

APPARATUS AND METHODS FOR SEPARATING SOLIDS FROM FLOWING LIQUIDS OR GASES

Field of the invention

This invention relates to apparatus and methods for separating solids or particulate matter
5 from flowing liquids or gases. The invention has particular, although not exclusive,
application to the filtration of floating and entrained solids from discharges of water. One
particular application of the invention is in relation to storm water drain technology.

Background to the Invention

There are many applications where it is desirable to separate solids from a flowing liquid.
10 Such applications include the following.

1. Separation of solids from storm water

In many parts of the world, storm water is directed to waterways and seas. Storm water is
a major carrier of solid pollutants, such as plastics, cans, tree branches and animal faeces,
amongst other things, to waterways and seas.

15 Endeavours have been made to date, to limit the passage of at least some of these materials
to waterways and seas. One method which has been used is to employ grates across outlets
from the drains. This method has been generally unsatisfactory because the size of the
grate must often be such as to enable water to pass, even if solid material is held against the
grate by water pressure. Accordingly, it has been necessary that the grate be of substantial
20 opening size. A further problem is that even large grates can become blocked, and it is
essential to provide a flow path around or over the grate to prevent build up of water
upstream in the drainage system. A second alternative proposed has been the use of
systems, such as cyclones and dynamic separators, to remove the waste. While these can
be efficient in some circumstances, they are often too expensive to be used in the whole of
25 a storm water drainage system.

2. Separation of liquid from sewerage

A major difficulty with many sewerage plants is the sheer volume of liquid to be handled. This is aggravated where a "mixed" system, that is, a system which carries both sewerage and storm water, is used. In many cases, sewerage plants could handle more sewerage if
5 the quantity of liquid delivered could be reduced. This could occur if, for example, liquid was removed from the sewerage before it enters into trunk sewers. To date, this has not been considered feasible.

Further, there are also many regions in the world where storm water and sewerage are received by the same system. This can cause difficulties where there are heavy rains which
10 overload the system, as it is undesirable to permit raw sewerage to pass to overflow.

3. Removal of pollutants from industrial wastes

Many industrial plants must pay prohibitive rates to discharge polluted liquids into sewers. It would be most desirable to separate a part of the pollution before the waste is delivered to sewers, and this will provide economies both to the plant and to the authority, if the cost
15 of the earlier removal of polluted matter was less than the cost of cleaning up pollution at a later time.

These are merely illustrations of the many uses to which an apparatus or method for separating solids from a flowing liquid, could be put. There are many other such applications which could be described.

20 In our International Patent Application number PCT/AU94/00061, we disclosed and claimed apparatus and methods for separating solids from flowing liquids. We believe that the apparatus and methods disclosed in that application provide very good results in applications requiring the separation of solids from flowing liquids. We have now developed improvements and/or refinements to the invention disclosed in that application,
25 which we believe provide even better results than those disclosed in our earlier application.

Summary of the Invention

The present invention generally provides an apparatus for separating solid or particulate matter from a flowing liquid or gas, the apparatus including:

a separation panel positioned in the path of flow of the liquid or gas, the separation panel
5 including a plurality of openings, wherein the openings are of a predetermined size such that only solid or particulate matter smaller than that size is able to pass through the openings, and wherein further, the configuration and arrangement of the openings on the separation panel is such that in use of the apparatus, solid or particulate matter larger than the predetermined size is substantially prevented from adhering to or obstructing the
10 separation panel.

Preferably, the arrangement of the openings in the separation panel is such that, in use of the apparatus, the openings are disposed at an angle relative to the direction of flow of the liquid or gas.

Preferably further, the configuration of the openings is such that each opening includes a
15 deflection means generally opposed to the direction of flow of the liquid or gas, to assist in deflecting solid or particulate matter entrained in the flow, away from the openings.

In a preferred form of the invention, the separation panel takes the form of a curved structure.

It is particularly preferred that the apparatus includes a generally cylindrical separation
20 panel. It is particularly preferred that the separation panel is in the form of an open ended generally cylindrical structure. In this preferred form of the invention, it is also preferred that the separation panel forms part of a larger separation chamber, into which, in use of the apparatus, the liquid or gas flow is introduced by an inlet means, so as to establish a circular flow of the liquid or gas within the separation panel. This circular flow enables
25 solids or particulate matter of a predetermined size entrained in the liquid or gas, to be trapped and to circulate within the confines of the separation panel. The circular motion of the flowing liquid or gas within the separation panel also results in the entrained solids or

particulate matter generally not adhering to the separation panel, but being entrained in the circular motion of the liquid or gas. In this way, the establishment of a circular flow motion of the gas or liquid within the separation panel is such as to enable the separation panel to act as a generally self-cleaning filter for the solid or particulate matter entrained within the flowing liquid or gas. The fact that the liquid or gas is able to pass freely through the openings in the separation panel means that the panel is able to filter solid or particulate matter of a predetermined size from the flowing liquid or gas, thereby enabling the liquid or gas to be discharged to an outlet means, at least substantially filtered of the solid or particulate matter.

- 10 It is also preferred that the configuration of the apparatus is such that in use, the flow of the liquid or gas outside the confines of the separation panel is in a direction opposite to the direction of flow of the liquid or gas within the confines of the separation panel. Such a configuration assists in maintaining the self-cleaning function of the separation panel, in use of the apparatus.
- 15 Preferably, the apparatus also includes means for facilitating the collection of the solid or particulate matter into a receptacle, from which it may be removed. In some embodiments of the invention, gravitational forces may combine with the circular motion of the gas or liquid within the cylindrical separation panel, so as generally to encourage the deposition of the solid or particulate matter into a receptacle which may be positioned generally below and/or above the separation panel, depending upon the specific gravity of the solid or particulate matter.. In the case of solids or particulate matter having a lower specific gravity than the liquid or gas, they will tend to float on the surface of the liquid or gas, in which case, they can be collected by a receptacle generally disposed above the separation panel. In the case of solids or particulate matter having a higher specific gravity than the liquid or gas, they will tend to settle under the action of gravitational forces, in which case, a receptacle to capture them will generally be positioned below the separation panel.

The apparatus may also include mechanical means to assist the deposition of the solid or particulate matter in the receptacle, through the action of gravity. Such means could take any number of forms, but would include, for example, providing the receptacle with a baffle or flange directed downwardly to encourage the deposition of settleable solid or
5 particulate matter.

The invention also provides a method for separating solid or particulate matter from a flowing liquid or gas, the method including the steps of:

- positioning a separation apparatus in the path of flow of the liquid or gas; and
- providing the separation apparatus with a separation panel having a plurality of
10 openings therethrough, wherein the openings are of a predetermined size such that only solid or particulate matter smaller than that size is able to pass through the openings, and wherein further, the configuration and arrangement of the openings on the separation panel is such that in use of the apparatus, solid or particulate matter larger than the predetermined size is substantially prevented from adhering
15 to, or obstructing the separation panel.

Preferably further, in the method, the arrangement of the openings is such that, in use of the apparatus, the openings are disposed at an angle relative to the direction of flow of the liquid or gas.

It is also preferred, in the method, that each of the openings includes a deflection means
20 generally opposed to the direction of flow of the liquid or gas, to assist in deflecting solid or particulate matter entrained in the flow, away from the opening.

Preferably, in the method described above, the separation panel takes the form of a curved structure.

Preferably further, in the method described above, the separation panel takes the form of a
25 generally cylindrical structure, and the separation apparatus includes inlet and outlet means for directing the flow of liquid or gas into, and out of, the separation apparatus

respectively. It is particularly preferred that the separation panel is an open ended generally cylindrical structure.

It is particularly preferred, in the said method, that the arrangement is such that the liquid or gas is introduced into the separation apparatus via the inlet means and presented to a
5 separation chamber which includes a generally cylindrical separation panel, so that a circular motion of the liquid or gas is established within the confines of the separation panel, so as generally to trap solid or particulate matter of a pre-determined size within the separation panel, yet at the same time, permit the liquid or gas to pass therethrough freely, and so that the separation panel is continually cleaned by the circular motion of the liquid
10 or gas within it.

Preferably further, in the method, the configuration of the apparatus is such that in use, the flow of the liquid or gas outside the confines of the separation panel is in a direction opposite to the direction of flow of the liquid or gas within the confines of the separation panel, so as to assist in maintaining the self-cleaning function of the separation panel, in
15 use of the apparatus.

Preferably further, the method also includes the step of providing means to facilitate the collection of the solid or particulate matter separated by the method, from the flowing liquid or gas. Such means could, for example, utilise the assistance of gravitational forces, to assist in the collection of the solid or particulate matter.

20 Preferably further, the method also includes means for facilitating the removal from the separation apparatus, of solids or particulate matter separated from the flowing liquid or gas.

Description of preferred embodiments of the Invention

In order that the invention may be further understood, we will now describe preferred
25 embodiments of it, by way of example only, with reference to the accompanying drawings, in which:

Fig 1 is a plan view of one example of a separator made in accordance with the invention;

Fig 2 represents a view (in the direction of the arrow marked "B" in Fig 1") of a vertical section of the separator shown in Fig 1, taken along the line A-A in that Figure;

Fig 3 shows an enlarged horizontal section of part of a separator panel for use in the invention; and

Fig 4 is a view from the side of a vertical section through an exemplary separator made in accordance with the invention.

Referring now to the accompanying drawings, Fig 1 shows a plan view of an apparatus which could be used to separate solids from a flowing liquid, such as water (and particularly, storm water). The apparatus shown, generally denoted 25, includes a separation panel 1, which as depicted, is of a generally circular shape, when viewed in horizontal cross-section. When viewed in three dimensions (as shown more particularly in Fig 2), it can be seen that the separation panel 1 has an open-ended generally cylindrical configuration.

As shown in Figs 1 and 2, the separation panel 1 is located within a separation chamber 2. The liquid enters the separation apparatus 25 via an inlet means 3, in the direction of the arrow 27 shown in Fig 1. As shown in Fig 1, the inlet channel 3 curves to the left until reaching the body 37 of the separator 25, where water and entrained solids or particulate matter are presented through an opening 8 into the interior 19 of the separation panel 1. The generally cylindrical configuration of the separation panel 1 is such that when the water leaves the opening 8 and enters the interior (or confines) 19 of the separation panel 1, a circular flow motion is established within the confines 19 of the separation panel 1, in the direction shown by the arrow 29 shown in Fig 1.

Referring now to Fig 3, it will be seen that the exemplary separation panel 1 depicted consists of a number of deflection means in the form of solid deflective segments 10 which generally present a closed face to the direction of flow of the liquid (as shown by the arrow numbered 31 in Fig 3) within the separation panel 1. Behind each deflective segment 10 in

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REPLACED

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the separation panel, there is an opening 9. As illustrated, each opening 9 is disposed at an angle to the direction of flow of the liquid in the separation panel 1. Moreover, the openings 9 are all of a predetermined size, which is such as to permit the passage only of particulate matter smaller in size than that of the openings. The liquid is of course, also
5 able to pass freely through the openings. In use of the separation apparatus 25, the effect of this arrangement of features is that only the liquid, and solids or particulate matter of a size smaller than that of the openings 9 are able to pass through the separation panel. Solids or particulate matter of a larger size are therefore trapped within the confines 19 of the separation panel. Moreover, the circular motion of the liquid within the confines 19 of the
10 separation panel means that trapped solids or particles are continuously deflected from the interior wall 33 of the separation panel. The net effect of this arrangement is therefore that the separation panel 1 is substantially self-cleaning.

Solids trapped within the confines 19 of the separation panel are therefore caused to continue moving by the circular flow until they settle under gravity, or, if floatable, are
15 retained on the surface. At the same time, untrapped solids and the liquid are able to pass through the separation panel into the upper portion 5 of the separation chamber 2, and thence to the outlet means 6 (which, as shown in Fig 1, may take the form of a channel, pipe or other suitable outlet structure).

As shown in Fig 3, preferably, the flow of the liquid or gas outside the confines of the
20 separation panel is in a direction opposite to the direction of its flow within the confines of the liquid or gas. This counter-current flow motion on opposite sides of the separation panel establishes a kinetic equilibrium which in turn facilitates the generally self-cleaning function of the circular flow motion established within the confines 19 of the separation panel.

25 As shown in Figs 2 and 4, the separation apparatus 25 may also include a receptacle 4, such as a collection sump, for the containment (and removal, if desired) of settleable solids. The sump 4 may be sized or configured so as to slow down the circular flow of the liquid



at the lower portion of the apparatus 25, so as to facilitate settlement of solids. The sump 4 may also be provided with any suitable means to facilitate the removal of settled solid or particulate matter. Such means could include, for example, periodic removal by education, or a mechanical bucket or basket that is suspended in the sump. Floatables which are left
5 floating on the top of the body of water treated by the separation apparatus 25 could be removed by any convenient means.

As shown more particularly in Fig 4, the separation apparatus may also include means for assisting the settlement of solids into the sump 4. The means shown in Fig 4 take the form of a downwardly directed annular flange or baffle 17, which assists in directing
10 downwardly moving solids into sump 4. The flange or baffle 17 also substantially prevents the circular motion of the liquid or gas within the upper regions of the separation chamber from being transferred into the sump 4.

Referring now to Fig 2, as illustrated, the cylindrical separation panel 1 may be fitted with a continuation part 7 of the same material (or of another, generally impervious material)
15 above the level of the normal inlet flow. This continuation part 7 ensures the retention of floating solids if the separation apparatus is subjected to head pressure (eg during flood conditions), if the apparatus is being used, for example, for the removal of litter from urban stormwater runoff.

Where particularly "purified" liquids or gases are required at the conclusion of the filtration
20 procedure, it is possible for the outlet from one separation apparatus according to the invention to feed into the inlet for a second such separator, and therefore, for the liquid or gas to be filtered sequentially by two or more such separators, arranged in series. In such an arrangement, the size of the openings in the separation panels for the second and subsequent separators could be sequentially (and increasingly) smaller, so that each
25 subsequent separator removes increasingly finer particles. Hence, by this arrangement, very high, or indeed, any desired level of filtration or purification could be achieved.

While much of the foregoing description of the preferred embodiments has been concerned with apparatus for separating solids entrained in liquids, it is to be understood that the invention is equally applicable to the separation of solids entrained in gases. Generally, for more efficient operation of gas/solid separators constructed in accordance
5 with the invention, it would be necessary for the separator to be constructed as a sealed unit, so as to prevent the undesired escape of gases undergoing filtration. (This is a feature which could also be utilised in some liquid/solid separators constructed in accordance with the present invention). In this way, solid matter entrained in exhaust gases and gaseous emissions from various manufacturing plants, could be filtered in much the same way as
10 solid-bearing liquids are treated, using the apparatus and methods of the present invention.

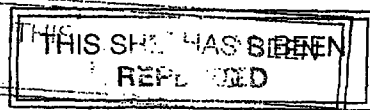
Those skilled in the art will therefore readily appreciate that the apparatus and methods of the present invention are capable of being put to many different uses, and that they embrace many modifications and variations. It is therefore also to be understood that the spirit and scope of the present invention is in no way limited to the particular details of the
15 preferred embodiments described herein, but extends to, and is to be determined by reference to each novel feature and combination of features defined by the appended claims.

**THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:**

1. An apparatus for separating solid or particulate matter from a flowing liquid or gas, the apparatus including:

a separation panel positioned in the path of flow of the liquid or gas, the separation
5 panel including a plurality of openings, wherein the openings are of a predetermined size such that only solid or particulate matter smaller than that size is able to pass through the openings, and wherein further, the configuration and arrangement of the openings on the separation panel is such that in use of the apparatus, solid or particulate matter larger than the predetermined size is
10 substantially prevented from adhering to or obstructing the separation panel.
2. An apparatus as claimed in claim 1, wherein the separation panel is in the form of a curved structure.
3. An apparatus as claimed in claim 1 or claim 2, wherein the separation panel is in the form of a generally cylindrical structure.
- 15 4. An apparatus as claimed in any of the preceding claims, wherein the separation panel is an open ended generally cylindrical structure.
5. An apparatus as claimed in any of the preceding claims, wherein the arrangement of the openings in the separation panel is such that in use of the apparatus, the openings are disposed at an angle relative to the flow of the liquid or gas.
- 20 6. An apparatus as claimed in any of the preceding claims, wherein the configuration of the openings is such that each opening includes a deflection means generally opposed to the direction of flow of the liquid or gas, to assist in deflecting solid or particulate matter entrained in the flow away from the openings.
7. An apparatus as claimed in any of the preceding claims, wherein the separation
25 panel is housed in or forms part of a separation chamber into which, in use of the apparatus, the liquid or gas flow is introduced by an inlet means so as to establish a





apparatus, the liquid or gas flow is introduced by an inlet means so as to establish a circular flow of the liquid or gas within the confines of the separation panel, and whereby the arrangement of these features is such as to enable solids or particulate matter of a predetermined size entrained in the liquid or gas, to be trapped within the confines of the separation panel.

8. An apparatus as claimed in claim 7, wherein the arrangement of the features in the apparatus is such that in use of the apparatus, the separation panel is generally self-cleaning.
9. An apparatus as claimed in claim 8, wherein the configuration of the apparatus is such that in use, the flow of the liquid or gas outside the confines of the separation panel is in a direction opposite to the direction of flow of the liquid or gas within the confines of the separation panel, so as to assist in maintaining the self-cleaning function of the separation panel, in use of the apparatus.
10. An apparatus as claimed in any of the preceding claims, wherein the apparatus additionally includes means to assist in collecting the solid or particulate matter trapped within the separation panel.
11. An apparatus as claimed in claim 10, wherein the means to assist in collecting the solid or particulate matter are biasing means which utilise gravitational forces to encourage the settlement of settleable solid or particulate matter.
12. An apparatus as claimed in claim 11, wherein the biasing means take the form of providing the apparatus with at least one downwardly directed baffle or flange to encourage the deposition of settleable solid or particulate matter.
13. An apparatus as claimed in any of the preceding claims, wherein the apparatus includes a receptacle for collecting the solid or particulate matter.
14. An apparatus as claimed in claim 13, wherein the apparatus additionally includes means for removing the solid or particulate matter from the receptacle.





15. An apparatus as claimed in claim 14, wherein the means for removing the solid or particulate matter from the receptacle include providing the receptacle with a removable container into which the solid or particulate matter may be received within the receptacle, in use of the apparatus.
- 5 16. A method for separating solid or particulate matter from a flowing liquid or gas, the method including the steps of:
- positioning a separation apparatus in the path of flow of the liquid or gas; and
 - providing the separation apparatus with a separation panel having a plurality of openings therethrough, wherein the openings are of a predetermined size such that
- 10 only solid or particulate matter smaller than that size is able to pass through the openings, and wherein further, the configuration and arrangement of the openings on the separation panel is such that in use of the apparatus, solid or particulate matter larger than the predetermined size is substantially prevented from adhering to, or obstructing the separation panel.
- 15 17. A method as claimed in claim 16, wherein the separation panel takes the form of a curved structure.
18. A method as claimed in claim 16 or claim 17, wherein the separation panel is in the form of a generally cylindrical structure.
19. A method as claimed in any of claims 16 to 18, wherein the separation panel is an
- 20 open ended generally cylindrical structure.
20. A method as claimed in any of claims 16 to 19, wherein the arrangement of the openings in the separation panel is such that in use of the apparatus, the openings are disposed at an angle relative to the flow of the liquid or gas.
21. A method as claimed in any of claims 16 to 20, wherein the configuration of the
- 25 openings is such that each opening includes a deflection means generally opposed





to the direction of flow of the liquid or gas, to assist in deflecting solid or particulate matter entrained in the flow away from the openings.

22. A method as claimed in any of claims 16 to 21, wherein the separation panel is housed in or forms part of a separation chamber into which, in use of the apparatus, the liquid or gas flow is introduced by an inlet means so as to establish a circular flow of the liquid or gas within the confines of the separation panel, and whereby the arrangement of these features is such as to enable solids or particulate matter of a predetermined size entrained in the liquid or gas, to be trapped within the confines of the separation panel.
23. A method as claimed in claim 22, wherein the arrangement of the features in the apparatus is such that in use of the apparatus, the separation panel is generally self-cleaning.
24. A method as claimed in claim 23, wherein the configuration of the apparatus is such that in use, the flow of the liquid or gas outside the confines of the separation panel is in a direction opposite to the direction of flow of the liquid or gas within the confines of the separation panel, so as to assist in maintaining the self-cleaning function of the separation panel, in use of the apparatus.
25. A method as claimed in any of claims 16 to 24, wherein the apparatus additionally includes means to assist in collecting the solid or particulate matter trapped within the separation panel.
26. A method as claimed in claim 25, wherein the means to assist in collecting the solid or particulate matter are biasing means which utilise gravitational forces to encourage the settlement of settleable solid or particulate matter.
27. A method as claimed in claim 26, wherein the biasing means take the form of providing the apparatus with at least one downwardly directed baffle or flange to encourage the deposition of settleable solid or particulate matter.





28. A method as claimed in any of claims 16 to 27, wherein the apparatus includes a receptacle for collecting the solid or particulate matter.
29. A method as claimed in claim 28, wherein the apparatus additionally includes means for removing the solid or particulate matter from the receptacle.
- 5 30. A method as claimed in claim 29, wherein the means for removing the solid or particulate matter from the receptacle include providing the receptacle with a removable container into which the solid or particulate matter may be received within the receptacle, in use of the apparatus.
- 10 31. An apparatus for separating solid or particulate matter from a flowing liquid or gas, substantially as hereinbefore described, and with reference to the accompanying drawings.
32. A method for separating solid or particulate matter from a flowing liquid or gas, substantially as hereinbefore described, and with reference to the accompanying drawings.

