Nov. 22, 1955 L. J. REVALLIER 2,724,580

METHOD OF MIXING A PULVERULENT SOLID MATERIAL AND A LIQUID

Filed June 17, 1953

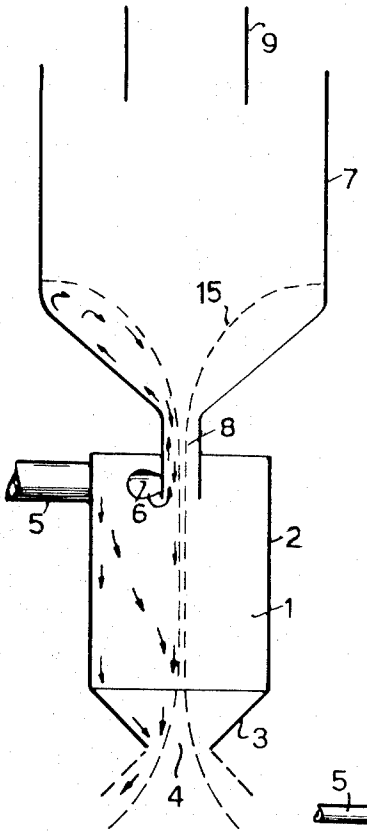


FIG. 1

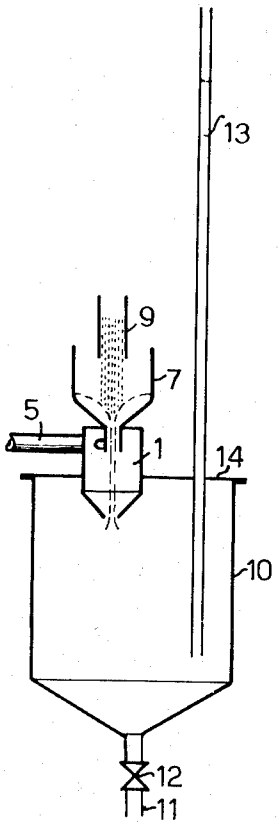


FIG. 2

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United States Patent Office 2,724,580 Patented Nov. 22, 1955

2,724,580

METHOD OF MIXING A PULVERULENT SOLID MATERIAL AND A LIQUID

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Application June 17, 1953, Serial No. 362,341

Claims priority, application Netherlands June 19, 1952

3 Claims. (Cl. 259—4)

My present invention relates to a method for mixing a pulverulent solid material and a liquid.

In mixing a pulverulent solid material with a liquid, difficulties are often encountered, e. g., because of the solid material reacting quickly at the surface and a layer is formed which it is difficult for the liquid to penetrate. As a result hereof clods are easily formed which are difficult to disperse. As examples I may mention the dissolving of solids in a solvent to form a colloidal solution, e. g., the dissolving of potato starch, cocoa or gluepowder in water. In mixing raw phosphates with strong acids these difficulties also arise, so that the complete decomposition is retarded.

Various methods have been proposed for the obviation of this drawback. It has been proposed, e. g., to make the liquid flow in a continuous film, e. g., out of a circular aperture, and to sprinkle the solid onto this film. It has also been proposed already to sprinkle the solid into a funnel of conical form along the wall of which a spiral flow of liquid is formed by feeding the liquid tangentially into the funnel.

The main object of my invention is to provide a new method of mixing a pulverulent solid material and a liquid whereby a very thorough mixing is achieved.

A further object of my invention is to provide such method in which in a new and efficient way a liquid layer is built up onto which the pulverulent solid material to be mixed with the liquid is sprinkled so as to accomplish the initial contact of said materials and thus avoiding the formation of clods.

Another object of my invention is to provide such method in which the resulting intimate mixture may be discharged against an overpressure while the initial contacting is performed in an open space, nevertheless.

Further objects will appear hereinafter and in the claims hereof.

According to my invention, there is provided apparatus for mixing a pulverulent solid material with a liquid, comprising a radially symmetrical chamber provided with opposed axial apertures and one or more feed passages disposed at or near one end in such a way that liquid fed therethrough at a sufficient rate will commence to rotate within the chamber around the wall thereof, and also comprising a space, which at least at one end portion is peripherally bounded by a substantially conical wall, located outside the feed end of the said chamber and co-axial with the said chamber, the narrow end of said space being adjacent the said chamber and leading into the interior thereof through the axial aperture at the feed end of the chamber the apparatus being so constructed that when positioned with its axis substantially vertically a rotating body of liquid may be established in the chamber from which body liquid continuously enters the said space and returns into the chamber through the said feed end axial aperture thus maintaining in said space a continuously renewing quantity of liquid in rotation around the wall of the space, and from which body

liquid continuously discharges through the other axial aperture of the chamber.

My invention includes the use of the said apparatus by sprinkling the pulverulent solid material to be mixed with the liquid, onto the liquid rotating in the said space, so that the said solid is drawn down into the radially symmetrical chamber, becomes thoroughly mixed with the liquid, and subsequently discharges with the liquid through the lower axial discharge aperture of the chamber.

In carrying out tests I found that the diameter of the axial aperture of the chamber leading into the space with the substantially conical wall, should be smaller than the diameter of the opposite axial (discharge) aperture of the chamber.

If a liquid is forced at a suitable rate through the feed passage(s) of the chamber of apparatus according to my invention, a liquid vortex is set up in the chamber so that a hollow core is formed. If the feed rate is raised the hollow core is narrowed. If the core diameter becomes smaller than the diameter of the passage leading into the space at least one end portion of which is peripherally bounded by a substantially conical wall (hereinafter called "the conical space"), rotating liquid enters the said space and rotates as above referred to, the liquid spiralizing upwards along the conical wall and then spiralizing inwards and becoming aspirated again into the chamber substantially along the axis of the apparatus.

Preferably, the conical space is open at the top, and as the rotating liquid is forced out of the chamber through its lower axial (discharge) aperture, an injector effect is here created, making it possible for the discharging liquid to discharge into a vessel in which there is an overpressure, without resulting in the liquid entirely filling the conical space over the chamber and possibly flowing over its brim.

The degree of the overpressure which may be overcome, depends on the ratio between the diameters of the upper axial aperture of the chamber and its lower, discharge, aperture. In general, it is found that the smaller this ratio, the greater the overpressure which may be overcome. Pressures up to 0.25 atm. gauge pressure may be easily overcome.

For a given apparatus, external pressure being constant, the level to which the liquid rises in the conical space is dependent on the rate at which the liquid is forced through the rotation chamber. If the resistance to discharge through the discharge aperture is high, by reason of the discharge taking place into a vessel in which an overpressure is created, an appropriately high feed rate is required in order to raise the liquid to the desired level in the conical space. Thus, it will be clear that when discharge is into a vessel as aforesaid, then while maintaining a constant feed pressure, the said level may be controlled by regulating the back pressure, e. g., by means of a regulating cock in the discharge passage from the said vessel.

When the pulverulent solid material is sprinkled onto the liquid rotating in the conical space, this material is rapidly sucked into the chamber along the axis thereof. Subsequently a complete mixing takes place in the rotation chamber under the influence of the strong centrifugal accelerations and high shearing stresses occurring in the liquid vortex. The mixture is subsequently discharged through the discharge aperture of the radially symmetrical chamber.

My invention will now be elucidated with reference to the apparatus illustrated by way of example and not of limitation in the accompanying drawings, in which:

Fig. 1 is a diagrammatic longitudinal section through one form of apparatus according to my invention and

Fig. 2 is a diagrammatic longitudinal section through

an apparatus which includes the apparatus shown in Fig. 1 and a discharge receiving vessel.

Referring to Fig. 1, **1** represents a radially symmetrical chamber comprising a cylindrical section **2** and an adjoining conical section **3**, in which there is a central circular discharge aperture **4**.

At **6** a tangentially directed liquid feed conduit **5** opens into the chamber. At the upper end of the chamber is a container **7**, the lower end portion of which is peripherally bounded by a conical wall, which is arranged coaxial with the chamber. The narrow end of the conical space leads into the interior of the chamber through the axial aperture at the feed end of the chamber, which aperture is defined by a short tubular portion **8** extending down into the chamber from the container **7**.

Over the container **7**, a feed conduit **9** is provided for supplying the solid material. This feed conduit may be of any form suited to the regular supply of pulverulent solid to the liquid in the conical space at the bottom portion of container **7**. By way of example, a vibrating gauze may be provided in the feed conduit **9**.

In the apparatus shown in Fig. 2, which may, e. g., be used for carrying out chemical or physical reactions between a solid material and a liquid, the apparatus shown in Fig. 1 is provided in the cover **14** of a vessel **10**, which vessel is provided at its lower end with a discharge conduit **11**, in which there is a regulatable cock **12**, and also with a riser **13**.

If a liquid, e. g., water, is forced through the tangential feed conduit **5**, a liquid vortex is generated in the rotation chamber **1**, and at a certain feed rate, liquid continuously enters the container **7** and returns into the chamber **1** through the tube **8** so that a continuously renewing quantity of liquid **15** is maintained in the container **7**, the said liquid rotating around the wall thereof. The non-tangential flow components are approximately directed as indicated by the arrows in Fig. 1. If, in the assembly of Fig. 2, the cock **12** is opened wider or less wide, the pressure in vessel **10** falls or rises, respectively, which pressure may be read from riser **13**.

If via the feed conduit **9** the solid material is sprinkled onto the surface of the liquid rotating in container **7**, this solid material is rapidly sucked into the chamber, along with the liquid; in the rotation chamber, the solid material is rapidly and completely mixed with the liquid, after which the resulting mixture is squirted into vessel **10** and finally removed via discharge conduit **11**.

Example

Water was fed under a gauge pressure of 3 atm. into the radially symmetrical chamber (**1**) of apparatus according to Fig. 2, having the following dimensions:

	Mm.
Inner diameter of cylindrical section (2)	34
Height of cylindrical section (2)	100
Dia. of discharge aperture (4)	14
Dia. of tangential feed conduit (5)	10

Maximum dia. of container (7)	60
Dia. of tube (8) (and thus of upper axial aperture of chamber 1)	8

A well developed eddy of liquid was formed in container **7**. By regulating cock **12** it was possible to adjust the overpressure in vessel **10** to 100 cm. of water. When this pressure was raised, the level of the liquid in container **7** rose until at last the liquid flowed over the brim thereof.

At a too low back pressure in vessel **10** the level of the liquid in space **7** fell slightly. When the diameter of the tube **8** was reduced to 5 mm. the back pressure in vessel **10** could be raised to about 250 cm. of water without the liquid overflowing from container **7**. When this diameter increased to 10 mm., no perceptible back pressure in vessel **10** could be built up without overflow taking place. When in the latter case, the feed pressure of the liquid was raised, some back pressure could still be overcome, however, while at diameters of the tube **8** smaller than 5 mm. the back pressure could be raised further still.

The amount of solid material which can be fed per litre of liquid pumped through the chamber, depends on the nature of the liquid and that of the solid. The rate of feed of solid must not be so high that the rotation of the liquid in container **7** is retarded too much.

I claim:

1. A method of mixing pulverulent solid material with a liquid which comprises the steps of continuously feeding liquid tangentially into a first vertically disposed radially symmetrical rotation space to generate a liquid vortex therein, discharging part of said liquid upwardly from said vortex in the form of a hollow cylindrical rotating body, permitting said upwardly moving rotating body of liquid to diverge in a second radially symmetrical rotation space disposed above said first rotation space, adding pulverulent solid material to the rotating body of liquid in said second space, said liquid and solid flowing axially downwardly from said second space into said first space, and discharging the resultant mixture downwardly from said vortex in the form of a cylindrical rotating body of greater diameter than said upwardly moving body.

2. A method according to claim 1, wherein the resultant mixture is discharged downwardly into a space in which the pressure exceeds atmospheric.

3. A method according to claim 2, including the step of controlling the process by varying the pressure in said discharge receiving space.

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