The present invention, which has resulted from applicant's investigations, relates to washer-mixer apparatus, that is apparatus used in the chemical industry for reacting with each other, or mixing with each other, or for emulsifying, products of different densities, and/or products existing in different physical states. More generally, the invention relates to apparatus adapted for putting into intimate contact two or more products which are miscible with difficulty.

The apparatus, which is the object of the present invention, is particularly intended for reacting products in a liquid state with products in a solid state existing in divided form.

The invention aims more particularly at an apparatus intended for washing or treating powder products with liquids, and it aims more particularly at that apparatus which has for its object the washing or treatment of dense powder products by means of liquids.

Up to now, the treatment of very heavy powders, such as washing by means of acids or the simple rinsing of such powders with water, presented great difficulties because the production of an intimate contact between the powder product and the liquid was most imperfect by reason of the rapid sedimentation of the products. Agitation or mechanical mixing of the powder is not of much help in the case of a very heavy powder and, moreover, presents serious drawbacks in the case where the powder to be treated by a liquid is not only dense but is also abrasive.

The present invention overcomes these difficulties and makes possible to treat efficiently by means of liquids powders which are both dense and abrasive.

The apparatus according to the invention comprises a washer vat or tank which is given a periodic or irregular movement, the said tank being divided into at least two compartments which communicate with each other by one or more orifices (openings) of reduced cross-section, the partition or partitions separating the compartments being disposed in such a way that the motions imparted to the tank produce differences in liquid level between the said compartments.

According to a preferred embodiment of the invention, the tank is given a periodic motion, and the openings connecting the various compartments are disposed at the lower end of the partition walls. According to this arrangement, the variations in the height of the liquid level in the compartments cause currents at the bottom which force the liquids to traverse the entire thickness of the powder and produce the suspension of said powder.

According to a simple form of embodiment, the washer tank is constituted of a cylindrical container having a flat bottom and provided with a partition placed along a diametral plane of the cylinder, and which partition is perforated with one or more openings near the bottom of the tank. If the tank be given a periodic motion, for example an oscillation about an axis which is parallel or substantially parallel to the plane of the partition, or about an axis comprehended in the plane of the partition, the liquid circulates alternately from one compartment to the other, passing through the entire thickness of the powder while creating a thorough mixing which multiplies the contacts between powder and liquid.

According to another embodiment, the washer-shaker tank is imparted a rotational movement, regular or irregular, about its axis, said axis being inclined at a certain angle relative to the vertical; at each half-revolution of the tank, the liquid circulation stream between the two compartments is reversed.

In an apparatus according to the invention, the most energetic mixing is obtained by giving the communication orifice between the different compartments the shape of a narrow slot disposed at the level of the bottom of the tank. The cross-section of the passage through said slot is determined experimentally in accordance with the density and the granulometry of the products to be treated, with the frequency and amplitude of the periodic motions imparted to the tank and in accordance with the relative quantities of powder and liquid introduced into the washer tank.

From what has been said, it will be understood that the novel washer arrangement does not act in the manner of an agitator mechanically mixing the powder but, rather, in the manner of a hydro-dynamic pump which produces circulation currents from one compartment to the other in order to place into intimate contact, by turbulence, the entire mass of powder with the treating solution or the wash water. Moreover, the friction of the powder against the interior walls of the tank is thereby reduced to a large extent, which is particularly advantageous in the case where abrasive powders are being treated.

In certain cases, namely, in the construction of mixer-washers of large dimensions, it is advantageous to provide for the division of the tanks into more than two compartments. For example, it is possible to mount in a cylindrical tank three partitions at intervals of 120°.

In a practical embodiment of the invention, use is made of movable separation partitions which, for example, slide in grooves or tracks in order to facilitate handling of the product and, in particular, emptying of the tank.

As will be readily understood, many variations can be made, without departing from the spirit of the invention, in order to increase still further the effect of the turbulence of the current circulating between the compartments. For example, deflecting surfaces, suitably oriented, can be provided at the bottom of the tank so as to impart a gyroscopic motion to the circulating current or to direct a portion thereof towards certain zones of the tank where the agitation is less intense; such surfaces can be curved.

In the same way, one can, according to the invention, select tanks of the most varied shapes so as to add to the liquid mixing a certain mechanical agitation effect; for example, the bottom of the tank can be given a polygonal shape in lieu of a round shape, or else, there can be mounted on the interior walls of the tank integral wings or ribs from which the powder falls back during the rotation or oscillation of the tank.

The invention will be better understood from the following description and the annexed drawings which represent, by way of a non-limiting example, one mode of carrying out the invention.

In the drawings:

FIGURE 1 is a vertical sectional view taken through the center of a washer-mixer apparatus according to the invention;

FIGURE 2 is a sectional view taken on the line 2—2 of FIGURE 1.

Referring to the drawings:

The washer element is formed of a cylindrical container having a flat bottom and inclined at 45° to the horizontal and rotating about its axis intercepted by the two compartments of a conventional motor-gear-reduction system which is not illustrated on the drawing.

In the diameter plane of the cylinder, there is mounted a partition slide in tracks 4', said partition com-
prising a notch 5 of reduced height which forms the passage between the two compartments 6 and 7.

During rotation of the tank, the levels 8 and 9 of each compartment tend to be placed in equilibrium (balance) through the notch 5 while creating a circulation current illustrated by the arrow 10.

The passage of the washing or treating solution from one compartment to the other produces the suspension of the powder 11 as a result of the turbulence produced in the mass.

The tank 1 can be made of any material resistant to the product to be treated; the tank is provided with a pouring lip (spout) 12.

The rotating frame which supports the tank is constituted of a circular plate 13 carrying in its center any suitable coupling device, such as a flange or sleeve 14 for connection with the motor-gear-reduction system. Retaining members 15 maintain the washer tank on the driving plate 13, and it is advantageous to mount a portion of the supporting frame for the tank on a hinge (not shown), or any other similar pivotal mounting device. It is thus possible to effect emptying of the washer tank by a simple swinging of the washer-motor-gear-reduction system assembly.

By way of example, it can be mentioned that, there has been used an arrangement according to the invention in which the washer tank was a cylindrical container with a flat bottom, having an interior diameter of 300 mm. and a height of 515 mm. and made of a plastic material, such as polyvinyl chloride or polyethylene. The tank had a capacity of 34 litres, the intermediate partition had at its lower end a notch 5 mm. high and 250 mm. wide, the axis of rotation was inclined 45° to the vertical, and the speed of rotation was 90 r.p.m.

It was found possible to carry out in this tank the washing of an abrasive tantalum powder having an apparent density of 12 and a particle size of 37μ. It was possible to treat in this tank 40 kg. of this powder in the presence of 15 litres of aqua regia which was renewed until the metallic impurities contained in the powder were completely eliminated. This powder was then rinsed with water in the same apparatus.

As is well understood, the invention is by no means limited to the example described and illustrated; it is capable of various modifications, obvious to a man skilled in the art, according to the intended use, without departing from the spirit and scope of the invention.

In particular, it is possible to add to the motor-gear-reduction system a speed changer so as to be able to select the speed most suitable for the product treated; similarly, one can select for the washing tank a shape which departs from the cylindrical form, in order to increase the difference in hydrostatic pressure between two adjacent compartments, and thereby increasing the speed of the circulation current at the bottom of the apparatus.

I claim:

1. Apparatus for mixing liquids with finely divided solid materials comprising, in combination: a container for the products to be mixed; means supporting said container for movement about an axis inclined to the vertical; means for moving said container about said inclined axis; at least one partition member mounted within said container and dividing said container into a plurality of compartments, said partition member contacting the bottom surface of said container; at least one opening extending through said partition along the bottom edge of said partition forming a passageway between said compartments, said opening being so small that the movement imparted to the container about said inclined axis produces differences in liquid level between the compartments, said opening being large enough so that liquid circulates alternately from one compartment to the other during said movement whereby the circulation of said liquid between the compartments causes the liquid to transverse the entire thickness of the finely divided materials to be treated causing a thorough mixing of the liquid and the finely divided materials.

2. Apparatus according to claim 1 comprising a cylindrical container; one partition member extending along a diametral plane and dividing said container into two compartments; and said means for moving said container about its inclined axis being rotary means.

3. Apparatus according to claim 1, wherein said opening is an extended narrow slot.

4. Apparatus according to claim 2 wherein said opening is an extended narrow slot.

References Cited in the file of this patent

UNITED STATES PATENTS

1,370,898 Middlemiss Mar. 8, 1921

OTHER REFERENCES

Great Britain, 654,992, complete spec. pub. June 27, 1951.