

PATENT SPECIFICATION (11)

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(54) IMPROVEMENTS IN OR RELATING TO APPARATUS COMPRISING A PARTICLE GROWTH-PROMOTING DEVICE

(71) We, PIELKENROOD-VINITEX B.V., a Dutch Body Corporate of 13 Industrieweg, Assendelft, The Netherlands, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to apparatus comprising a device for promoting growth of particles in a flowing liquid, prior to separation of the particles from the liquid.

In our earlier Patent Specification No. 1,433,171 there are proposed devices for causing coalescence of particles suspended in a carrier liquid, comprising an inlet and an outlet, the inlet communicating with a supply for the liquid suspension, and the outlet being arranged to be connected to a settling device for separating the coalesced particles from the carrier liquid.

In such devices use is made of the transverse velocity gradients caused by friction against the walls of the device, as a consequence of which the suspended particles can overtake one another, so that particle growth by coalescence will occur. In one preferred embodiment the device consists of a basin in which consecutive chambers are separated by means of vertical partitions, and the liquid can pass alternately below and over alternate partitions. In order to prevent the coalesced particles from being disrupted by shearing forces caused by the velocity gradients, the cross-section of consecutive chambers is increased step-wise or gradually in the sense of flow, so that the flow velocity will decrease accordingly. Furthermore, in order to increase the velocity gradients, partitions may be arranged in these chambers, which partitions are, in particular, corrugated and, if desired, slidable. However, this previously proposed device cannot readily be adapted for use in installations of small size since difficulties can arise when reducing the dimensions of the device. In particular the use of suitable corrugated plates will be difficult as the passages between the crests of adjacent plates and between crests and ad-

jacent walls cannot be maintained at the desired width without difficulties, and, moreover, the velocity in such passages may easily become too high. The manufacturing cost of smaller devices will be disproportionately higher.

According to the present invention, there is provided apparatus comprising a settling device and a device intended to promote particle growth in a flowing liquid suspension prior to separation of the grown particles from the liquid in the settling device, said growth-promoting device comprising a duct having an inlet arranged to receive the liquid suspension and an outlet arranged to discharge the liquid suspension towards an inlet of the settling device, said duct being formed by at least one tube, the cross-sectional size of the or each tube being such that with liquid suspension flow at the design flow rate of the settling device, wall friction will cause differences in the flow velocity of the particles relative to each other in the liquid suspension flow so that particle growth by coalescence is obtained, and the cross-section of the or each tube is such that at any point in the liquid suspension flow, the flow velocity is sufficient to prevent separation of particles in the liquid suspension flow, but is lower than the velocity at which the coalesced particles will be disrupted by a shearing action as a consequence of velocity gradients in the vicinity of that point.

The duct may be formed from commercially available tubes, and in particular plastics tubes; also flexible tubes can be used, and the duct can be formed by a plurality of tubes with alternating flow directions interconnected by bends. Each succeeding tube may have a greater diameter than the preceding tube or the diameter of the duct may increase progressively. Several tubes may be interconnected in parallel and may incorporate stop or regulating valves. The duct may comprise a helicoidally coiled tube.

The velocity gradients can be further increased by providing suitable cores in the tubes.

Embodiments of the invention will now be

described, by way of example only, with reference to the accompanying diagrammatic drawing, in which:

Figure 1 is a schematic cross-section of a part of a growth-promoting device of apparatus according to the invention;

Figures 2A and 2B are simplified representations of the growth-promoting devices having branches connected in parallel; and

Figures 3 to 5 are fragmentary cross-sections of modified forms of the growth-promoting device.

There is shown in Figure 1 a part of a particle growth-promoting device comprising a plurality of substantially vertical tubes 1, which are interconnected by means of bends 2 to form a continuous passage. The inlet of the passage is connected to a supply (not shown) for the liquid to be treated, and the outlet of the passage is connected to a settling device (not shown) such that the liquid will flow in the sense indicated by the arrows through the consecutive tubes.

The friction against the tube walls then causes transverse velocity gradients increasing the probability that the particles suspended in the liquid will overtake others whereby particle growth by coalescence will occur.

In the case shown the diameter of the consecutive tubes 1 increases, so that the velocity of the liquid and the velocity gradients both decrease. Alternatively the tubes can each have the same diameter.

If at the flow velocity which is required for obtaining the desired effect, an insufficient volumetric flow rate is obtained, several tubes 1 can be connected in parallel. Figure 2A shows such an arrangement in which several tubes 1 are connected in parallel between a supply duct 3 and a settling device 4. Stop or regulating valves 5 allow the number of operative tubes and/or the flow rate therein to be varied at will. Figure 2B shows another arrangement in which the use of tubes of increasing diameter is simulated by gradually connecting more tubes with the same diameter in parallel. Also in this case stop or regulating valves can be used.

The bends 2 can be provided, if necessary, with drain valves 6 (see Figure 1).

Instead of rigid tubes, flexible tubes (i.e. hoses) can alternatively be used, so that the separate bends 2 will be superfluous. Furthermore, helically wound rigid or flexible tubes can be used so as to obtain a reduction in space.

In order to increase the velocity gradients, a cylindrical core 7 can be arranged, as shown in Figure 3, along the axis of the tube 1. The core 7 can be slidably introduced through the wall of the tube so as to enable the length of the core parts extending in the tube and thus its influence on the flow, to be varied. If longitudinal velo-

city gradients are desired, either the wall of the tube 1 can be corrugated, or a corrugated core 7¹ can be used, and it is also possible to apply both measures, as shown in Figure 4. In the latter case a variable phase difference between both corrugations can be obtained by shifting the core 7¹ with respect to the tube 1¹, so as to control the velocity gradients accordingly in a similar manner to that described in Patent Specification No. 1,433,171 in which mutually slidable corrugated plates are used for this purpose.

Furthermore, it is possible to make the corrugations in the wall and/or the core helicoidal, with the helix of the wall corrugations being of opposite hand to that of the core corrugations.

A corrugated core 7¹ can be manufactured from plastics in the desired shape, but can also, as shown in Figure 4, be composed from balls 10 supported on a rod 9; as shown one set of alternate balls are of a different diameter to that of the other set of alternate balls. Corrugated tubes can be formed from plastics in the desired shape, and it is also possible to shape straight tubes into corrugated form.

A different distribution of the velocity gradients can be obtained by replacing one of the tubes 1 by two S-bends 11 (Figure 5) joined together or by bending a hose into this shape. A further development thereof is winding a tube or hose in helicoidal shape, as mentioned already above.

Furthermore, it is possible to provide a flexible tube with constrictions by means of clamps in order to obtain a velocity gradients corresponding to the velocity gradients obtained with corrugated tubes.

The devices particularly described may be formed from commercially available tubes with a round cross-section in which very favourable velocity gradients can be obtained. In this manner it becomes possible to construct a growth-promoting device which is suitable for use with smaller separation devices, by means of very simple elements.

WHAT WE CLAIM IS:—

1. Apparatus comprising a settling device and a device intended to promote particle growth in a flowing liquid suspension prior to separation of the grown particles from the liquid in the settling device, said growth-promoting device comprising a duct having an inlet arranged to receive the liquid suspension and an outlet arranged to discharge the liquid suspension towards an inlet of the settling device, said duct being formed by at least one tube, the cross-sectional size of the or each tube being such that with liquid suspension flow at the design flow

described, by way of example only, with reference to the accompanying diagrammatic drawing, in which:

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Figures 3 to 5 are fragmentary cross-sections of modified forms of the growth-promoting device.

There is shown in Figure 1 a part of a particle growth-promoting device comprising a plurality of substantially vertical tubes 1, which are interconnected by means of bends 2 to form a continuous passage. The inlet of the passage is connected to a supply (not shown) for the liquid to be treated, and the outlet of the passage is connected to a settling device (not shown) such that the liquid will flow in the sense indicated by the arrows through the consecutive tubes.

The friction against the tube walls then causes transverse velocity gradients increasing the probability that the particles suspended in the liquid will overtake others whereby particle growth by coalescence will occur.

In the case shown the diameter of the consecutive tubes 1 increases, so that the velocity of the liquid and the velocity gradients both decrease. Alternatively the tubes can each have the same diameter.

If at the flow velocity which is required for obtaining the desired effect, an insufficient volumetric flow rate is obtained, several tubes 1 can be connected in parallel. Figure 2A shows such an arrangement in which several tubes 1 are connected in parallel between a supply duct 3 and a settling device 4. Stop or regulating valves 5 allow the number of operative tubes and/or the flow rate therein to be varied at will. Figure 2B shows another arrangement in which the use of tubes of increasing diameter is simulated by gradually connecting more tubes with the same diameter in parallel. Also in this case stop or regulating valves can be used.

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In order to increase the velocity gradients, a cylindrical core 7 can be arranged, as shown in Figure 3, along the axis of the tube 1. The core 7 can be slidably introduced through the wall of the tube so as to enable the length of the core parts extending in the tube and thus its influence on the flow, to be varied. If longitudinal velo-

city gradients are desired, either the wall of the tube 1 can be corrugated, or a corrugated core 7¹ can be used, and it is also possible to apply both measures, as shown in Figure 4. In the latter case a variable phase difference between both corrugations can be obtained by shifting the core 7¹ with respect to the tube 1¹, so as to control the velocity gradients accordingly in a similar manner to that described in Patent Specification No. 1,433,171 in which mutually slidable corrugated plates are used for this purpose.

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WHAT WE CLAIM IS:—

1. Apparatus comprising a settling device and a device intended to promote particle growth in a flowing liquid suspension prior to separation of the grown particles from the liquid in the settling device, said growth-promoting device comprising a duct having an inlet arranged to receive the liquid suspension and an outlet arranged to discharge the liquid suspension towards an inlet of the settling device, said duct being formed by at least one tube, the cross-sectional size of the or each tube being such that with liquid suspension flow at the design flow



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- rate of the settling device, wall friction will cause differences in the flow velocity of the particles relative to each other in the liquid suspension flow so that particle growth by coalescence is obtained, and the cross-section of the or each tube is such that at any point in the liquid suspension flow, the flow velocity is sufficient to prevent separation of particles in the liquid suspension flow, but is lower than the velocity at which the coalesced particles will be disrupted by a shearing action as a consequence of velocity gradients in the vicinity of that point.
2. Apparatus according to claim 1, wherein the duct comprises a plurality of substantially vertical sections interconnected by bends.
3. Apparatus according to claim 1, wherein the duct comprises a helicoidally wound tube.
4. Apparatus according to any one of claims 1 to 3, wherein the diameter of the duct increases from the inlet to the outlet either step-wise or progressively.
5. Apparatus according to any one of claims 1 to 4, further comprising a core extending along the axis of at least part of the duct.
6. Apparatus according to any one of claims 1 to 5, wherein the wall of the duct is corrugated.
7. Apparatus according to claim 5, or claim 6 when dependent on claim 5, wherein the core is corrugated.
8. Apparatus according to claim 7, wherein the corrugated core is formed by bodies having a rounded surface and supported on a rod.
9. Apparatus according to claim 6 or claim 7, wherein the corrugations are of helical form.
10. Apparatus according to claims 6 and 7 and 9, wherein the corrugations of the duct and those of the core are of opposite hand.
11. Apparatus according to any one of claims 6 to 10 when dependent on claim 5, wherein the core is movable axially of the duct.
12. Apparatus according to claim 6, wherein the duct comprises a number of generally S-shaped bends.
13. Apparatus according to claim 6, wherein the duct comprises a flexible tube and the corrugations in the wall of the flexible tube are obtained by means of clamps which constrict parts of the tube.
14. Apparatus according to any one of claims 1 to 13, wherein the duct comprises a plurality of tubes connected in parallel.
15. Apparatus according to claim 14, comprising stop or regulating valves in the parallel tubes.
16. Apparatus according to claim 14 or 15, wherein the duct comprises further tubes connected in parallel at the outer ends of the first-mentioned parallel tubes whereby the number of tubes connected in parallel increases from the inlet towards the outlet of the device, each of said tubes being of substantially the same diameter.
17. Apparatus substantially as hereinbefore described with reference to the accompanying drawings.
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