# PATENT SPECIFICATION (11) 1 473 525

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(21) Application No. 35911/74 (22) Filed 15 Aug. 1974
(31) Convention Application No. 7312337
(32) Filed 7 Sept. 1973 in
(33) Netherlands (NL)
(44) Complete Specification published 11 May 1977
(51) INT CL² B01D 17/02
(52) Index at acceptance
B1D 500 511 513 522 563 566 602

(19)

## (54) IMPROVEMENTS IN OR RELATING TO SEPARATING DEVICES AND PARTICLE GROWTH-PROMOTING DEVICES

(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 the separation of components suspended in a liquid flow and to devices for promoting the growth of such components.

In Patent Specification No. 1,433,171 there is described a device for promoting the growth of particles suspended in a carrier liquid to facilitate subsequent separation of the particles from the liquid. In this device, the carrier liquid with suspended particles to be separated therefrom is led through substantially vertically extending passages between substantially parallel walls, which walls will cause therein by friction with the liquid a transverse velocity gradient so that the particles can overtake one another, which leads to an increase of the chance of coalescence between such particles, and thus, particle growth. These walls are preferably in the form of corrugated plates, the generatrices of the corrugations of these plates being directed transversely to the flow direction, i.e. substantially horizontally. If desired alternating corrugated plates can be made slidable in the flow direction so as to allow the phase relationship between the corrugations of adjacent plates to be varied, which has an influence on the velocity gradient in the flow.

In Patent Specification No. 1,351,801 there is described a separating device in which a carrier liquid with suspended particles to be separated therefrom is led through passages between parallel corrugated plates which are inclined with respect to the horizontal plane, the flow direction either including an angle with, and in particular being directed perpendicularly to the direction of the generatrices of the corrugations, or being directed in the direction of these generatrices, in such a manner that the particles separated from the liquid are collected in the valleys or the crests of these corrugations, and can be removed along the slope of these plates towards collecting spaces.

In such devices it is very important that the corrugated plates remain uniformly spaced. In the case of flows transversely to the corrugations the danger exists that vibrations are generated in the plates. Since corrugated plates have a high rigidity in one direction, it is, for supporting such plates, generally sufficient to support the plates at their extremities in the crests and/or valleys or half-way between the crests and the valleys, or to provide supporting bottoms thereon. Such a support is, however, insufficient for suppressing vibrations, and, in the case of mutually slidable corrugated plates, such a support is not possible, or only possible when using complicated auxiliary means.

According to the invention, there is provided a device for promoting the growth of components suspended in a liquid flow, or for separating suspended components from a liquid flow, said device comprising an assembly of substantially parallel corrugated plates located in liquid container means having means for leading the liquid flow between the plates of the assembly and means for discharging the liquid after passage through the assembly, each plate of the assembly being separated from an adjacent parallel plate by at least one substantially plane grid comprising a first set of parallel rigid rods interconnected by means of a second set of rods directed transversely to the rods of the first set to form a rigid unit, the plane of each grid extending substantially parallel to the general planes of the plates.

Such grids can be constructed in various ways, and can, in particular, be arranged to support alternating plates slidably with respect to the intermediate plates.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying diagrammatic drawings, in which:

Figures 1 and 2 are fragmentary views of a plate-supporting cage;

Figures 3A, B and C are fragmentary views showing different cage arrangements;

Figure 4 is a fragmentary view of a composite cage with a plane auxiliary plate;

Figure 5 is a fragmentary view of a subdivided cage; and

Figure 6 is a partial view of a cage divided into separate parts.

In Figures 1 and 2 the basic structure of a rigid cage for supporting a plate 1 is shown schematically. The plate 1 is formed with corrugations of another repetitive profile which provides alternate crests and valleys; for convenience such a plate will be termed herein simply as a "corrugated plate". This cage consists of two parallel substantially plane grids, each consisting of rods 2 and 3 crossing each other substantially perpendicularly and being interconnected at the crossing points, which grids define a compartment 4. The grids extend parallel to the general plane of the plate 1. The rods 2 are directed transversely to the generatrices of the corrugations of plate 1 disposed in the compartment 4, and contact the crests 5 of these corrugations; it will be understood that by the phase generatrices of the corrugations as used herein there is meant lines which move along generally sinusoidal or similar paths to define the alternate crests and valleys. The connections between the rods 2 and 3 are, for instance, welded connections. The rods 3 are positioned in such a manner that they do not impede the contact between the crests 5 and the rods 2 as clearly appears from Figure 1.

The rods 2 of both grids are interconnected at least at one extremity by means of rods 6 extending transversely to the planes of the grids. For this purpose, any two rods 2 of both grids and a transverse rod 6 can consist of a single U-shaped rod. It is also possible to form the rods 2 of both grids from one single rod bent into generally square-wave form, in which case any two adjacent rods of a grid are interconnected at one extremity by a part of the rod which is directed parallel to the rods 3, and the two grids are interconnected at the opposite extremity by parts of the rod which are transverse to the planes of the grids.

After inserting the corrugated plate 1, transverse rods 6 can be provided also at the other extremity. It is also possible to weld transverse rods 7 at the lateral sides to the extremities of the rods 3 or to the rods 2 connected to extremities.

Such cages can be arranged side by side in a basin, so that the grids of adjacent cages will contact one another, the corresponding dimension of the basin being equal to the total width of these cages so that the whole assembly closely fits in the basin without play. It is preferred to position the rods 2 of the grids in the manner shown in Figure 3A. The rods of one cage are indicated at 2', and those of the next one at 2". These rods, then, contact the crests 5 of the plate in the compartment 4 of the first cage as well as those of the plate in the compartment 4 of the adjacent cage. This can be realised in a simple manner by making the distance from the first rod of a grid to the adjacent edge of this grid smaller than the distance from the last rod of this grid to the opposing edge, so that, on rotating alternate cages through 180°, the desired position of the rods 2 will be obtained.

In practice, however, it is preferred not to use separate cages to be juxtaposed, but a simple composite cage or a small number of such cages, each cage comprising the desired number of compartments 4, each compartment being separated from an adjacent one by a single grid consisting of rods 2 and 3. The rods of the different grids of such a cage can, again, be obtained by bending single rods a number of times.

Figures 3B and 3C show two possible positions of the plates 1 in adjacent compartments 4. The arrangement shown intended for a particle growth promoting device as described in Patent Specification No. 1,433,171, in which a liquid flow with suspended particles is fed vertically upwards or downwards between the plates 1. In Figure 3B in which the plate corrugations are all in phase, mainly the transverse velocity gradient caused by friction against the plates will be utilised for effecting particle growth by coalescence, increased by some additional velocity differences caused by the alternating deflections of the flow by the curves of these plates. In the arrangement of Figure 3C, however, the passage is alternately widened and narrowed, which leads to another flow configuration with velocity gradients directed substantially in the flow direction. The flow resistance, is, in this case, higher than in the case of Figure 3B.

It is now possible to obtain a gradual transition between the adjustment of Figures 3B and 3C if a plurality of cages of Figure 1 are fixed at such a distance between adjacent cages that exactly one

separate cage can fit in each interspace, the rods 2' of which fit, in the manner shown in Figure 3A, between the rods 2" of the adjacent fixed cages, the former rods then abutting the crests 5 of the plates 1 disposed in the fixed cages, and, on the other hand, the rods 2" of these fixed cages abut the crests 5 of the plate in the intermediate cages. By making these intermediate cages displaceable through at least half a wavelength of the corrugations of the plates 1, a transition from the arrangement of Figure 3B to that of Figure 3C can be obtained. It will be clear that these intermediate cages can be united into a single displaceable unit which is substantially similar to the unit formed by the fixed cages but which is inversely positioned.

Figure 4 shows another embodiment in which, between two cages with compartments 4, a narrower interspace 8 is provided in which a plane plate 9 is fitted which remains at a distance from the crests 5 of the corrugated plates 1 disposed in the compartments 4, which distance is determined by thickness of the rods 2. This plate narrows the passage between two facing crests 5, and thus increases the flow resistance, and at the same time the velocity gradient in the longitudinal direction is increased, as the ratio between the cross-sections of the wider and narrower parts is increased. If, as shown, the plate 9 extends only along a part of the corrugations, the resistance will, of course, be lower than in the case of a plate extending along all the corrugations. In this manner an adjustment of the configuration of the velocity gradient can be obtained. The plate 9 can be made slidable so as to obtain a variable adjustment.

In Figure 4 the adjacent plates 1 are shown in phase opposition. However, if the plates are in phase, a narrowing of the passage will be obtained between the curves of the plates and the intermediate plane plate 9, which will lead to a modification of the flow configuration.

The corrugated plates used for these purposes have, in the wave direction, i.e. transversely to the generatrices of the corrugations, a standard length, which, therefore, comprises a definite number of wavelengths. Although it is possible to weld together such plates so that a continuous wave is obtained, it is simpler to subdivide the cage compartments 4 in the manner shown in Figure 5 into secondary compartments by means of intermediate rods 10, which are, for instance, welded to the rods 2 or 3, each secondary compartment having, in the direction in question, the dimensions of a standard length of the corrugated plate. In this manner it is possible to join such plates without a phase difference. If required these plates are provided with recesses fitting around the transverse rods 10.

It is, of course, also possible to give these cages a dimension corresponding to the standard length, in particular in the case of a combined cage consisting of a plurality of cages juxtaposed with or without an interspace, and a number of such cages can be vertically stacked. The rods can be provided with directing members in order to obtain a correct alignment of the plates. In particular adjacent transverse rods 6 of such cages can be arranged mutually offset, which rods can bear, for instance, on longitudinal rods 3 at the extremities of adjacent cages.

In the embodiment of Figure 4 the plane plate 9 can serve as a supporting member on which the transverse rods of a superposed cage can bear. It is also possible, as shown in Figure 6, for a plate 9" of one cage to project beyond one end of the cage and to stop short of the other end so that the projecting part of the plate 9" fits into the space formed in a similar superposed cage by virtue of its plate 9' stopping short of the end of the cage.

It will, furthermore, be clear that what has been said in respect of Figure 5 regarding plates with a given standard length, also applies for plates with a standard width in the direction of the generatrices of the corrugations, in which case either the compartments 4 can be subdivided into secondary compartments in the direction in question, or individual cages can be juxtaposed in that direction.

The described cages can also be applied in separating devices in which the plates are positioned at an angle with respect to the horizontal plane, for instance as described in Patent Specification No. 1,351,801, in which the generatrices of the corrugations extend between the higher and lower sides of these plates, and the liquid flow is directed transversely thereto (and generally horizontally). It is often desired, in this case, to make the distance between the crests of the plates larger than shown in Figure 3C, and then an arrangement corresponding to Figure 4 but without the plane intermediate plate 9 can be used. Although in such cases plates with corrugations in phase are generally preferred, arrangements with the corrugations in phase opposition or with an intermediate phase relationship can alternately be used, and, if desired, the phase relationship can be made variable.

An advantage of these cages in such separating devices is, again, that a distributed support is obtained so that

additional supporting members which often reduce the flow cross-section become superfluous, and vibrations in the plates at certain flow velocities are prevented.

Also such cages can be used in plate separators in which the flow is directed parallel to the generatrices of the corrugations. If, as is often the case, plates with rather deep corrugations are used, in which the crests of a plate extend into the intermediate spaced between the crests of an adjacent plate for example as described in Patent Specification No. 1,295,123, rectilinear transverse rods contacting these crests and directed transversely to the corrugations cannot be used. Instead the crests of the plates may be suspended on longitudinal rods only which rods are, at their extremities, connected by suitable transverse rods, and, if necessary, corrugated transverse rods can be provided in intermediate points.

The pole support particularly described avoids the disadvantage of the previously proposed supports discussed earlier and provides a simple, yet effective, supporting action.

WHAT WE CLAIM IS:—

1. A device for promoting the growth of components suspended in a liquid flow, or for separating suspended components from a liquid flow, said device comprising an assembly of substantially parallel corrugated plates located in liquid container means having means for leading the liquid flow between the plates of the assembly and means for discharging the liquid after passage through the assembly, each plate of the assembly being separated from an adjacent parallel plate by at least one substantially plane grid comprising a first set of parallel rigid rods interconnected by means of a second set of rods directed transversely to the rods of the first set to form a rigid unit, the plane of each grid extending substantially parallel to the general planes of the plates.

2. A device according to claim 1, wherein at least some adjacent pairs of grids are interconnected by rods extending transversely to the planes of the grids whereby to form rigid cages which house the plates located between the grids of each pair.

3. A device according to claim 2, wherein in each said grid the rods of one of said sets are directed transversely to the generatrices of the corrugations of an adjacent corrugated plate and contact the crests of those corrugations directed towards the grid.

4. A device according to claim 3, wherein the rods of the said one set are so located that when a plurality of cages are juxtaposed the adjacent sets of rods of adjacent cages are mutually off-set so that sets of rods contact the crests of the plates located inside adjacent cages as well as the plates located inside their own cages, the thickness of the rods corresponding to the desired distance between the crest planes of adjacent plates.

5. A device according to claim 2 or claim 3, wherein at least one pair of adjacent cages comprises a grid common to both of the cages.

6. A device according to any one of claims 2 to 5, wherein the opposed grids of each cage are interconnected at predetermined distances between opposite ends of the cage by means of additional transverse rods so as to subdivide the cage into a plurality of compartments, said distances corresponding to a standard length of the plates.

7. A device according to any one of claims 2 to 5, wherein each said cage has a length corresponding to a standard length of the plates whereby when two or more cages are juxtaposed in the length direction of the plates the corrugations of the plates in the adjacent juxtaposed cages can join without a phase difference.

8. A device according to any one of claims 1 to 3, wherein a pair of said grids separates at least one pair of adjacent plates, and the grids of each said pair are separated by an intermediate compartment.

9. A device according to claim 8, wherein the intermediate compartment contains an intermediate plane plate, and the liquid container means is so arranged that the flow direction of the liquid is substantially transverse to the generatrices of the corrugations.

10. A device according to claims 7 and 9, wherein two or more cages can be stacked in the length direction of the plates and the rods extending to the plane of the grids at the lower end of one cage are arranged to bear on the end face of the intermediate plate of an underlying cage.

11. A device according to claims 7 and 9, wherein the intermediate plate projects at one end from a said cage, and is retracted at the opposite end in such a manner that, when a plurality of such cages are juxtaposed in the length direction of the plates, the projecting plate portion of one cage fits into the space beyond the plate of an adjacent cage.

12. A device according to claim 9, wherein the intermediate plate extends in the flow direction, only through a part of the intermediate compartment.

13. A device according to claim 9, wherein the intermediate plate is slidable in the flow direction.

additional supporting members which often reduce the flow cross-section become superfluous, and vibrations in the plates at certain flow velocities are prevented.

Also such cages can be used in plate separators in which the flow is directed parallel to the generatrices of the corrugations. If, as is often the case, plates with rather deep corrugations are used, in which the crests of a plate extend into the intermediate spaced between the crests of an adjacent plate for example as described in Patent Specification No. 1,295,123, rectilinear transverse rods contacting these crests and directed transversely to the corrugations cannot be used. Instead the crests of the plates may be suspended on longitudinal rods only which rods are, at their extremities, connected by suitable transverse rods, and, if necessary, corrugated transverse rods can be provided in intermediate points.

The pole support particularly described avoids the disadvantage of the previously proposed supports discussed earlier and provides a simple, yet effective, supporting action.

WHAT WE CLAIM IS:—

1. A device for promoting the growth of components suspended in a liquid flow, or for separating suspended components from a liquid flow, said device comprising an assembly of substantially parallel corrugated plates located in liquid container means having means for leading the liquid flow between the plates of the assembly and means for discharging the liquid after passage through the assembly, each plate of the assembly being separated from an adjacent parallel plate by at least one substantially plane grid comprising a first set of parallel rigid rods interconnected by means of a second set of rods directed transversely to the rods of the first set to form a rigid unit, the plane of each grid extending substantially parallel to the general planes of the plates.

2. A device according to claim 1, wherein at least some adjacent pairs of grids are interconnected by rods extending transversely to the planes of the grids whereby to form rigid cages which house the plates located between the grids of each pair.

3. A device according to claim 2, wherein in each said grid the rods of one of said sets are directed transversely to the generatrices of the corrugations of an adjacent corrugated plate and contact the crests of those corrugations directed towards the grid.

4. A device according to claim 3, wherein the rods of the said one set are so located that when a plurality of cages are juxtaposed the adjacent sets of rods of adjacent cages are mutually off-set so that sets of rods contact the crests of the plates located inside adjacent cages as well as the plates located inside their own cages, the thickness of the rods corresponding to the desired distance between the crest planes of adjacent plates.

5. A device according to claim 2 or claim 3, wherein at least one pair of adjacent cages comprises a grid common to both of the cages.

6. A device according to any one of claims 2 to 5, wherein the opposed grids of each cage are interconnected at predetermined distances between opposite ends of the cage by means of additional transverse rods so as to subdivide the cage into a plurality of compartments, said distances corresponding to a standard length of the plates.

7. A device according to any one of claims 2 to 5, wherein each said cage has a length corresponding to a standard length of the plates whereby when two or more cages are juxtaposed in the length direction of the plates the corrugations of the plates in the adjacent juxtaposed cages can join without a phase difference.

8. A device according to any one of claims 1 to 3, wherein a pair of said grids separates at least one pair of adjacent plates, and the grids of each said pair are separated by an intermediate compartment.

9. A device according to claim 8, wherein the intermediate compartment contains an intermediate plane plate, and the liquid container means is so arranged that the flow direction of the liquid is substantially transverse to the generatrices of the corrugations.

10. A device according to claims 7 and 9, wherein two or more cages can be stacked in the length direction of the plates and the rods extending to the plane of the grids at the lower end of one cage are arranged to bear on the end face of the intermediate plate of an underlying cage.

11. A device according to claims 7 and 9, wherein the intermediate plate projects at one end from a said cage, and is retracted at the opposite end in such a manner that, when a plurality of such cages are juxtaposed in the length direction of the plates, the projecting plate portion of one cage fits into the space beyond the plate of an adjacent cage.

12. A device according to claim 9, wherein the intermediate plate extends in the flow direction, only through a part of the intermediate compartment.

13. A device according to claim 9, wherein the intermediate plate is slidable in the flow direction.

14. A device according to claim 2 and claim 8, wherein the or each intermediate compartment contains a further said cage housing a corrugated plate, said latter cage being slidable transversely to the direction of the generatrices of the corrugations.

15. A device according to claim 14, wherein the or each slidable cage is movable through at least the length of one half wavelength of the corrugations, so as to enable the corrugations of the plate in the slidable cage to be moved between a position in phase with the adjacent fixed plates, and a position in phase opposition with these plates.

16. A device according to claim 2 and any one of claims 3 to 15, wherein the opposite grids of the or each cage comprise a rod bent into generally square wave form to form the rods of one said set in both grids and transverse connecting rods between the two grids.

17. A device according to any one of claims 1 to 16, intended to promote the growth of particles suspended in a substantially vertical liquid flow, wherein the grids are directed substantially vertically, and the generatrices of the corrugations of the plates extend substantially horizontally.

18. A device according to any one of claims 1 to 16, intended to act as a separation device in which the separated components are collected in the crests and/or valleys of the plates, wherein the grids are inclined to the horizontal.

19. A device substantially as hereinbefore described with reference to the accompanying drawings.

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Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1977
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.