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(71) Applicant: **Doppstadt Familienholding GmbH  
42555 Velbert (DE)**

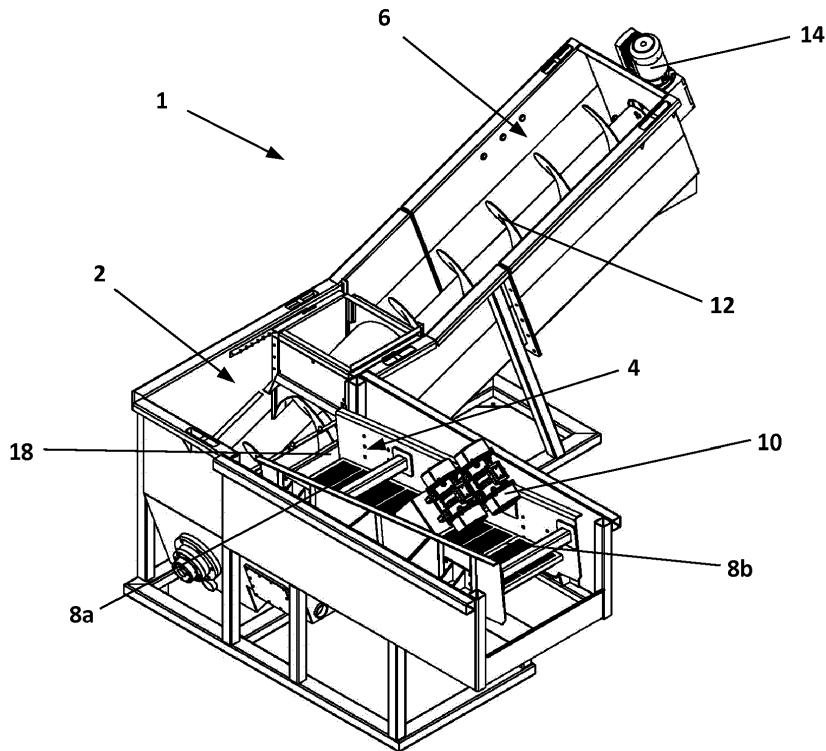
(72) Inventor: **COULTON, Richard  
Earlswood  
Chepstow NP16 6RH (GB)**

(74) Representative: **Von Rohr Patentanwälte  
Partnerschaft mbB  
Rüttenscheider Straße 62  
45130 Essen (DE)**

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(54) **HYDRAULIC DENSITY SENSOR**

(57) The present invention concerns a hydraulic density separator and a method of effecting hydraulic density separation. The invention is particularly, but not exclusively concerned with the separation of materials, such as roadside sweepings, containing wooden elements such as twigs.



**Fig. 2**

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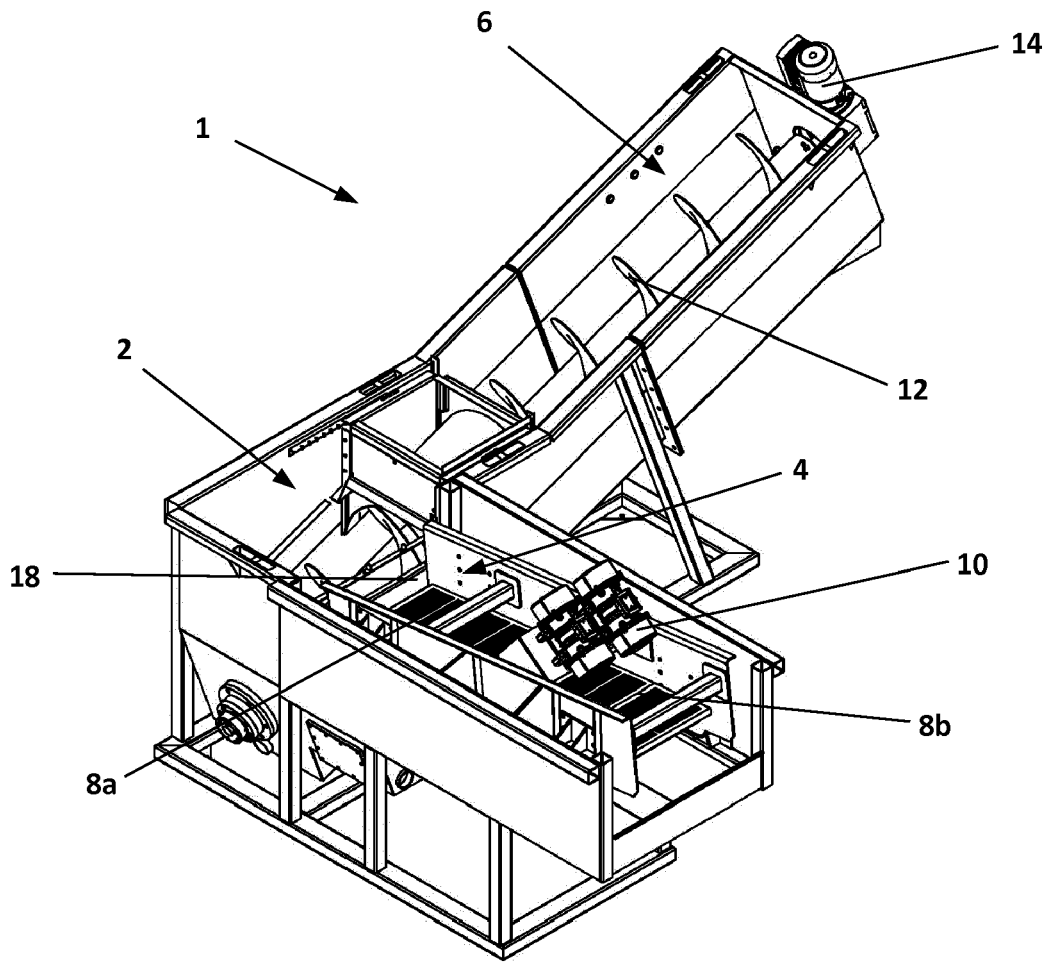


Fig. 2

## Description

**[0001]** The present invention concerns a hydraulic density separator and a method of effecting hydraulic density separation. The invention is particularly, but not exclusively concerned with the separation of materials, such as roadside sweepings, containing wooden elements such as twigs.

**[0002]** In a known density separator that may be employed to treat materials collected from the roadside, the materials are introduced into water. Stones and other high density materials sink and low density materials such as leaves and dry twigs float. That enables much of the low density material to be separated from the high density material.

**[0003]** The separation process does, however, have various drawbacks. One particular problem arises with twigs and other wooden debris which, although less dense than water when dry, can become denser than water when wet; in the latter case, the debris sinks along with stones and other high density debris and is not separated therefrom. A further problem arises in the handling of the debris which floats: it proves difficult to separate the floating debris, which may contain rotting leaves and twigs, from the water in which it is floating. If the water is not removed effectively from the debris then the subsequent collection and treatment of the debris is made more difficult and the amount of water that can be recycled in the separation process is reduced. On the other hand, if extra efforts are made to remove more water an increased amount of the lighter debris is likely to be left with that water.

**[0004]** The present invention seeks to mitigate one or more of the above-mentioned problems.

**[0005]** The afore-mentioned problem is essentially solved with the features of claim 1 and/or 10. Advantageous embodiments are the subject matter of the dependent claims.

**[0006]** According to the first aspect of the invention there is provided a hydraulic density separator for separating higher density elements and lower density elements of solids material, the apparatus comprising:

- a first compartment for receiving a mixture comprising higher density elements and lower density elements, and water;
- a flow generator configured to provide an upward flow of water within the first compartment;
- means in the first compartment for removing higher density elements that have settled from a lower region of the first compartment; and
- a second compartment for receiving a mixture comprising water and lower density elements from the first compartment, the second compartment comprising a mesh screen configured to move lower den-

sity elements from a first position to a second position spaced apart from the first position;

- 5 - wherein a water flow path is provided from an upper region of the first compartment into the second compartment and over a portion of the mesh screen such that lower density elements entrained by the flow of water are deposited on the mesh screen; and
- 10 - wherein the upward flow of water within the first compartment provided by the flow generator is configured in such a way that elements being slightly denser than water are carried to the second compartment.

15 **[0007]** By providing an upward flow of water within the first compartment, it becomes possible to cause an element that is slightly denser than water to be carried upwards with the floating elements. In that way, a piece of saturated wood, for example, may be kept with other floating elements even though it may be denser than water. Thus, a sufficient upward flow may allow a denser than water object to be carried upward by the flow within the first compartment and onto the mesh screen.

20 **[0008]** Due to the hydraulic density separator it becomes possible to provide a buoyancy which lifts elements having a (slight) higher density than water up to an upper region in the first compartment and transfers those elements to the second compartment. Therefore, the buoyancy and/or the "created" uplift of the elements being denser than water enable(s) elements, in particular wet and/or saturated wood, to be transported to the second compartment and to be separated from the elements having a higher density.

25 **[0009]** According to the invention it becomes possible to use the wet, saturated wood as a RDF waste and/or as burning material. Wet, saturated wood, like twigs, can be used to generate energy based on the combustion of the separated, burning material. In consideration of ecological, environmental aspects, the separation of the elements being slightly denser than water, which become part of the group "lower density elements", enables to separate material which can subsequent to the separation be used as burning material. Otherwise, the elements being slightly denser than water would be disposed together with the "higher density elements".

30 **[0010]** The upward flow of water creates a movement and a direction of movement of the elements being slightly denser than water which is in the direction of the uplift / buoyancy. The uplift / buoyancy is in particular directed towards the opposite direction to the gravitation force. The gravitation force drags in particular the higher density elements downwards in the first compartment.

35 **[0011]** The inventive sink-method of the separated material enables the separation of RDF waste material, in particular burning material, like wet, saturated wood which can be separated from mixed waste and building rubble and/or construction waste which are part of the group "higher density elements".

**[0012]** The elements being slightly denser than water preferably have a density of 1020 to 1300 kg/m<sup>3</sup>. The elements being slightly denser than water can have in particular a density that is up to 25 % higher than the density of the water, preferably between 2 % to 15 %, more preferably between 5 % to 10 %, higher than the density of water.

**[0013]** After passing over a portion of the mesh screen the flow path may continue from a lower region of the second compartment to the first compartment. For example, the water may flow from a lower region of the second compartment into a lower region of the first compartment. In that way water is recycled and therefore overall water consumption of the separator much reduced. The water may flow through the flow generator as it passes back into the first compartment or the flow generator may be provided in a separate water flow path.

**[0014]** The separator may further comprise one or more vibrators for vibrating the mesh screen. By vibrating the screen the draining of water through the screen may be enhanced, with the result that less water remains with the debris on the screen. The mesh screen may act as a conveyor. In a preferred arrangement the vibration of the screen provides the conveying function. The vibration may act to move elements on the screen from an end of the screen adjacent to the first compartment to an opposite end. At the opposite end the elements may be arranged to fall off the end into a collecting means. The mesh screen may be upwardly inclined towards said opposite end.

**[0015]** The separator may further comprise an auger located partially within the first compartment for removing higher density elements that have settled from a lower region of the first compartment. The auger may be a screw auger. The auger may be upwardly inclined from an end located in the first compartment. The auger may have an outlet at its upper end. Higher density elements may fall from the outlet of the auger into a collecting device.

**[0016]** A weir may be located between the first compartment and the second compartment, the flow path passing from the upper region of the first compartment to the second compartment over the weir.

**[0017]** Preferably, the weir has a border which separates the first compartment from the second compartment. The border can be configured in such a way that the upward flow of water can flow over the border of the weir. Moreover, the border of the weir can be rounded so that the grade of turbulence of the flow of water can be decreased, in particular up to 50 %. Therefore, the weir can be configured in such a way that the grade of turbulence of the flow of water can be decreased between the first and second compartment and/or by passing and/or flowing from the first compartment to the second compartment.

**[0018]** Apertures in the screen may be elongate. The apertures may have a width in the range of 0.5mm to 10mm and more preferably in the range of 1mm to 5mm.

The apertures may have a length of about 20mm. Apertures of this kind reduce the risk of elongate objects such as twigs passing through the screen. The screen may be made of various materials. The screen may be made of polyurethane. The screen may be made of steel.

**[0019]** The flow generator may comprise an axial flow pump. The flow rate of the flow produced by the generator may be adjustable. By adjusting the flow rate of the flow the density threshold at which the higher and lower density elements are separated may be adjusted. For example, increasing the flow will allow denser elements to be entrained upwards by the flow. Decreasing the flow will reduce the maximum density of the elements that are carried upward by the flow. In this way the separation point of the separator can be adjusted to take account of the relative densities of the elements in any particular mixture. This enables the separator to be adapted to provide the most suitable separation for a variety of different materials.

**[0020]** In particular, the axial flow pump is a waste water pump which provides the upward flow of water. The pump of the flow generator is preferably resistant against waste and/or dirt and/or impurities of the recirculating water. According to the invention there is in particular no need for throttles for the reason that the recirculation of the water and the operation and the control of the upward flow and the flow generator can be taken over from the pumps of the flow generator, in particular the waste water pump(s).

**[0021]** The hydraulic density separator is a compact solution, wherein the flow of water can in particular be recirculated and/or transferred within the compartments. Water from the second compartment can be transferred to the first compartment and vice versa.

**[0022]** Nevertheless, it is still possible to add fresh water. This is advantageous for the reason that water may be carried out together with the separated elements.

**[0023]** Preferably, at least one bypass is related to the first and/or second compartment, wherein the bypass can be constructed in such a way that water, in particular dirt water, can be removed from the first and/or second compartment. The removed water can be subsequent to the bypass be cleaned and be injected again in the first and/or second compartment, in particular via at least one second bypass. In particular, there is no need for a degassing station for the water for the reason that there is no integration of valves and/or throttles which can only operate with "clean" and/or pure water.

**[0024]** Moreover, the elements being slightly denser than water, which can be transported from the first compartment to the second compartment together with the lower density elements, can be carried out of the second compartment together with the lower density elements, in particular over the mesh screen.

**[0025]** The lower density elements can also be indicated as buoyant and/or floatable elements, wherein the elements being slightly denser than water are almost buoyant and/or floatable. The elements being slightly

denser than water nevertheless can be carried by the upward flow of water.

**[0026]** Preferably, the elements being slightly denser than water can be "pulled" by the upward flow of water, in particular the upward drag flow, from the first compartment to the second compartment. The drag and/or the flow resistance of the elements being slightly denser than water is of such a size that the upward flow of water can carry these elements being slightly denser than water.

**[0027]** Preferably, if the velocity of the flow, in particular the upward drag flow, increases, the flow resistance and/or drag will increase as well, in particular disproportionately and/or overproportionately.

**[0028]** Furthermore, the invention relates to a method for separating higher density elements and lower density elements according to claim 10.

**[0029]** According to a second aspect of the invention there is provided a method of separating higher density elements and lower density elements, the method comprising the following steps:

- providing a separator as defined above,
- introducing water into a first compartment;
- introducing a mixture comprising elements of differing densities into the first compartment;
- causing water to flow at a first rate from a lower region of the first compartment to an upper region of the first compartment, and from the upper region of the first compartment into a second compartment and over a mesh screen located in the second compartment thereby transporting elements having a density less than a first threshold value from the first compartment to the second compartment and depositing said elements on said screen;
- transporting said elements using said screen;
- removing higher density elements from a lower region of the first compartment; and
- transporting elements being slightly denser than water, in particular having a density of 1020 to 1300 kg/m<sup>3</sup>, preferably of 1100 to 1250 kg/m<sup>3</sup>, within an upward flow of water provided by a flow generator of the separator from the first compartment to the second compartment.

**[0030]** The mixture may comprise waste including one or more of stones, soil, twigs, plastic objects, and/or leaves. More particularly: the higher density elements may include stones; the lower density elements may include twigs.

**[0031]** The method may comprise the following further step:

- causing water to flow at a second, different, rate from a lower region of the first compartment to an upper region of the first compartment and into a second compartment thereby transporting elements having a density less than a second, different, threshold value from the first compartment to the second compartment.

**[0032]** It will of course be appreciated that features described in relation to one aspect of the present invention may be incorporated into other aspects of the present invention. For example, the method of the invention may incorporate any of the features described with reference to the apparatus of the invention and *vice versa*.

**[0033]** An embodiment of the present invention will now be described by way of example only with reference to the accompanying schematic drawings of which:

Fig. 1 is a plan view of a hydraulic density separator according to an embodiment of the invention;

Fig. 2 is an isometric view of the separator shown in Fig. 1;

Fig. 3 is an end view of the separator shown in Fig. 1; and

Fig. 4 is a schematic view of a hydraulic density separator according to another embodiment of the invention.

**[0034]** Fig. 1 is a plan view of a hydraulic density separator 1 in accordance with a first example embodiment of the invention. The separator 1 comprises a first compartment 2, a second compartment 4 adjacent to a first side of the first compartment 2, and a third compartment 6 adjacent to a second side of the first compartment 2. The first and second sides of the first compartment 2 are at right angles to each other. A weir 18 divides the first compartment 2 from the second compartment 4. A mesh screen 8 extends along the length of the second compartment 4 and has a first end 8a adjacent to the weir 18 and a second end 8b at the distal end of the second compartment. As is apparent from the isometric view of Fig. 2, the mesh screen 8 is inclined such that the first end 8a is lower than the second end 8b. Two vibratory motors 10 are connected to the screen 8. A screw auger 12 extends through the first compartment 2 (where it is located at the bottom of the first compartment) and into the third compartment 6. As is apparent from Fig. 2, the auger 12 and the third compartment 6 are inclined such that the end of the auger 12 located in the first compartment 2 is lower than the end of the auger 12 located in the third compartment 6. A motor 14 is located at the distal end of the third compartment 6 and turns the auger 12. A slot 18 is located in the bottom of the third compartment 6 beneath the end of the auger 12. In the front elevation of Fig. 3 an axial pump 16 can be seen mounted

on the separator 1 beneath the second compartment 4. It will be appreciated that other elements, for example the control system and electronics required to operate the separator 1 have not been included in Figs. 1 to 3 for the sake of clarity.

**[0035]** Prior to operation, the first compartment 2 is filled with water. In use, the material to be separated is introduced from above (for example, via an upwardly inclined conveyor - not shown) to the first compartment 2. The flow generator 16 generates an upflow of water in the first compartment 2. Lower density elements of the solids material to be separated will be entrained upwards by the flow of water, and carried over the weir 18 into the second compartment 4. As the flow of water and lower density elements enter the second compartment 4 they pass over the mesh screen 18 which will retain the lower density elements, while the water passes through to the underside of the screen. From the underside of the screen 18 the water is returned to the first compartment 2 via the pump 16. Meanwhile, higher density elements of the solids material whose density means the force of gravity still causes them to sink rather than rise, despite the influence of the upflow, will settle to the bottom of the first compartment 2. The auger 12 moves these higher density elements from the bottom of the first compartment 2 to the third compartment 6. After passing along the length of the auger 12 the higher density elements drop through the slot 18 and may be collected in a hopper (not shown) located beneath the third compartment 6. Meanwhile, the motors 10 vibrate the mesh screen 8 thereby causing the elements retained by the screen 8 to move along the screen from the first end 8a to the second end 8b. When they reach the second end 8b of the screen 8 the elements may drop into a hopper (not shown) located beneath the second compartment 4. The flow rate of the upflow may be increased or decreased by varying the power supplied to the pump 16 thereby enabling adjustment and/or alteration of the density threshold wherein elements of solids having a density greater than the threshold sink to the bottom of the compartment over time. Thus, separators in accordance with the present example embodiment may be more versatile than those of the prior art and may be able to separate a wider range of mixtures of materials, including mixtures where the difference in density between the higher and lower density elements in different mixture varies over a wide range. Separators in accordance with the present example embodiment may also offer improved separation of higher and lower density elements as the flow rate can be adjusted during the sorting process.

**[0036]** As the water returns to the first compartment 2 from the second compartment 4 the circulating flow is essentially a closed loop, with just a small amount of additional water required to replenish that lost with the lower and higher density solids. Accordingly, separators in accordance with the present invention may reduce the volume of water required for the separation operation (because the water is recirculated) thereby avoiding the

amount of contaminated water that must be safely disposed of after completion of the separation process.

**[0037]** The mesh panel 8 has a grid-like structure defining a plurality of apertures 24. In the embodiment shown the apertures are elongate and have a width of about 2 mm and a length of about 20mm. In use water carrying lower density elements passes over the screen, and the elements on top of the screen while the water passes through the apertures 24. Separators in accordance with the present embodiment may offer an improved separation rate.

**[0038]** Fig. 4 shows a schematic view of the hydraulic density separator. The arrow in the first compartment 2 indicate the upward flow of the water provided by the flow generator 16. In the first compartment 2 the flow generator 16 creates an upward flow of water which is configured in such away that elements being slightly denser than water are carried to the second compartment 4. The elements being slightly denser than water may have a density between 1020 to 1300 kg/m<sup>3</sup> and/or have a density that is up to 25 % higher than the density of water, preferably between 2 % to 17 % higher than the density of water.

**[0039]** The arrow in the second compartment 4 is directed to the ground which indicates that the lower density elements and the elements being slightly denser than water are transferred to the mesh panel 8. The mesh panel 8 can be a conveyor and/or can comprise one or more vibrators for vibrating the mesh screen.

**[0040]** The height of the weir 18 can be adjusted according to the separation process.

**[0041]** Moreover, Fig. 4 shows that the weir 18 has a border which separates the first compartment 2 from the second compartment 4. The border of the weir 18 is rounded so that the grade of turbulence of the upward flow of water can be decreased, in particular between 10 % to 70 %.

**[0042]** The pump 16 shown in Fig. 4 can be an axial water pump, in particular a dirt water pump. The hydraulic density separator 1 in the embodiment of Fig. 4 does not have throttles and/or valves. The pump 16 can be driven via a motor.

**[0043]** The higher density elements can be lift up in the embodiment of Fig. 4 via an auger 12 which moves the higher density elements from the bottom of the first compartment 2 to third compartment 6.

**[0044]** The motor of the pump 16 can be controlled, in particular to create the uplift and/or buoyancy for the upward flow of water in the first compartment 2.

**[0045]** The higher density elements can be non-floatable elements, wherein the lower density elements are floatable elements and/or the elements being slightly denser than water are almost floatable elements which can be transported by the upward flow of water.

**[0046]** The elements being slightly denser than water can be later used as RDF waste and/or burning material.

**[0047]** Whilst the present invention has been described and illustrated with reference to particular em-

bodiments, it will be appreciated by those of ordinary skill in the art that the invention lends itself to many different variations not specifically illustrated herein. By way of example only, certain possible variations will now be described.

**[0048]** Where in the foregoing description, integers or elements are mentioned which have known, obvious or foreseeable equivalents, then such equivalents are herein incorporated as if individually set forth. Reference should be made to the claims for determining the true scope of the present invention, which should be construed so as to encompass any such equivalents. It will also be appreciated by the reader that integers or features of the invention that are described as preferable, advantageous, convenient or the like are optional and do not limit the scope of the independent claims. Moreover, it is to be understood that such optional integers or features, whilst of possible benefit in some embodiments of the invention, may not be desirable, and may therefore be absent, in other embodiments.

### Claims

1. A hydraulic density separator for separating higher density elements and lower density elements of solids material, the apparatus comprising:
  - a first compartment for receiving a mixture comprising higher density elements and lower density elements, and water;
  - a flow generator configured to provide an upward flow of water within the first compartment, the apparatus being configured such that the rate of said flow can be adjusted to allow the maximum density of elements that will be entrained by said flow and rise upwardly to be varied;
  - means in the first compartment for removing higher density elements that have settled from a lower region of the first compartment,
  - a second compartment for receiving a mixture comprising water and lower density elements from the first compartment, the second compartment comprising a mesh screen configured to move lower density elements from a first position to a second position spaced apart from the first position;
  - wherein a water flow path is provided from an upper region of the first compartment into the second compartment and over a portion of the mesh screen such that lower density elements entrained by the flow of water are deposited on the mesh screen; and
  - wherein the upward flow of water within the first compartment provided by the flow generator is configured in such a way that elements being slightly denser than water are carried to the sec-

ond compartment.

2. A separator according to claim 1, wherein after passing over a portion of the mesh screen the flow path continues from a lower region of the second compartment to the first compartment.
3. A separator according to any previous claim, further comprising one or more vibrators for vibrating the mesh screen.
4. A separator according to any preceding claim, wherein the mesh screen acts as a conveyor.
5. A separator according to any previous claim, further comprising an auger located partially within the first compartment for removing higher density elements that have settled from a lower region of the first compartment.
6. A separator according to any previous claim, comprising a weir located between the first compartment and the second compartment, the flow path passing from the upper region of the first compartment to the second compartment over the weir.
7. A separator according to any preceding claim, wherein the apertures in the screen are elongate.
8. A separator according to any preceding claim, wherein the apertures in the screen have a width in the range of 1 to 5mm.
9. A separator according to any preceding claim, wherein the flow generator comprises an axial flow pump.
10. A method of separating higher density elements and lower density elements, the method comprising the following steps:
  - providing a separator according to any preceding claim,
  - introducing water into the first compartment;
  - introducing a mixture comprising elements of differing densities into the first compartment;
  - causing water to flow from a lower region of the first compartment to an upper region of the first compartment, and from the upper region of the first compartment into a second compartment and over the mesh screen located in the second compartment thereby transporting elements having a density less than a threshold value from the first compartment to the second compartment and depositing said elements on said screen;
  - transporting said elements using said screen;
  - removing higher density elements from a lower

region of the first compartment; and

- transporting elements being slightly denser than water, in particular having a density of 1020 to 1300 kg/m<sup>3</sup>, preferably of 1100 to 1250 kg/m<sup>3</sup>, within an upward flow of water provided by a flow generator of the separator from the first compartment to the second compartment.

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11. A method according to claim 10, wherein the mixture comprises waste including one or more of stones, soil, twigs, plastic objects, and/or leaves.

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12. A method according to claim 11, wherein the higher density elements include stones.

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13. A method according to claim 11 or 12, wherein the lower density elements include twigs.

14. A method according to any of claims 10 to 13, the method comprising the following further step:

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- causing water to flow at a second, different, rate from a lower region of the first compartment to an upper region of the first compartment and into a second compartment thereby transporting elements having a density less than a second, different, threshold value from the first compartment to the second compartment.

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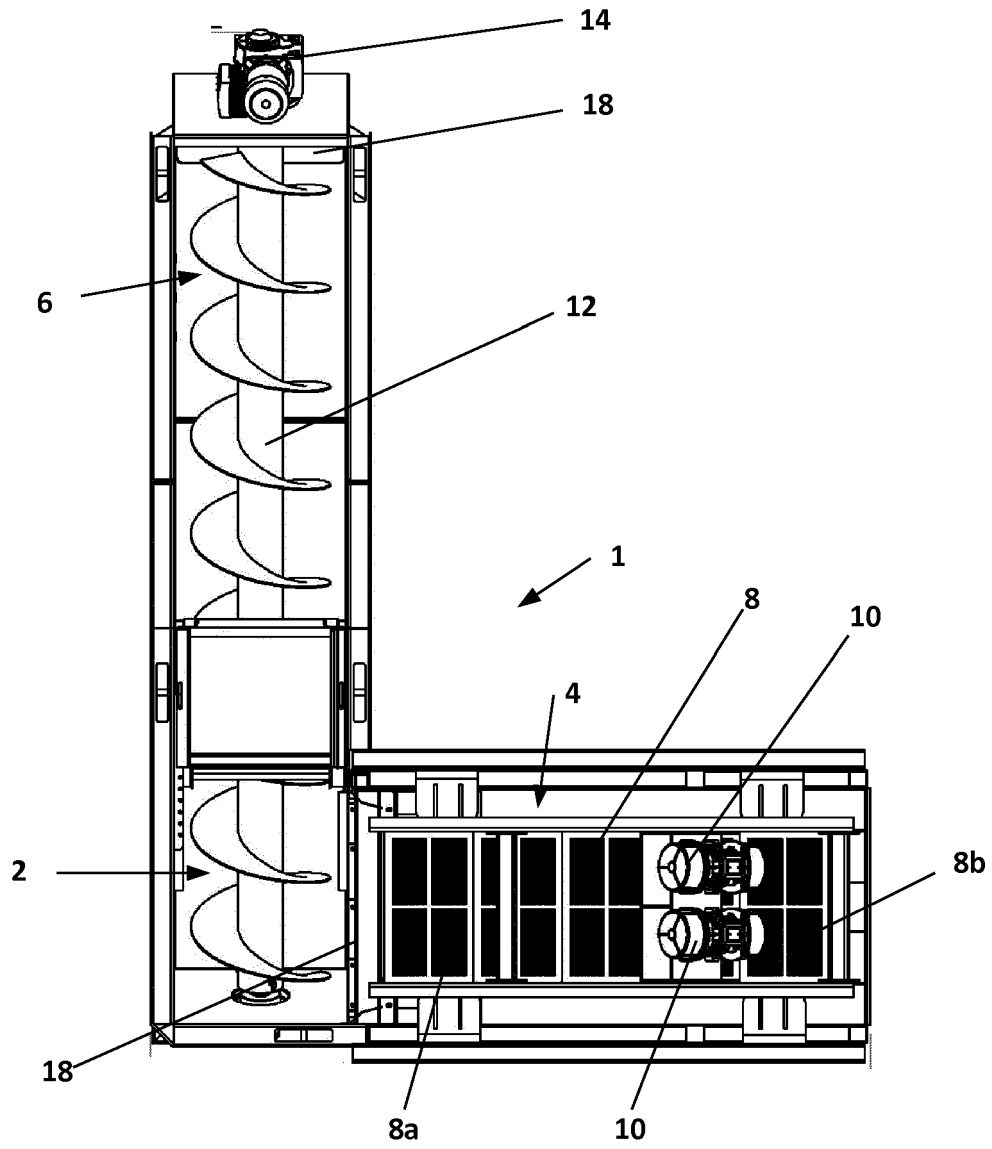


Fig. 1

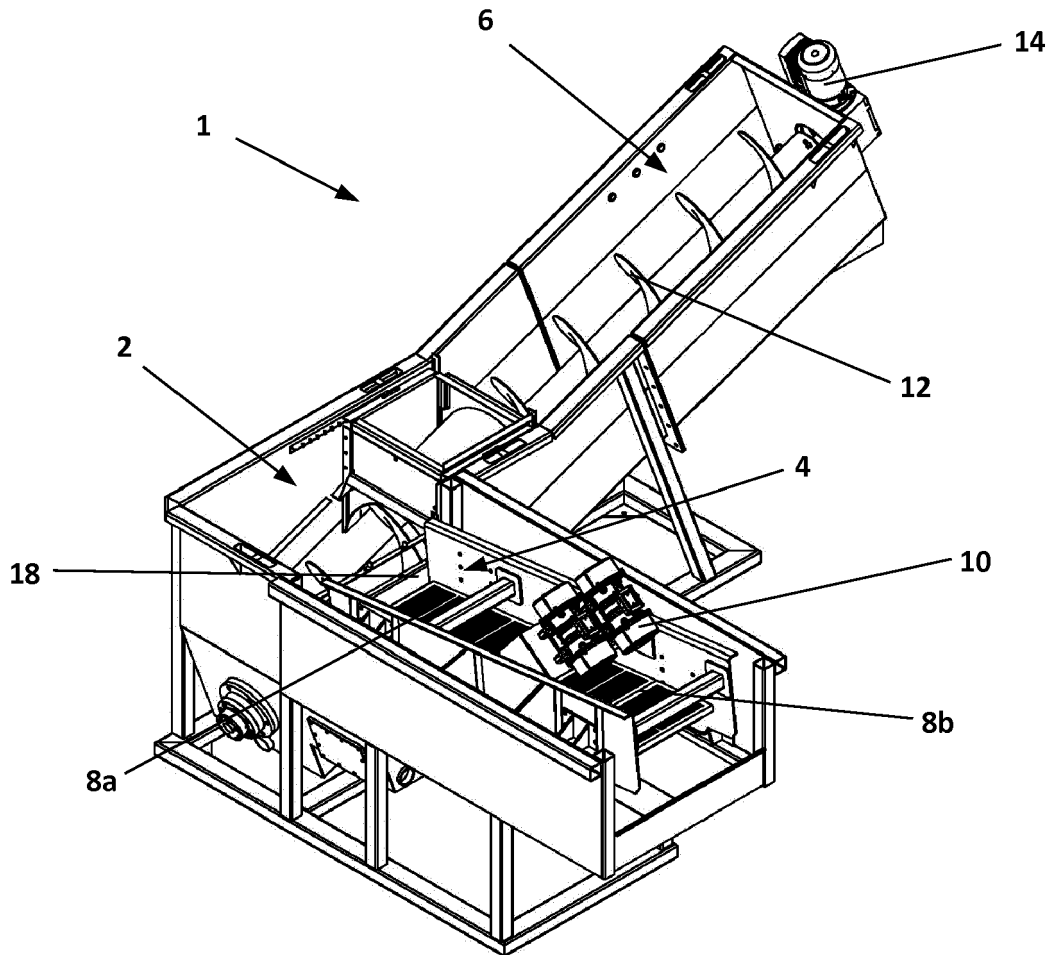


Fig. 2

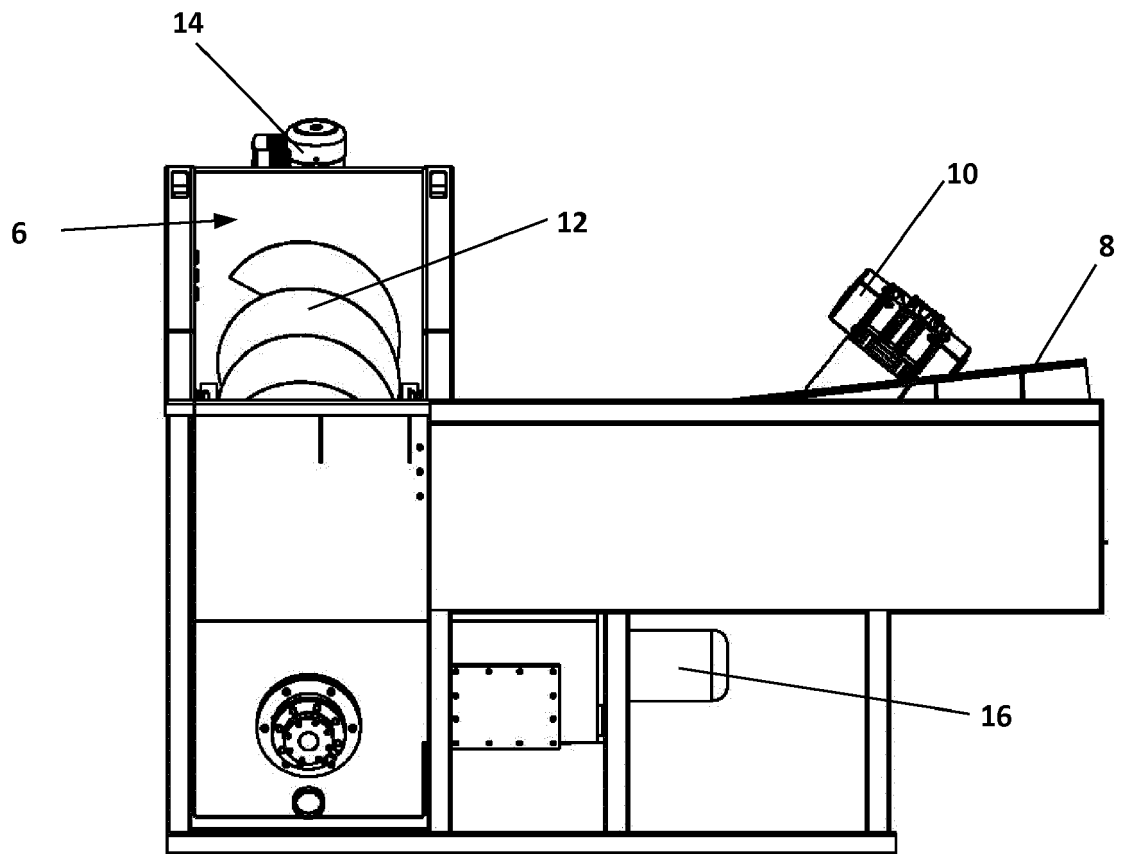


Fig. 3

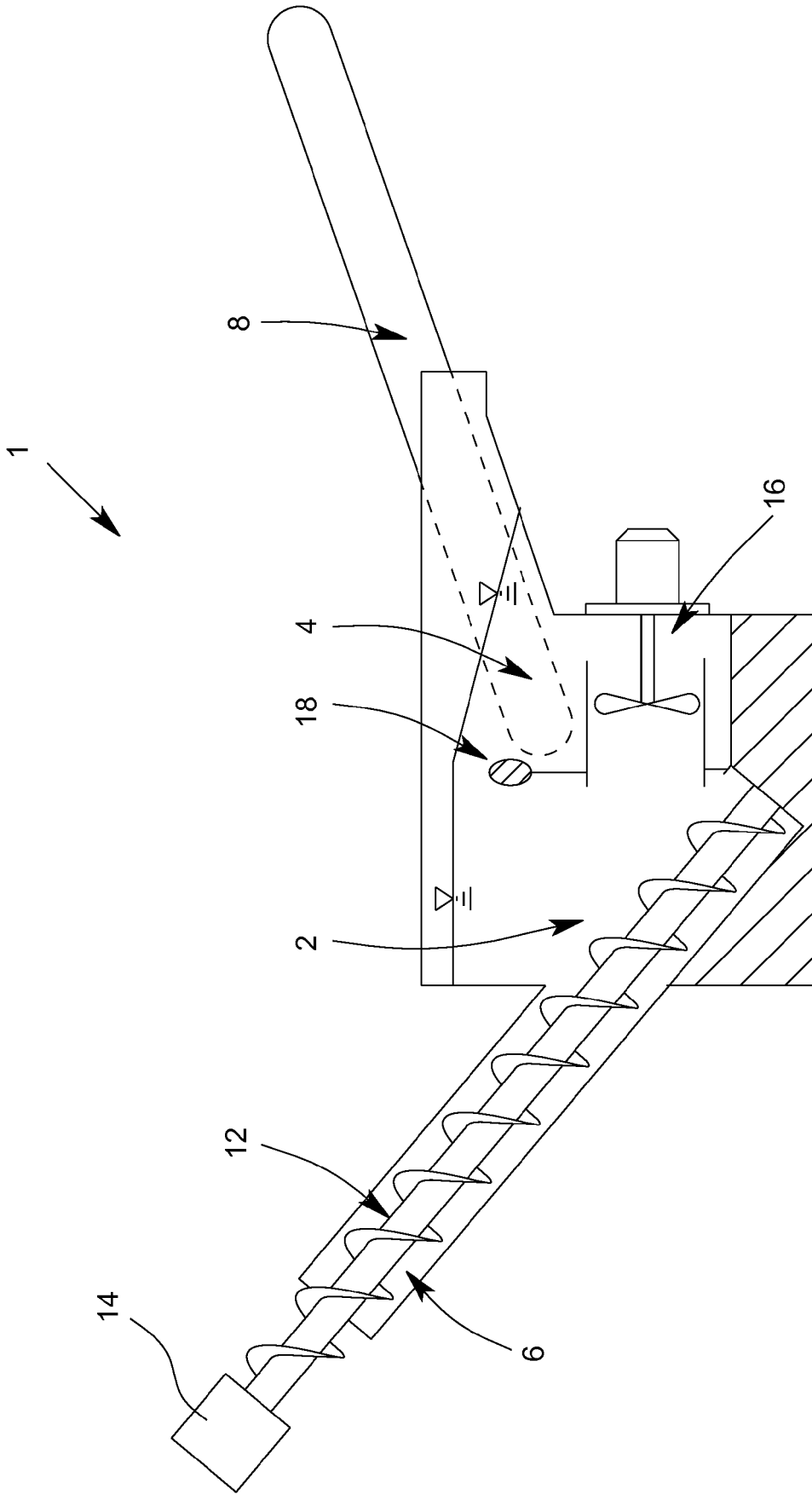


Fig. 4



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Application Number  
EP 19 17 9588

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The present search report has been drawn up for all claims			
Place of search <b>Munich</b>		Date of completion of the search <b>2 October 2019</b>	Examiner <b>Leitner, Josef</b>
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons	
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ANNEX TO THE EUROPEAN SEARCH REPORT  
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