

PATENT SPECIFICATION

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(54) IMPROVEMENTS IN AND RELATING TO THE TREATMENT OF LIQUIDS

(71) I, DAVID ALAN BURT, a British Subject, of 45/47 South Street, Bishop's Stortford, Hertfordshire, 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:—

This invention relates to methods of and apparatus for the treatment of liquids, more specifically to the treatment of liquids for the separation of suspended matter. The invention can be applied with advantage to the treatment of industrial effluents, though it is of wider application.

The invention has for its object to provide an improved method of and means separating suspended matter from liquids.

The present invention provides a separator comprising a container provided with means dividing the container into a first section, an intermediate section and a third section, and a separator element in the intermediate section, said separator element comprising a plurality of inclined superposed spaced corrugated sheets, channel means connected to the undersides of the crests of the corrugations of said sheets for collecting material rising on the undersides of the crests, and further channel means connected to the uppersides of the troughs of the corrugations for collecting material falling on the uppersides of the troughs, the dividing means comprising a flat topped weir dividing the first and intermediate sections, the width of the flat top of the weir in the direction in which liquid will flow across it being such that, in use, the liquid flows over the weir under conditions of laminar flow.

The present invention further provides a method of separating suspended matter from a liquid utilising the separator as above comprising causing said liquid to flow from the first section to the intermediate section under conditions of laminar flow through said separator element into the third section, collecting

matter rising on the undersides of the crests of the corrugations of the sheets, collecting matter falling on the uppersides of the troughs of said corrugations, and removing from the third section the liquid from which suspended matter has been separated.

Features and advantages of the invention will appear from the following description of an embodiment thereof, given by way of example, in conjunction with the accompanying drawings, in which:—

Figure 1 is a vertical diagrammatic sectional view through a liquid treatment installation;

Figure 2 is a plan view of the installation of Figure 1, with the covers partly in position;

Figure 3 is a perspective view, partially broken away, of a separator element for use with the installation of Figure 1;

Figure 4 is a broken away side view of a part of the separator element of Figure 3; and

Figure 5 is a perspective view of a spacer block used in the separator element of Figure 3.

The treatment installation shown in these Figures comprises a main outer container formed as a reinforced concrete structure but which may be a tank. The structure has side walls 10 and 11, with a central dividing wall 12, to provide in effect two separation units, side by side, with common inlets and outlets. The side walls and the dividing walls are vertical and parallel, and the floor of the installation is shaped, as is more clearly shown in Figure 1, so as to present a first section 13 which is approximately horizontal, and which terminates at a barrier 14. The barrier 14 is roughly triangular in section, and provides a long downwardly sloping floor 15. The top edge of this barrier, at 16, is flat and horizontal.

The floor 15 extends to a further substantially horizontal section 17, in which barrier 18 defines an outlet chamber 19. The top 20 of barrier 18 is at the same level as the top 16 of barrier 14 and is also flat.

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Two baffles are provided, the first of which is at 21, in the inlet side of the apparatus and the second at 22, approximately above the lower end of the sloping floor 15. The arrangement of the barriers and baffles in the two parallel units is the same.

In the middle part of each unit of the installation is a separator element 25. As shown in Figure 3, the construction of a suitable element comprises a stack of sheets 50 of corrugated material mounted with a frame 51; the number, dimensions, spacing and material of these sheets depends upon the materials to be treated or separated but successful results have been obtained using corrugated unplasticised p.v.c. sheet, as commercially available. The sheets are stacked with the crests of the corrugations in alignment. The separator element is disposed in the centre section of the container at an angle; resting on the sloping floor of the centre section. The corrugated sheets are held in spaced relationship within the frame by spacers assembled on rods. To improve the mechanical strength, the bottom sheet of the separator element can be of aluminium, and the sheets can be sealed to the side walls 10, 11 and 12 of the container between which the separator element extends. The topmost sheet 50a of the separator stack is of greater length than the others above the level of the top of baffle barrier 14 and hence the level of the liquid in the container.

At each end of the separator element are disposed a series of vertical channel section members, arranged with channels facing towards the centre of the separator element; the members 52 at the upper end are disposed adjacent the crests of the topmost corrugated sheet and the members 53 at the lower end of the separator element, are positioned adjacent the troughs of the sheets of the separator element. Openings 54 are provided in the topmost sheet 50a to allow liquid in the members 52 to travel up out of separator element.

The sheets 50 are joined to spacer blocks 55 (Figure 5) by shaped slots 56 in the blocks and centrally located by the channel members 52 as shown in Figure 4. This has the advantage that the sheets tend to be self-locating in the stack, which greatly facilitates assembly. A similar arrangement is used for joining sheets to the channel members 53. A spacer block 55 is shown in more detail in Figure 5. A crest of a sheet 50 is received in the shaped slots 56 and material collected on the underside of the crest passes through an opening (not shown) in the block 55 in the direction of the arrow A and thence into the channel member 52 attached to the spacer block by

being received on shoulders 58 of the block as shown in Figure 3.

The angle at which the separator element is arranged in the central section of the container has been found to be important in securing optimum performance of the separator. It appears desirable that the angle of inclination of the separator element should be approximately 40° to the horizontal, and preferably within a few degrees of this angle. An angle of 45° appears to be too great, and 35° too little; these results have been obtained using a separator element for the separation of which is principally oil in water, and separation of other materials from water may require other angles of inclination, as may be readily determined by experiment. Also, it appears desirable that the plane of the lowermost sheet of the separator element should intercept the level of liquid in the central section as determined by the height of the barrier 14, with the object of securing laminar flow through the section, and particularly the separator element.

In one practical form of the invention the separator element has overall dimensions of 48 inches wide 47-1/2 inches deep and 8 ft long with a 9 inch extension on the top sheet. The element consisted of 58 sheets of natural transparent unplasticised rigid P.V.C. 3 inch corrugated sheets. Each sheet was 8 ft long, combined with 47-7/8 inches with corrugations, 25/32 inch pitch and 2-7/8 inch crest to crest. The thickness did not exceed 1/16 inch, the weight did not exceed 8 oz per ft², the coefficient of linear expansion did not exceed 2.0×10^{-5} per $^\circ\text{F}$ and tensile strength exceeded 7,000 lbs/in. The water absorption was about 0.10%.

The element was boxed by 1"x1"x3/16" angles on the sides and edges, two straps 1-1/2" wide and 3/16" thick, 2'0" from each end of the element, on the sides and bottom and similarly at the top of the element.

The intermediate straps were of 1-1/2"x1-1/2"x3/16" channel across the top with two lifting eyes to each strap, each lifting eye capable of lifting 500 lbs. The sides of the element were enclosed with unplasticised rigid P.V.C. flat sheet 1/25" thick between the edge of the corrugated sheets and the angles or straps.

The collection channels consisting of 1" web and 1/2" flange x 3/32 thickness overall steel channels, tack welded to the straps at the top and bottom. Seventeen channels were provided, centrally placed on the crests at the top of the element and on the troughs at the bottom of the element. The top channels were 4'6" long and the bottom 4'0".

The P.V.C. sheets were separated by 1/4" diameter bolts with 3/4" long hollow steel distance pieces of internal diameter 9/32

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inches. The bolts were provided at alternate
crests on the lower steel frame and
alternate troughs on the upper frame. The
straps were drilled to take the bolts top and
bottom.

In operation, the fluid to be treated is
admitted from an inlet at 24 to the first
section of the container, which acts as a
sediment tank. An opening (not shown)
leads to an overflow chamber. A trash tray
26 can be located in each input section if
desired to collect solid sediment and any
solid foreign bodies.

In the input section, the liquid will rise to
the level of the weir formed by the top edge
16 of barrier 14. The operation of the
installation appears to be much concerned
with the flow conditions which exist at this
weir. For example, the weir is broad in the
sense that the length of flow over the weir is
sufficiently extended for the flow to be
laminar as it leaves the downstream edge of
the weir. I have found that when the flow is
laminar, the discharge from the laminar
flow stream into the body liquid below the
weir, which is relatively inert, gives rise to
agglomeration or aggregation of oil
particles suspended in the liquid under
treatment, with consequent improvement
in the efficiency of the apparatus in
removing suspended material.

The liquid, after passing over the weir at
the top of barrier 14, flows through the
separator element, in laminar flow
conditions. In this flow of liquid through
the separator element, any content of the
liquid which is lighter than water will tend
to rise to the crests of the corrugations in
the sheets, and, by buoyancy, will rise up
the inclined sheets, against the flow of
liquid, until at the top of the separator, the
separated lighter components will enter the
channels of the upper channel members 52,
and continuing to rise by buoyancy, will
pass through the openings 54 in the topmost
sheet to be discharged into that portion of
the central section of the container above
the separator, there to be contained by the
upper part of the baffle 22 and the
extension of the top-most sheet of the
element. Any materials which are
essentially heavier than water will, in
somewhat similar fashion, be carried down
the troughs of the corrugations, to be
discharged into the channels of the lower
members, and to collect at the lower end of
the sloping floor in section 17.

The light components such as oil, which
rise to the surface are drawn off by a swivel
type oil skimmer 28, consisting of a
horizontal pipe at liquid level, with a
longitudinal slot into which surface oil can
enter and be drawn off into collection
chamber 29. The heavier particles

collecting at the lower end of sloping floor
15 in section 17 can be drawn off through a
suction pipe.

The liquid will accumulate behind the
weir formed by the top of the barrier 18. I
have found that where the liquid to be
separated includes light oils such as
kerosene these tend to collect in this part of
the installation, behind barrier 18. Such
light oils can be prevented from passing
over the weir by means of baffles; in Figure
1, two such baffles are used, located at 32
and 33. The baffles are of anodised
aluminium and extend fully across the
width of the separator unit. Anodised
aluminium repels the kerosene which builds
up behind the baffles. In practice, it has
been found to evaporate but if necessary it
can be drawn off by a skimmer.

The liquid passing over the weir at the
top of baffle 18 collects in the outlet
chamber at 19 the liquid is drawn off,
through outlet pipe 34. It has been found
advantageous to maintain an undulating or
resonant motion of the liquid in outlet
chamber 19; this can be established by
making the chamber of appropriate volume
and using suitable flow condition.

An installation as described has proved
highly successful in practice, and an
installation in trial conditions used to treat
an effluent containing 400 parts per million
of polluting material to approximately 1
part per million at the outlet.

The rate of flow of liquid into the unit is
carefully controlled, in order to secure an
optimum speed of movement of the liquid
downwardly between the sheets of the
separator element 25. The optimum speed,
for best separation, depends upon the
liquids being treated and the dimensions of
the parts, but for the material mentioned
above, speeds in the region of 5 to 15
millimetres per second have been found
satisfactory.

I have discovered that the oily water
mixture if passed through the unit in
laminar flow, will separate more quickly
than turbulent flow. To achieve laminar
flow the influent is passed over the
broadcrested weir of dimensions to suit the
flow. It is also desirable to pass the effluent
over a similar weir at the outlet so that the
flow throughout the tank is uniform. A
broad crested weir may be defined as a
broad crested regular obstruction over
which flow occurs. The broad crest must be
of such a dimension that the profile of the
fluid surface over the crest will be parallel
to the weir surface. The conditions of flow
over this weir can be deduced from the
general hydraulic energy equation. In the
embodiment shown, the flat top 16 of the
weir formed by the barrier 14 has a width,
i.e., in the flow direction, of 250 mm. A

lesser width such as 170 mm, suffices in some conditions. The flat topped portion 20 of baffle 18 has a width of 200 mm to ensure laminar flow over the top 20 and hence through the unit.

At the broad crested weir 16, the influent undergoes a change of speed from tranquil to rapid and returning to tranquil flow. During this process the oil particles tend to coalesce readily, and when the specific gravity of the oil/water at the weir section has changed considerably, the congealed oil flows to the separator unit. The particle size of the coalesced oil has been found to be considerably greater than the oil globule size of the influent, and thus separates at a much greater speed.

It is necessary to design each plant for the specific influent. The parameters required are flow, globule size and coalesced size, temperature, specific gravity, viscosity and degree of pollution. Each parameter has its own importance in my process.

The rate of rise in the separator element is governed by the globule size, specific gravity and viscosity which in turn is determined by the temperature and flow. The size of the broad crested weir is determined by the maximum flow, viscosity and specific gravity of the influent.

In the above embodiment, the channel members 52 and 53 are at right angles to the direction of flow through the separator unit and therefore at 40° to the vertical. The construction of the separator element can be altered so that the channel members are at an angle to the horizontal which is greater than 40° and in some cases can be up to 90°. It is to be understood that the angle which the sheets 50 make with the horizontal remains at the optimum angle for separation in this case 40°. This can be done with the arrangement as shown in Figure 1 by displacing the sheets relative to each other until the unit 25 assumes shape of a parallelogram. Decreasing the angle which the channels make with the vertical has the advantage that the matter in the channels will tend to rise faster toward the exit ends of the channels.

The size and inclination of the separator element is determined by the rate of rise and degree of pollution.

There are circumstances in which it may be convenient to reverse the flow of fluid through the separator element, from the bottom to the top. In this case the results can be supplemented by the use of an overflow device, consisting of a sloping surface, corrugated by horizontal corrugations over which the liquid from the discharge end of the separator will pass. Along the line of the corrugations, at a region where, with the appropriate rate of

liquid flow there will be a region of reduced pressure, slots can be cut, by which air will be admitted to the liquid, and drawn into it by reason of the reduced pressure created by the liquid flow. Such an arrangement is of use when treating liquid containing oxygen-demanding organic materials.

In trials, it has been found advantageous to provide another baffle arrangement at the inlet of the separator. It is also desirable to use a baffle at the inlet when reverse flow operation is in use. The maximum rate of flow over the weir has been found to be about 700 mm/sec.

WHAT I CLAIM IS:—

1. A separator comprising a container provided with means dividing the container into a first section, an intermediate section and a third section, and a separator element in the intermediate section, said separator element comprising a plurality of inclined superposed spaced corrugated sheets, channel means connected to the undersides of the crests of the corrugations of said sheets for collecting material rising on the undersides of the crests, and further channel means connected to the uppersides of the troughs of the corrugations for collecting material falling on the uppersides of the troughs, the dividing means comprising a flat topped weir dividing the first and intermediate sections, the width of the flat top of the weir in the direction in which liquid will flow across it being such that, in use, the liquid flows over the weir under conditions of laminar flow.

2. A separator as claimed in Claim 1, wherein the width of the weir is at least 170 mm.

3. A separator as claimed in Claim 2, wherein the width of the weir is 250 mm.

4. A separator as claimed in Claim 1, 2 or 3, wherein the dividing means comprises a further flat topped weir dividing said third and intermediate sections, which further weir is in the direction in which liquid will flow across it such that, in use the liquid flows over the further weir under conditions of laminar flow.

5. A separator as claimed in any one of the preceding claims, wherein the separator element is supported with said corrugated sheets at an angle to the horizontal in the range of 35° to 45°.

6. A separator as claimed in Claim 5, wherein the separator element is disposed in said intermediate section in a position such that the projection of the lowermost sheet intersects the plane including the flat top of the first-mentioned weir in said intermediate section within the intermediate section.

7. A separator substantially as



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5 lesser width such as 170 mm, suffices in some conditions. The flat topped portion 20 of baffle 18 has a width of 200 mm to ensure laminar flow over the top 20 and hence through the unit.

10 At the broad crested weir 16, the influent undergoes a change of speed from tranquil to rapid and returning to tranquil flow. During this process the oil particles tend to coalesce readily, and when the specific gravity of the oil/water at the weir section has changed considerably, the congealed oil flows to the separator unit. The particle size of the coalesced oil has been found to be considerably greater than the oil globule size of the influent, and thus separates at a much greater speed.

20 It is necessary to design each plant for the specific influent. The parameters required are flow, globule size and coalesced size, temperature, specific gravity, viscosity and degree of pollution. Each parameter has its own importance in my process.

25 The rate of rise in the separator element is governed by the globule size, specific gravity and viscosity which in turn is determined by the temperature and flow. The size of the broad crested weir is determined by the maximum flow, viscosity and specific gravity of the influent.

30 In the above embodiment, the channel members 52 and 53 are at right angles to the direction of flow through the separator unit and therefore at 40° to the vertical. The construction of the separator element can be altered so that the channel members are at an angle to the horizontal which is greater than 40° and in some cases can be up to 90°. It is to be understood that the angle which the sheets 50 make with the horizontal remains at the optimum angle for separation in this case 40°. This can be done with the arrangement as shown in Figure 1 by displacing the sheets relative to each other until the unit 25 assumes shape of a parallelogram. Decreasing the angle which the channels make with the vertical has the advantage that the matter in the channels will tend to rise faster toward the exit ends of the channels.

50 The size and inclination of the separator element is determined by the rate of rise and degree of pollution.

55 There are circumstances in which it may be convenient to reverse the flow of fluid through the separator element, from the bottom to the top. In this case the results can be supplemented by the use of an overflow device, consisting of a sloping surface, corrugated by horizontal corrugations over which the liquid from the discharge end of the separator will pass. Along the line of the corrugations, at a region where, with the appropriate rate of

liquid flow there will be a region of reduced pressure, slots can be cut, by which air will be admitted to the liquid, and drawn into it by reason of the reduced pressure created by the liquid flow. Such an arrangement is of use when treating liquid containing oxygen-demanding organic materials.

In trials, it has been found advantageous to provide another baffle arrangement at the inlet of the separator. It is also desirable to use a baffle at the inlet when reverse flow operation is in use. The maximum rate of flow over the weir has been found to be about 700 mm/sec.

WHAT I CLAIM IS:—

1. A separator comprising a container provided with means dividing the container into a first section, an intermediate section and a third section, and a separator element in the intermediate section, said separator element comprising a plurality of inclined superposed spaced corrugated sheets, channel means connected to the undersides of the crests of the corrugations of said sheets for collecting material rising on the undersides of the crests, and further channel means connected to the uppersides of the troughs of the corrugations for collecting material falling on the uppersides of the troughs, the dividing means comprising a flat topped weir dividing the first and intermediate sections, the width of the flat top of the weir in the direction in which liquid will flow across it being such that, in use, the liquid flows over the weir under conditions of laminar flow.

2. A separator as claimed in Claim 1, wherein the width of the weir is at least 170 mm.

3. A separator as claimed in Claim 2, wherein the width of the weir is 250 mm.

4. A separator as claimed in Claim 1, 2 or 3, wherein the dividing means comprises a further flat topped weir dividing said third and intermediate sections, which further weir is in the direction in which liquid will flow across it such that, in use the liquid flows over the further weir under conditions of laminar flow.

5. A separator as claimed in any one of the preceding claims, wherein the separator element is supported with said corrugated sheets at an angle to the horizontal in the range of 35° to 45°.

6. A separator as claimed in Claim 5, wherein the separator element is disposed in said intermediate section in a position such that the projection of the lowermost sheet intersects the plane including the flat top of the first-mentioned weir in said intermediate section within the intermediate section.

7. A separator substantially as



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hereinbefore described with reference to the accompanying drawings.

8. A method of separating suspended matter from a liquid utilising the separator according to any preceding claim, comprising causing said liquid to flow from the first section to the intermediate section under conditions of laminar flow through said separator element into the third section, collecting matter rising on the undersides of the crests of the corrugations of the sheets, collecting matter falling on the uppersides of the troughs of said corrugations, and removing from the third section the liquid from which suspended matter has been separated.

9. A method according to Claim 8, wherein the liquid is water and the width of the flat top of the weir separating the first

section from the intermediate section in the direction of liquid flow is at least 170 mm.

10. A method according to Claim 9, wherein the width of the flat top of the weir is 250 mm.

11. A method according to Claim 8, 9 or 10, wherein the rate of flow of liquid into the separator element is up to 15 millimeters per second.

12. A method of separating suspended matter from a liquid substantially as hereinbefore described with reference to the accompanying drawing.

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