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Mochizuki

[11] **3,727,770**

[45] **Apr. 17, 1973**

[54] **SEPARATING PLATE ASSEMBLY FOR TREATMENT OF SUSPENSION**

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July 31, 1970 Japan 45/67097

[52] **U.S. Cl.** **210/522**

[51] **Int. Cl.** **B01d 21/24**

[58] **Field of Search**.....210/521, 522, 532

[56] **References Cited**

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Primary Examiner—Reuben Friedman
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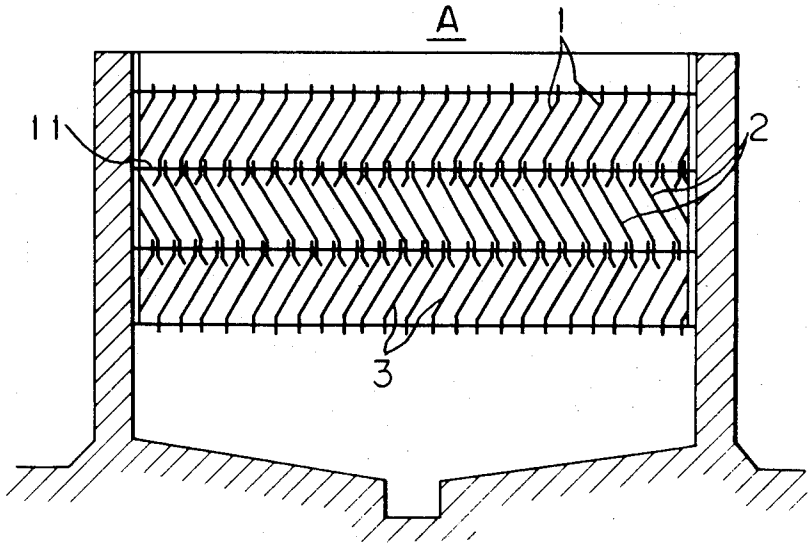
[57] **ABSTRACT**

A multi-stage separating plate assembly comprises a plurality of vertical rows of inclined separating plates arranged in a zig-zag series of plates, said rows being laterally spaced to form a liquid guide path between adjacent rows. A given separating plate at any stage in one of said rows has the lower end thereof extending across the major part of the guide path which it partially defines and close to the upper surface of the next lower separating plate in the adjacent row inclined in the opposite direction.

11 Claims, 17 Drawing Figures



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SHEET 1 OF 3

FIG. 1

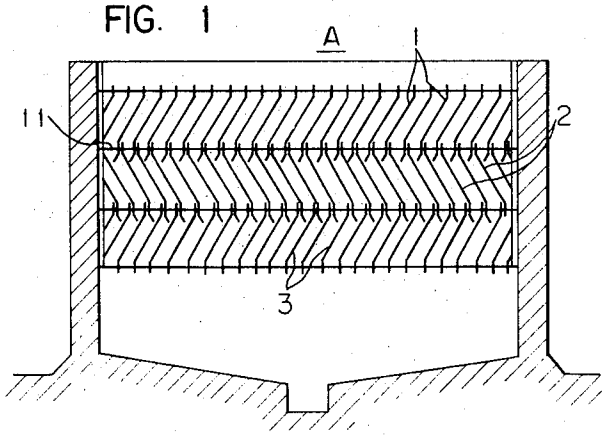

FIG. 2

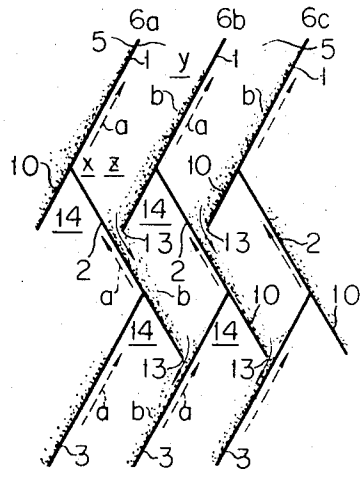

FIG. 3

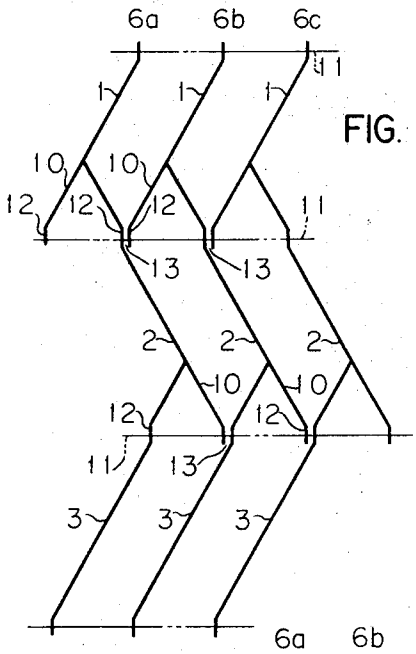

FIG. 4

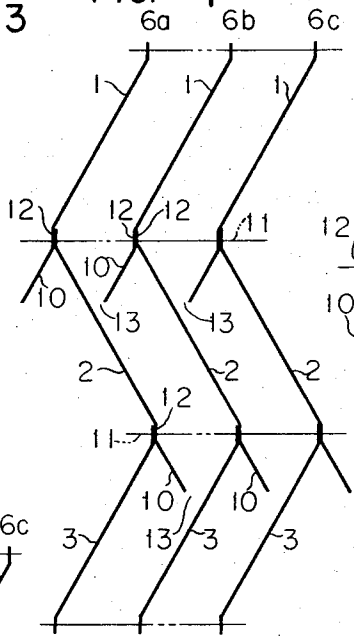

FIG. 5

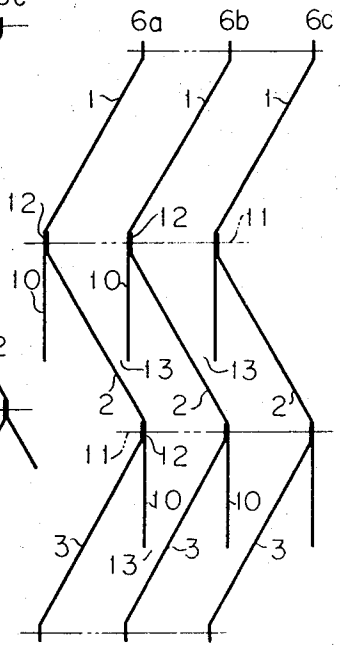

FIG. 6

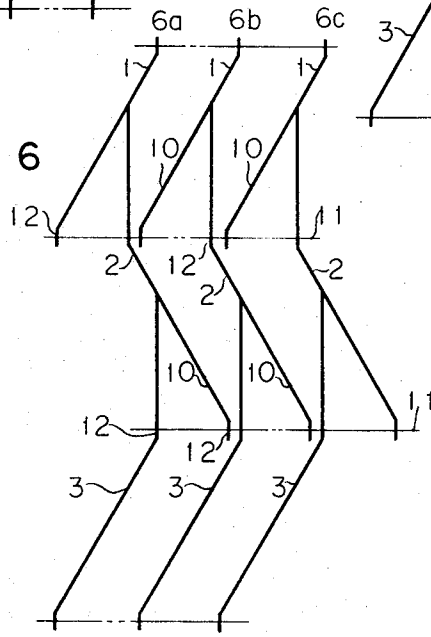

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FIG. 7

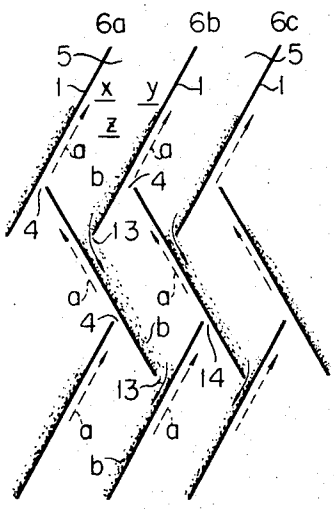

FIG. 8

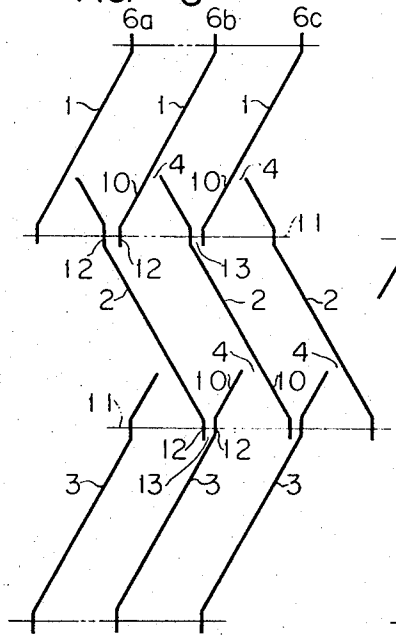

FIG. 9

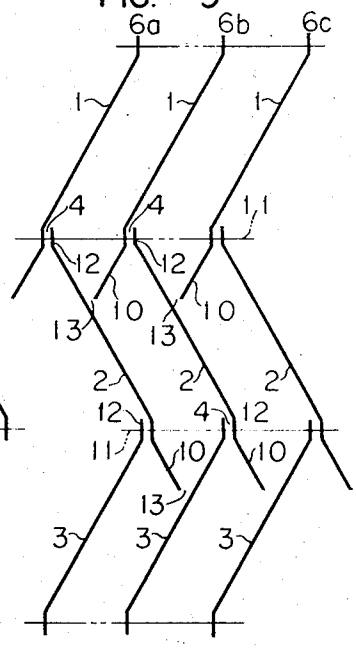

FIG. 10

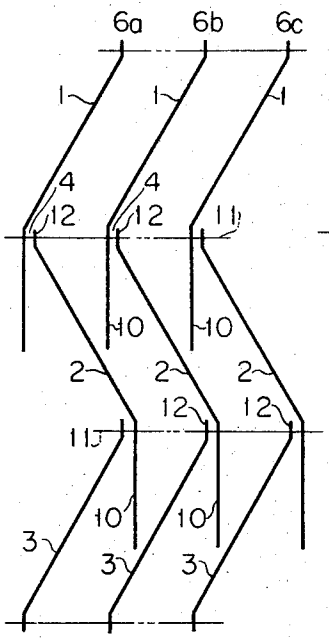

FIG. 11

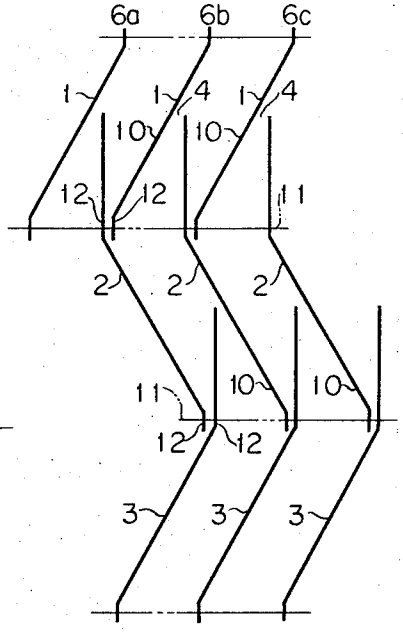

FIG. 12

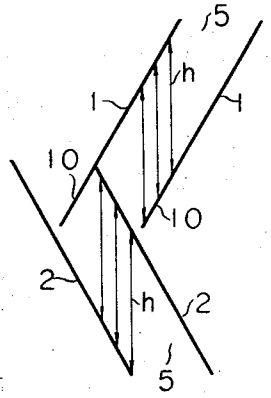

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FIG. 13

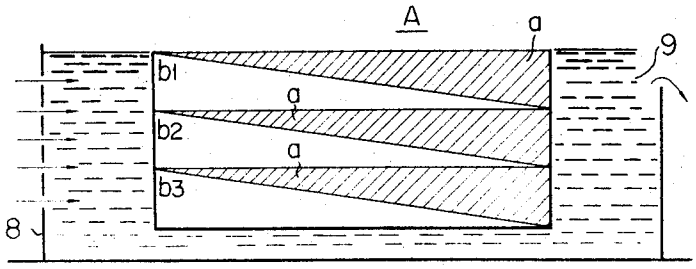


FIG. 14

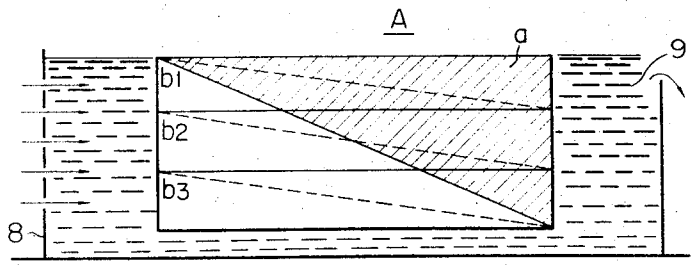


FIG. 16

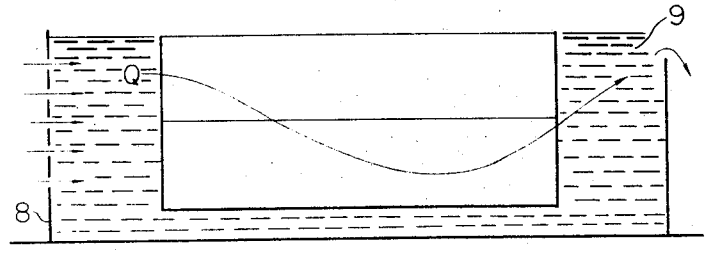


FIG. 15a

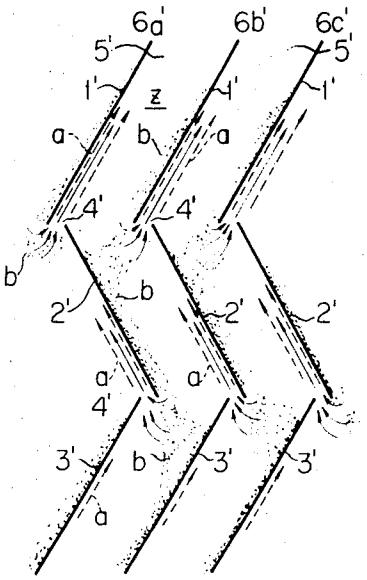
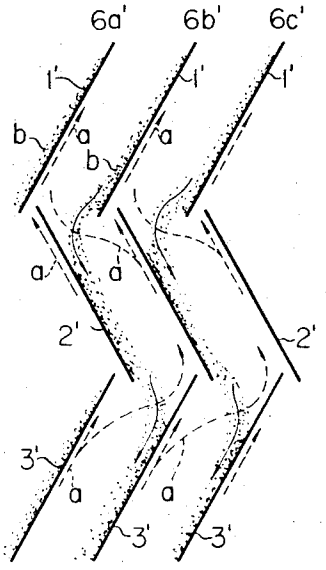


FIG. 15b



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SEPARATING PLATE ASSEMBLY FOR TREATMENT OF SUSPENSION

BACKGROUND OF THE INVENTION

This invention relates to an improvement in a horizontal flow type of apparatus for subjecting a suspension to separation, in which the suspension is continuously separated into settled particles and clarified liquid which is substantially free of the settled particles, through the use of a plurality of vertical rows of a zig-zag series of separating plate members, said rows being laterally spaced to form a liquid guide path between adjacent rows.

The hitherto known apparatus of the aforementioned type employs a plurality of vertical rows of inclined separating plates so arranged vertically that the adjacent separating plates in the same row are inclined in substantially opposite directions to each other in such a manner as to allowing the lowermost end of the upper plate to project slightly downwardly over the uppermost end of the lower plate. When the suspension is introduced into a settling tank with such a separating apparatus, the suspended particles are progressively thrown from the suspension against the upper surface of each inclined separating plate and then the settled particles successively slide down on the said upper surface toward the upper surface of the next lower separating plate at a lower stage in the adjacent row while passing across the liquid guide path formed between the adjacent rows. A clarified liquid zone substantially free of the settled and suspended particles, which zone is established in each liquid guide path, is therefore disturbed by the descending flow of the settled particles, resulting in a poor separation efficiency. Furthermore, when treating a suspension liable to flow in a dense current, such a suspension tends to flow toward the bottom of the tank because the guide path is of a vertically continuous chimney-like form. This causes the upper portion of the apparatus not to act as a separating apparatus, resulting in only partial settling and a poor separation efficiency.

SUMMARY OF THE INVENTION

In accordance with the invention, a multi-stage separating plate assembly is provided comprising a plurality of laterally spaced zigzag vertical rows each having inclined separating plates successively arranged above one another and inclined alternately in substantially opposite directions each separating plate at any stage in one of said rows having a partition wall extending downwardly therefrom close to the upper surface of the next lower separating plate in the adjacent row and across the major part of the space between the adjacent rows. In a settling tank equipped with such an improved separating plate assembly, the settled particles thrown from the suspension onto the upper surface of each separating plate at any stage in one of said rows can slide down toward the upper surface of the next lower separating plate in the adjacent row without disturbing a claified liquid zone substantially free of the suspended and settled particles, and since the liquid guide path is partitioned by the partition walls provided on the separating plates, the suspension has no tendency to flow toward the bottom of the tank.

An object of the present invention is therefore to provide an improved separating plate assembly of the

type described which promotes efficiency in subjecting the suspension to segregation.

Other objects and advantages of the present invention will become apparent from the following detailed description taken in conjunction with the accompanying drawings in which similar reference characters denote similar parts throughout the figures.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagrammatic cross section of one example of a settling tank in which a separating plate assembly of the present invention is contained;

FIGS. **2** to **11** are diagrammatic fragmental views of different embodiments of the present invention, each showing a cross section of a portion of the separating plate assembly;

FIG. **12** is a view for explanating one feature of the present invention;

FIGS. **13** and **14** are diagrammatic views for explaining a process for clarification of the suspension in the separating apparatus of FIGS. **2** to **6** and FIGS. **7** to **11**, respectively;

FIGS. **15***a* and **15***b* each show diagrammatically a portion of a conventional separating plate assembly, in section; and

FIG. **16** is a diagrammatic view for explaining a disadvantage of the conventional assemblies of FIGS. **15***a* and **15***b*.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings and in particular to FIG. **1**, there is shown a multi-stage separating plate assembly of the present invention installed in a settling tank A in a conventional manner, which tank is shown here as having a substantially rectangular cross-sectional shape by way of example. However, the tank may be of any cross sectional shape desired. A suspension that is to be subjected to separation in the tank A is fed horizontally i.e., in a direction perpendicular to the surface of the drawing at a suigable speed. As will be appreciated, the tank A may be or may not be of a batch type.

For a better understanding of the present invention, certain conventional separating apparatus of the type described will be first illustrated in detail in conjunction with FIGS. **15***a* and **15***b* prior to the description of the preferred embodiments of this invention.

FIG. **15***a* shows a part of a conventional multi-stage separating plate assembly which comprises a plurality of laterally (i.e., in a direction perpendicular to that of suspension flow) equispaced vertical rows **6***a*′, **6***b*′, and **6***c*′, each consisting of a plurality of separating plates **1**′, **2**′ and **3**′ alternately inclined in substantially opposite direction relative to each other and arranged in a zigzag series. Therefore, any pair of adjacent zigzag rows of plates define between them a liquid guide path **5**′. In operation, for each guide path **5**′, there are created a zone *x* of a clarified liquid *a* along the lower surface of each of the inclined separating plates **1**′, **2**′ and **3**′, a zone *y* of settled materials, i.e., concentrated particles *b* settled on the upper surface of each of the separating plates, and an intermediate zone *z* existing between these zones *x* and *y*. In the zone *z*, the separation of the clarified liquid *a* from the suspended particles *b* is in progress. The collections of the particles *b*

settled on the upper surface of each of the separating plates 1', 2' and 3' are caused by the gravity acting thereon to successively descend or slide down across the intermediate zone *z*, with the attendant disadvantage that the liquid in the intermediate zone *z* is remixed with the descending particles *b*. Additionally, such descending particles *b* once separated from the liquid medium are also remixed with the ascending clarified liquid *a* in the zone *x* every time it goes through successive gaps 4' provided between the adjacent plates of each row. That is, a portion of the settled particles *b* in the vicinity of each gap 4' is attracted as shown by solid arrows toward and entangled into the ascending flow of the clarified liquid *a* shown by dotted arrows.

With the aforesaid conventional separation apparatus, as described above, the unfavorable remixing of the concentrated particles *b* with the clarified liquid *a* and the liquid in the intermediate zone *z* occurs throughout the whole separating plate assembly, resulting in a poor separation efficiency of the apparatus.

FIG. 15*b* shows another embodiment of a conventional separating apparatus, in which each gap 4' is reduced in width in order to eliminate the abovementioned disadvantage. In such an apparatus with the reduced gaps, however, a portion of the clarified liquid *a* ascending along the lower surface of each separating plate tends to move upwardly away from a direction of inclination of the associated separating plate and across the guide path 5', so that the settled particles *b* sliding down along the upper surface of the associated separating plate, e.g., the separating plate 1' in the row 6*b*' are scattered about, whereupon a portion of the settled particles *b* are remixed into the flow of the clarified liquid *a* along the lower surface of the separating plate 1' in the adjacent row 6*a*'. This also results in a poor separation efficiency of the apparatus.

Another problem lies in the fact that in these prior art apparatus each guide path 5' is chimney-like in form extending between the adjacent rows of the multi-stage separating plates continuously from the surface of the liquid to be treated to the bottom of the tank with approximately same width. This fact causes, where it is necessary to continuously treat a liquid Q liable to flow in a dense current, such as a liquid of high density or a liquid containing heavy particles in suspension, a downward flow of the liquid of the abovementioned kind to build up in the tank A as shown in FIG. 16. Accordingly, the upper portion of the apparatus is utilized hardly at all and does not act as a separation apparatus. In other words, only some separating plates effectively act on the liquid to be treated and the liquid flows out over an overflow weir 9 without complete settling of the suspended particles. In FIG. 16, reference numeral 8 represents an evener wall with a plurality of holes for the suspension to pass through.

A further problem lies in the fact that as the guide path 5' continues to extend vertically in the abovementioned manner, there can occur, in each guide path 5', counter flows extending in upward and downward directions due to the counter flows of the settled particles *b* and clarified liquid *a*, i.e., the ascending flow of the clarified liquid *a* along the lower surface of each separating plates and the descending flow of the settled particles *b* along the upper surface of each separating plate. This also results in a poor separation efficiency.

This invention provides a multi-stage particle-separating plate assembly having an improved efficiency of separation of the suspended particles from the suspension thereof.

Referring now to FIG. 2, there is shown a part of an embodiment of a multi-stage particle separating plate assembly according to the invention which assembly is somewhat similar to those of FIGS. 15*a* and 15*b* except that there is no gap between adjacent particle separating plates of the same row and each liquid guide path between adjacent rows is partitioned by partition walls extending from the lower ends of the associated particle separating plates across the liquid guide path. It is to be understood that, although the three-stage particle separating plate assembly comprising three rows each consisting of three particle separating plates is shown, the assembly may employ any desired number of rows each consisting of any desired number of particle separating plates.

In FIG. 2, reference numerals 1, 2 and 3 show particle separating plates (which may be referred to as first, second third-stage particle separating plates, respectively) inclined alternately in opposite directions to each other and successively arranged to form a zigzag row of particle separating plates. In this manner, a plurality of rows 6*a*, 6*b* and 6*c* are provided in a laterally equispaced relationship. Preferably, all of the particle separating plates in the same stage are inclined in the approximately same direction and all of the particle separating plates in the next stage are inclined in the substantially opposite direction to that of the first stage of particle separating plates. Each of the particle separating plates 1, 2 and 3 are provided at its lower end with a partition member 10 which downwardly extends across the major part of the liquid guide path 5 between the adjacent rows and close to the upper surface of the lower next stage particle separating plate in the adjacent row and ending just short of the next lower stage plate to leave a space 13 between the lowermost end of the member 10 and the said upper surface. The partition wall 10, therefore, partitions the associated liquid guide path 5 and intermediate zone Z into parts.

The partition wall 10 is illustrated as being an integral part of the associated particle separating plate, however, it need not be an integral part.

It is noted that the space 13 has to be large enough to allow the settled particles *b* to pass easily therethrough and to present them from passing across the intermediate zone *z*.

In operation, when the settling tank A is supplied with a suspension, the suspended particles *b* in the suspension begin to settle under the action of gravity onto the upper surface of each of the separating plates 1, 2 and 3 and then slide down through each spaces 13 toward the upper surface of each of the lower stage separating plates in the adjacent row. That is to say, the suspended particles *b* settled on the upper surfaces of the first and second stage separating plates 1 and 2 in the row 6*b* slide down respectively onto the upper surfaces of the second stage separating plate 2 in the lefthand row 6*a* and third stage separating plate 3 in the righthand row 6*c* without passing across the intermediate zone *z*, in which the settling of the suspended particles *b* is in progress, and then successively through the spaces 13 toward the bottom of the tank A. Although the settling operation has been described in

conjunction with the specific separating plates, it is to be understood that such a settling movement occurs throughout the particle separating assembly. In the meantime, the clarified liquid *a* obtained ascends in the clarified liquid zone *x* along the lower surface of each of the separating plates **1**, **2** and **3** and collects in a trigonal space **14** defined by the partition member **10** and the upper portion of the separating plate in the next lower stage to the separating plate from which the partition member extends. With respect to the separating plate assembly of FIG. **2**, the movements of the clarified liquid *a* and suspended particles *b* are shown in FIG. **13**. Namely, the particles *b***1**, *b***2** and *b***3** in the respective stages settle slowly during the travel of the suspension from the inlet to the outlet of the apparatus, and in the meantime the clarified liquid is produced in each stage as shown by the hatched portion of the figure and flows substantially horizontally toward the weir **9**.

As described hereinbefore, the present invention has provided an improved apparatus in which each separating plate has a partition wall so depending therefrom as to interrupt the intermediate zone between any pair of adjacent zigzag rows of the separating plates. With such an apparatus, the settled particles sliding down the plates are prevented from passing across the intermediate zone in the guide path, and are allowed only to move down onto the upper surface of the next lower stage separating plates in the adjacent row. It is stated again that this results in overcoming the following disadeantages of the heretofore known apparatus;

1. Both the intermediate zone in which the segregative treatment of the suspension is being effected to a certain extent and the ascending clarified liquid separated from the suspended particles are agitated due to collision with the already settled out particles; and

2. The settled out particles are taken up into a continuous flow of clarified liquid passing upwardly through the gaps along the lower surface of each of the separating plates.

Furthermore, the apparatus of the present invention provides a guide path which is partitioned by the partition walls so that it is not a vertically continuous chimney-like space tending to cause counter flows in the guide path and therefore the liquid in such an apparatus is not agitated. In addition, the apparatus according to the invention can be adapted for the treatment of a liquid which would create a current, resulting in extreme improvement in separation efficiency.

With respect to the embodiments shown in FIGS. **3** to **6**, at substantially midway of the height between the lower and upper ends of each pair of successive separating plates **1** and **2**, and **2** and **3** in each row, there is provided a pair of vertically extending opposed portions **12**, having a bar **11** fixed thereto to carry the separating plate assembly. The supporting bar **11** may be connected to the portions **12**, either by directly joining them together or by means of fittings.

In FIG. **3**, for example, one of the paired portions **12**, is provided at the lower end of the partition wall **10** of the separating plate **1** in the row **6***b* and the other is provided at a corresponding portion of the separating plate **2** in the adjacent row **6***a*. The paired portions **12**, are spaced a suitable distance to form the said space **13** therebetween.

In FIG. **4**, for example, one of the paired portions **12**, is provided at the base of the partition wall **10** of the separating plate **1** in the row **6***b* and the other is provided at the upper end of the separating plate **2** in the same row.

The assembly of FIG. **5** is similar to that of FIG. **4** except that each partition wall **10** extends vertically downwardly rather then obliquely.

The assembly of FIG. **6** is similar to that of FIG. **3** except that the upper portion of the separating plate above the portion **12** extends vertically upwardly rather then obliquely.

These embodiments shown in FIGS. **3** to **6** have the same separating effect at that described in conjunction with FIG. **2**. It is to be noted that, with the apparatus shown in FIGS. **2**, **3** and **4**, since the settling distance *h* in the guide path is substantially uniform as shown in FIG. **12**, i.e., there is no portion having an extremely large settling distance, there is no possibility that the suspended particles *b* will overflow with the horizontal flow without settling and the time required for the treatment of the suspension is not prolonged.

FIG. **7** shows still another embodiment of the assembly, the construction of which is similar to that of FIG. **2** except that a gap **4** is formed between the successive separating plates in the same row. In operation, when the suspension to be treated enters the tank, the suspended particles *b* in the suspension descend in the direction of the gravity and are deposited on the upper surface of each of the separating plates **1**, **2** and **3**. Then, the settled particles on the upper surfaces of, for example, the separating plates **1** and **2** in the row **6***b* slide down respectively onto the upper surfaces of the separating plates **2** and **3** in the adjacent rows **6***a* and **6***c* without passing across the intermediate zone *z* in the associated guide path **5**. In this manner, the settled particles *b* successively slide down stepwise toward the bottom of the tank. At the meantime, the clarified liquid is created below the lower surfaces of, for example, the separating plates **2** and **3** and continuously flows in a zigzag path in the vertical and horizontal component directions through the gaps **4** along the lower surfaces of the separating plates while being separated from the particles *b* sliding-down and reaches the upper surface portion of the liquid to be treated, from which it is directed toward the overflow weir **9** (FIG. **14**). The movements of the suspended particles *b* and clarified liquid *a* are shown in FIG. **14**, from which it will be appreciated that the settling of the suspended particles *b***1**, *b***2** and *b***3** in the respective stages is completed during their travel from one end to the other of the apparatus and in the meantime more clarified liquid *a* is produced in the higher portion of the tank than in the lower portion as shown by the hatched portion because of the presence of the gaps **4**. Therefore, a larger volume of the clarified liquid can flow out of the tank, resulting in a high separating efficiency.

According to the arrangement of FIG. **14**, an improved separation effect can be expected because the clarified liquid ascends while flowing in the horizontal component direction. The clarified liquid in the arrangement of FIG. **2** goes only with the horizontal flow toward the overflow weir **9**. Furthermore, even when treating a liquid having suspended particles and a liquid medium between which a relatively great difference in specific gravity exists, there is no possibility of causing

the inconvenience of the clarified liquid produced in each compartment defined by, for example, the partition wall **10** of the plate **1** of the row **6***b*, the mid portion of the plate **2** of the row **6***a*, the partition wall **10** of the plate **2** of the row **6***a* and the upper portions of the plates **2** and **3** of the row **6***b*, running over this compartment and consequently ascending toward another upper compartment over the extremity of the partition wall **10** or through the spacing **13** to cause a disturbance in the liquid.

It will therefore be understood that in the arrangement of FIG. **7**, like the embodiment shown in FIG. **2**, there is no disturbance in the liquid due to the sliding-down movement of the settled particles in the vicinity of the gap **4** opening into the guide path, no remixing of these settled particles into the ascending clarified liquid, and no influence of current due to the density of the liquid.

Further embodiments are shown in FIGS. **8** to **11** which correspond in construction to the embodiments shown in FIGS. **3** to **6**, respectively, except that the gap **4** is formed between successive separating plates of the same row. Therefore, these embodiments have the same effect as the embodiments of FIGS. **3** to **6**.

Although various specific embodiments have been described above, it will be readily understood by those skilled in the art that various rearrrangements of parts and modifications of parts may be accomplished without departing from the spirit and scope of the invention.

What I claim is:

1. A multi-stage separating plate assembly for subjecting a substantially horizontally flowing suspension to a separation into settled particles and clarified liquid, comprising a plurality of laterally equispaced vertical rows each consisting of a plurality of separation plates extending substantially parallel to the flow of the suspension and alternately inclined in opposite directions and arranged in a zigzag series, the corresponding separating plates on the same horizontal level being inclined in the same direction and forming a stage of plates and two adjacent rows forming a suspension guide path therebetween, each of said separating plates in each row having at its lower end a partition member extending across the guide path and terminating close to the upper surface of the separating plate which is in the now adjacent thereto and which is one stage below said separating plate, thereby to partition the major part of said suspension guide path formed by said two adjacent rows and thereby to form a trigonal space in each row defined by said partition member and the upper portion of the separating plate in the same row and one stage below said each separating plate, whereby the clarified liquid collects in said trigonal space and flow of settled out particles from the portion of the guide path above the partition can flow to the portion of the guide path below the partition without interfering with the clarified liquid or being disturbed by the flow of the clarified liquid in said trigonal space.

2. An assembly according to claim **1** wherein each partition member extends in the same direction as the inclination of said separating plate.

3. An assembly according to claim **1** wherein the free end of each of said partition members and a corresponding portion of said separating plate spaced from said free end are bent substantially vertically and a bar attached to the vertically bent portions in each stage to carry the multi-stage separating plate assembly.

4. An assembly according to claim **3** wherein the upper portion of each of said separating plates above said bend thereof extends vertically upwardly until it reaches the separating plate one stage above said each separating plate.

5. As assembly according to claim **1** wherein, in each row, the lower end of one of said separating plates and the upper end of the separating plate in the stage below said one separating plate are bent substantially vertically and a bar attached to the bent portions in each stage to carry the multi-stage separating plate assembly.

6. An assembly according to claim **5** wherein said partition members extend vertically downwardly.

7. An assembly according to claim **1** wherein, in each row adjacent separating plates are spaced to leave therebetween a gap for clarified liquid produced in each trigonal space to pass upwards therethrough.

8. An assembly according to claim **7** wherein the free end of each of said partition members and a corresponding portion of said separating plate spaced from said free end are bent substantially vertically and a bar attached to the vertically bent portions in each stage to carry the multi-stage separating plate assembly.

9. An assembly according to claim **8** wherein the upper portion of each of said separating plates above said bend thereof extends vertically upwardly and stops just short of the separating plate one stage above said each separating plate to leave said gap between said upper portion and the lower surface of the separating plate one stage above said each separating plate.

10. An assembly according to claim **7** wherein, in each row, the lower end of one of said separating plates and the upper end of the separating plate in the stage below said one separating plate are bent substantially vertically and a bar attached to the bent portions in each stage to carry the multi-stage separating plate assembly.

11. An assembly according to claim **10** wherein said partition members extend vertically downwardly.

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