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APPARATUS FOR PUMPING SLURRY AND LIKE FLUIDS

Filed Sept. 23, 1964

FIG. 1

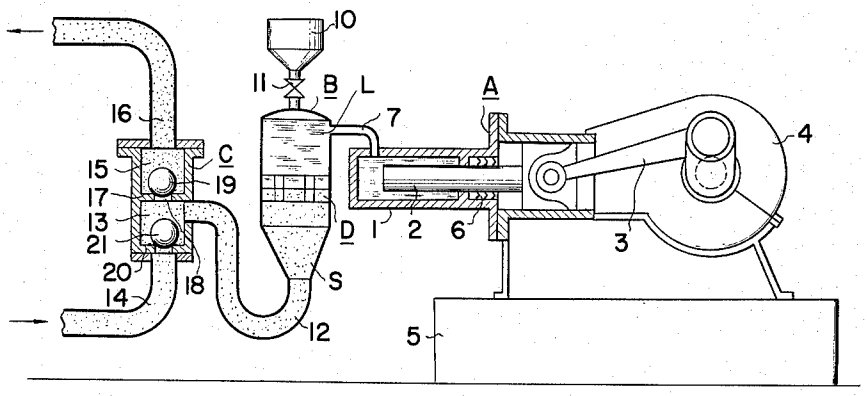


FIG. 2

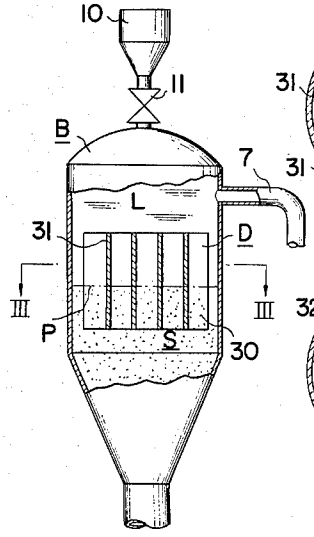


FIG. 3

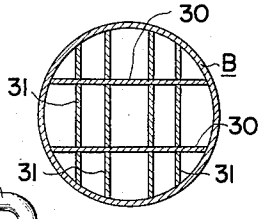


FIG. 4

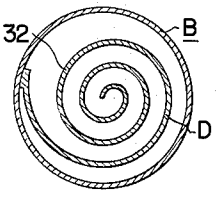


FIG. 5

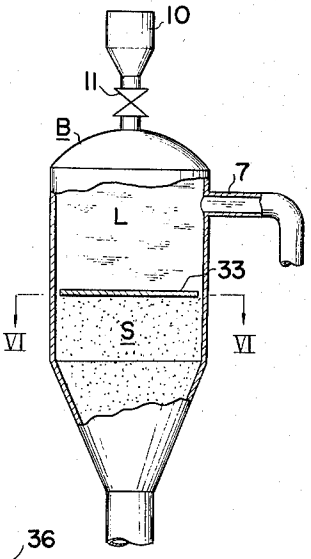


FIG. 6

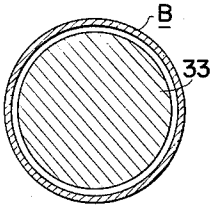
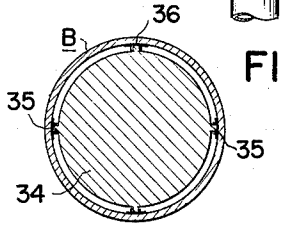


FIG. 7



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3,241,496

APPARATUS FOR PUMPING SLURRY AND LIKE FLUIDS

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6 Claims. (Cl. 103—165)

This invention relates to an apparatus for pumping slurry such as ore slurry or sludgy water.

Difficulties arise in the case of pumping slurry, such as ore slurry or sludgy water, containing particles therein. For example, in the piston or plunger type of pumps which have been widely used, the slurry to be pumped is directly introduced into the cylinder with the particles contained in the slurry, thus causing wear of the parts of the pump. Such wear results in damage to the pump and therefore necessitates replacement of the parts.

To overcome such difficulties, the aforementioned invention has proposed a pumping apparatus adapted for pumping slurry wherein a valve box for pumping is provided which is operated by a cylinder-plunger assembly through a tank containing therein the slurry and a liquid medium such as oil, having a lower specific gravity than that of the slurry. In the tank of this apparatus, a boundary plane is formed between the slurry and the liquid medium lying thereon, and in the operation of the cylinder-plunger assembly, it moves up and down to discharge the slurry from the valve box while serving to prevent the ingress of the slurry into the cylinder-plunger assembly.

However, when the capacity and especially the transverse cross-sectional area of the tank are small relative to the discharge capacity of the cylinder-plunger assembly, the boundary plane between the slurry and the liquid medium oscillates violently with resulting intermixing of the slurry and the medium. When a high degree of such intermixing occurs, the liquid medium advances to the valve box, with the result that it is discharged with the slurry from the box, while the slurry enters the cylinder-plunger assembly, thereby giving rise to wear and corrosion thereof. Accordingly, in actual application, the capacity and especially the transverse cross-sectional area of the tank must be selected to be as large as possible so as to reduce the speed of the vertical movement of the boundary plane, thereby to ensure a stable up and down movement of the plane.

A main object of this invention is to provide improvements in the pumping apparatus of the aforementioned invention.

Another object of this invention is to provide a pumping apparatus of the above character, wherein said boundary plane formed in the tank can be maintained in stable condition regardless of the capacity and the transverse cross-sectional area of the tank, and, therefore, the intermixing of the slurry and the liquid medium is effectively prevented.

A further object of this invention is to provide boundary plane stabilizing means which ensures stable vertical displacements of the boundary plane and restrains horizontal movement of the plane during the vertical displacement of the same.

Still another object of this invention is to provide boundary plane stabilizing means which is interposed between the slurry and the liquid medium as a thin layer so as to prevent the intermixing of the slurry and the medium.

The above and other objects of this invention will become more apparent as the description proceeds in connection with the accompanying drawings in which like parts are designated by like reference characters, and in which:

FIG. 1 is a diagrammatic elevational view of the apparatus according to this invention;

FIG. 2 is an elevational view, partly in section and with parts cut away, of a tank and stabilizing means therein of the apparatus shown in FIG. 1;

FIG. 3 is a horizontal section of the tank and stabilizing means, taken along the line III—III of FIG. 2;

FIG. 4 is a similar horizontal section of the tank and modified stabilizing means according to this invention;

FIG. 5 is an elevational view, partly in section and with parts cut away of the tank having therein another modified stabilizing means;

FIG. 6 is a horizontal section of the tank and stabilizing means, taken along the line VI—VI of FIG. 5; and

FIG. 7 is a similar horizontal section of the tank, showing still another modification of the stabilizing means.

Referring now to FIG. 1, the pumping apparatus of this invention generally comprises a cylinder-plunger assembly A, a vertically arranged tank B communicating with the assembly A, and a valve box C communicating with the tank B.

The cylinder-plunger assembly A comprises a cylinder 1 and a plunger 2 slidably arranged therein to make reciprocating movements therealong. The plunger 2 is connected at the right end portion thereof with a crank mechanism 3 driven by a suitable prime mover 4. The cylinder 1 and prime mover 4 are suitably supported on a pedestal 5. A packing 6 is provided about the plunger 2 to form a liquid tight support for the plunger.

The interior of the cylinder 1 is connected to a vertically arranged tank B through a conduit 7 leading into the upper portion of the tank B. The tank B has thereon a reservoir 10 which stores a liquid medium as hereinafter described, and supplies the same into the tank through a valve 11. The tank B is connected with a valve box C through a conduit 12 extending from the bottom of the tank.

The valve box C includes a lower inlet chamber 13 communicating with a suction inlet 14 and an upper outlet chamber 15 communicating with a discharge outlet 16. Between the inlet and outlet chambers 13 and 15, there is provided an annular partition 17 extending radially inwardly from the inner wall of the box C and having therein an opening 18, which affords communication between the inlet and outlet chambers 13 and 15. The annular partition 17 carries thereon a ball 19 and cooperates therewith to form valve means. The bottom of the inlet chamber 13 has an annular partition 20 similar to the partition 17, which partition 20 also has therein an opening which affords communication from the suction inlet 14 to inlet chamber 13 and carries a ball 21 thereon. The partition 20 and ball 21 cooperate to form valve means. The inlet chamber 13 is connected with the conduit 12 above mentioned. Thus, the tank B and the inlet chamber 13 are always in communication.

The valve box C and the lower half portion of the tank are filled with slurry to be pumped, which is designated by the numeral S and occupies the stippled part in FIG. 1. The upper half portion of the tank B and the cylinder 1 are filled with a liquid medium L such as oil which has a lower specific gravity than that of the slurry and is of such nature that it does not mix with, dissolve into, or react with the slurry to be pumped. The liquid medium L may be supplied from the reservoir 10 into the tank by opening the valve 11.

Since the liquid medium is lighter than and does not mix with the slurry S, it naturally forms a distinct boundary plane between the slurry and itself.

Within the tank B, there is provided stabilizing means D at the level of the boundary plane. The stabilizing means D is shown in detail in FIGS. 2 and 3 and consists of partitioning plates **30** extending vertically and transversely of the tank B and secured to the inner wall of the tank and partitioning plates **31** extending vertically and transversely of the tank so as to intersect the plates **30** at right angles thereto and secured to the inner wall of the tank. These partitioning plates **30** and **31** vertically extend a substantial distance upwardly and downwardly from the boundary plane shown as P in FIG. 2, and form a grate which divides the interior of the tank into a plurality of vertically extending spaces at the middle portion of the tank.

In the operation of the pumping apparatus shown in FIGS. 1 and 2, the plunger **2** of the cylinder-plunger assembly A is horizontally driven by means of the prime mover **4** through the crank mechanism **3**, so as to make reciprocating movements. In the compression stroke of the plunger **2**, the liquid medium L within the cylinder **1** is forced into the tank B through the conduit **7** thus lowering the level of the boundary plane P in the tank. This causes the slurry S within the tank B to flow into the inlet chamber **13** of the valve box C through the conduit **12**, which in turn causes a pressure rise within the inlet chamber **13** so that the ball **21** is seated in the opening in the annular partition **20** to tightly close the opening, and the ball **19** floats away from the partition **17** to open the opening **18** therein. Thus, the slurry S within the inlet chamber **13** is forced to flow through the outlet chamber **15** into the discharge outlet **16**.

In the subsequent return stroke of the plunger **2**, pressure reduction within the cylinder **1** causes the liquid medium L to flow into the cylinder, which causes the rise of the level of the boundary plane P and causes in turn a pressure reduction within the inlet chamber **13**. Thus the lower ball **21** floats away from the annular partition **20** to open the opening therein so as to cause the slurry to be drawn through the suction inlet into the inlet chamber **13**, and the upper ball **19** tightly seats in the opening of the partition **17** to close the opening **18**. Thus, when the reciprocating movements of the plunger **2** is continuously repeated, the slurry S can be pumped from the suction inlet **14** to the discharge outlet **16**.

Since the liquid medium L is lighter than the slurry S, the distinct boundary plane P is formed as hereinbefore described. However, when the capacity and especially the transverse cross-sectional area of the tank B is small relative to the discharge capacity of the cylinder-plunger assembly A, the boundary plane P violently moves vertically and horizontally during the operation of the apparatus. This violent movement of the boundary plane P usually results in intermixing of the slurry and the medium, with the resultant discharge of the medium from the valve box C and the resultant ingress of the slurry into the cylinder **1**, which ingress may cause wear and corrosion of the cylinder **1** and the plunger **2**.

The stabilizing means D according to the present invention efficiently eliminates the disturbance of the boundary plane P. The vertical extent of the partitioning plates **30** and **31** is determined so as to be sufficiently longer than the vertical extent of the movement of the boundary plane P.

According to the arrangement of the stabilizing means D, the boundary plane P is divided into a plurality of sections and the extent of interference between the slurry and the medium is confined within each section with the result that the horizontal movement of the slurry and the medium at the level of the plane P is limited and reduced to a minimum degree, and the vertical flow of the slurry and the medium due to the vertical movement of the boundary plane is guided within each section by the partitioning plates **30** and **31**, thus maintaining a stable boundary plane P between the slurry and the liquid medium.

Thus, even when the speed of the vertical movement of the boundary plane is large, the boundary plane can undergo vertical movement without being disturbed, and intermixing of the slurry and the liquid medium does not occur. Speed increase of said vertical movement causes decrease of diameter of the tank, whereby the tank wall is made to be thinner, material cost and manufacturing cost are reduced, and weight of the apparatus is decreased. Moreover, the increase in the speed of the movement of the boundary plane makes it possible to increase the pumping capacity of the apparatus while the plunger can be maintained free from wear since it is always immersed in the liquid medium which is not ingressed with slurry. This affords efficient operation of the apparatus even under high pressure conditions.

Referring to FIG. 4, modified stabilizing means is illustrated. The stabilizing means D shown in this figure comprises a vertically extending plate **32** of spiral transverse cross-section, rigidly secured at one edge thereof to the inner wall of the tank B. The plate **32** defines therein a continuous spiral passage and serves as a guide for the vertical movement of the slurry and the liquid medium, thereby stabilizing the boundary plane.

Referring to FIGS. 5 and 6, another modification of the stabilizing means is shown. The modified means comprises a flat circular diaphragm or plate **33** of a specific gravity which is higher than that of the liquid medium L but lower than that of the slurry S. The diaphragm or plate **33** has a diameter slightly less than the inside diameter of the tank B to form an annular clearance thereabout and is always in floating condition at the level of the boundary plane.

In operation, the diaphragm or plate **33** moves upwardly and downwardly together with the vertical movement of the boundary plane and prevents the intermixing of the slurry S and the liquid medium L.

FIG. 7 illustrates a modification of the diaphragm or plate. The modified diaphragm or plate **34** has at the peripheral edge thereof projections **35** slidably engaging vertical guide grooves **36** formed in the inner wall of the tank B.

While preferred embodiments of this invention have been shown and described, it is to be understood that this invention may be modified or changed without departing from the spirit and scope of the invention, as set forth in the appended claims.

What we claim is:

1. An apparatus for pumping slurry or the like comprising a cylinder-plunger assembly operable alternately to discharge therefrom and such thereinto a liquid medium, a valve box including therein a chamber connected to a suction inlet and a discharge outlet, said valve box having first valve means arranged between said suction inlet and said chamber so as to be closed upon increase of the pressure within said chamber and opened upon reduction of the pressure within the same and second valve means arranged between said chamber and said discharge outlet so as to be opened upon increase of the pressure within said chamber and closed upon reduction of the pressure within the same, a vertically arranged tank communicating at the upper end portion thereof with the interior of said cylinder-plunger assembly and at the lower end portion thereof with said chamber, both said valve box and the lower half portion of said tank being filled with the slurry to be pumped and both said cylinder-plunger assembly and the upper half portion of said tank being filled with said liquid medium which has a specific gravity lower than that of said slurry and is of such nature that it does not mix with, dissolve into, or react with the slurry, so that said liquid medium and said slurry form therebetween a horizontal boundary plane within said tank, and stabilizing means disposed within said tank at the position of said boundary plane to prevent disturbance of said boundary plane.

2. The apparatus as set forth in claim **1** wherein said

stabilizing means consists of at least one vertically extending plate which serves to guide up and down movements of said boundary plane and restrains horizontal movements of the slurry and the liquid medium.

3. The apparatus as set forth in claim 1 wherein said stabilizing means consists of a plurality of partitioning plates extending vertically and transversely of said tank and forming a grate which divides the interior of the tank into a plurality of vertically extending spaces.

4. The apparatus as set forth in claim 1, wherein said stabilizing means consists of a vertically extending plate of spiral transverse cross-section, rigidly secured within said tank.

5. The apparatus as set forth in claim 1, wherein said stabilizing means is a flat diaphragm or plate of a specific gravity higher than that of said liquid medium but lower

than that of said slurry, and is floating at the level of said boundary plane in a manner to prevent the intermixing of the slurry and the liquid medium.

6. The apparatus as set forth in claim 5, wherein said diaphragm or plate has on the periphery thereof projections which are in sliding engagement with guide grooves vertically formed in the inner wall of said tank.

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