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(71) Applicant (for all designated States except US): **OUTOTEC OYJ** [FI/FI]; Riihitontuntie 7, FI-02200 Espoo (FI).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **NYMAN, Bror** [FI/FI]; Ruuspolku 1, FI-28450 Vanha-Ulvila (FI). **LILJA, Launo** [FI/FI]; Liisankatu 19 A 13, FI-28360 Pori (FI). **HULTHOLM, Stig-Erik** [FI/FI]; Sitomantie 1, FI-28360 Pori (FI). **GRAU, Rodrigo** [FI/FI]; Rentukantie 9 as. 1, FI-28660 Pori (FI).

(74) Agent: **OUTOTEC OYJ, IPR MANAGEMENT**; P.O. Box 86, FI-02201 Espoo (FI).

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(54) Title: METHOD FOR MIXING GAS INTO SLURRY DURING FLOTATION AND APPARATUS FOR THAT

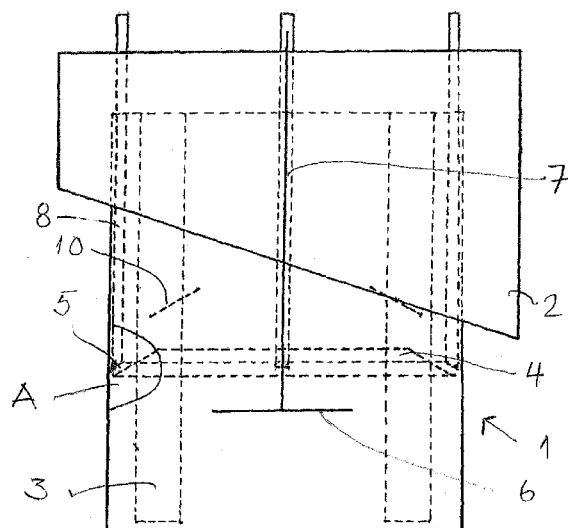


Fig. 1

(57) Abstract: The invention relates to a method and apparatus for mixing gas into slurry during flotation and for guiding the slurry dispersion upwards in the reactor in a controlled manner. The method utilises the combined effect of a powerful mixer and devices placed inside the reactor. The method and apparatus are especially suitable for the flotation of metal-bearing ores that are difficult to process.



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METHOD FOR MIXING GAS INTO SLURRY DURING FLOTATION AND APPARATUS FOR THAT

FIELD OF THE INVENTION

- 5 The invention relates to a method and apparatus for mixing gas into slurry during flotation and for guiding the slurry dispersion up the reactor in a controlled manner. The method makes use of the combined effect of a powerful mixer and the equipment placed inside the reactor. The method and the apparatus are especially suited for the flotation of metal-containing ores
10 that are difficult to process.

BACKGROUND OF THE INVENTION

- US patents 5,240,327 and 5,078,505 describe method and equipment, which with the help of which gas and solids are mixed into a liquid and to attain a
15 toroidal double loop flow. The desired circulation is attained in a reactor, which is equipped with a mixer with a powerful downdraught, baffles typical for the embodiment and a back-flow guiding member. The baffles are wider and are situated further from the cylinder surface of the reactor than standard baffles. In addition, the reactor is equipped with at least one back-
20 flow guiding member. If there are two guiding members, the lower one is fixed and the upper one may be moved in a vertical position. The back-flow guiding members are placed horizontally. According to Figure 2, the upper guiding member is narrower, so that its inner edge is at the same distance from the rotor shaft as the lower one. By means of the mixer, baffles and
25 back-flow guiding member, a moderately strong slurry flow is attained in the reactor downwards towards the reactor wall, which is diverted by the reactor wall partially upwards and partially to circulate downwards, back to the mixer via the bottom. The back-flow guiding member enables the adjustment of the quantity and direction of the upward moving flow. It is advantageous that the
30 flow rises from the centre upwards and returns downwards along the edges. When the reactor is used for instance as a flotation cell, the mineral particles

adhering to the air bubbles rise up and are discharged into the trough as overflow.

US patent 4,548,765 describes a mixer, in which there are dispersing blades
5 located above and below a circular plate attached to the mixer shaft and directional blades placed at the end of arms outside the circular plate. The centre of gravity of the blades is below the circular plate. The mixer is intended for mixing gas, liquid and solids together into a good dispersion, whereby chemical reactions can proceed in a controlled manner.

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In contrast, US patent 7,070,174 describes a mixing apparatus, which consists of two mixers fixed onto the mixer shaft. The mixer is intended for closed reactors, for example vertical autoclaves. The purpose of the mixing
15 apparatus is to disperse gas into slurry, where the gas is fed into the reactor from above the surface of the slurry.

In the apparatus accordant with US patent 7,070,174, the upper mixer comprises a central plate attached to the shaft, inner blades attached to the central plate and outer blades attached to the outer edge of the central plate.
20 The inner edge of the inner blades above the central plate is made to narrow outwards in an arc and below the central plate the inner edge is straight. The outer edge of the inner blade is vertical all along its length. The outer blades are attached directly to the central plate at the same point as the inner blades. The outer blades are rectangular and their angle of inclination to the
25 central plate is 30 – 60 degrees. The centre of gravity of the upper mixer blades is above the central plate.

The mixing apparatus also includes a lower mixer, which consists of a round central plate and blades attached to its outer edge. The outer edge of the
30 blades and the inner edge above the central plate are vertical, but the part of the inner edge below the central plate narrows outwards in an arc. The purpose of the upper blades of the mixer is to bring about a vortex that sucks

the gas from the surface of the liquid and to disperse the gas into small bubbles. Since the upper mixer is not able to achieve effective mixing of the slurry in addition to dispersion, the mixing apparatus is equipped with a lower mixer with the purpose of obtaining a good mixing of the slurry itself and
5 further to disperse the gas bubbles into smaller bubbles and mix them into the slurry. The lower mixer takes considerably more power than the upper mixer. The mixing apparatus is intended always to comprise at least two of the mixers described above.

10 PURPOSE OF THE INVENTION

The methods and apparatus of the prior art are intended mainly for normal mixing solutions, in which the power factor demanded of the mixer is not very high. The mixing apparatus described in US patent 7, 070,174 achieves effective mixing but it requires at least two mixers on the shaft.

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The purpose of the method accordant with this invention is to achieve an even more effective gas dispersion into slurry as well as a controlled mixing pattern of the dispersion that is formed, whereby the mineral particles adhering to the gas bubbles are made to rise to the surface of the slurry and
20 to exit the slurry circuit. The flotation apparatus comprises a reactor and adjustable periphery cones, baffles and a rotor mixer with substantial mixing power placed inside it.

SUMMARY OF THE INVENTION

25 The essential features of the invention will be made apparent in the attached claims.

The invention relates to a mixing apparatus for mixing gas into slurry in a flotation process, whereby the apparatus comprises a reactor, a froth
30 launder, a rotor mixer located inside the reactor, flow baffles and periphery cones. The periphery cones in the mixing apparatus are located in the reactor between the baffles and the reactor wall and are set from the sides of

the reactor towards the centre in an ascending position at an angle of 20 – 40°. The rotor mixer is equipped with inner and outer blades attached to a circular plate, which are attached symmetrically in elevation in relation to the plane formed by the circular plate.

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It is typical of the apparatus accordant with the invention that the number of periphery cones is two, where the distance of the outer edge of the fixed, lower cone from the reactor wall is of the order of 0.02 – 0.03 times the reactor diameter and the radial width is of the order of 0.06 – 0.08 times the

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According to one embodiment of the invention, the distance of the outer edge of the upper adjustable cone from the reactor wall is of the order of 0.002 – 0.003 times the reactor diameter.

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According to another embodiment of the invention, a guide plate parallel to the periphery cones is attached to the baffle above the periphery cones at a height that is 1.5 – 1.7 times the mixer diameter. The length of the guide plate in the radial direction of the reactor is of the order of 0.11 – 0.14 times

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It is typical of the apparatus accordant with the invention that the number of both inner and outer blades in the rotor mixer is 5 – 8. The inner edge of the inner blade in the rotor mixer, which includes the sections above and below

the circular plate, is curved in the direction of the mixer shaft so that the upper edge and lower edge of the blade are horizontal inwards from the outer edge for a distance that is 35-50% of the total blade width. The outer blades of the rotor mixer are at a 50 – 70°, preferably 60° angle to the plane formed by the circular plate.

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According to one embodiment of the apparatus accordant with the invention, the inner and outer blades of the rotor mixer face each other, i.e. the arm

connecting the circular plate to the outer blade is attached to the circular plate at the same point as the inner blade.

According to another embodiment of the apparatus accordant with the invention, the inner and outer blades of the rotor mixer are attached to the circular plate at different points. The inner and outer blades are offset to each other by between $0 - 36^\circ$. According to one embodiment of the apparatus, the offset between the inner and outer blades is adjustable.

10 The invention also relates to a method for mixing of gas into slurry in an apparatus, which consists of a reactor, froth launder, and rotor mixer, baffles and periphery cones that are situated inside the reactor. A slurry dispersion is formed from the gas and slurry fed into the reactor by means of the rotor mixer and baffles, and is subjected to a powerful rotation below the mixer, and above the mixer it is made to rise first upwards and then the direction of the slurry dispersion is diverted from the side of the reactor towards the centre at an angle of $20 - 40^\circ$ by means of ascending periphery cones; in the upper section of the reactor the slurry dispersion is made to spread across the whole cross-section of the reactor and to discharge partially as overflow into the froth launder and partially to return along the reactor walls back to the mixer.

According to one embodiment of the flotation method accordant with the invention, the direction of the upward-rising slurry dispersion towards the centre is intensified by means of a guide plate that is attached to the baffle and is parallel to the periphery cone.

LIST OF DRAWINGS

Figure 1 presents the principle drawing of a mixing apparatus accordant with the invention as seen from the side,

Figure 2 is a cross-section of the mixing apparatus,

Figure 3 is an enlargement of point A in Figure 1,

Figure 4 presents a mixer suitable for the mixing apparatus as seen from the side,

Figure 5 presents a mixer accordant with Figure 4 as seen from above and includes one positioning alternative for the mixer blades in accordance with
5 the invention, and

Figure 6 present a mixer accordant with Figure 4 as seen from above including another alternative for positioning the blades.

DETAILED DESCRIPTION OF THE INVENTION

10 The mixing method and mixing apparatus accordant with the invention relate to flotation methods where gas, generally air, is fed in. It is characteristic of the method that a strong vertical circulation pattern is formed in the reactor, which is attained with a mixer specially developed for the purpose, and with periphery cones to adjust the direction of the vertical flow. The abbreviation
15 VFIB (Vertical Flow Intensity Balanced) reactor could be used for this agitated reactor. The reactor is preferably a vertical cylinder, with a filling height (effective height) of 0.8 – 1.4 times that of the cylinder diameter. Instead of the vertical baffles normally located on the reactor wall, vertical plates set closer to the mixer are used, which can also act as a stator at the
20 same time. It is typical of the method that effective, controlled mixing, extending throughout the entire reactor is achieved by using only one mixer, where the tip speed of the outer blades is a maximum of around 5 – 7 m/s, since the power factor of the mixer accordant with the invention is as much as 4 – 10.

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When the method and apparatus accordant with the invention are used in flotation, in principle no separate conditioning is required, since the mixing solution accordant with the invention has proved so effective that both conditioning and flotation can be handled simultaneously. In the method
30 accordant with the invention, mixing extends equally strongly throughout the entire area of the reactor below the periphery cones. A flotation cell is usually equipped with a stator formed of vertical plates that surround the rotor. The

arrangement in question brings about a relatively powerful, almost radial and slightly ascending primary pumping jet, which is nevertheless clearly attenuated by the stator. The arrangement works quite well in horizontal trough-model cells, particularly if they have several rotor/stator mechanisms in the same trough. When the size range of the cell is 50 – 500 m³, the structure has to be symmetrical and in this case for example a vertical cylinder is a good solution. Technically a vertical cylinder is a good solution regarding the flow, and changes in scale are easier to calculate and control.

At times the attainment of adequate and effective mixing and dispersion in large flotation cells can present difficulties. A conventional rotor-stator structure does not necessarily always achieve the kind of mixing pattern that allows air to mix into the slurry and further the mineral particles that have adhered to the air bubbles rise above the liquid surface so quickly that they do not have time to flocculate with each other and therefore remain in the slurry. When the mineral particles remain swirling in the slurry, their surface may also oxidise, which is an undesirable phenomenon.

With the method and apparatus accordant with this invention a strong slurry circulation is now achieved both above and below the mixer. It is characteristic of the method accordant with the invention that in an agitated reactor air is fed into the reactor via the hollow shaft of the rotor mixer and is dispersed into the slurry by means of the inner blades of the mixer, and that a powerful circulation of the dispersed slurry is then made in the reactor by means of the outer blades of the mixer. Firstly a strong obliquely downward flow of the slurry dispersion is formed by means of the mixer, and then partially turns downwards at the reactor walls, circulating back to the mixer. The other part of the flow turns upwards and rises up along the reactor walls, where it is diverted towards the centre of the reactor and continues to rise upwards in the centre of the reactor, guided by the periphery cones ascending from the reactor sides towards the centre. The direction of the slurry flow obliquely to the centre and then upwards can be further intensified

by means of guide plates attached to the baffles and parallel to the periphery cones. The flow in the upper section of the reactor again spreads out tranquilly across the entire reactor cross-section. Some of the slurry is discharged into the froth launder and some circulates back along the reactor walls to the mixer. The periphery cones and guide plates enable a flow of slurry rising upwards and extending outwards, known as a "mushroom" flow, which is an advantageous flow pattern in flotation.

As a result of the powerful upper circulation, all the material in the flotation reactor, which is not discharged as overflow, is made to return again for mixer dispersing treatment. This promotes the frothing of ore that is difficult to process. For example, strongly flocculated ore does not have time to reflocculate and thus weaken the flotation outcome. The powerful mixing occurring below the mixers achieves the dispersion of air into the ore slurry, the adherence of the chemicals to the surfaces of the solids and the dissolution of any flocculation that may have occurred.

Figure 1 shows a typical vertical reactor 1 used for flotation, and the froth launder 2 that surrounds its upper part on the outside. A cross-section of the reactor is shown without the froth launder in Figure 2. The slurry to be treated is fed into the reactor normally from the lower section and removed from the upper section of the reactor as overflow via the froth launder. Baffles 3 are located in the reactor or flotation cell that are the type described in US patent 5,078,505, wider than standard baffles and at some distance from the reactor walls. The radial length (width) of the baffles is around 0.11 – 0.14 times the reactor diameter and the distance of their outer edge from the reactor wall is around 0.08 – 0.1 times the reactor diameter. The number of baffles is 6 – 10 depending on the size of the reactor. Additionally the reactor is equipped with two periphery cones 4 and 5, which are set between the reactor wall and baffles above the mixer 6. The air to be fed into the reactor is introduced for instance via a hollow mixer shaft 7. The diameter of the rotor mixer is preferably around 35 – 45% of the reactor diameter and is

placed into the reactor at a height from the bottom that is 0.7 – 1 times the diameter of the mixer.

The periphery cones are shown in more detail in Figure 3. The distance of the lower cone 4 from the bottom is around 1 – 1.2 times the mixer diameter. It is characteristic of the periphery cones that they are installed in an ascending position from the reactor sides towards the centre rather than horizontally in accordance with the prior art, so that they are at an angle of around 20 – 40 degrees to the horizontal. In the solution accordant with the invention, the purpose of the periphery cones is particularly to guide the direction of the upward-rising slurry flow towards the centre and partially to prevent a downward flow. This is achieved by locating the periphery cones fairly close to the reactor wall. The periphery gap of the lower, fixed cone i.e. the distance of the outer edge of the cone from the reactor wall, is preferably about 0.02 – 0.03 times the reactor diameter and the periphery gap of the upper periphery cone 5, the height of which can be adjusted for example by means of the member 8, is only around 0.002 – 0.003 times the reactor diameter. The width of the lower cone in the radial direction of the reactor is around 0.06 – 0.08 times the reactor diameter. When the upper periphery cone is in its lower position, it almost touches the lower cone and in that case they form a single surface that strongly guides the slurry flow to the centre of the reactor. Only a minor part of the slurry flow returns to the mixer through the gap between the reactor wall and the periphery cone. The lower periphery cone may be further equipped with appendages 9 from the cone directed towards the centre, which attenuate the strengthening rising flow along the baffles.

When the reactor is equipped with periphery cones ascending towards the centre, the slurry flow turns evenly and the mineral particles attached to the air bubbles are not released from the bubbles. This is particularly important when the material to be frothed is heavy and rises poorly with air.

It is still preferable in some cases to attenuate the upward flow formed as a result of the periphery cones by means of a guide plate 10 attached to each baffle, as shown in Figures 1 and 2. Guide plates are attached above the periphery cones, typically at a height from the reactor bottom of 1.5 – 1.7
5 times the mixer diameter. The guide plate is rectangular and is at the same angle to the horizontal as the guide cones, that is, it rises towards the centre of the reactor at an angle of 20 – 40 degrees. The length of the guide plate in the radial direction of the reactor is the same magnitude as that of the baffle and the width is about half of that. The guide plate is attached to the baffle so
10 as to be symmetrical on either side in terms of width.

One important part of the apparatus to be used in flotation is a mixer 6 that achieves powerful mixing, shown in more detail in Figure 4. It is characteristic of the mixer of the mixing apparatus accordant with the
15 invention that the mixer suspended on a shaft 7 comprises a circular plate 11 symmetrically attached to the lower end of the shaft, inner mixer blades 12 attached radially to the plate both above and below it, and outer blades 14 attached to the circular plate by means of an arm 13. Compared to mixers accordant with the prior art the power factor of the mixer is exceptionally
20 large, $N_p = 4-10$, whereby the preferred tip speed of the mixer of 5 – 7 m/s is ensured in large flotation units ($50 - 500 \text{ m}^3$) also when it is wished to raise the volume-specific mixing power to the range of 1.5 – 5.0 kW/m³. Usually with mixers of the prior art a power factor of 2.4 – 3.0 can be reached. When the tip speed of the outer blades rises above the limit mentioned above, the
25 wear on the mixing mechanism is increased considerably. The number of both inner and outer blades in a mixer accordant with the invention is from 5 to 8. Since gas is routed into the mixing, the mixer shaft 7 may be arranged to be hollow inside, so that the gas feed can take place through it to below the circular plate when required. Of course gas can also be fed from the
30 lower section of the mixer towards the circular plate via a separate feed pipe. The ratio of the mixer diameter to the mixing/flotation reactor is around 0.35 – 0.40.

In order to increase the mixing power both on the parts above and below the mixer, the mixer is formed so that the blades are located symmetrically with regard to the circular plate, whereby an equally large part of the blades is above and beneath said circular plate. To improve mixing efficiency, now the inner edge 15 of the inner blade, which includes the part both above and below the circular plate, is made curved in the direction of the mixer shaft, preferably in the form of a parabola, however such that the upper edge 16 and the lower edge 17 of the blade are horizontal from the outer edge inwards for a distance that is 35-50% of the total width of the blade. The outer edge 18 of the inner blade is typically vertical and extends preferably beyond the circumference of the circular plate by a distance that is in the order of for instance 0 – 2% of the diameter of the mixer. The inner blades are fitted perpendicular to the circular plate and extend preferably the same distance above and below the plane formed by the circular plate. The height of the inner blades is in the region of 38 – 46% and the width 14 – 20% of the total diameter of the mixer. The inner blades are particularly designed to disperse gas into slurry, so they may also be termed dispersion blades.

Arms 13 are attached to the outer edge of the circular plate 11, and in turn outer blades 14 are fixed onto the outer end of said arms. The outer blades are rectangular in shape and their height is in the region of 3 – 3.5 times their width. The width of the outer blades at the point of the circular plate is in the region of 10 – 20%, preferably 15%, of the total mixer diameter. The blades are at an angle of 50 – 70°, preferably 60° to the plane formed by the circular plate. The outer blades are also symmetrical with regard to the circular plate, i.e. they extend essentially the same distance above and below the plane formed by the circular plate. The length of the arms 13 attaching the outer blades to the circular plate is in the region of 3-4 % of the total mixer diameter.

In the embodiment according to Figure 5 the inner and outer blades are both 6 in number, but the quantity may vary between 5 and 8. The number depends mostly on the size of the reactor into which the mixer is placed. The blades in Figure 5 are located so that the inner and outer blades face one another, i.e. the arm connecting the circular plate to the outer blades is attached to exactly the same point as the inner blade.

In the embodiment according to Figure 6 there are also 6 outer and 6 inner blades, but now the blades are attached to the circular plate at a different point from each other. The blades in Figure 6 are offset to each other by 30 degrees. It is characteristic of the mixer solution accordant with the invention that the blades may be displaced to each other by $0 - 36^\circ$ depending on the number of blades and the mixing requirements. When the blades are offset to each other, twice as many dispersion points are generated around the mixer in the material to be mixed compared to when the blades face each other. When a mixer according to Figure 6 is placed in a reactor, which is over 50 m^3 in size and dimensioned in the manner described above, the tip speed of the inner blades rises to over 4 m/s, in other words clearly into the dispersion zone. The final result obtained is a more even dispersing of gas into the solution or slurry in the reactor. The offset is at maximum when the outer blades are exactly between the inner blades. Thus the maximum offset is between $36 - 22.5^\circ$ depending on the number of blades. It is also characteristic of the mixer apparatus accordant with the invention that the offset between the blades can be adjusted as required.

In the case according to Figure 6, in which the number of both inner and outer blades is 6, an effective solution for the placement of the inner and outer blades is that the inner blades are preferably in the region between 20° before and 10° after the outer blades in relation to the rotation direction of the mixer. When the inner blade moves in front, the gas coming from below the circular plate will rise radially with the forward eddies from the inner blades and will fall into the domain of the immediately following outer blades. The

gas is dispersed very evenly when the offset is for instance 20 degrees, whereby the gas ends up in a wider space to be dispersed by the outer blades and in that case dispersion efficacy is achieved particularly from the effect of the parts above the circular plate. When the offset is in the region of 5 degrees, a powerful local dispersion is achieved when the gas and slurry are discharged upwards and outwards through the small gaps formed by the inner and outer blades.

The respective location of the inner and outer blades has an especially powerful effect when the mixer is dimensioned for a reactor with a volume of over 100 m³. In that case the absolute transfer lengths of the gas are considerable, but the effect of the distance can be reduced by increasing the number of mixer blades.

EXAMPLES

Example 1

Concentration tests were performed on serpentinised nickel ore in a VFIB flotation reactor accordant with the invention, with a diameter of 362 mm and an effective height of 437 mm. The mixer used in flotation was in accordance with the invention, 144 mm in diameter and with a power factor of 6.2.

The majority of the nickel ore to be treated was pentlandite, and it was ground to a fineness of 90% -40 µm, so that the majority of the nickel sulphides had been released into individual sulphide particles. Since sulphide particles are very susceptible to oxidation, the flotation test was started immediately after grinding. The ore was slurried in a sodium chloride solution with a concentration of around 2.5%, so that the slurry density became 150 g ore/litre. The analysis of the ore was Ni 0.44%, Fe 4.2%, Mg 23.2% and S 0.71%, which revealed that magnesium silicates were the main components of the ore.

The operating speed of the mixer in the flotation test was 470 rpm and the air feed 22.5 l/min. Flotation chemicals were added for 6 minutes before the air feed. Air was fed in five 5-minute periods every 6 minutes. The addition of flotation reagents, i.e. depressant and collector chemicals, was carried out
5 when the air feed was not on. The flotation result was that when the nickel concentrate yield from each of the five periods was added together, the cumulative nickel yield was 83%, the magnesium yield 34.7% and the sulphur yield 81.5%. The result was considered to be good, because 15 – 20% of the nickel was distributed in the silicates in the ore.

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The flotation test was repeated with the difference that a mixer as described in US patent 4,548,765 was used. The corresponding cumulative nickel yield was at the level of 57%. On closer inspection it was found that ore flocculation was the reason for the decreased nickel yield, because this
15 mixer of the prior art achieved a mixing power that was too low. The mixing power decreased progressively, and it was found that even at the level of 400 rpm, flocs appeared in the upper part of the ore slurry. The flocs encase the sulphide particles, whereupon their adherence to air bubbles is prevented and the nickel yield decreases. Flocculation is in fact a typical
20 characteristic of iron-magnesium silicate-type nickel ores, and is due to the electrically charged silicates in which the nickel-bearing sulphide particles are encased.

The example shows that a satisfactory nickel yield can be achieved by
25 raising the mixing power and making the mixing to be evenly distributed in the flotation cell. The average volume-specific mixing power given by a mixer accordant with the invention was 4.71 W/l before air feed and 3.50 W/l during air feed. The corresponding figures with a mixer of the prior art were 2.6 W/l and 1.4 W/l. One advantage of the mixing solution accordant with the
30 invention is the fact that the vertical mixing range it achieves is significantly greater than with a mixer of the prior art, where the majority of the shaft power is directed downwards.

PATENT CLAIMS

1. A mixing apparatus for mixing gas into slurry in a flotation process, whereby the apparatus consists of a reactor (1), a froth launder (2), a rotor mixer (6), baffles (3) and periphery cones (4,5) located inside the reactor, **characterised in that** the periphery cones (4,5) in the mixing apparatus are located in the reactor between the baffles (3) and the reactor wall and that they are set in an ascending position from the reactor sides towards the centre at an angle of 20 – 40°, and that the rotor mixer (6) is equipped with inner and outer blades (12,14) attached to a circular plate (11) and arranged symmetrically in terms of elevation with regard to the plane formed by the circular plate.
2. An apparatus according to claim 1, **characterised in that** the periphery cones are two in number, so that the distance of the outer edge of the lower, fixed cone (4) from the reactor wall is in the region of 0.02 – 0.03 times the reactor diameter.
3. An apparatus according to claims 1 and 2, **characterised in that** the width of the lower periphery cone (4) in the radial direction is in the region of 0.06 – 0.08 times the diameter of the reactor.
4. An apparatus according to claims 1 and 2, **characterised in that** the distance of the outer edge of the upper, adjustable cone (5) from the reactor wall is in the range of 0.002 – 0.003 times the diameter of the reactor.
5. An apparatus according to claim 1, **characterised in that** a guide plate (10) parallel to the periphery cones (4,5) is attached to the baffle (3) above the periphery cones at a height that is 1.5 – 1.7 times the diameter of the reactor.

6. An apparatus according to claims 1 and 5, **characterised in that** the length of the guide plate (10) in the radial direction of the reactor is in the range of 0.11 – 0.14 times the diameter of the reactor.
- 5
7. An apparatus according to claim 1, **characterised in that** both the inner and outer blades (12,14) in the rotor mixer are 5 – 8 in number.
8. An apparatus according to claim 1, **characterised in that** the inner edge (15) of the inner blade in the rotor mixer, which includes both the parts above and below the circular plate (11), is formed in a curve in the direction of the mixer shaft (7) so that the upper edge (16) of the blade and the lower edge (17) are horizontal inwards from the outer edge (18) for a distance that is 35-50 % of the total width of the blade.
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- 15
9. An apparatus according to claim 1, **characterised in that** the outer blades (14) of the rotor mixer are at an angle of 50 – 70°, preferably 60°, to the plane formed by the circular plate (11).
- 20
10. An apparatus according to claim 1, **characterised in that** the inner blades (12) and outer blades (14) face each other, i.e. the arm (13) connecting the circular plate to the outer blade is attached to the circular plate at the same point as the inner blade.
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11. An apparatus according to claim 1, **characterised in that** the inner blades (12) and outer blades (14) are attached to the circular plate (11) so that they are offset to each other.
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12. A mixer according to claim 11, **characterised in that** the inner blades (12) and outer blades (14) are offset to each other by between 0 – 36°.
- 5 13. A mixer according to claim 11, **characterised in that** the offset between the inner and outer blades is adjustable.
- 10 14. A flotation method for mixing gas into slurry in an apparatus, which consists of a reactor (1), a froth launder (2), a rotor mixer (6), baffles (3) and periphery cones (4,5) located inside the reactor, **characterised in that** by means of the rotor mixer (6) and baffles (3) a slurry dispersion is formed of the gas and slurry fed into the reactor, which slurry dispersion is subjected to a powerful rotation below the mixer and is made to rise above the mixer, first upwards and then the direction of the slurry dispersion is made to turn from the side of the reactor towards the centre by means of periphery cones (4,5) ascending at an angle of 20 – 40 °; in the upper section of the reactor the slurry dispersion is made to spread out across the entire cross-section of the reactor and to discharge partially as overflow into the froth launder (2) and partially to return along the reactor walls back to the mixer.
- 15 20 25 15. A method in accordance with claim 14, **characterised in that** the upward-rising direction of the slurry dispersion towards the centre is intensified by means of a guide plate (10) attached to the baffle (3) that is parallel to the periphery cones.

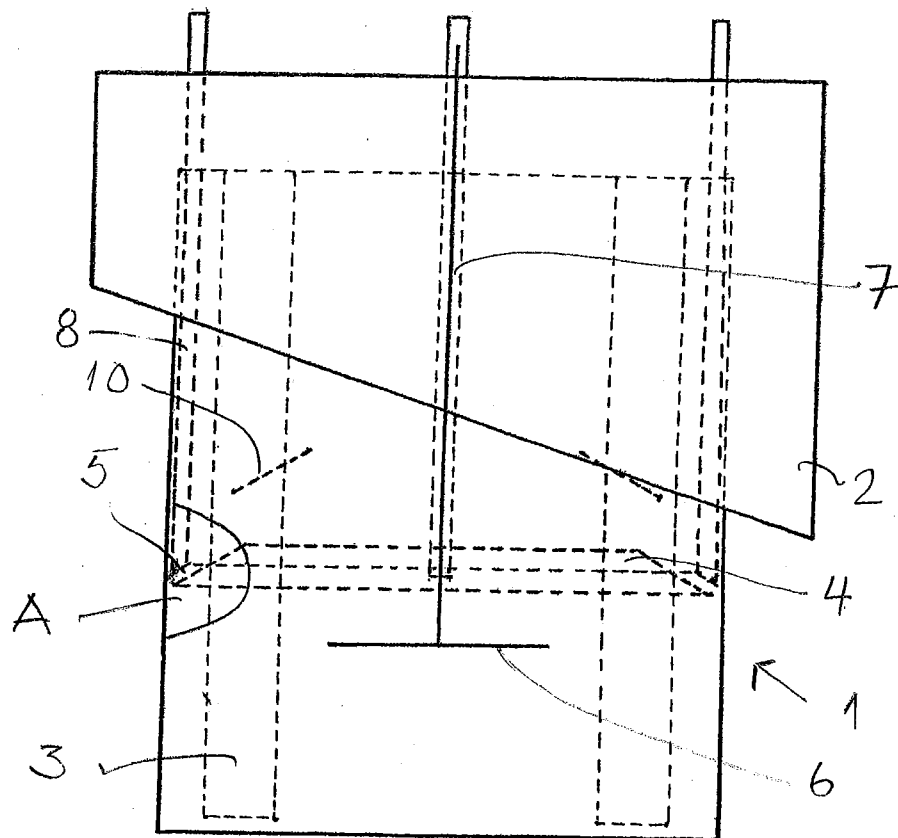


Fig. 1

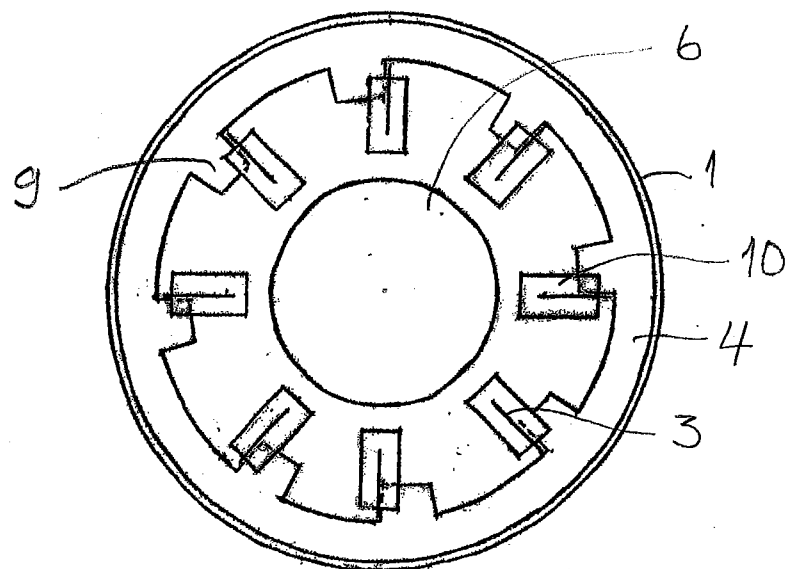


Fig. 2

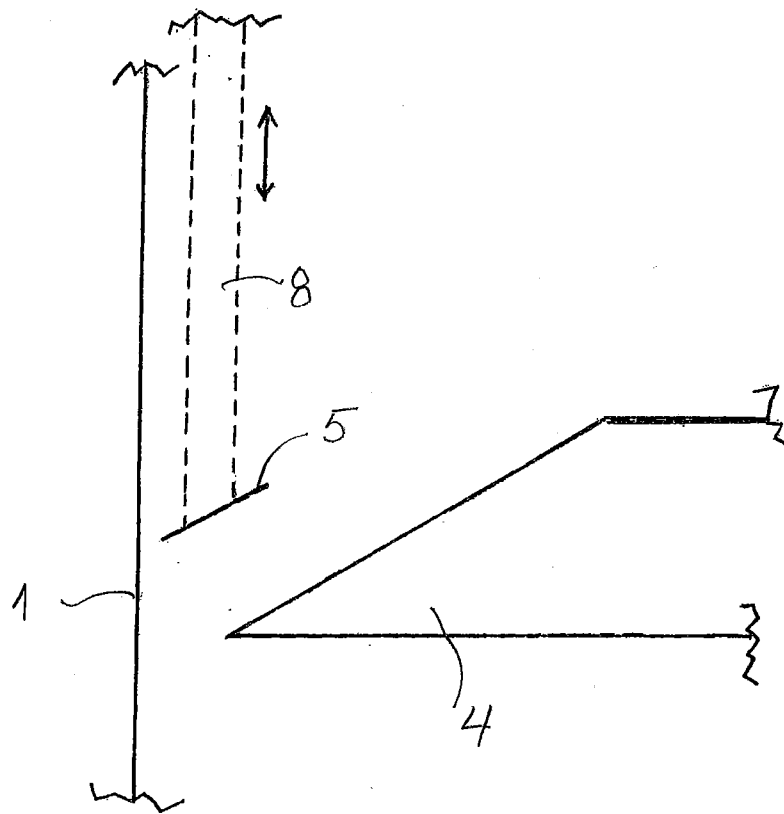


Fig. 3

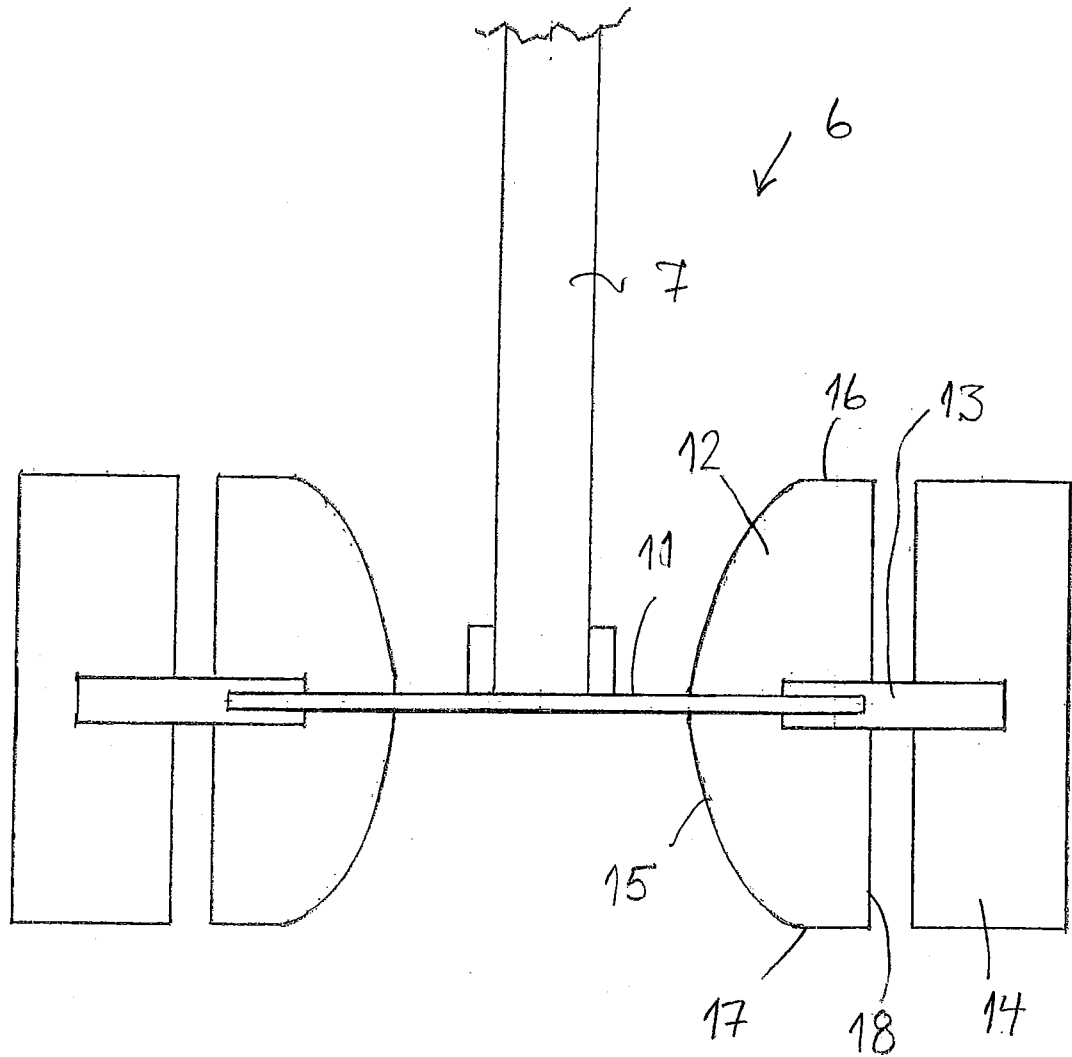


Fig. 4

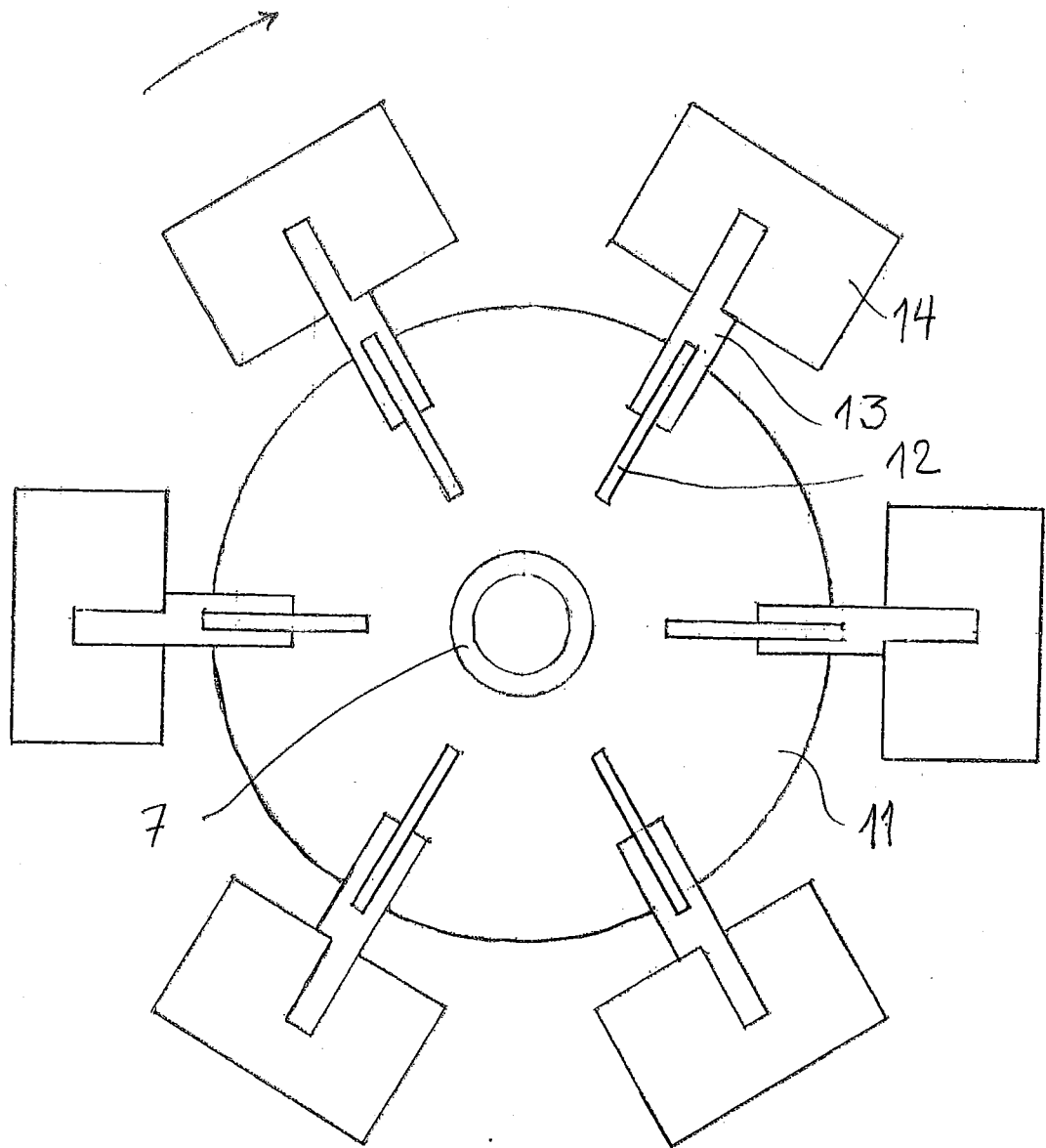


Fig. 5

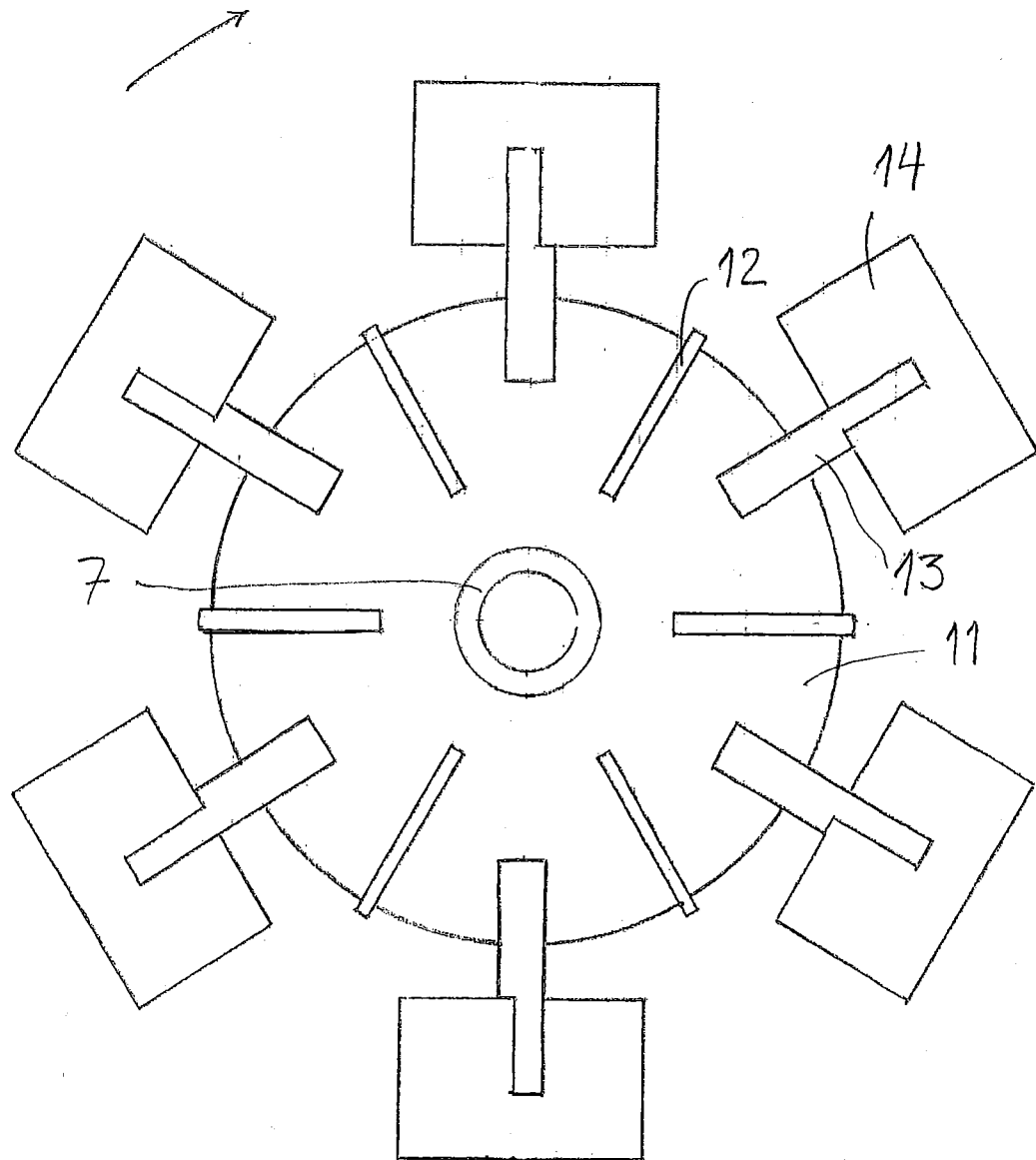


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2009/050789

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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)

IPC: B01F, B03D, B01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
FI, SE, NO, DKElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5240327 A (NYMAN BROR G et al.) 31 August 1993 (31.08.1993) Figures 1 and 3; cited in the application	1-15
A	US 5219467 A (NYMAN BROR G et al.) 15 June 1993 (15.06.1993) Figure 1; column 4, lines 21-29	1-15
A	WO 03035265 A1 (OUTOKUMPU OYJ) 01 May 2003 (01.05.2003) abstract; Figures 1 and 2	1-15
A	WO 0207890 A1 (OUTOKUMPU OYJ) 31 January 2002 (31.01.2002) abstract; Figures 1 and 2	1-15

☐ Further documents are listed in the continuation of Box C.
 ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

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08 February 2010 (08.02.2010)

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Name and mailing address of the ISA/FI
National Board of Patents and Registration of Finland
P.O. Box 1160, FI-00101 HELSINKI, Finland
Facsimile No. +358 9 6939 5328

Authorized officer
Pirkko Karinen
Telephone No. +358 9 6939 500

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/FI2009/050789

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International application No.
PCT/FI2009/050789

Form PCT/ISA/210 (patent family annex) (July 2008)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2009/050789

CLASSIFICATION OF SUBJECT MATTER

Int.Cl.

B01F 7/16 (2006.01)

B01F 3/04 (2006.01)

B03D 1/16 (2006.01)

B01J 19/18 (2006.01)