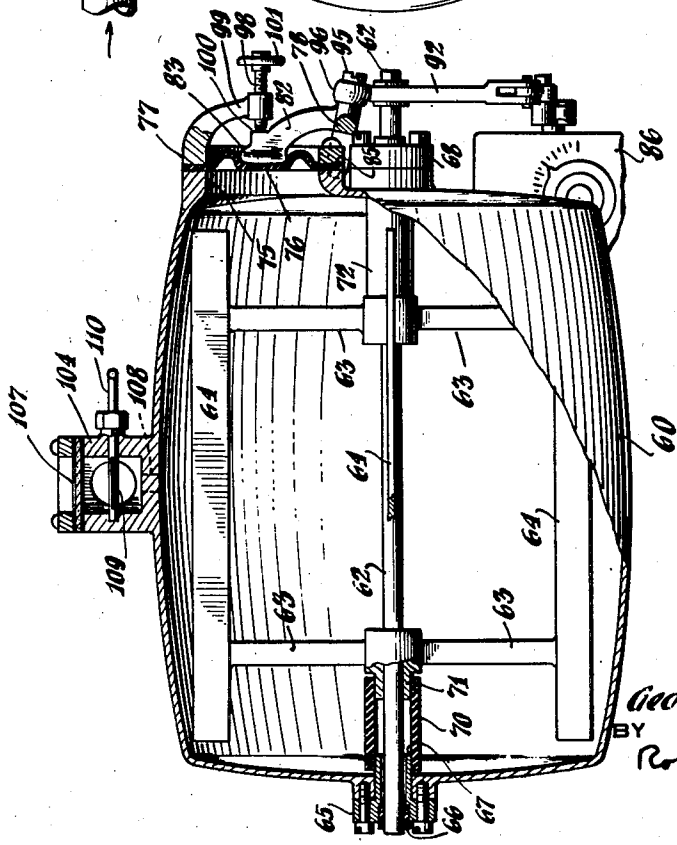


Fig. 5

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2,508,987

SLURRY FEEDING APPARATUS

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Application December 26, 1946, Serial No. 718,525

15 Claims. (Cl. 259—4)

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This invention relates to slurry feeders, by which is meant apparatus for supplying predetermined quantities of a liquid suspension of finely divided solid material. In an important specific aspect the invention relates to instrumentalities wherein the slurry is advanced in a constant or intermittent flow to a body of liquid with which it is to be mixed, the receiving body of liquid being disposed, for example, to flow past the locality of slurry supply in a suitable conduit.

One embodiment of slurry feeding devices of the described character is in connection with the supply of filter aid in filtering systems. Thus in water filtration apparatus it is sometimes desirable to feed a relatively continuous but usually small quantity of a solid material such as diatomaceous earth into the water as the latter goes to the filter. Such introduction of filter aid is conveniently done by first making a slurry of the material and then mixing the slurry with the water, but difficulties arise in apparatus for accomplishing the feeding operation automatically. The proposed slurry component, such as the described siliceous material, tends to settle in the liquid quite rapidly, and consequently, if pumps, valves or other moving parts such as bearings, are exposed to the slurry feed, the material will not only tend to clog them during operation but will settle quickly at any time when the apparatus is stopped, leaving a deposit of the solid material which seriously interferes with resumption of operation. Where the suspended material is of a relatively abrasive nature, as in the case of diatomaceous earth, there is also an undesirable tendency toward excessive wear of such moving parts even if they are not clogged by the material settling out. Furthermore, many divided solids, again exemplified by siliceous material of the type described, do not lend themselves readily to their maintenance in suspension, and in settling out tend to form a relatively coherent mass or cake. In consequence it is necessary to provide some means to keep the material in suspension, and in addition to provide for re-suspension from a settled, cake-like mass when operation of the equipment may have been interrupted.

Accordingly, important objects of the present invention are to provide slurry feeding apparatus overcoming difficulties of the sort explained, and particularly to provide devices for feeding a slurry or the like wherein bearing parts such as pistons, valves, and shaft bearings are not exposed to the slurry. A further object is to provide a feeder of simplified construction, adapted to afford a substantially continuous delivery of the slurry, preferably into a flowing stream of liquid, and including liquid-displacing instrumentalities that are free of pockets and bearing surfaces. Other objects are to provide improved slurry feeding equipment wherein rugged and efficient means is employed for maintaining the solids in suspension and for re-suspending the solids as necessary, and also to provide novel combinations of instrumentalities for simultaneously feeding and agitating the slurry.

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To these and other ends the nature and principles of the invention may be conveniently understood by reference to certain specific embodiments described and illustrated herein by way of example. Referring to the drawings:

Fig. 1 is an end elevation of one embodiment, with certain parts cut away or in vertical section;

Fig. 2 is in part a side elevation, but chiefly a section on line 2—2 of Fig. 1;

Fig. 3 is a plan view of the device of Fig. 1;

Fig. 4 is an end elevation of another embodiment; and

Fig. 5 is in part a side elevation, but chiefly a section on line 5—5 of Fig. 4.

As stated hereinabove, one use of apparatus embodying the invention is in feeding a slurry of a suitable filter aid into a stream of liquid which is being supplied to a filter for removal of a suspended foreign matter, e. g. as in mobile or portable apparatus for the purification of drinking water. An instance of such type of filter is the apparatus disclosed and claimed in my copending application, Serial No. 531,757, filed April 19, 1944, now Patent No. 2,423,172, dated July 1, 1947, for Filtering apparatus. In that device the filter itself includes a screen-like member, which should first be subjected to a flow of water carrying a relatively large amount of the filter aid, for example diatomaceous earth (kieselguhr). This preliminary operation builds up a so-called precoat on the filter, permitting the latter to commence its filtering operation as water is pumped through. Thereafter in normal use further small quantities of the filter aid should be added relatively continuously to the incoming water, both to entrap suspended foreign solids in the water and to keep building up a relatively porous body on the filter screen so that accumulated solids do not promptly choke the filter.

With the described type of equipment it has been found desirable to feed the filter aid in the form of a slurry, into the flowing stream of water while the latter is being delivered by a pump or otherwise under a suitable head, to the filter. The specific embodiments of the present inven-

tion shown in the drawings are eminently satisfactory for such purpose, although it will be understood that the illustrated apparatus may be used in a variety of other situations where it is desired to feed a slurry, e. g., a suspension or dispersion of divided solids, into a flowing body of liquid. It will be understood that since neither the water supply nor its ultimate destination, such as the filter, is a part of the present invention, no illustration of the same is included in the drawings.

Referring to Figs. 1 to 3 inclusive, the apparatus comprises a generally cylindrical tank 10 for a supply of the slurry to be fed, the tank being constructed, e. g. with curved ends or edges, to have good pressure resistance and rigidity. The water or other liquid to receive the slurry may flow under pressure through a conduit comprising inlet and outlet portions 11, 12 respectively, and between the latter, through a slurry feed box or chamber 14 that is disposed at an upper part of the tank 10. For example in the device shown, the chamber 14 is of elongated shape, having a square cross-section, and crosses the top of the tank so that the lower side of the chamber is part of the upper wall of the tank. The opposite top side of the chamber may comprise a window 15 of glass, lucite or the like, providing a sight glass for observation of the slurry feed.

A part of the upper end of the slurry tank 10 is conveniently of a sloping configuration slanting downwardly from the feed chamber 14 and has a large flanged opening into which a dished, flanged cover 16 hinged at one side may be tightly seated on a sealing gasket 17 and locked in place by a clamping bolt 18.

The lower side 20 of the chamber is provided with a port or opening 21 of relatively small diameter, affording continuous communication between the slurry tank and the chamber. The effective diameter of the passage 21 is preferably a small fraction of that of the conduit into which it opens; for example, in one device of this type where the vertical cross-sectional area (i. e. the transverse area) of the conduit constituted by the slurry chamber 14 was about 1.5 square inches, excellent results were had with the passage 21 having a transverse area of about 0.03 square inch or slightly less. The wall 20 is also pierced by another passage comprising a short tube or conduit member 22 communicating with the interior of the tank 10 and extending into and opening at a region in the middle of the chamber 14. A butterfly valve or vane 24 is carried on a horizontal shaft 25 crossing the chamber, the shaft being rotatable in bearings in the front and rear walls 26, 27 of the latter. The shaft actually extends through the front wall 26 and a handle 29 is secured at its outer end, so that the vane 24 may be manually rotated to occupy either the full line position of Figs. 1–3 or the dotted line position also shown in Figs. 1 and 2.

The location of the vane 24 is such that in its full line position it closes the mouth of the tube 22 whereby the only effective communication between the chamber and the tank is through the opening 21. In its dotted line position, at right angles to the other location, the vane extends across the chamber, and while it should not have a sealing engagement with the chamber walls, it provides a sufficient partial obstruction to cause a minor but appreciable part of the stream to be by-passed through the slurry tank. The ultimate purposes of the vane 24 are more fully explained below, but in the apparatus shown its effect is well served without such close fit around its periphery as would involve bearing parts that should not be exposed to liquid with a high density of suspended particles, present under some conditions of operation.

An upper part of the side wall of the tank 10 has a relatively large and preferably circular opening 30. A diaphragm 32, of rubber or other suitable flexible material, is peripherally secured against a shoulder around the opening 30 by a ring 33 and a driving arm 35 is fastened and sealed to the diaphragm 32 externally at its mid point by a bolt 36 through the diaphragm. On the inner side of the latter the bolt also secures the upper end of a spring arm 38, i. e., a strip of stiff but resilient sheet metal, which carries at its lower end an agitator plate 39, the arrangement being such that when the upper end of the arm 38 is rocked, the plate is swept across the tank with its lower edge relatively close to the bottom.

The short driving arm 35 extends somewhat downwardly and joins integrally with a pair of lateral arms 40, 41 extending in opposite directions and having rearwardly turned ends so as to constitute a bail-like structure which is pivoted at its ends, i. e. at 42, 43 to suitable projections 44, 45 on the clamping ring 33. The bail 40—41 and its attached arm 35 are thus mounted to rock about a horizontal axis 46; and the projections 44, 45, or the pivot bearings for the bail, are so disposed that this axis is in the plane of the diaphragm but offset from the center of the latter. A long vertical link 47 has its upper end pivoted between a pair of lugs 48 which extend from the bail, so that the latter and its associated structure can be actuated by vertical reciprocation of the link. Any suitable driving means may be employed for such purpose, for example an electric motor having adjustable speed transmission or control; thus in the drawings a variable speed motor mechanism is represented by its housing 50 and rotates a drive shaft 51 carrying an eccentric 52 to which is pivoted the lower end of the link 47. In consequence, operation of the motor mechanism reciprocates the link in a substantially vertical direction, so that the bail 40, 41 is thereby rocked about its axis, likewise rocking or similarly moving the parts assembled with the bail, i. e., the diaphragm actuating arm 35, the diaphragm itself, the agitator arm 38 and the agitator plate 39.

As stated, the axis about which the assembled structure is rocked, is substantially offset relative to the center of the diaphragm. It is of very distinct advantage that the axis lie in the plane of the diaphragm, but at a region separated from the diaphragm center, e. g. somewhat below, as shown in Figs. 1 and 2. As a result, the described oscillation of the diaphragm affords a periodic change in the volume of the space enclosed by the tank 10, the diaphragm constituting in effect a portion of the tank wall. If the line of the pivot axis 46 intercepted the center of the diaphragm, a rocking motion of the latter would not effectively change the tank volume, since inward displacement at the lower part of the diaphragm would be equally compensated by outward displacement at the top; but with the offset relation shown, the imparted rocking movement is equivalent, in effect, to a reciprocation of the diaphragm along an axis perpendicular to its faces. At the same time, the angular oscillation

is effective as such to rock the agitator blade or plate 39, for purposes presently to be described.

The operation of the apparatus may now be explained, together with one manner in which it may be used, for example to supply filter aid in connection with a filter as described in my cited patent application, it being understood that the device may be employed in other ways and for any of a wide variety of slurry-feeding purposes. It will here be assumed that an appropriate supply of liquid flowing under a suitable head, for instance water carrying suspended matter to be filtered, is connected with the inlet pipe 11, so that the water or other liquid may flow continuously through the conduit section comprising the inlet 11, the chamber 14 and the outlet 12, whence it may pass to the filter or other locality of further treatment or use, not shown. Preferably before such flow is initiated, the slurry tank should be filled or at least should be given a charge of the material intended as the solid component of the slurry. For that purpose, the cover 16 of the slurry tank 10 is opened, the desired quantity of filter aid is inserted—say ¾ of a pound of finely divided diatomaceous earth, where the tank 10 has a capacity of about one gallon—and the cover is replaced and clamped. With the butterfly valve 24 in its full line position, the water supply to the inlet 11 is turned on and the filter discharge is temporarily run to waste. Assuming that the illustrated structure was originally empty of liquid, this operation will serve to fill it with water, and in particular will fill the slurry tank 10 through the opening 21. The motor 50 can be started, and during this preliminary run the connecting rod 47 will then rock the slurry agitator plate 39 so that the solid material in the tank is vigorously mixed into the incoming water, to achieve the desired state of suspension.

If in use of the device with a filter it is desired to build up a preliminary coat of the slurry solids on the filter screen, the butterfly vane 24 is then turned to its dotted-line or vertically transverse position, as seen in Figs. 1 and 2. In this "precoat" setting, and with water under pressure still supplied to the conduit 11, direct flow through the chamber 14 is substantially obstructed and a considerable portion of the water is caused to flow directly into and out of the slurry tank, through the conduit 22 and aperture 21. This operation may be carried on for a short time, say 5 to 10 seconds, or until observation of the filter shows that the filter wire is sufficiently precoated. Thereupon the vane 24 is returned to its parallel position, i. e., parallel to the sight window 15 as shown in full lines, so that it closes the mouth of the tube 22 and permits free passage of the water through the slurry feed chamber.

The apparatus is now in condition for normal operation, and with the drive motor 50 continuing to acuate the arm 47, the ultimate filter output or other discharge may be run to the locality of use, as desired. During such operation, the vertically reciprocating arm 47 continues to rock the assembly, including the bail 40—41 and the arm 35, about the axis 46 and accomplishes a twofold result, as will now be readily understood. In the first place, the agitator plate 39 is rocked back and forth continuously through a considerable arc so as to keep the slurry particles in suspension and to prevent the building up of a cake or mass in the lower part of the tank 10. In the second place, the diaphragm 32 is effectively pulsed back and forth in such manner as to change the volume of the slurry tank periodically. The result of this action is to cause a periodic exchange of liquid between the tank and the chamber 14 through the opening 21. As the diaphragm is pushed inward, a small quantity of slurry is forced from the tank into the liquid in the conduit, and is immediately carried away in such liquid, so that it does not return to the tank upon the reverse or outward stroke of the diaphragm. During the latter stroke an equal quantity of fresh liquid from the conduit is drawn into the tank, where, with the aid of the constant agitation caused by the member 39, it immediately becomes part of the slurry, so that upon the next outward stroke of the diaphragm a further small quantity of slurry is delivered into the conduit.

When the supply of filter aid or other slurry component in the tank 10 is in effect exhausted or is depleted below a useful solid-to-liquid ratio, and it is then desired to replenish the solid material, the flow of water to the conduit 11 should be turned off (by means not shown) so that the tank cover 16 can be opened. To avoid spilling liquid, and also to make room for the added quantity of filter aid or the like, it may be necessary at the same time to drain off some of the liquid in the tank. For that purpose a drain valve 54 may be provided in the bottom of the latter.

The described apparatus provides a desirably continuous feed of slurry, literally periodic but in effect continuous by virtue of turbulence and mixing in the conduit structure, particularly in the pipe (not shown) that carries the treated liquid beyond the conduit portion 12 to a point of use. The feed is brought about simply by the exchange of liquid back and forth through the passage 21, and there are no valves or other bearing parts in the slurry tank, or in any connections intermediate such tank and the conduit for liquid being supplied with the slurry. Furthermore, the structure for producing this exchange of liquid, i. e. the diaphragm 32, is similarly free of rubbing parts such as pistons, valves or bearing surfaces exposed to the slurry; and thus throughout there are no bearing surfaces to be impaired in operation by wear due to the slurry in its concentrated condition as it exists in the tank 10. In addition there is no opportunity for slurry to collect in unwanted places should the operation be interrupted at any time, or at the end of a run.

At the same time, a desirable agitation of the slurry is continuously maintained, by an economy of means through the medium of the same structure that effects pulsation of the diaphragm.

By reason of the preferably springy or resilient nature of its supporting strip 38 the agitator plate 39 is peculiarly effective, not only in preventing deposit of a cake in the bottom of the tank, but also in breaking up or dislodging any compacted mass of particles which may accumulate there, as during periods of non-operation. Were the entire agitator structure a heavy, rigid assembly rigidly connected to the rocking bail 40—41, the plate might become so locked in a body of slurry particles that an attempt to operate the arm 47 after a period of rest might be ineffective and might well result in bending, distortion, or even breakage of some part. Although other resilient arrangements may be employed, for example by using a rigid supporting bar 38 and making the plate 39 itself of thin, resilient metal, the illustrated structure is simple and effective. If a cake is formed about the lower end of the plate, most of the rocking mo-

tion at the bolt 36 will be taken up by the spring 38, but there will be some slight agitation of the plate which will eventually build up until the slurry cake is loosened and broken, all of this occurring without damage to any of the mechanical parts.

Figs. 4 and 5 show another embodiment of the invention, adapted to be incorporated, for instance, in filtration systems of somewhat larger capacity than might usually be employed with devices of the sort shown in Figs. 1 to 3. The apparatus of Figs. 4 and 5 comprises a horizontally disposed, barrel-shaped slurry tank 60 which may have an opening in an upper part of its cylindrical wall with a removable cover structure, such opening and cover being conveniently identical with the corresponding arrangement (including the cover parts 16—18) in Fig. 2 and therefore not shown. Disposed coaxially with the tank and carried, as explained below, in suitable bearings at the ends of the latter, a horizontal shaft 62 mounts a plurality of radially extending arms 63 which may be arranged in pairs in corresponding planes extending radially from the shaft as shown, each pair of arms 63 serving to support an agitator blade 64 extending lengthwise of the tank and thus arranged to sweep in a cylindrical path about the axis of the shaft and near the tank wall. The arms 63 are preferably made of resilient sheet metal or otherwise of spring-like construction so as to prevent jamming, breakage or other impairment of function, for the same reason and with the same effect as in the case of the resilient arm 38 in Fig. 2.

Upon a flange around a central opening in the left-hand end of the tank 60 (Fig. 5), a ring 65 is mounted, seating a bearing 66 for the shaft 62 and having a sleeve portion 67 that extends into the tank with clearance around the shaft. Similar bearing structure generally designated 68 is provided at the opposite end of the tank, where the shaft projects out for driving connection.

In the preferred operation of this device the shaft 62 is rocked through a substantial but limited angle about its axis, rather than rotated continuously in a single direction, and sealing means are provided to prevent access of the slurry to the shaft bearings and in such manner as to avoid the use of stuffing boxes or other bearing parts exposed to the slurry. Thus, referring to the left-hand end of the shaft, there is disposed about the latter a sleeve 70 of rubber or other flexible impervious material, secured at its inner end around a collar 71 on the shaft, in sealed relation. The outer end of the sleeve 70 fits over and is similarly fastened to the rigid stationary sleeve 67. An identical flexible sleeve 72 is arranged in an identical manner at the other end of the shaft, i. e. providing a like closure between that part of the shaft and the right-hand wall of the tank.

With this arrangement, a complete seal is afforded between the shaft and the ends of the tank, yet the flexibility of the sleeves 70, 72 is sufficient to permit a considerable angular displacement of the shaft and thus of the agitator plates 64, for instance through an angle of 120°, or even as much as 180°. At the same time, no bearing or sliding surfaces of any sort are exposed to the slurry, thus avoiding effects of abrasion by the slurry or other results occasioned by the lodging of slurry particles between moving surfaces. Any desired number of agitator blades 64 may be used, for example four spaced 90° apart, of which three are visible in the drawing.

At an upper part the right-hand end (Fig. 5) of the tank 60 has an opening 75 across which a flexible diaphragm 76 is clamped by a ring 77, the arrangement being similar to corresponding parts of Figs. 1–3. To actuate the diaphragm a rocker comprising a bail 78 pivoted at its inwardly turned ends 80, 81 to appropriate projections on the ring 77 has an upwardly and inwardly extending arm 82 terminating in a shoe 83 that abuts the center of the diaphragm. By rocking the bail and arm structure about its horizontal axis 85, the shoe 83 is reciprocated more or less perpendicularly to the diaphragm so that the latter is moved inwardly each time the shoe advances toward the tank. Although if desired the shoe may be fastened to the diaphragm and a spring return provided for the assembly in cooperation with the driving means described below, under most circumstances the pressure of liquid in the tank is sufficient to effect outward return of both the diaphragm and the shoe at the end of the inward stroke of the latter.

As in the case of Figs. 1–3, any suitable source of power may be employed to actuate the agitator and diaphragm, and for purposes of illustration, a variable-speed electric motor mechanism is indicated by its housing 86, and rotates a shaft 87. An arm 88 secured to the shaft carries a crank-pin 89, pivoting one end of a long link 90 which at its further end is pivoted to the end of an arm 92 carried on the projecting part of the shaft 62. The arm 92 also has a portion constituting a cam 94, having a curved but fairly sharp rise through an angle equal to that through which the arm 92 is oscillated by the described mechanism. A stud 95 on the outer side of the bail 78 rotatably mounts a roller 96 having a surface in the shape of a central zone of a sphere and constituting a follower for the cam 94. The arrangement of the complete mechanism is such that as the crank arm 88 is rotated by the drive motor 86, the arm 92 is swung back and forth through, say, 90° or so, to rock the agitator blades correspondingly, and from a position such as shown in Fig. 4, the cam 94 moves the follower 96 upwardly to the high point of the cam and thereby rocks the shoe 83 to effect an inward stroke of the diaphragm, the pressure of liquid in the tank serving to return the diaphragm and shoe and to keep the follower on the cam during each return stroke of the arm 92.

For mechanical adjustment of the diaphragm stroke and thus for adjustment of the rate of slurry feed the inner end of a screw 98 threaded in a bracket 99 projecting from the clamping ring 77 (all shown in Fig. 5 but omitted for clarity in Fig. 4) constitutes a stop for a rear face 100 of the shoe 83, so that, for example, by turning up the screw by its handle 101, the rearward travel of the shoe and diaphragm is interrupted at any desired earlier time than when the parts are disposed as shown. A shorter stroke, and correspondingly reduced rate of slurry feed, are thus obtained, it being understood that the roller 96 then engages the cam 94 only during a corresponding latter part of the rising cam surface.

At the top of the tank there is mounted a slurry conduit or chamber 104 with inlet and outlet pipes 105, 106, all similar in function to the like structure 11—14—12 of Figs. 1–3 and constituting a part of a conduit line for water or other

liquid into which small quantities of slurry are to be delivered. The chamber 104 has a sight glass 107 at the top and through its lower wall, constituting part of the tank wall, has a small passage 108, similar to the opening 21 of Figs. 1 and 2. A butterfly vane 109 is mounted in the chamber on a shaft 110 to be turned by a handle 111, these parts being also identical in structure and function with the elements 24, 25 and 29 in Figs. 1 and 2, and likewise as in those figures, another passage extending through the lower wall, comprising a conduit to be closed by the vane in its horizontal position, may be provided, but for brevity is omitted from the showing of Figs. 4 and 5.

The operation of the apparatus shown in Figs. 4 and 5 is generally similar to that of Figs. 1–3. The tank 60 is filled with the slurry of which feed is desired, simply by inserting the required amount of dry pulverulent material in the tank and permitting the tank to fill with liquid from the conduit chamber 104, the drive mechanism being actuated to rock the agitator assembly and thus stir up the particles in the liquid. If the device is being used to supply filter aid and a pre-coat is desired for the filter, the vane 109 may be turned to its vertical, blocking position for a short run of the apparatus, and may then be restored to its normal horizontal setting. Thereafter as the liquid to be supplied with slurry traverses the chamber 104 and the drive mechanism continues to operate, periodic displacement of the diaphragm effects corresponding periodic change in the volume of the tank, so as to exchange liquid between the chamber 104 and the tank through the passages 108 and thus to effect supply of rapidly succeeding small quantities of slurry into the flow through the chamber. At the same time the agitator blades 64 are rocked about the axis of the shaft 62 to keep the slurry in suspension and the spring mounting of the blades, particularly at times of restarting after a period of idleness have the same function and advantages as the like arrangement in Figs. 1–3. As explained above, the rate of feed may be changed by rotating the knob 101; upon the resulting displacement of the screw 98 the length of stroke of the diaphragm is varied, and in consequence the amount of liquid exchange which occurs in each cycle is adjusted.

It will be noted that in each of the specific embodiments of the invention illustrated, the diaphragm-actuating means and connected structure such as the agitator assembly of Fig. 2 are independently supported so that there is no unnecessary strain on the diaphragm and the latter need not be under tension to hold such parts, all by way of contribution to long life of the diaphragm.

The apparatus of the present invention affords a simple and effective means for feeding slurry or other quantities of liquid from a container thereof into a flowing stream, the device being of particular utility for slurries of rapidly settling material or of abrasive substances. That is to say, there are no bearing surfaces or other moving parts exposed to the relatively concentrated slurry, nor are there localities where settling of the slurry, as during periods of shutdown, would have undesirable effects. As the same time, provision is made for maintaining the slurry particles in suspension, for dislodging them from a settled cake, and for accomplishing these results without permanent distortion or breakage of agitator blades or other parts. In many cases, moreover, the described apparatus, and subcombinations thereof, can be used for a variety of other purposes than those set forth above.

It is also to be understood that the invention is not limited to the specific structures herein disclosed by way of example, but may be embodied in other forms without departure from its spirit.

I claim:

1. In a slurry feeder, in combination, a slurry tank, a conduit for liquid into which slurry is to be fed, disposed at an upper part of the tank, said tank and conduit having a passage between them, a diaphragm associated with said tank and exposed on one side to the contents of the latter, a drive member secured to said diaphragm, agitator structure in the tank connected for displacement by said drive member, said agitator structure including a resilient member permitting an extremity of the structure to bend relative to said drive member, and means rocking said drive member about an axis spaced from the center of the diaphragm, for simultaneously changing the volume and agitating the contents of the tank.

2. In apparatus of the character described, in combination, a conduit, a closed, pressure-tight tank, said tank and conduit having a continuously open passage between them, opening through a side wall of the conduit and said conduit being adapted to carry a continuous flow of liquid past said opening of the passage, between localities separate from the tank, and means including a diaphragm for periodically increasing and decreasing the volume of said tank, to cause liquid to flow repeatedly and alternately through said passage from the conduit into the tank and from the tank into the conduit, said tank being disposed to hold a body of liquid therein adjacent said passage for liquid communication therethrough to the conduit, and said conduit separating the liquid in the conduit from the liquid in the tank except at said passage.

3. In a slurry feeder, in combination, a slurry tank having an outlet, a diaphragm associated with said tank and exposed on one side to the contents of the latter, a drive member fastened to said diaphragm, agitator structure extending into the tank from the diaphragm and connected to the diaphragm for displacement by said drive member through the diaphragm, and means for rocking said drive member about an axis spaced from the center of said diaphragm, for simultaneously changing the volume and agitating the contents of the tank.

4. In a slurry feeder, in combination, a slurry tank having associated means to effect feed of slurry from the tank, agitator structure in the tank, a transmission member extending through a wall of the tank and connected to said structure to transmit reciprocative motion to the latter, said agitator structure including a resilient member permitting an extremity of the structure to bend relative to said transmission member, and flexible sealing means intermediate the transmission member and the tank wall.

5. In a slurry feeder, in combination, a slurry tank having associated means to effect feed of slurry from the tank, agitator structure in the tank, and actuating means connected thereto for rocking said agitator structure, said actuating means extending through and being movably sealed to a wall of the tank, and said structure including a resilient member permitting an extremity of the structure to bend relative to said actuating means.

6. In a slurry feeder, in combination, a slurry tank, a conduit for a flowing liquid into which slurry is to be fed, said tank and conduit having two passages between them, control means settable alternatively to close one passage while permitting unobstructed flow of liquid in the conduit and maintaining the other passage open, or to obstruct the conduit intermediate the passages while permitting flow of liquid in both passages, and means for periodically changing the volume of the tank, to effect feed of slurry into the conduit when said control means is in its first-mentioned setting, by displacement of liquid back and forth through the single passage then open, said control means in its second-mentioned setting providing continuous flow of liquid from the conduit into and out of the tank through the passages respectively, thereby selectively to afford a feed of slurry from the tank into the conduit at a higher rate than when the control means is in its first-mentioned setting.

7. In a slurry feeder, in combination, a slurry tank, a conduit for a flowing liquid into which slurry is to be fed, said tank and conduit having a passage between them, means associated with the conduit and including a supplemental passage intermediate the tank and conduit, and valve means in the conduit for said passage, for diverting liquid in the conduit through a path leading directly into and out of the tank, through said passages in succession, said associated means being alternatively settable for diverting the liquid as aforesaid or for preventing access between the conduit and tank except through the first-mentioned passage, and means for advancing liquid alternately and successively from the conduit to the tank and from the tank to the conduit, said last-mentioned means being thereby operable, when said associated means is set to prevent the aforesaid access except through the first passage, to cause successive quantities of slurry to be advanced into the conduit through said first passage, and said associated means in its setting for diverting liquid flow continuously into and out of the tank providing, selectively, a feed of slurry from the tank into the conduit at a higher rate than when the associated means is in its other setting.

8. In a slurry feeder, in combination, a slurry tank, a conduit for a flowing liquid into which slurry is to be fed, said tank and conduit having a passage between them, a reciprocable diaphragm in a wall of the tank for effecting periodic exchange of liquid between the tank and the conduit through said passage, a vane in the conduit near the passage selectively movable into a first position transverse of the conduit to obstruct flow therein or into a second position lengthwise of said conduit, and means providing a supplemental passage between the tank and the conduit, having an opening in the conduit disposed to be separated from the other passage in the conduit by the vane in its first position and to be closed by the vane in its second position.

9. In apparatus of the character described, in combination, a tank, a conduit for a flowing liquid into which liquid from the tank is to be fed, said conduit extending in opposite directions to respective localities separate from the tank and being adapted to carry liquid in continuous flow from one of said localities to the other separately from the interior of the tank, said tank and conduit having a passage between them for said feed into the liquid flowing in the conduit, means including a diaphragm for periodically increasing and decreasing the volume of said tank, reciprocable agitator structure in the tank, actuating means for said structure extending through and flexibly sealed to a wall of the tank, and driving means including a reciprocating member having operating connection both to said diaphragm and said actuating means, for simultaneously reciprocating both the diaphragm and the agitator structure.

10. In a slurry feeder, in combination, a closed, pressure-tight slurry tank, a conduit for liquid into which slurry is to be fed, said conduit being adapted to carry a continuous flow of said liquid from one locality to another, said tank and conduit having a passage between them which opens into the conduit at a point intermediate said localities and which has a small cross-sectional area relative to that of the conduit, and means comprising a flexible wall in said tank and means to reciprocate said wall, for periodically changing the volume of the tank.

11. In a slurry feeder, in combination, a tank to hold a slurry, a conduit for liquid into which slurry is to be fed, said conduit extending in opposite directions to localities separate from the tank and being adapted to carry a continuous flow of liquid under pressure from one locality to another, said tank and conduit having a passage between them which opens into the conduit between said localities, said tank being adapted to maintain, in the contained slurry adjacent said passage, pressure transmitted through the latter from the conduit, and means in said tank for periodically changing the volume thereof.

12. In apparatus of the character described, in combination, a closed, pressure-tight, liquid-containing tank having a continuously open outlet passage at the upper part thereof, a conduit for carrying a continuous flow of liquid under pressure from one locality to another, said outlet passage opening into said conduit between said localities, a diaphragm in the wall of the tank continuously exposed to liquid therein, and means for reciprocating the diaphragm, so that when the conduit carries the aforesaid flow of liquid under pressure, liquid is alternately advanced from the conduit to the tank and from the tank to the conduit, under corresponding pressure.

13. In apparatus of the character described, in combination, a conduit adapted to carry a continuous flow of liquid under pressure from one locality to another, a liquid-containing tank, said tank and conduit having a passage between them which opens into the conduit at a point between said localities, and said tank being adapted to maintain, in the contained liquid adjacent said passage, pressure transmitted through the latter from the conduit, and means including a diaphragm and means for reciprocating the same, to effect advance of liquid through said passage alternately from the tank to the conduit and from the conduit to the tank.

14. In apparatus of the character described, in combination, a conduit for a flow of liquid continuously from one locality to another, a closed, pressure-tight, liquid-containing tank, said conduit and tank having a continuously open passage between them for direct communication between liquid in the conduit and liquid in the tank, said passage opening into the conduit at a point intermediate the aforesaid localities and said passage having a cross-sectional area which is small relative to that of the conduit, and means associated with the tank for alternately forcing liquid from the tank through the passage into the con-

duit and withdrawing liquid from the conduit through the passage into the tank.

15. In apparatus of the character described, in combination, a conduit structure carrying a flowing liquid, a tank structure containing a body of liquid separate from the liquid in the conduit, said conduit extending in opposite directions to respective localities separate from the tank and being disposed and adapted to carry said flowing liquid in continuing flow from one locality to the other past the tank, said structures having a continuously open passage between the tank and the conduit, opening into the latter at a point between said localities, said conduit separating its contained flow of liquid from the tank except at said point and said tank being disposed and adapted to maintain its contained liquid adjacent said passage at a pressure substantially equal to the pressure of the liquid in the conduit at said passage, so that the liquid in the conduit normally tends to flow past the tank without intermixture of liquid between the structures, and means associated with one of said

structures and engaging the liquid therein for periodically advancing liquid through the passage alternately from the conduit into the tank and from the tank into the conduit so that successive quantities of liquid in the tank are swept into and carried away with the liquid flowing past in the conduit.

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