

Nov. 22, 1955

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2,724,508

SEPARATOR FOR SOLID-LIQUID SLURRY

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2 Sheets-Sheet 1

Fig. 1

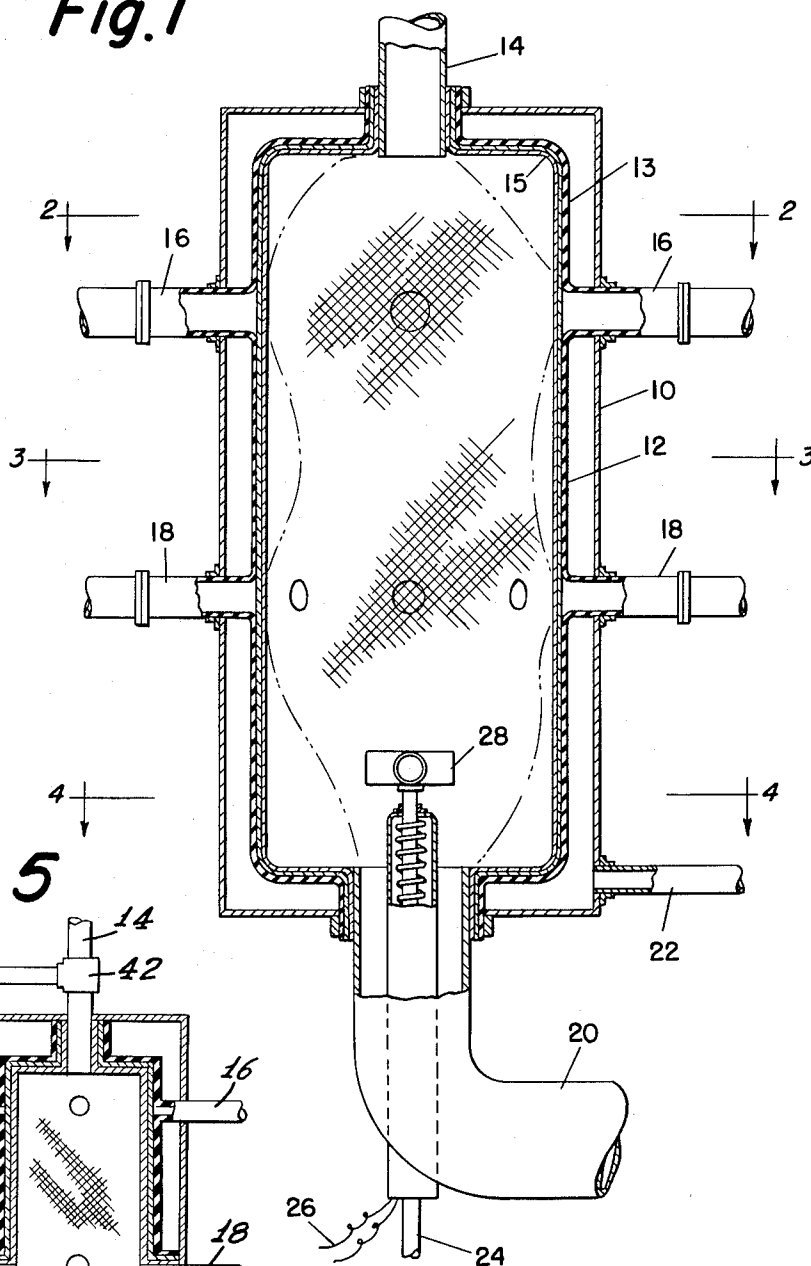
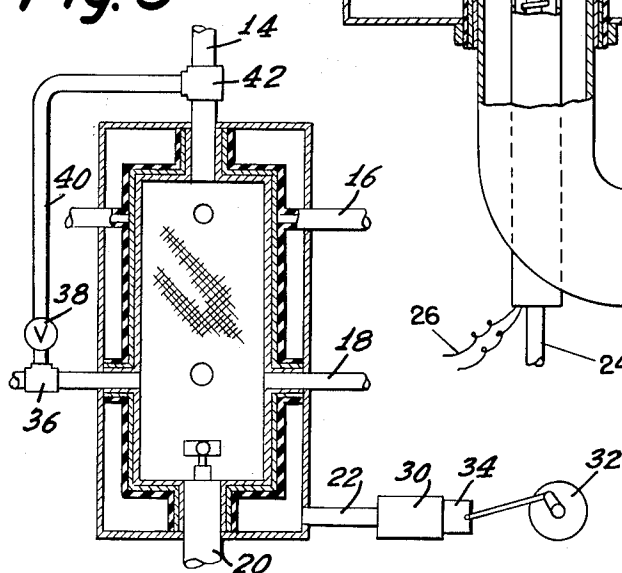


Fig. 5



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Fig. 2

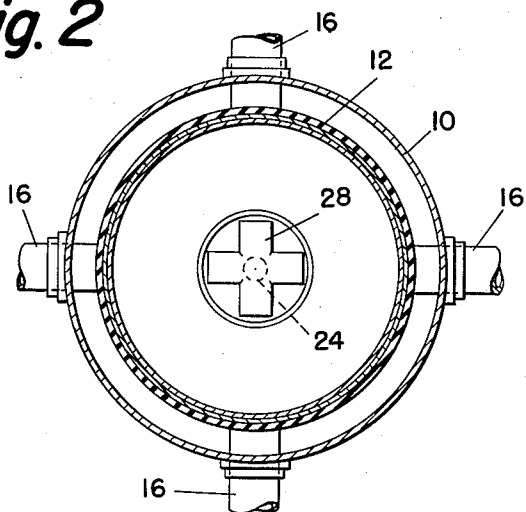


Fig. 3

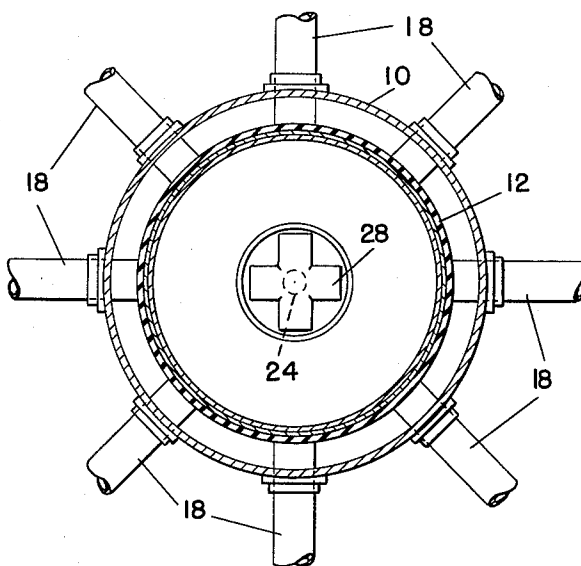
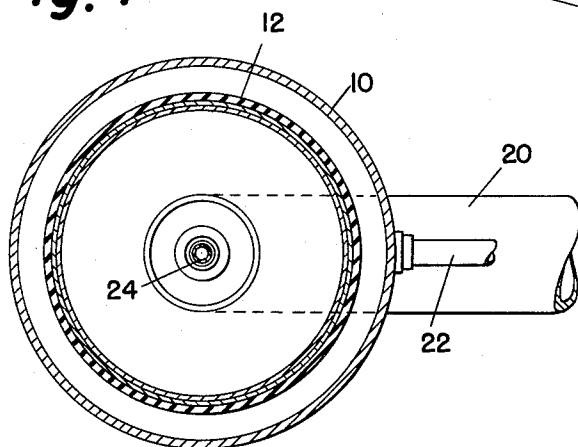


Fig. 4



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18 Claims. (Cl. 210—178)

This invention relates, in general, to the separation of mixtures of chemical compounds, and specifically to apparatus for the continuous separation of compounds forming a slurry of liquids and solids.

The efficient movement of liquids containing solids in sufficient concentration to be termed a slurry has been approached in many ways. Pistons, screw conveyors, chain-mounted scrapers, to mention a few, have been used with varying degrees of success. Normally the mother liquor is introduced at one end of a device employing one or more of these moving means, and the solids are moved for extraction from the other end. To preserve the purity of the mass of particles in the solids bulk, it is necessary to remove the solids-supporting liquid before the particles form a dense mass or cake at the removing end.

As an additional problem to removing the liquid pressed by the above means from the slurry, the mass must be constantly moved through the separator. Turbulence must be reduced to a minimum and the particles massed toward the removing end must be continuously removed. Turbulence and obstruction to continuous movement reduce the efficiency of the apparatus.

It is an object of this invention to provide a simple and efficient apparatus for continuously separating solids from a slurry mixture.

Another object is to provide an apparatus for moving the solids of a slurry to one end of the device for removal without turbulence in the slurry mass which would obstruct the continuity of the process.

A further object of the invention is to provide an improved apparatus wherein the mass of solid particles from a slurry is continuously and efficiently removed from the device.

With the above objects in view, the invention resides in the novel features of construction, and their combination, which will be more particularly described, claimed and shown in the drawing, in which:

Figure 1 is a longitudinal sectional view through a unit incorporating a practical example of the invention; and

Figures 2, 3 and 4 are sectional views of the device represented in Figure 1, taken on lines 2—2, 3—3 and 4—4 respectively.

Figure 5 is a repetition of Figure 1 to reduced scale showing alternate structure and operating elements.

In the drawing, a fluid-tight container 10 encloses a flexible container 12. This container 12 in addition to being sufficiently flexible to respond over its entire surface to externally applied pressure must be chemically resistant to the materials which pass through it. For example, in the purification of para-xylene for which such a device is particularly useful, the flexible container consists of an outside cover of leak-proof material such as neoprene with a matte of several layers of nylon cloth fitted inside the neoprene cover to act in the dual capacity of a filter and contact surface resistant to any deleterious effect of the slurry passed through it.

Passing through the fluid-tight container 10, which is sufficiently resistant to the pressures used as not to be

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deformed in operation, a plurality of conduits designed to engage the flexible container 12 in sealing relation introduce and remove the materials of the operation. A mixture of solids and liquids forming a slurry enters the device preferably at the top as through conduit 14. This slurry may be a mixture of crystals and mother liquor as used in the example of operation, or other mixtures. Together with the means for removing a large volume of the liquid originally supporting the solids, an effluent removal means for a remaining portion of this liquid, later recycled if desired, and a purified solid removal means comprise conduits 16, 18 and 20 respectively. All these conduits are sealably attached to the flexible container 12 and are in sealing engagement with the pressure resistant or substantially rigid housing 10 to support the operation of a pulsating hydraulic fluid supplied through conduit 22.

In the disclosure of Figure 1, the flexible container 12 comprising a neoprene outer sack 13 with several layers of inner filtering fabric such as nylon, is positioned symmetrically within the rigid container 10. Except for the opening of the slurry transmitting conduit 14 and the solids receiving conduit 20, the intervening conduits 16 and 18 connecting to the neoprene flexible container are covered with the nylon matte 15. Although such filtering effect is possibly always necessary for the upper conduits 16 in order to prevent the solids of the slurry from escaping before the full squeezing action of the device becomes effective, it is also possible that the nylon covering the conduit 18 outlets may in some instances be abandoned as indicated in Figure 5. As noted later, all, part or none of the liquid or part solid and liquid material passing outwardly through conduits 18, should they be open as suggested, may be recycled through conduit 14, as desired. This is shown also in Figure 5, where T fitting 36 receives conduit 40, valved at 38 and connects with conduit 14 at T fitting 42. Symbolic sealing means are indicated for the conduits as they pass through the rigid container 10 and also for the external connections. Well known packing boxes, sealing rings, leak-proof flanges or other means may be satisfactorily used. Mechanical details for these elements have, therefore, been omitted in favor of clarity of the drawing, since this is considered a matter of mechanical skill and any desired means will serve the purpose.

The structure at the bottom of the device is one means for assisting in removing the purified solids. It will be evident that these means, shown here as liquid supply and thermal control elements, can be eliminated and the device will remove the solid directly with little or no change in the structure as described up to this point. However, the additional elements shown at the bottom of Figure 1 are introduced to facilitate the movement of the solids, especially where they are of the nature of a crystalline mass responsive to liquid washes and thermal control, through the flexible container, and also affords additional means for extracting a less diluted or purer solid from the operation, in some cases.

In addition to conduit 20 adapted to receive the solid effluent, these solid removal assisting elements include a conduit 24 extending upwardly thereof into the bottom of the flexible container 12 to terminate in a distribution head 28. This carries, in fluid form, a selected material which is effective in making the solid particles more easily removable. Such a material may be a wash, melted solid or other treating fluid, as required. As shown this is assisted by temperature coils 26 wound around the conduit 24 which maintains the fluid material to condition the solid in the removing process at the most effective temperature.

The operation of the device will be discussed relative to the purification of para-xylene as one use to which the

device may be put. It will be evident, however, that the application is broader, and the device may be used as a separator or filter for a number of purposes, such as the recovery of naphthalene and like processes where a slurry is separated into solid and liquid components.

Both these instances consider a crystalline solid and represent a present use for all the elements shown forming the complete combination. The basic device can be used also, as will be recognized by those versed in the art, to remove solids such as filtering clays and catalysts from supporting liquids. In these latter instances either or both of the auxiliary elements for washing or thermal control can be omitted from the separating structure.

Regarding use as a para-xylene separating device, the concentrated crystalline body in the mother liquor is received in flexible container 12 through conduit 14. The slurry is at a low temperature usually in the range of -80° F. A large portion of the supporting liquid termed "mother liquor" here is removed through the initial filtrate removing conduits 16 which enter the housing 10 near the top of the flexible container 12.

These conduits 16 may be peripherally spaced and of varying diameters with respect to each other or to other conduits lower on the structure as indicated in the sectional views, Figures 2, 3 and 4 of the drawing. No particular relationship of conduit capacity is intended in these figures for the broad coverage of this invention as the specific requirements of each separate use may require some variation. The figures of the drawing indicate the general requirements of the idea.

Pulsating pressure in form of liquid or gas for uniform effect is admitted to the housing 10 through conduit 22. Figure 5 develops this part of the device to include a simple cylinder 30, reciprocating piston 34 and operating eccentric drive motor 32. A pulsating pressure delivered through conduit 22 to the interior of rigid container 10 is the obvious result. Although conduit 22 is shown as entering the lower right corner of the housing it will be understood that this is also symbolic placement, and that such pulsating pressure may be admitted at any convenient point or points, vertically or peripherally. The effect of such pressure within the rigid housing 10 is to compress the flexible container 12 in the free areas. By "free areas" is meant those portions of the flexible container 12 not fastened or made more rigid by connections. This is indicated by the trace of the phantom line showing the inner possible effect of such pressure on the surface of the flexible container in Figure 1 of the drawing.

The most satisfactory operation resulting in the continuous movement of the slurry from the entrance to the exit of the flexible container will be obtained by a proper balance of the opposed pressures inside and outside the flexible container 12. One possible operating condition might require alternating pressures internally and externally of the flexible container to obtain the proper result. This and other possible relations appear self-evident, and will vary with the desired results. As the liquid of the slurry is removed first by the conduits 16 through which filtrate escapes and the conduits 18 transferring more of this liquid either as a recycle effluent or directly from the receiver, the solids mass, crystals in the example, becomes more compact at the exit. The operating pressure in conduit 14 must be sufficient to move the particle mass downwardly and the escaping liquid outwardly.

At the same time the pulsating pressure externally applied to the flexible container 12 must be of sufficient force to give an undulating movement to the container. This pressure cannot be great enough to collapse the container, yet must be of sufficient force to urge the crystalline mass toward the removing means, and keep this mass from becoming immovably solid. By such differential pressure flexing the container 12, the crystal or solids mass is prevented from becoming caked, being maintained in a broken state, deposit on the nylon surface is refused,

and the liquid of the slurry is urged to drop the solids and escape through the side outlet conduits such as 16 and 18 shown.

With such pressure balance established the crystals of purified material of the example are presented for removal at the lower section of the flexible container where conduit 20 joins. The preferred means for this removal shown here is to liquefy the crystals in this lower zone and remove the resulting liquid. By raising the temperature at this locus and injecting a proper melting agent at correct temperature this can be readily accomplished.

The conduit 24, in this instance, returns melted solid, wash liquid or other selected fluid material to the immediate vicinity of the removal conduit 20 connection with flexible container 12 as at distribution head 28. Additionally, heating means such as coils 26 of electrical resistances supplies heat to the locus of solids removal and further preserves the effective temperature of the selected solid conditioning fluid. Such treatment removes the solid particles continuously and promptly, making way for additional slurry from above.

It will be evident that the various elements comprising the combination of this invention, particularly as disclosed in the embodiment of the example, can be varied in size, position and relative arrangement without deviating from the spirit and scope of the invention as expressed in the appended claims.

What is claimed is:

1. A device for the separation of solids and liquid forming a slurry comprising a pressure resistant housing, a pressure responsive inner container in said housing, a slurry inlet conduit and solids outlet conduit at the top and bottom of said container respectively extending through and in sealed engagement with said housing to connect with said inner container, a plurality of outlet conduits vertically and peripherally spaced to withdraw the separated liquid passing from the inner container through the housing and in sealed engagement with said housing, filtering means covering said liquid outlet conduits proximate the inner container, and fluid pressure means connected to said housing for compressing the inner container and expelling solids and liquid therefrom into said outlet conduits.

2. A device for the separation of solids and liquid forming a slurry comprising a non-deformable cylindrical housing, a flexible container forming a substantially unobstructed passage in said housing positioned in spaced relation thereto, an inlet conduit in sealed engagement with and extending through the top of the housing to transmit the slurry to the flexible container, a solids outlet conduit engaging the bottom of the flexible container through said housing in sealed engagement, a plurality of liquid outlet conduits vertically and peripherally engaging the flexible container in sealed engagement through the wall of the cylindrical housing, and a conduit connected to said housing to admit a pulsating operating pressure to flex said flexible container.

3. The device defined in claim 2 further characterized by said flexible container comprising a leak-proof outer covering and an internal cover of erosion-resistant liquid filtering material, said internal cover being open to receive the slurry inlet and solids outlet conduits and extending over the vertically and peripherally spaced liquid outlet conduits to filter the solids from the escaping liquid.

4. The device defined in claim 2 further characterized by a liquid injecting conduit extending into the lower portion of the flexible container concentrically of the solids outlet conduit, liquid distribution means terminating said liquid injecting conduit above the outlet conduit opening in said flexible container, and means in thermal transmission contact with said liquid injecting conduit to heat the liquid passing therethrough.

5. A device for the separation of solids and liquid forming a slurry comprising an elongate flexible container having an inlet in the top, a solids outlet in the

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bottom and a plurality of liquid outlets vertically and peripherally spaced in the sides thereof between said inlet and outlet, a rigid housing enclosing said flexible container in spaced relation therefrom and in sealing engagement with the inlets and outlets of the flexible container, pressuring means connected to said housing to periodically flex said container moving the solids to the bottom thereof and squeezing the liquid outwardly through the liquid outlets, and injecting means positioned to transmit solid conditioning fluid into the mass of solid at the juncture of the flexible container and the solid outlet.

6. The device defined in claim 5 further characterized by a heating means in cooperation with said injecting means and positioned to extend into the solid mass with the injecting means at the bottom of the flexible container.

7. A device for the separation of solids and liquids forming a slurry, comprising a rigid housing, a flexible container secured within, and in sealed relation to, and spaced from, the casing, said container having an inlet at the top for admission of slurry and an outlet at the bottom for discharge of solids, said container comprising an outer covering impervious to the liquid of the slurry and an inner layer of liquid-filtering material, a multiplicity of liquid outlet conduits extending through the housing and extending also through, and in sealed relation to, the outer covering and at their open inner ends engaging the inner layer to receive liquid filtered therethrough.

8. A device for the separation of solids and liquids of a slurry as defined in claim 7 and comprising also an inlet for a pulsating pressure fluid opening into the space between the casing and the flexible container.

9. The device as defined in claim 7 comprising also an inlet conduit opening into the flexible container in the vicinity of said solids outlet for admission of material adapted to render the solids more free-flowing.

10. The device as defined in claim 9 including also means to heat the last named material flowing into the container.

11. The device as defined in claim 8 comprising also an inlet conduit, opening into the flexible container in the vicinity of said solids outlet, for conveyance of material adapted to render the solids more free-flowing.

12. A device for the separation of solids and liquid forming a slurry comprising an elongate flexible container of a leakproof outer cover and an erosion-resistant liquid filtering internal cover forming a substantially unobstructed passage therethrough; said flexible container having an inlet in the top, an outlet in the bottom open for the passage of solids and liquid, and a plurality of peripherally spaced outlets covered by the internal filtering cover in the sides thereof between the inlet and outlet; a rigid housing enclosing said flexible container in spaced relation

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therefrom and in sealing engagement with said inlets and outlets of the flexible container; and pulsating pressuring means connected to said housing to periodically flex said container moving the solids to the bottom and the liquid out through the outlets.

13. The device of claim 12 further characterized by the peripherally spaced outlets of the flexible container being arranged in an upper and a lower plane between the inlet and the outlet and extending radially through the rigid housing.

14. The device of claim 13 further characterized by the peripherally spaced outlets in the lower plane being open to receive both solids and liquid from the flexible container, and conduit means connecting said outlets externally of the rigid housing to the inlet in the top of the flexible container for recycling the slurry.

15. The device of claim 12 further characterized by an injecting means positioned to engage the mass of solids at the juncture of the flexible container and the solids outlet.

16. The device of claim 15 further characterized by a heating means cooperating with said injecting means extending into the mass of solids at the bottom of the flexible container.

17. A device for the separation of solids and liquids forming a slurry, which comprises a casing, a flexible container within and spaced from the casing and having an inlet for slurry at one end and an outlet for solids at the other end, the flexible container being composed of an outer leak-proof layer and an inner filtering layer, a number of liquid outlet tubes extending through the casing and sealed from communication with the space between the casing and the container and at their inner ends open to receive liquid filtered through the inner layer of the container, and means to maintain fluid pulsation in the space between the casing and the container.

18. A device as specified in claim 17 comprising also liquid outlet tubes whose inner ends open freely into the interior of the container, relatively close to said outlet, and a conduit connection between the last mentioned tubes and the slurry inlet to provide for reprocessing any solids-containing liquid conveyed therethrough.

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