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(54) Title: CENTRIFUGAL SEPARATOR, METHOD FOR SEPARATING

(57) Abstract: A centrifugal separator comprising a rotatably arranged upwardly extending first element (2) with elongate elements (17) connected thereto and an upwardly extending second element (3), wherein the first element and the second element are approximately concentrically arranged with respect to each other resulting in an inner element (2) and an outer element (3) and wherein the elongate elements extend from the first element towards the second element, further comprising a supply opening (8) arranged at an outer end of the separator on a radius between the inner element and the outer element for supplying a dispersion comprising particles to be separated and further comprising a discharge opening arranged at an opposite outer end for discharging separated fluid and/or particles, wherein the supply opening (8) is arranged proximate to the outer element.

Fig. 1
Title: Centrifugal separator, method for separating

The invention relates to a centrifugal separator.

Centrifugal separators are commonly known and are generally used for separating particles from a dispersion comprising said particles. A dispersion can be considered as a system in which particles are dispersed in a continuous phase of a different composition, e.g. a mud comprising clay particles in water, algae particles in water, contaminant particles in lubricant, water in oil. A dispersion may comprise two or more phases, such as a dispersed phase and a continuous phase. The dispersed phase may be solid or liquid. The continuous phase is a fluid, viz. a gas or a liquid, usually a liquid. Thus, a dispersion is a fluid comprising one or more components. The components may be for example solid particles dispersed in the fluid or may be liquid particles dispersed in a fluid.

The principle of a centrifugal separator is commonly known. The centrifugal separator creates an artificial field of gravity by using the centrifugal force. Due to the difference in specific gravity of the different components in the dispersion, one or more components may be separated and collected. A drawback of the known centrifugal separators is that they are more effective at an outer region of the separator. The dispersion may need to travel a significant distance after being supplied to the centrifugal separator to reach the more effective region of the separator. When part of the dispersion does not pass this most effective region, the separation may therefore be inefficient and/or ineffective.

US-A-3 810 347 describes a centrifugal separator for separating three phase mixtures, comprising an inner barrel and an outer drum, weirs and septa, wherein the septa acts to fix the inner barrel to the outer drum. US-A-3 810 347 does not disclose that the outer drum of the centrifuge separator is removable. Further, the separation of solids from a mixture described in US-A-
3 810 347 is by means of an inverted weir with an external valve arranged longitudinally within the centrifuge. The solids are deposited by centrifugal force on the inner wall of the outer drum and are periodically removed via the external valve. US-A-3 810 347 does not disclose that the septa collects or accumulates any solids.

An object of the invention is to provide a centrifugal separator that obviates at least one of the abovementioned drawbacks.

Thereto, the invention provides for a centrifugal separator comprising a rotatably arranged upwardly extending first element with elongate elements connected thereto and an upwardly extending second element, wherein the first element and the second element are approximately concentrically arranged with respect to each other resulting in an inner element and an outer element and wherein the elongate elements extend from the first element towards the second element, further comprising a supply opening arranged at an outer end of the separator on a radius between the inner element and the outer element for supplying a dispersion comprising particles to be separated and further comprising a discharge opening arranged at an opposite outer end for discharging separated fluid and/or particles, wherein the supply opening is arranged proximate to the outer element.

By providing the supply opening proximate to the outer element, the dispersion can be supplied at the region where the centrifugal separator is more effective. The dispersion is enforced to flow towards the most effective region. The centrifugal separator thus may become more efficient and/or more effective. The supply opening may be an annular opening arranged near the outer element or may be multiple openings arranged for example as an annular ring near the outer element.

The centrifugal separator may be arranged such that the first element is the outer element and the second element is the inner element. The elongate elements may be connected to the outer element and may extend inwardly. The elongate elements may be vanes, brush-like elements, blades, paddles or
When vanes are used, these vanes preferably have a predetermined curvature. Many variants of elongate elements can be possible. The elongate elements may be flexible and/or flexibly mounted. Typically, the elongate elements extend over a length of the separator from one end of the separator comprising an inlet opening towards another upper end of the separator.

Also, the centrifugal separator may be arranged such that the first element is the inner element and the second element is the outer element. The elongate elements may be connected to the inner element and may extend outwardly. The outer element is approximately concentrically arranged with respect to the inner element, meaning that the outer element surrounds the inner element. The outer element and/or the inner element may be cylindrical, tubular or cubical or may have any other upwardly extending form. The outer element may be drum-shaped such that the inner space between the inner element and the outer element, i.e. where separation takes place may be closed during centrifuging. Via the supply opening the dispersion is directly supplied to the inner space.

The first element may be a rotational shaft and the second element may be a tubular sleeve. The rotational shaft and the tubular sleeve may form a drum of the centrifugal separator. The rotational shaft may be approximately centrally positioned in the tubular sleeve, wherein the tubular sleeve may surround the rotational shaft. The tubular sleeve may be a stationary element, thus the first element, the rotational shaft, with the elongate elements may rotate in the second element, the tubular sleeve. However, the second element may also be a rotational element, so the first element, the second element and the elongate elements may rotate together. Preferably, the first element and the second element rotate with the same speed such that during rotation there is approximately no velocity difference between the first element and the second element. In an embodiment, the elongate elements can extend from the first element until the second element and/or can even rest on the second element such that the first element and the
second element are mechanically coupled during rotation. The second element can then during rotation be taken along with the first element. Also, the first and the second element can both be driven by the same drive system, or they can each have an own drive system which may be synchronized. By rotating the first element and the second element with the same rotational speed, turbulence of the dispersion and/or friction between separated particles and the tubular sleeve can be minimized.

The supply opening for supplying dispersion to the centrifugal separator may be arranged at an outer end of the centrifugal separator. The outer end may be an upper end or a lower end. Via the supply opening the dispersion may be supplied in the inner space between the inner element and the outer element.

By providing a disc arranged between the inner element and the outer element, an opening between the inner wall of the outer element and an outer edge of the disc may provide for the supply opening. The supply opening may be arranged as an annular opening between the disc and the outer element. Also, the supply opening may comprise a multitude of smaller openings that may be arranged in a ring-shaped outer region of the disc, near the outer element. The disc may be for example a separate plate, or may be a bottom plate of the centrifugal separator. The disc may be connected to the inner element and/or may be connected to the outer element or may be a separate element provided in the centrifugal separator.

By providing a disc, a single feed supply may be sufficient to distribute the supplied dispersion to the supply opening provided by the disc. The disc may be arranged downstream of the feed supply. The feed supply may be arranged inside or outside the drum of the separator. The feed supply may be arranged inside the drum of the separator, for example the feed supply may be arranged through a rotational shaft of the inner element or may end directly in the inner space of the drum, the disc may then e.g. also be placed inside the inner space. The feed supply may also be arranged outside the drum.
of the separator and the dispersion may for example be guided from the feed supply to the supply opening or supply openings via supply lines, or the disc may be arranged outside the inner space wherein the dispersion via the feed supply is fed e.g. against the disc. Instead of a disc also other arrangements may be provided to supply the dispersion proximate the outer element, e.g. supply lines and/or openings in a bottom plate of the separator. The disc may be a plate-type element or may be e.g. curved or may for example have ribs and/or canals to enforce the dispersion outwards. Also, more than one disc may be provided to enforce the dispersion outwards multiple times. The discs may be arranged as baffle plates distributed over the inner space with a distance between subsequent discs. Each disc may be provided with openings at an outer edge proximate the outer element.

The dispersion fed to the centrifugal separator from the feed supply may meet the disc and may be directed by the disc to the outer edge of the disc where the supply opening is provided for. However, the disc may also be provided upstream the feed supply. In that case an inverter plate may be provided to turn the supplied dispersion from the feed supply towards the disc. Preferably, the disc is arranged proximate to the feed supply, so the distance the fed dispersion may travel before meeting the disc may be limited. By providing the disc and the supply opening at an outer edge of the disc, the fed dispersion may be supplied to the centrifugal separator at an outer radius and the efficiency and/or effectivity of the centrifugal separator may be increased.

Alternatively and/or additionally, the feed supply may have a ring-shaped discharge opening and/or for example a cone-like end piece. Also, the feed supply may feed the dispersion in a collecting chamber from which radially outwardly extending tubes may guide the dispersion to the supply opening and/or to the outer region near the outer element of the separator.

The disc may be oriented substantially transverse to the upwardly extending inner element, so as to direct the dispersion supplied via the feed supply and encountering the disc towards the supply opening at the outer edge
of the disc. In an embodiment, the disc may for example be oriented at a small angle upstream with respect to the transverse orientation, so the dispersion encountering the disc may be 'helped' moving to the supply opening at the outer edge via the sloped orientation of the disc. The disc may be conical or pyramidal of which the sides may have a slope of approximately 2 to 10 degrees.

By providing the disc with discharge openings, upon termination of the rotation, remaining separated particles and/or remaining liquid and/or remaining dispersion can flow back to the feed supply via the discharge openings. For example, when the dispersion comprises solid particles dispersed in a liquid, the solid particles may be separated from the liquid during use of the centrifugal separator and may e.g. collect at an outer radial edge of the centrifugal separator and/or between and/or on the elongate elements of the separator. The liquid particles of the dispersion may in use for example be collected at an outer upper and/or lower end of the centrifugal separator, e.g. at a centripetal rotor. However, after termination of the rotation, particles and/or the non-separated dispersion that are still in the centrifugal separator will flow downwards and may have to be removed from the centrifugal separator at a lower end. By providing discharge openings in the disc, the liquid particles of the dispersion and/or the non-separated dispersion may flow through the discharge openings back to the feed supply, without dissolving the solid particles collected at an outer edge.

By arranging the discharge openings proximate to the inner element, dispersion fed by the feed supply tends to move outwards, and may not encounter the discharge openings. By placing the discharge openings relatively close to the inner element, the discharge openings may be avoided by dispersion as an entrance opening to the drum and the dispersion may enter the drum via the openings at an outer edge of the disc. Also, by providing the discharge openings relatively close to the inner element, it may be avoided that the liquid that is separated from the dispersion during use of the centrifugal
separators flows downward via the discharge openings, thereby a short-circuit may occur.

A multi-phase dispersion may fall apart in different phases during use of the centrifugal separator, such as a gaseous phase, a liquid phase and/or a solid phase, due to the artificial gravity. The gaseous phase can usually be found at a relative small radius near and around the inner element. The solid phase can usually be found at a relative large radius near the outer edge of the drum, near the outer element. The liquid phase can usually be found between the gaseous phase and the solid phase. Advantageously, the discharge openings are provided in the region where the gaseous phase occurs, thus proximate to the inner element. The discharge openings can then be arranged on approximately the same radial distance from the inner element, as a ring that falls e.g. within the gaseous phase-zone. During rotation, the liquid phase may form an upwardly extending hollow cylindrical level. Preferably, the discharge openings are provided in the gaseous region, i.e. within the hollow liquid cylindrical level. Preferably, the diameter of the discharge openings may be smaller than the diameter of the liquid hollow cylindrical level during rotation to avoid a short-cut of liquid particles flowing back through the discharge openings. Upon termination of the rotation, the hollow liquid cylinder collapses and forms an approximately horizontal liquid plate-like level. Then the dispersion can reach the discharge openings and can flow back to the feed supply. Thus, during rotation of the centrifugal separator an artificial 'lock' is provided for the discharge openings.

By providing the second element as a removable element with respect to the first element, discharging the collected solid particles from the drum may become relatively easy. The solid particles, separated from the dispersion, may stick or accumulate to the elongate elements of the first element. By removing the second element with respect to the first element, the collected solid particles can be better reached to remove them from the elongate elements and from the centrifugal separator. Preferably, the second
element is axially movable with respect to the first element, e.g. the second element can axially slide with respect to the first element. Preferably, the second element as outer element is removable with respect to the first element as inner element for collecting particles accumulated on the elongate elements.

By flexibly mounting the elongate elements on the first element and/or to provide flexible elongate elements, the elongate elements can move under influence of the rotation and for example enforce particles and/or dispersion moving outwardly to a region with larger centrifugal force for better separation. The elongate elements may be for example vanes or brush-like elements or blades or paddles. For example elongate elements such as vanes can be curved in order to enforce the particles and/or dispersion moving outwardly. Preferably, the vanes are concavely curved when viewed in the direction of rotation. By curvedly pre-forming of the vanes the efficiency of the centrifugal separator may be increased, because more dispersion may reach the outer region of the drum where the centrifugal forces are higher. For example, the elongate elements may be flexible, such that when the outer element is removed for collecting the accumulated particles, the elongate elements may stretch under influence of the rotational forces. The elongate elements may be manufactured for instance from plastic and/or plate steel.

Additionally and/or alternatively, the elongate elements can be flexibly mounted, for instance can be hingedly connected, such that when the outer element is removed for collecting the accumulated particles, the elongate elements pivot under influence of the rotational forces.

Examples of centrifugal separators comprising an inner and an outer rotatable element with elongate elements and of which the outer element is removable with respect to the inner element are described in publications WO-A-2009/05355 or WO-A-00/32297 which are incorporated herein by reference. Such types of separator are commercially available under the trademarks Evodos™. An Evodos™-type separator comprises vanes as elongate elements. The vanes of the Evodos™-type separator can be flexible
and/or flexibly mounted. Alternatively separators as described in WO-A-00/32297 may be used which comprise brush-like elements as elongate elements. The brush-like elements can be flexible and/or flexibly mounted.

Also, by removing the second element and then starting rotation of the first element, the flexibly mounted elongate elements can move outwardly and the solid particles collected on the elongate elements can be accelerated outwardly from the elongate elements. Thus, the collected particles can be relatively effectively removed from the elongate elements. In an other embodiment, the elongate elements itself can be flexible, so the elongate elements can move under influence of the centrifugal force of the centrifugal separator.

The invention further relates to a method for separating particles from a dispersion comprising said particles by using centrifugal force of the above mentioned centrifugal separator, comprising supplying a dispersion comprising particles to be separated to an inner space between the inner element and the outer element through a supply opening at an outer end of the separator proximate the outer element, discharging at an opposite outer end the separated particles and/or the separated fluid.

Further advantageous embodiments are represented in the subclaims.

The invention will further be elucidated on the basis of exemplary embodiments which are represented in a drawing. The exemplary embodiments are given by way of non-limitative illustration of the invention.

In the drawing:

Fig. 1 shows a schematic view of an embodiment of the centrifugal separator according to the invention; and

Fig. 2 shows a schematic perspective view of the embodiment of Fig. 1.

It is noted that the figures are only schematic representations of embodiments of the invention that are given by way of non-limiting example.
In the figures, the same or corresponding parts are designated with the same reference numerals.

Fig. 1 and Fig. 2 show a centrifugal separator 1 with an upwardly extending inner element 2 and an upwardly extending outer element 3. The inner element 2 and the outer element 3 are approximately concentrically arranged, the outer element 3 surrounds the inner element 2 and the inner element 2 is approximately centrally arranged within the outer element 3. The outer element 3 may be arranged as a closed drum. Between the outer element 3 and the inner element 2 an inner space 11 is provided where the separation takes place under influence of the centrifugal force.

The inner element 2 is in this embodiment carried out as a hollow shaft, but can have a different cross-section such as e.g. triangular or rectangular or oval. The outer element 3 is in this embodiment provided as a cylindrical sleeve surrounding the inner element, but can have different cross-sections, such as e.g. triangular or rectangular or oval. In particular in the embodiment shown in Fig. 2, the inner element 2 and the outer element 3 rotate during use with the same rotational speed. The inner element 2 and the outer element 3 are mechanically coupled via elongate elements 17. In this embodiment, the elongate elements are provided as vanes 17. The vanes 17 are connected to the inner element 2 and rest against the outer element 3. Via the vanes 17, the inner element 2 and the outer element 3 are here mechanically coupled. The outer element 3 is rotated by the vanes 17 and the inner element 2 with the same rotational speed. In this embodiment, the inner element 2 is a rotational shaft and the outer element 3 is a tubular sleeve. A mechanical coupling between the inner element 2 and the outer element 3 during rotation can also provided otherwise, e.g. the inner element 2 and the outer element 3 can be driven by a same drive unit or can be driven by different drive units which may be synchronized or may be mechanically coupled by spacer elements such as rods, the coupling of which may be undone upon termination.
of the centrifuging allowing the outer element to be removed with respect to the inner element.

The centrifugal separator 1 can be used for separating one or more components from a liquid e.g. separating solid particles dispersed in a liquid from the liquid. From the centrifugal separator 1 the solid particles can be collected and the liquid can be collected. A centrifugal separator can be used for separating various types of dispersions, e.g. algae dispersed in water, soft solids dispersed in oil, water dispersed in oil.

Separation of particles from the dispersion is based on the difference in specific gravity of the particles dispersed. By rotation of the first element with vanes 17 an artificial field of gravity is created due to the centrifugal force. The centrifugal force, thus the artificial gravity, is higher at a larger distance from the centre of rotation; therefore separation of the dispersion is more efficient at the outer edges of the centrifugal separator 1. This can be relevant, in particular, when a dispersion comprises particles with approximately the same specific gravity as the fluid in which they are dispersed. To direct the dispersion to the outer region of the centrifugal separator 1, the dispersion is supplied through a supply opening 8 that is arranged near the outer element 3. The supply opening 8 is arranged at a radius between the inner element 2 and the outer element 3. In this embodiment, the supply opening 8 is shown in Fig. 1 as an annular opening adjacent an inner wall 9 of the outer element 3, having a radius that is only slightly smaller than the radius of the outer element 3. A supply opening 8 provided in the range between approximately half of the distance between the outer element 3 and the inner element 2 and approximately adjacent the outer element 3 is understood to fall within the scope of the invention.

In the embodiment shown in Fig. 1 is the inner element 2 provided as the first element with vanes 17 connected thereto (for simplicity's sake the vanes are not shown in Fig. 1, they are shown in Fig. 2) and is the outer element 3 provided as the second element. It may be clear that in other
embodiments the outer element may be provided as the first element with vanes 17 connected thereto and the inner element may be provided as the second element. In this embodiment, the vanes 17 are flexibly and/or flexibly mounted on the first element.

The centrifugal separator 1 is closed at an upper end with an upper closing end piece 4 and a lower end with a lower closing end piece 5. The upper and the lower closing end pieces 4, 5 are in this embodiment mounted on the first element 2. The outer element 3 is in this embodiment removable arranged with respect to the inner element 2. By removing the outer element 3 with respect to the inner element 2, the inner element 2 becomes free of the outer element 3. By rotating the inner element 2, particles accumulated on the vanes 17 can be launched from the vanes 17 and can be collected for further processing. The vanes 17 can thus be cleaned. When the vanes 17 are cleaned, the outer element 3 can be placed over or around the inner element 2 again and the separator 1 can be closed for a further run to separate dispersion.

Through the hollow rotational shaft 2 a dispersion feed line 6 is provided. At a lower end of the dispersion feed line 6, a dispersion feed supply 7 is arranged for feeding the dispersion to the centrifugal separator 1. The dispersion feed supply 7 is here a lower end of the feed line 6 with holes therein through which the dispersion can be launched to the centrifugal separator 1. The thus launched dispersion encounters the lower closing end piece 5 and is directed upwards towards the disc 10. Via the disc 10 the dispersion is directed to the outer edge of the disc 10 where the supply opening 8 is located. Via the supply opening 8, the dispersion can be supplied to the inner space of the drum 11 of the centrifugal separator 1.

In this embodiment, the feed supply and the supply opening are located at a lower end of the centrifugal separator 1, but they can also be located at an upper end of the centrifugal separator 1. Also, the dispersion feed line may be connected directly to the centrifugal separator and may not have to run through the rotational shaft.
The dispersion can thus be supplied to a more effective outer region of the inner space of the drum 11 where the centrifugal force and thus the artificial gravity is the largest.

A dispersion subject to the artificial gravity generated by the centrifugal forces, usually falls apart in three phases: a gaseous phase, a liquid phase and a solid phase. The gaseous phase is usually located in an inner region 12 near the inner element 2. The solid phase, e.g. solid particles, is usually located in an outer region 13. The liquid phase is usually located in an intermediate region 14, having a hollow cylindrical liquid level. More than one liquid phase 14a, 14b may be formed, e.g. water and oil. The solid particles of the dispersion may be separated from the dispersion and may collect in the outer region 13. There, the solid particles tend to stick to the vanes 17 of the centrifugal separator 1. The liquid particles can be collected via the centripetal pumps 15 located at the upper end of the centrifugal separator 1.

When the drum 11 is relatively filled with solid particles and/or the vanes 17 are relatively full with stuck solid particles, the rotation of the rotational shaft 2 can be terminated. The liquid and/or dispersion not separated yet will flow downward to be discharged from the drum 11. Discharging can be done via the openings 8, however the openings 8 may be blocked with solid particles. To accommodate discharge of the liquid and/or dispersion, discharge openings 16 are provided in the disc 10.

The discharge openings 16 are here located proximate the inner element 2, in particular the discharge openings 16 are located within the radius of the inner region 12 of the gaseous phase, i.e. within the hollow cylindrical liquid level. By arranging the discharge openings 16 relatively close to the inner shaft 2 and/or within the inner region 12 of the gaseous phase, it can be minimized and/or avoided that dispersion enters via the discharge openings 16 into the drum 11. Also it can be minimized and/or avoided that liquid and/or dispersion may flow through the discharge openings 16 out of the drum 11 during rotation of the rotation shaft 2.
After discharging of the liquid and/or dispersion, the sleeve element 3 can be removed from the centrifugal separator 1, for example by shifting it axially upwards. Then rotation of the rotational shaft 2 can be started again and the flexible and/or flexibly mounted vanes 17 can be swung outwardly and the solid particles stuck to the vanes 17 can be loosened from the vanes 17 and can be collected.

In another embodiment, the vanes 17 may be relatively stiff and/or fixedly mounted to the first element. Harvesting the solid particles stuck to the vanes 17 can for example be done by emptying the drum e.g. by hand or with a shovel.

Many variants will be apparent to the person skilled in the art. For example, instead of a disc, the dispersion feed line may supply the dispersion directly in the inner space between the inner element and the outer element at a radius near the outer element. The dispersion feed line may then have an end opening that is arranged as supply opening to supply the dispersion at the outer region, e.g. as an annular cone or the like. All variants are understood to be comprised within the scope of the invention as defined in the following claims.
Claims

1. A centrifugal separator comprising a rotatably arranged upwardly extending first element with elongate elements connected thereto and an upwardly extending second element, wherein the first element and the second element are approximately concentrically arranged with respect to each other resulting in an inner element and an outer element, wherein the outer element is removable with respect to the inner element and wherein the elongate elements extend from the first element towards the second element, further comprising a supply opening arranged at an outer end of the separator on a radius between the inner element and the outer element for supplying a dispersion comprising particles to be separated and further comprising a discharge opening arranged at an opposite outer end for discharging separated fluid and/or particles, wherein the supply opening is arranged proximate to the outer element.

2. The centrifugal separator according to claim 1, wherein the supply opening is an annular opening near the outer element.

3. The centrifugal separator according to claim 1 or 2, wherein the supply opening is provided by an opening between an inner wall of the outer element and an outer edge of a disc arranged between the inner element and the outer element.

4. The centrifugal separator according to any one of the preceding claims, further comprising discharge openings for discharging dispersion from the separator upon termination of rotation of the first element and the second element of the separator.

5. The centrifugal separator according to claim 4, wherein the discharge openings are arranged proximate to the inner element.
6. The centrifugal separator according to claim 4 or 5, wherein the discharge openings are arranged on approximately the same radial distance from the inner element.

7. The centrifugal separator according to any one of the claims 3 - 6, wherein the disc is provided with the discharge openings.

8. The centrifugal separator according to any one of the preceding claims, wherein the separator is provided with an upper closing end piece.

9. The centrifugal separator according to claim 8, wherein the upper closing end piece is mounted on the first element.

10. The centrifugal separator according to any one of the preceding claims, wherein the separator is provided with a lower closing end piece.

11. The centrifugal separator according to claim 10, wherein the lower closing end piece is mounted on the first element.

12. The centrifugal separator according to any one of claims, wherein the disc is oriented substantially transverse to the upwardly extending inner element.

13. The centrifugal separator according to any one of the preceding claims, wherein the inner element is the first element and the outer element is the second element.

14. The centrifugal separator according to claim 13, wherein the first element is a rotational shaft.

15. Method for separating particles from a dispersion comprising said particles by using centrifugal force of a centrifugal separator according to any one of the previous claims, comprising supplying a dispersion comprising particles to be separated to an inner space between the inner element and the outer element through a supply opening that is arranged at an outer end of the separator proximate to the outer element, discharging at an opposite outer end the separated particles and/or the separated fluid.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

INV. B04B1/04 B04B7/12 B04B11/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<tr>
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<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<td>X</td>
<td>US 787 179 A (C.A. HULT) 11 April 1905 (1905-04-11) page 2, line 49 - line 61 page 3, line 105 - page 4, line 28 figures 1-2</td>
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<td>US 3 810 347 A (KARTINEN E) 14 May 1974 (1974-05-14) cited in the application on column 3, line 33 - column 4, line 49 column 5, line 14 - line 60; figures 1-3</td>
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<td>GB 729 169 A (GLACIER CO LTD) 4 May 1955 (1955-05-04) page 2, line 81 - line 115; figures 1-2</td>
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Date of the actual completion of the international search 8 December 2010

Date of mailing of the international search report 14/12/2010

Authorized officer Leitner, Josef

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