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Van Koppen

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[54] **PULSE COLUMN WITH PISTON DRIVE AND RESILIENT GAS CUSHION**

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.** **B01d 11/04,** B01f 3/08

[58] **Field of Search** ....23/267 C, 270.5, 310, 309

[56] **References Cited**

UNITED STATES PATENTS

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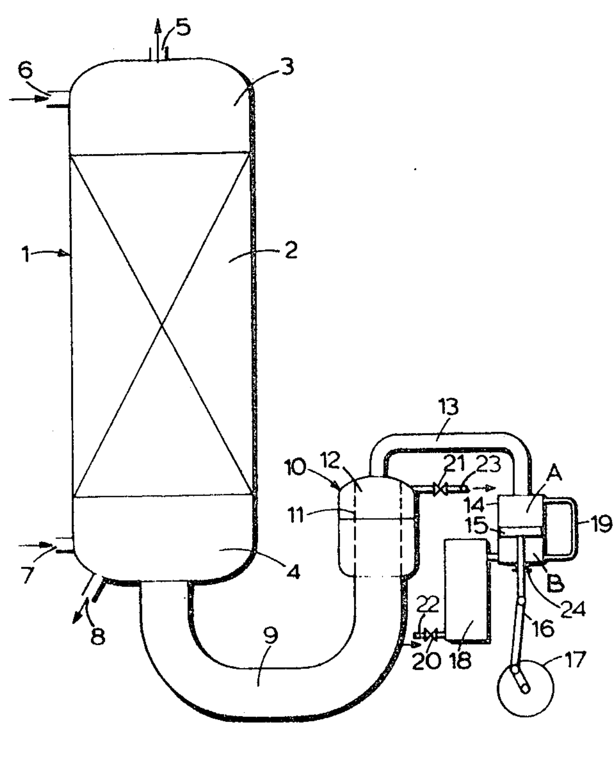
[57] **ABSTRACT**

For controlling the amplitude of pulsations of liquid in a column partly filled with the liquid and having a pulsing chamber which communicates with a gas cushion alternately compressed and expanded at a constant amplitude and frequency comprising: increasing and decreasing the amount of gas in the gas cushion. In the installation according to the invention the space behind the piston in the cylinder is connected with a buffer space, the volume of which is at least as large as that of the gas cushion, while the spaces in front of and behind the piston in the cylinder are connected by means providing a restricted communication.

9 Claims, 2 Drawing Figures



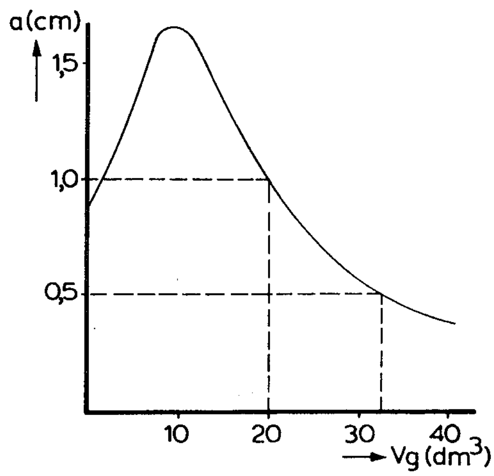


FIG.2

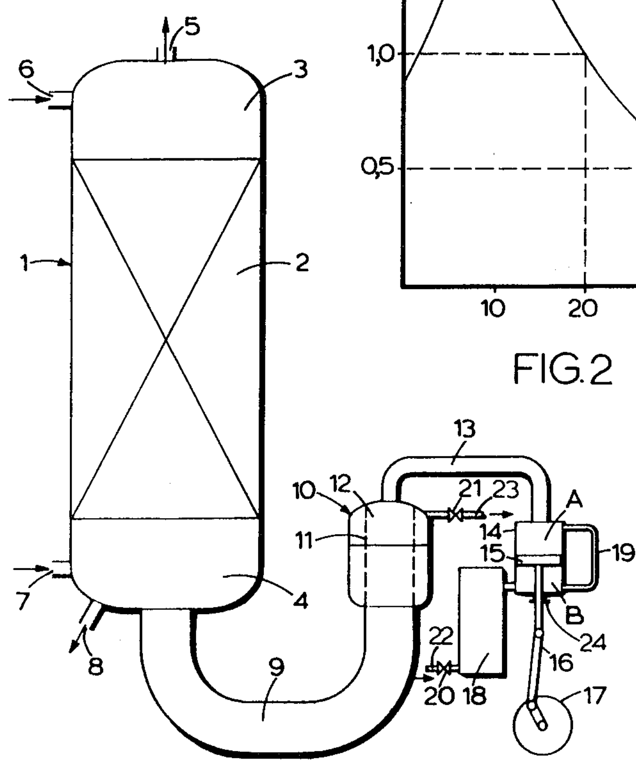


FIG.1

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PULSE COLUMN WITH PISTON DRIVE AND RESILIENT GAS CUSHION

BACKGROUND AND SUMMARY OF THE INVENTION

The invention relates to an installation used to impart a pulsating motion to a liquid in a column, in which the lower end of a tube is connected with the lower part of the column and devices have been installed to utilize a pulsed pneumatic pressure at a gas cushion over the liquid surface in the tube, consisting of a cylinder and a motor-driven piston. Such a pulse installation has been proposed by Thornton in U.S. Pat. No. 2,818,324, and has the advantages that corrosive column-liquids are not in contact with the pulse installation and that the cavitation problem (occurring when pulsing is too fast, particularly in the case of volatile, organic liquids) is avoided. Because of the compressibility of the gas, however, a larger pulsing capacity is required to obtain a similar result.

The invention aims at meeting this drawback and providing a pulse installation with piston drive and resilient gas cushion, such as is disclosed in the aforementioned United States patent, but in which the required amount of power is reduced.

In the installation according to the invention the space behind the piston in the cylinder is connected with a buffer space, the volume of which is at least as large as that of the gas cushion, while the spaces in front of and behind the piston in the cylinder are connected by means of a narrow connecting line. In most cases the size of the piston can be selected to be undersize, relative to the size of the cylinder so that the air crevice between the piston rings and the cylinder wall can serve as the connecting line mentioned.

Another purpose of the invention is to provide a pulse installation of the type in question, in which control of the pulsing amplitude is effected in a simple manner.

With the device of Thornton, the maximum displacement of the liquid according to FIG. 2 of his U.S. Pat. No. 2,818,324 automatically adjusts to the frequency set. However, according to Thornton the two variables, displacement and frequency, can be made independent by constructing a pulse installation so large that the desired amplitude occurs at the highest operating frequency desired and by controlling the amplitude at lower frequencies by reducing the stroke of the piston. To this end, with Thornton, the motor is constructed as lineair air-motor, while both the speed and the stroke of this motor are adjustable.

In operating the installation according to the invention, on the other hand, control of the desired pulsing amplitude is obtained by varying the quantity of gas in the gas cushion, while keeping the frequency as well as the stroke of the piston constant. This method has the advantage that the driving mechanism need not be constructed as a variable one and can, therefore, be of optimum efficiency. In addition, the mechanism will be sturdier and cheaper.

Other advantages and features of the invention will be explained on the basis of an example of the construction shown in the attached drawing. The principles of the invention will be further hereinafter discussed with reference to the drawing wherein a preferred embodiment is shown. The specifics illustrated in the drawing are intended to exemplify, rather than limit, aspects of the invention as defined in the claims.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a diagrammatical, vertical cross-section of a pulse column provided with an installation according to the invention.

FIG. 2 is a graph of the relation between the pulsing amplitude (a) and the average volume (V_g) of the gas cushion.

In FIG. 1, 1 represents a pulse column, which, over part of its length, is provided with a filling **2**. Above and below the part containing the filling there are the collecting spaces **3** and **4**, which are equipped with liquid-connections **5** and **6**, and **7** and **8**, respectively. Near the bottom end of the column there is a connection **9** connecting the pulse column **1** with a pulsing chamber **10**. The chamber **10** is only partially filled with liquid and above the liquid surface there is a gas cushion **12**. A tube **13** connects the gas cushion with a cylinder **14**. In the cylinder **14**, a piston **15** can be moved upwards and downwards with the aid of a crank-connecting rod mechanism **16**, or a similar mechanism, and a motor **17**. Therefore, the sum of the volumes of **12**, **13** and cylinder **14** above the piston **15**, with the piston **15** in mid-position, is to be considered as the average volume (V_g) of the gas cushion.

The space B behind the piston **15** in the cylinder **14** is connected with a buffer space **18** which has a volume which is at least as large as that of the gas cushion **12**. This buffer space **18** may, if necessary, form a whole with, or be an extension of, said space B in cylinder **14**. The space A in front of the piston **15** in the cylinder **14** is connected with the space B behind the piston via a narrow connecting line **19**. In many cases the air crevice between the piston and the cylinder wall can serve as connecting line. A supply line **22** for gas emanating from a source not indicated in detail is preferably connected to the buffer space **18**, which line can be closed by means of a valve **20**. Preferably at the top of the chamber **10**, a discharge line **23** is installed, which can be closed by means of a valve **21**.

FIG. **2** is a graph which at a certain frictional resistance coefficient ($\xi = 15$) of the column filling, renders the stroke (a) of the liquid motion in the column as a function of the average volume (V_g) of the gas cushion, the stroke volume and the number of strokes per time unit of the piston **15** being considered constant.

The graph is for a pulsed packed column having a height of about 8 meters and an inner diameter of about 0.75 meters. The column filling was about 6 meters high, and consisted of ceramic Raschig rings of 25 mm outer diameter. The column liquors were various liquids, having a specific weight not very different from 1, and a dynamic viscosity below 5 cP (centipoises). The particular gas used in the gas cushion was nitrogen (N_2). displacement of the piston was about 3 liters. The volume of the gas cushion (including the space A) could be varied from 13 to 40 liters and the stroke (a) varied then between 1,5 and 0,4 centimeters.

The extraction efficiency of the system may, in the case of a chosen stroke frequency, depend on the stroke (a) of the liquid pulsations. In the installation according to FIG. **1**, the stroke (a) depends on the gas volume V_g in the manner indicated in FIG. 2. By preference, processing will take place in the descending part of the curve. This will not only yield a larger range of control, but also be simpler from a construction point of view because of the pertaining, larger gas volume. For the stroke to be enlarged or reduced, the gas volume V_g will be reduced or enlarged with the aid of the two valves **20** and **21**. The pressure amplitude in chamber **10** has shown to be substantially proportional to the pulsing amplitude a; these pressure fluctuations, therefore, can serve as a measure of the pulsing amplitude *a*.

By the provision of the buffer space **18**, the pressure variations behind the piston are kept smaller than, for instance, 0.1 atm, while the piston **15** is relieved in its upward and downward motion, which is not only favorable in relation to energy, but also reduces the frictional losses in the driving mechanism **16**. Starting up is easier, too, and further, the stresses occurring in the driving mechanism **16** are smaller.

The quantity of gas present in the gas cushion **12** can be kept constant via the supply line **22** with the aid of automatically operating devices known by themselves, which are not shown in the figures, for an unintentional gas loss would cause the amplitude of the pulsations in the column to become greater. The only point where loss of gas will inevitably occur is from the stuffing box **24** where the piston rod is passed through the cylinder cover. Notably, if nitrogen is applied, as is the case with such inflammable column liquids as benzene, this stuffing box should be of good quality. In addition, by continuously purging gas via line **22**, space **18**, space B, line **19**, space A, line **13** and space **12** to the discharge line **23**, it is also achieved that any droplets or vapors of the column liquid accumulating in the chamber **10** are discharged.

The diameter of the pulsing chamber **10** is so wide that during the pulsations, the accelerations occurring always remain smaller than the acceleration of the gravity *g*. The advantage of this is that drop formation at the liquid surface does not occur. (As in the case of Thornton, formation of vapor bubbles in the column liquid, the so-called cavitation, cannot occur either.)

In the pulsing chamber **10** a vertically arranged wave damper **11** consisting of a perforated plate or something similar can be provided both to avoid excessive wave motions and to prevent the liquid from being flung up at the liquid surface.

In those cases that vapor might condense in the cylinder **14**, it is advisable for the cylinder **14** to be placed higher than the connecting line **13** and the liquid surface in the pulsing chamber **10**.

In the pulsing chamber **10**, a float valve (not shown) can be installed (in a manner as is known, for instance, from FIG. 4 of the British Pat. Specification No. 780,406) to avoid the influx of column liquid into the line **13**.

It should now be apparent that the process and apparatus for pulsating a liquid in a pulsating column as described hereinabove possesses each of the attributes set forth in the specification under the heading 'Background and Summary of the Invention' hereinbefore. Because the process and apparatus for pulsating a liquid in a pulsating column of the invention can be modified to some extent without departing from the principles of the invention as they have been outlined and explained in this specification, the present invention should be understood as encompassing all such modifications as are within the spirit and scope of the following claims.

What is claimed is:

1. As an improvement for a combination which includes:

an extraction column partly filled with liquid to be pulsed and with filling means for enhancing extraction; a U-shaped pulsing chamber external of the column having a connection with the lower end of the column with means defining a gas cushion above the liquid surface in the chamber; a piston slidably received in a sealed cylinder external of said pulsing chamber and communicating with the gas cushion; and means for oscillating the piston in the cylinder to increase and decrease the force with which the gas cushion acts upon the liquid surface in the chamber in order to cause the liquid in the column and the chamber to pulsate;

means defining a sealed buffer chamber external of said pulsing chamber and having a volume at least as large as the average volume of the gas cushion, said buffer chamber being communicated to said cylinder on the opposite side of said piston from said gas cushion; and means providing restricted communication between the cylinder on the same side of said piston as the gas cushion and on the same side of said piston as the buffer chamber.

2. The apparatus of claim **1** wherein the pulsing chamber is of such great cross-sectional area that during the pulsations, the acceleration of liquid at the liquid surface due to pulsation is always less than the acceleration due to gravity.

3. The apparatus of claim **2** further including perforated plate means within the pulsing chamber for retarding wave motion at the liquid surface.

4. The apparatus of claim **1** wherein said means for oscillating the piston comprises a motor.

5. The apparatus of claim **4** wherein said motor is connected to the piston by means providing a constant amplitude and frequency of piston travel.

6. The apparatus of claim **1** further including means for continuously admitting gas to said buffer chamber and means for continuously discharging gas from the gas cushion for purging the gas cushion of liquid.

7. The apparatus of claim **1** wherein the increase and decrease in pressure within the cylinder on the opposite side of the piston from the gas cushion during pulsations has a magnitude of less than 0.1 atmosphere.

8. The apparatus of claim **1** further including means for increasing and decreasing the amount of gas within the system comprising the gas cushion, the buffer chamber and the restricted communication for varying the amplitude of pulsations in the column.

9. As an improvement for a combination which includes:

an extraction column partly filled with liquid to be pulsed and with filling means for enhancing extraction; a U-shaped chamber external of the column having a connection with the lower end of the column with means defining a gas cushion above the liquid surface in the chamber; a piston slidably received in a sealed cylinder external of said pulsing chamber and communicating with the gas cushion; and means for oscillating the piston in the cylinder to increase and decrease the force with which the gas cushion acts upon the liquid surface in the chamber in order to cause the liquid in the column and the chamber to pulsate; means defining a sealed buffer chamber external of said pulsing chamber having a volume at least as large as the average volume of the gas cushion, said buffer chamber being communicated to said cylinder on the opposite side of said piston from said gas cushion.

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