Dec. 22, 1953 G. M. BOOTH 2,663,553

DISSOLVING APPARATUS

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Fig. 1

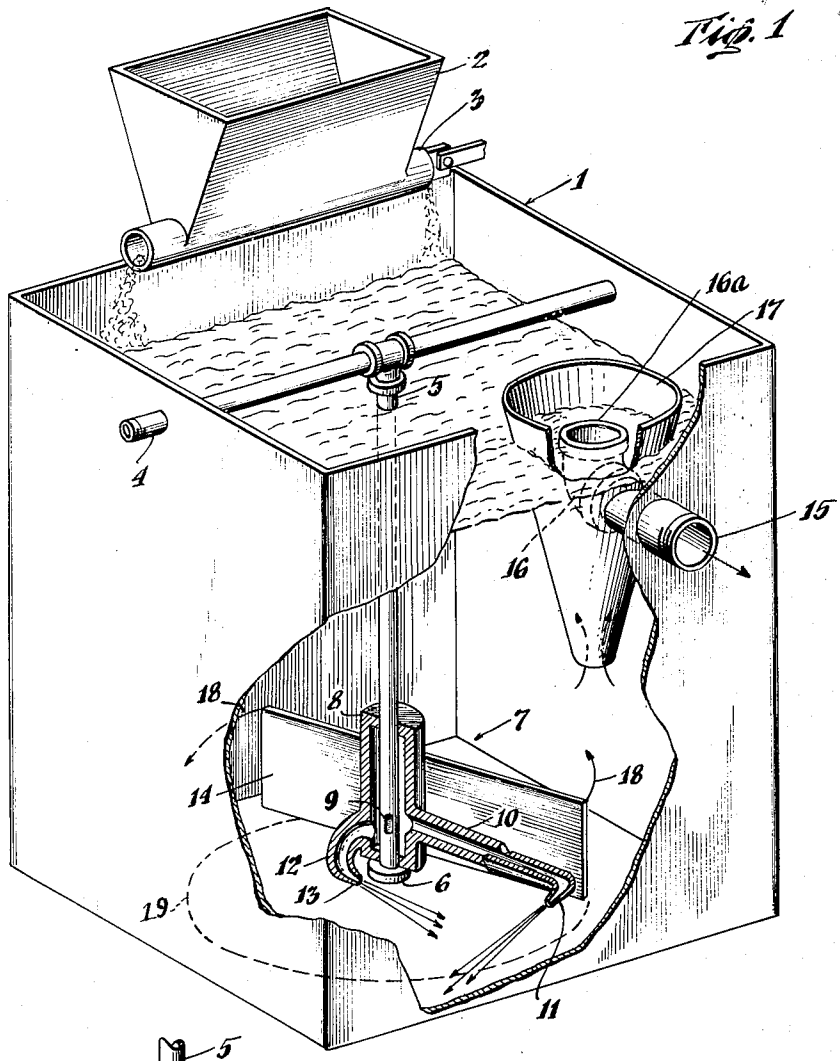
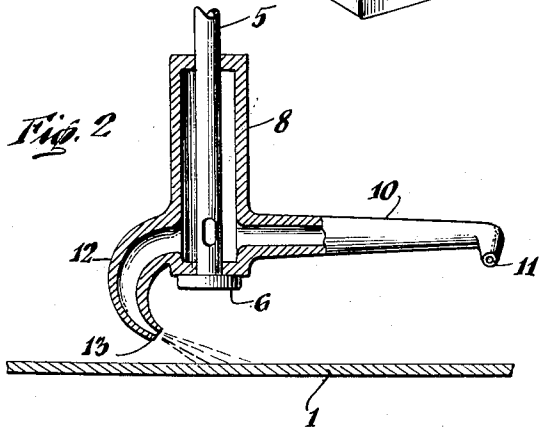


Fig. 2



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DISSOLVING APPARATUS

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8 Claims. (Cl. 259—8)

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The present invention relates to apparatus for dissolving solid particles in a liquid solvent. It is particularly intended for use in processes where the solid particles must approach complete solution to a predetermined degree before being discharged from the dissolving apparatus. Certain features of the invention are of especial utility in connection with dissolving apparatus of this particular type, while other features are of more general utility.

Dissolving apparatus generally consists of a tank having an inlet for solid particles and an inlet for the solvent, an agitator for stirring the mixture and an outlet for the resulting solution. The time required for a particle of a given substance to dissolve completely in a given solvent is dependent upon the size of the particle, providing other conditions such as temperature, etc., are equal. However, in dissolving apparatus of the prior art, the length of time during which a given particle remains in the apparatus is commonly determined by chance, or by the law of averages, and without regard to the particle size.

In many cases, the apparatus which receives the solution from the dissolving apparatus and the process which takes place in that receiving apparatus are not critical with regard to the presence of small solid particles which were not completely dissolved in the dissolving apparatus. In other cases, the discharge conduit leading from the dissolving apparatus is sufficiently long and tortuous to provide sufficient time and agitation so that any small particles carried into that conduit will dissolve before reaching either a point where the solution is to be used or a point where the velocity of flow is reduced so that the particles might settle out and clog the apparatus.

In other cases, it is essential that the dissolving process be carried substantially to completion before the solution is discharged from the dissolving apparatus. Such a condition arises where for some reason the unit which receives the solution cannot properly or safely utilize the small solid particles. An example of such a situation is found in the fluoridation of water. In such a process it is desired to mix sodium fluoride with water in a very small concentration. Such small concentrations are beneficial to the users of the water, but higher concentrations are definitely harmful. It is, therefore, necessary to make sure that no solid particles of fluoride carry over into the treated water where they might produce local concentrations of

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harmful strength. In such situations, the dissolving apparatus of the prior art does not produce a completely satisfactory result.

It is known that the maximum size of the solid particles which will be carried along by smoothly flowing stream of liquid is dependent upon the velocity of the stream. This is true only of smoothly flowing streams. The relationship between particle size and stream velocity does not hold where the flow is turbulent. This principle has been utilized in order to classify solid particles on the basis of their size. Such a classification of particles is sometimes termed "hydraulic classification."

Dissolving apparatus necessarily involves the creation of turbulent conditions in order to mix the solid particles with the liquid solvent. Because of this necessary turbulence, it has been difficult, in dissolving apparatus of the prior art, to control the solution discharged with respect to the maximum size of solid particles which may be entrained therein. The turbulence required has heretofore prevented the use of the hydraulic classification principle to limit that maximum size.

It is an object of the present invention to provide improved dissolving apparatus wherein the dissolving process approaches completion to the extent that the maximum size of the solid particles discharged from the apparatus with the solution may be definitely predetermined.

A further object of the invention is to provide such dissolving apparatus in which the maximum size of the solid particles discharged is determined by the use of the principle of hydraulic classification.

A further object is to provide improved dissolving apparatus of the type described which is compact and requires a minimum amount of energy for the necessary agitation.

The foregoing and other objects of the invention are attained by utilizing a conventional dissolver tank with a conventional inlet for the solid material particles. A novel combined agitator and inlet for the liquid solvent is provided, together with a novel outlet for the solvent. The liquid inlet includes a vertical pipe in the center of the tank and a hollow rotor mounted on the closed lower end of the pipe. The rotor is in communication with the interior of the pipe and carries two nozzles. One of the nozzles is directed at a tangent to a circle concentric with the rotor axis, so that the reaction from the jet of liquid issuing from that nozzle tends to turn the rotor. The other nozzle extends below the end

of the inlet pipe and is directed radially inward toward the axis of the rotor. That nozzle is substantially at right angles to the driving nozzle. Both nozzles are directed slightly downwardly so that their jets sweep over the bottom surface of the tank. The two jets are complementary in that the surface not swept by one jet is swept by the other. Furthermore, the jets are alternately effective to move any solid particles resting on the tank bottom, so that such particles are repeatedly swept back and forth by the jets and thereby reduced in size. The rotor also carries a vane which serves to limit the speed of rotation of the rotor and the turbulence produced thereby.

The tank is provided with a solution outlet including an upwardly diverging conduit whose downstream end extends above the surface of the liquid in the tank, and an overflow weir within that conduit. As the liquid passes upwardly through the diverging conduit, its velocity is decreased due to the increasing cross-sectional area of the conduit. The minimum velocity is reached at the crest of the weir, and that minimum velocity establishes the maximum particle size which can be carried over the weir and out into the discharge conduit.

Other objects and advantages of the present invention will become apparent from a consideration of the following specification, taken together with the accompanying drawings in which:

Fig. 1 is an angular projection of a dissolver embodying the present invention, with certain parts broken away and others shown in section; and

Fig. 2 is a cross-section view of a detail of the dissolver of Fig. 1.

The dissolving apparatus illustrated in the drawings, has been used for the dissolving of sodium fluoride in water.

Referring to the drawings, there is shown a tank 1, above which is positioned a hopper 2 equipped with a feeder 3 by which the solid particles to be dissolved are fed into the open upper end of the tank 1. The feeder 3 may be of the type described in the copending application of John S. Ballard, Serial No. 284,993, filed April 29, 1952. Any other suitable form of feeding mechanism may be used.

A horizontal inlet pipe 4 extends across the tank 1 near its top, being fastened to the opposite sides of the tank, for example, by welding. Near its center, the inlet pipe 4 is connected through a T connection with a vertical, downwardly extending pipe 5. The pipe 5 has a flange 6 at its lower end, and is closed at that end.

A rotor, generally indicated at 7, is journalled on the lower end of the pipe 5 and is supported by the flange 6. The rotor 7 includes a generally cylindrical, hollow body 8 whose interior is in fluid communication with the interior of the pipe 5 through one or more openings 9. A conduit 10 in fluid communication with the interior of the body 8 is mounted on the body 8 and extends radially outward therefrom. At its outer end, the conduit 10 terminates in a nozzle 11, which is directed tangentially with respect to a circle concentric with the axis of rotation of the rotor 7 and at a slightly downward angle.

Another conduit 12 is mounted on the body 8 and extends in a generally U-shaped curve to a point below but spaced radially from the lower end of pipe 5, where it carries a nozzle 13 directed radially inward toward the axis of rotation of the rotor 7 and also directed at a slight angle downwardly toward the bottom of the tank 1.

Although the conduits 10 and 12 are shown integral with the body 8, other equivalent structures may be used. The angular directions of the nozzles 11 and 13 may be varied substantially from the specific directions shown, although that relationship is preferred.

One or more vanes 14 may be attached to the rotor 7. The vanes 14 are inherently effective to produce some turbulent mixing action in the tank, but the principal reason for using them in the present invention is to retard the rate of rotation of the rotor under the influence of the reaction from the nozzle 11.

A discharge pipe 15 extends through one side of the tank 1, being fastened thereto by any suitable means, as by welding. Inside the tank 1, the pipe 15 carries an upturned elbow 16, whose open upper end 16a serves as an overflow weir. A conical conduit 17 encircles the weir 16a being supported on the pipe 15, for example by welding. The conduit 17 is concentric with the overflow weir and is upwardly diverging. It is open at its lower end, so that the solution leaving the tank flows upwardly through the diverging conduit and thence over the crest of the weir 16a.

When the apparatus is in operation, the solid material is fed at a substantially constant rate by the hopper 2 and the feeder 3. The solvent liquid is also supplied at a substantially constant rate through the pipes 4 and 5, the hollow body 8, conduits 10 and 12 and nozzles 11 and 13. The reaction of the jet issuing from nozzle 11 tends to rotate the rotor 7 on the pipe 5 in the direction indicated by the arrows 18. As the rotor turns, the jet issuing from the nozzle 11 sweeps substantially all the area of the tank bottom lying outside a circle concentric with the axis of rotation of the rotor and having a radius substantially equal to the radial distance of the axis from the nozzle 11. This circle is indicated by a dotted line 19 in the drawing. The jet issuing from nozzle 13 is effective at the same time to sweep substantially all the area of the bottom inside the circle 19. The jet from nozzle 13 tends to sweep any solid particles which may be resting on the bottom upwardly and outwardly toward the outside of the tank. Any such particles which are swept to the outside and deposited there by the action of the jet from nozzle 13 are picked up by the jet from nozzle 11 on its next passage. This jet is deflected by the walls of the tank and tends to move the particles upwardly and back toward the center of the tank. If the particles fall to the bottom again, they will be picked up by the jet from nozzle 13 on the next rotation of the rotor. This cycle of back and forth movement of the particles is continued until such time as the particles are reduced in size to a point where they no longer fall to the bottom of the tank. As the size of the particles continues to decrease, they become free to move upwardly to the higher levels of the tank. The liquid above the level of the rotor 7 is substantially less turbulent than the liquid in the lower levels, which is constantly being agitated by the jets from nozzles 11 and 13.

The liquid flowing upwardly through the bottom of the conduit 17 may carry with it at that point solid particles of substantial size. As the liquid continues to flow upwardly through the conduit 17, its velocity is reduced, since the cross-sectional area of the conduit continually increases

in an upward direction. The size of the particles which may be carried by the upwardly flowing stream is reduced in proportion to the decrease in the stream velocity. For given rates of supply of solvent and solute, the diameter of the conduit 17 at the level of the crest of the weir determines the minimum upward velocity and hence the maximum size of the particle which may be carried over into the discharge pipe 15. Any particles larger than that maximum size which move through the bottom of the conduit 17 stop moving upwardly when they reach a certain level within that conduit, which level is determined by the particle size. Such particles may either remain there until they are reduced in size by the action of the stream moving past them, or they may move laterally against the side of the conduit 17, where the stream velocity is lower. They may remain at the side for a time until their size is reduced, or they may collect to form a mass which is large enough to slide down the walls of the conduit 17 and out through its bottom.

The agitation of the mixture within the tank to cause solution of the solid particles is produced almost entirely by the jets of liquid issuing from the nozzles 11 and 13. The rotation of the rotor 7 is effective to change continuously the direction of those jets, but, as pointed out above, it is desired to minimize as far as possible turbulence created by the rotation of the rotor. For that reason, the vane 14 is provided to slow its rotation.

The jets from the nozzles are deflected and scattered, first by the tank bottom and then by the tank walls, so that the more violent turbulent movements are rather closely confined to the lower portions of the tank. Consequently, the liquid in the upper parts of the tank is relatively quiet. The hopper 2 and feeder 3 are located on the opposite side of tank 1 from conduit 17. The larger particles of solid material entering the tank from above tend to fall rather quickly through the quiet liquid in the upper parts of the tank. Erratic movements of such larger particles is confined to the lower levels where the jets are effective to agitate the liquid.

An important feature of the apparatus is thus the attainability of significant effects of hydraulic classification in the main body of the tank 1 itself. Because of the restriction of turbulence to the lowermost region around the nozzles, the greatly predominant tendency of larger particles is to fall rather than to rise at localities above such region. Thus any but very small particles are to a considerable extent inhibited from flowing into the lower end of the conduit 17, and as already explained, are effectively prevented from reaching the discharge point at or near the liquid surface. The apparatus, in contrast to bulky prior equipment involving a long so-called retention time, accomplishes a high degree of dissolving in a relatively very small space and in an economical way.

The provision of a mechanism for hydraulically limiting the size of solid particles discharged with the solution secures that limitation without the use of a strainer or filter which could become clogged.

Although the tank 1 is illustrated as being square, and the rotor 7 as being substantially centrally located in the tank, it will be appreciated that other forms of tank, e. g., oblong, may be used, and that more than one rotor may be used. Multiple rotors may be arranged in a suitable array so that their jets will sweep substantially the entire bottom of the tank.

The nozzles 11 and 13 are shown and described as directed downwardly at a slight angle to the horizontal. The particular angle used depends on the spacing between the nozzles and the tank bottom. Where the nozzles are very close to the tank bottom, they may be directed horizontally and will still be effective to sweep all the bottom of the tank. As the spacing between the nozzles and the tank bottom increases, the downward angle of the nozzles must be increased, to insure effective sweeping of the tank bottom.

It is to be understood that the invention is not limited to the specific apparatus herein shown and described, but may be embodied in other forms without departure from its spirit.

I claim:

1. Dissolving apparatus, comprising a tank having an inlet for solid solute particles, an inlet for liquid solvent, means to agitate the mixture of solvent and solute particles, and an outlet for liquid solution, said outlet comprising means effective to limit hydraulically the maximum size of solid particles discharged through the outlet with the solution, said hydraulic limiting means comprising a generally vertical, upwardly divergent conduit section having an intake opening at its lower end and a discharge opening at its upper end.

2. Dissolving apparatus as defined in claim 1, including an overflow weir defining said discharge opening.

3. Dissolving apparatus, comprising a tank having an inlet for solid solute particles, an inlet for liquid solvent and an outlet for liquid solution, said outlet comprising a vertical, upwardly divergent conduit extending above and below the surface of the liquid in the tank, an overflow weir in said conduit adjacent but below the upper end thereof, said conduit being open at its lower end and being effective to decrease the velocity of the liquid as it flows upward in accordance with the divergence of the conduit to a minimum upward velocity at the crest of the weir, so that the only solid particles carried over the crest are those having a size smaller than a maximum determined by said minimum upward velocity, and conduit means adjacent said weir on the downstream side thereof to receive and discharge liquid passing over the weir.

4. Dissolving apparatus as defined in claim 3, in which said weir is the open upper end of a vertical outlet pipe, and said divergent conduit is generally conical and concentric with said weir.

5. Dissolving apparatus, comprising a tank having an inlet opening for solid solute particles and an outlet for liquid solution, an inlet pipe for liquid solvent supported within said tank and extending vertically therein and having its lower end closed and adjacent but spaced from the bottom of the tank, a rotor journalled on said pipe for rotation about the axis thereof and adjacent the lower end thereof and comprising a hollow body having its interior in fluid communication with the interior of the pipe, a first conduit extending outwardly from said body, a first nozzle at the outer end of said first conduit directed substantially tangentially with respect to the axis of the pipe, a second conduit extending outwardly from said body and downwardly to a point below the end of the pipe, and a second nozzle at the end of said second conduit and

directed toward the axis of the pipe, said first nozzle being effective when a jet of liquid is discharged therefrom to apply a rotating torque to the rotor due to the reaction of the jet, said first nozzle also being effective upon each revolution of the rotor to sweep with its jet all the tank bottom outside a circle having a radius substantially equal to the radial distance of the first nozzle from the rotor axis, said second nozzle being effective upon each revolution of the rotor to sweep with its jet at least all the tank bottom inside said circle.

6. Dissolving apparatus as defined in claim 5, in which said first and second nozzles are directed at a slight downward angle.

7. Dissolving apparatus as defined in claim 5, in which said outlet comprises a vertical, upwardly divergent conduit extending above the surface of the liquid in the tank, said conduit having its lower end spaced substantially below the liquid surface and spaced substantially above said rotor and nozzles, an overflow weir in said conduit adjacent but below the upper end thereof, said conduit being open at its lower end and being effective to decrease the velocity of the liquid as it flows upward in accordance with the divergence of the conduit to a minimum upward velocity at the crest of the weir, so that the only solid particles carried over the crest are those having a size smaller than a maximum determined by said minimum upward velocity, and conduit means adjacent said weir on the

downstream side thereof to receive and discharge liquid passing over the weir.

8. Dissolving apparatus, comprising a tank, having an inlet for solid solute particles, means for introducing liquid solvent into the tank, comprising jet means directing said liquid about the lowermost region of the tank for producing turbulence throughout said lowermost region, said jet means being constructed and arranged to confine said turbulence substantially to said lowermost region alone, and means defining an outlet for liquid solution, said outlet comprising means effective to limit hydraulically the maximum size of solid particles discharged through the outlet with the solution, said hydraulic limiting means comprising a generally vertical, upwardly divergent conduit section having an intake opening at its lower end and a discharge opening at its upper end, said intake opening being spaced above said lowermost region.

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