(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
30 August 2007 (30.08.2007)

PCT

(10) International Publication Number
WO 2007/096457 A2

(51) International Patent Classification:
F28C 1/00 (2006.01) *F28C 3/06* (2006.01)

(21) International Application Number:
PCT/FI2007/000034

(22) International Filing Date:
13 February 2007 (13.02.2007)

(25) Filing Language: Finnish

(26) Publication Language: English

(30) Priority Data:
20060176 23 February 2006 (23.02.2006) FI

(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)*: **VAARNO, Jussi** [FI/FI]; Omenatie 41, FI-02430 Masala (FI). **HYÖDYNMAA, Tapio** [FI/FI]; Leikkimäki 1 A 9, FI-02400 Kirkkonummi (FI). **TUUPPA, Eero** [FI/FI]; Esperantotie 3 C, FI-02230 ESPOO Espoo (FI). **LEHTONEN, Markus** [FI/FI]; Kalkerinlenkki 11, FI-01830 Lepsämä (FI).

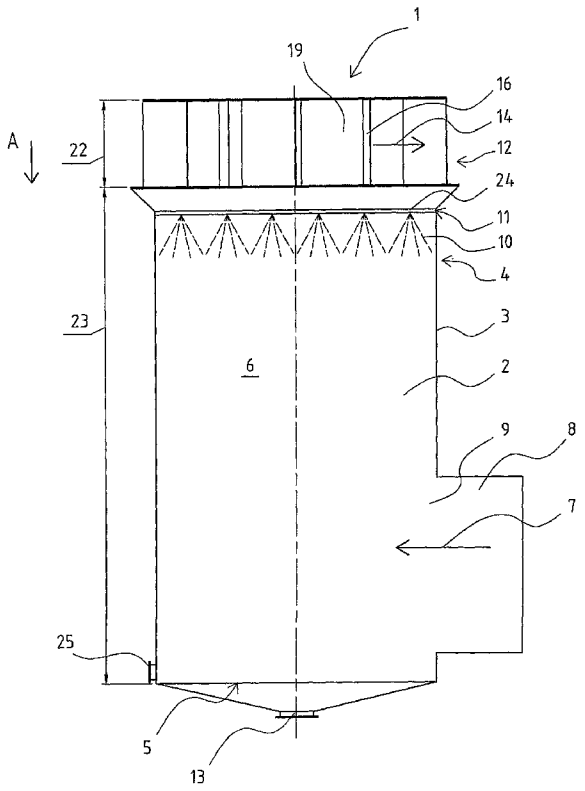
(74) Agent: **OUTOTEC OYJ**; IPR Management, P.O.box 86, FI-02201 Espoo (FI).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT,

[Continued on next page]

(54) Title: ARRANGEMENT AND METHOD FOR COOLING A SOLUTION



(57) Abstract: The invention relates to a cooling equipment for cooling liquid, comprising: a cooling tower that is mainly cylindrical in the vertical direction, in which case the cooling air feed equipment and the exhaust air discharge equipment are arranged, with respect to the cooling tower, so that both the cooling air flowing direction from the inlet aperture to the cooling space and the exhaust air flowing direction from the discharge equipment is horizontal and parallel to the tangent of the outer surface of the cooling tower. The invention also relates to a method for cooling liquid.

WO 2007/096457 A2

RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *of inventorship (Rule 4.17(iv))*

Published:

— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

ARRANGEMENT AND METHOD FOR COOLING A SOLUTION

The present invention relates to an arrangement and method, defined in the independent claims, for cooling a solution in a cooling tower.

When separating zinc from an electrolytic solution containing zinc ions and sulfuric acid, the temperature of the electrolyte generally rises. Typically, for cooling solutions such as electrolyte, or an acidic solution containing slurries or metals, there are used cooling towers where the cooling process is based on the evaporation of liquid drops in the upwardly flowing air from the liquid drops to be cooled. Generally the air flow is colder than the liquid flow, in which case the downwardly flowing liquid is cooled owing to heat transfer. Consequently, convection takes place in the cooling process, and droplets moving against the air flow are evaporated. Heat is emitted, as the liquid is cooled in the cooling tower. In cross-section, cooling towers are typically either hexagonal or quadrangular cylinders. The solution to be cooled is conducted to the tower in a known fashion through the top part thereof, and the cooling air is fed in through the side of the cooling tower. During the cooling process, droplets containing particle material are separated from the solution. Said droplets are separated from the gas contained by the harmful particle material in separate droplet separator devices prior to letting the gas out. The separated liquid is conducted back to the cooling tower. During the cooling process, the impurities are accumulated on the tower walls and floor as well as to the droplet separator elements, which creates a need to frequent maintenance procedures.

When feeding the cooling air to the cooling tower horizontally at one spot provided in the tower wall, problems arise mainly owing to an uneven distribution of the gas. When the gas is conducted horizontally to the tower, it must turn 90 degrees in order to move in the vertical direction in the cooling tower. Both this fact and the large size of the air-feeding fan with respect to the dimensions of the tower can result in an uneven distribution of the gas in the cooling space of the cooling tower. In addition, another problem has been how

to ensure an efficient recovery of the droplets. Conventionally, separated droplets are collected by separator devices that are arranged horizontally against the flow. In said devices, the droplets are gathered on the surface of strip-like structures, and the liquid circulated by gravity is directed against the gas flow back to the cooling tower. The higher the gas velocity, the more effectively the droplets are separated. However, a drawback with horizontally arranged devices for collecting and separating droplets is that the gas velocity must be restricted, which reduces the efficiency of the cooling tower. In the planning of cooling towers, attention must be paid to the emissions discharged therefrom, because cooling towers are often remarkable sources of emissions in a process, for example in zinc plants. Likewise, when evaluating the functionality of cooling towers, attention must be paid to the maintenance procedures of said towers. Often the towers require several maintenance operations within a short period of time, wherefore it is important that the maintenance is carried out rapidly and easily.

The efficiency of a cooling tower can be improved by enhancing an even distribution of the cooling air. Conventionally the cooling air distribution in the cooling tower has been attempted to be improved by placing an obstacle in front of the cooling air feed aperture in the vertical direction, in which case the direction of the air flow can be turned more upwardly.

The publication CA 2271424 A1 discloses a cooling tower for cooling liquid. In the arrangement according to said publication, there is described a multilayer wall arrangement for a cooling tower, where the wall consists of an outer wall and an air-permeable, flexible inner wall, in which case part of the air is injected through pores arranged in the inner wall to the cooling space, where it meets the liquid to be cooled. The object of this arrangement is to remove deposits accumulated on the inner wall. However, an optimal cooling solution is not achieved by this arrangement, owing to the pressure loss caused by the inner wall.

The object of the present invention is to eliminate some of the drawbacks of the prior art and to realize a new way for cooling liquid. A particular object of the invention is to introduce a new cooling equipment and method, in which case the cooling efficiency is increased both by feeding cooling air to the cooling space and by conducting the outwardly flowing air out of the cooling tower both horizontally and tangentially with respect to the cooling tower. The essential novel features of the invention are apparent from the appended claims.

Remarkable advantages are connected to the invention. The invention relates to a cooling equipment for cooling liquid, comprising: a cooling tower that is mainly cylindrical in the vertical direction, said cooling tower including an outer surface, an upper part of the cooling tower and a bottom part, which together define the cooling space; cooling air feed equipment comprising at least one inlet aperture on the cooling tower outer surface; means for feeding cooling air to the inlet aperture and further to the cooling space of the cooling tower; liquid feed equipment comprising means, such as liquid nozzles, for feeding the liquid to be cooled to the cooling space, discharge equipment for the exhaust air, as well as means for removing the cooled liquid, in which case the cooling air feed equipment and the exhaust air discharge equipment are arranged, with respect to the cooling tower, so that both the flowing direction of the cooling air from the inlet aperture to the cooling space and the flowing direction of the exhaust air out of the discharge equipment is horizontal and parallel with the tangent of the outer surface of the cooling tower. By means of a cooling equipment according to the invention, an even distribution of cooling air is advantageously achieved in the cooling zone, and the cooling process is enhanced. By feeding cooling air to the cooling space horizontally, preferably in the vicinity of the bottom part of the cooling tower and in parallel with the tangent of the outer surface of the cooling tower, the component of the horizontal rotation speed of the air flow is simultaneously raised. Thus the delay time of the cooling air in the cooling space is increased, and consequently the cooling efficiency of the liquid droplets flowing in the tower is improved.

According to the invention, the exhaust air discharge equipment comprises a housing element including at least four, preferably eight, outlet apertures arranged vertically with respect to the horizontal cross-section of the cooling tower. According to an embodiment of the invention, the outlet apertures are placed equidistantly in the housing element, in which case each plane parallel to the surface of the outlet aperture forms an equally large angle with the tangent of the outer surface of the cooling tower. According to an embodiment of the invention, in each outlet aperture, there is vertically installed at least one droplet separator element for separating the liquid droplets from the exhaust air. According to an embodiment of the invention, the droplet separator element is formed of at least two adjacently positioned, air-permeable vertical plates with a corrugated profile. When air also is conducted out through the upper part of the cooling tower both horizontally and tangentially, it is possible to use vertically installed separator devices for separating air and the droplets contained therein, in which devices the return circulation of the liquid flows in perpendicular to the exhaust air flow, which increases the gas velocity and improves the cooling efficiency. Droplet separator devices that are arranged vertically with respect to the cooling tower are more effective than horizontally arranged separator devices. By using a cooling equipment according to the invention, the size of the cooling tower is remarkably reduced, while the cooling efficiency is, however, increased. This brings forth advantageous savings in the material expenses of the cooling tower. In addition, the cooling arrangement according to the invention makes the maintenance operations of the liquid feed equipment and exhaust air discharge equipment easier because of the practical positions thereof. According to an advantageous embodiment of the invention, the ratio of the height of the outlet aperture and the height of the cooling tower in the vertical direction is 1:5, in which case an optimal cooling efficiency is achieved.

The invention is described in more detail with reference to the appended drawings, where

Figure 1 illustrates a cooling equipment according to the invention

Figure 2 shows a cooling equipment according to the invention, seen in a cross-section of the embodiment illustrated in figure 1

Figure 3 illustrates a cooling equipment according to the invention

Figure 1 illustrates a cooling equipment 1 according to the invention for cooling liquid, such as electrolyte. Figure 2 shows a cross-section of the embodiment of figure 1, seen from the direction A. Figure 3 illustrates a cooling equipment according to the invention, seen as three-dimensional. The cooling equipment 1 comprises a cooling tower 2 with a mainly cylindrical cross-section in the vertical direction, provided with an outer surface i.e. wall 3, an upper part 4 and a bottom part 5 of the cooling tower, which together define the cooling space 6. Most advantageously the shape of the cooling tower 2 is a cylinder in the vertical direction, but it may also have a shape where the cross-section becomes wider in the upper part 4, in which case a wider acceleration area is achieved for the air flow before it is exhausted from the cooling tower. The upper part and the bottom part are closed while the cooling is in operation. The outer surface 3 of the cooling tower is typically made of fiberglass or a corresponding material. The cooling air 7 is fed in the cooling space 6 of the cooling tower 2 horizontally with respect to the cooling tower, and in parallel with the tangent 15 of the outer surface of the cooling tower, by means of cooling air feed equipment 8, comprising at least one inlet aperture 9 arranged on the outer surface 3 of the cooling tower, and means such as a fan for feeding the cooling air further to the cooling space 6 of the cooling tower. There may also be several inlet apertures arranged at different spots of the outer surface 3. The liquid 10 to be cooled is fed by means of liquid feed equipment 11, comprising means such as for example liquid nozzles 24 for injecting the liquid 10 to be cooled to the cooling space 6. The liquid drops to be cooled, such as electrolyte drops, move in the cooling tower against the vertically upwardly proceeding air flow 20, in which case water is evaporated therefrom. In the cooling space of the cooling tower, the air flow becomes turbulent, and its velocity in the horizontal direction increases. Smaller droplets are separated from the downwardly flowing cooled drops, which droplets are conducted to the

exhaust air discharge equipment 12, which is in communication with the cooling space 6. In the exhaust air discharge equipment 12, liquid droplets are separated from the air and can be recirculated to be recooled in the cooling tower 2. The cooled liquid is removed for instance through a hole 13 provided in the bottom part 5 of the cooling tower, or through an overflow aperture 25, and sent to further processing.

The exhaust air discharge equipment 12 according to the invention comprises an at least partly hollow housing element 19, provided according to the example with eight outlet apertures 16 arranged vertically with respect to the horizontal cross-section of the cooling tower 2. When the outlet apertures are arranged in the vertical direction in relation to the exhaust air flow 14, the exhaust air flow 14 is allowed to be discharged horizontally and in parallel with the tangent 15 of the outer surface 3 of the cooling tower. The outlet apertures 16 are positioned equidistantly in the housing element 19, in which case each plane 17 parallel to the surface of the outlet aperture forms an equally large angle B with the tangent 15 of the outer surface of the cooling tower 2. The ratio of the vertical height 22 of the outlet aperture 16 and the vertical height 23 of the cooling tower is preferably 1:5. Naturally the number, height, position and angle B of the outlet apertures 16 can vary depending on the quantity of the liquid to be cooled and the cooling air fed in, as well as on the cooling demand. Each outlet aperture 16 is provided with a droplet separator element 18 arranged vertically in parallel with the outlet aperture surface, which separator element 18 separates liquid droplets from the exhaust air 14, and the droplets can be recirculated back to the cooling tower. According to an example, the droplet separator element 18 is formed of at least two adjacently arranged, air-permeable vertical plates with a corrugated profile. A maintenance level 21 can be installed to surround the cooling tower 2, in the vicinity of the upper part 4 thereof, from which maintenance level 21 the maintenance of the cooling equipment is easily carried out.

For a man skilled in the art, it is obvious that the various different embodiments of the invention are not restricted to the examples described above, but may vary within the scope of the appended claims.

CLAIMS

1. Cooling equipment (1) for cooling liquid, comprising:
   - a cooling tower (2) that is mainly cylindrical in the vertical direction, having an outer surface (3), an upper part (4) and a bottom part (5) of the cooling tower, defining the cooling space (6),
   - cooling air feed equipment (8), comprising at least one inlet aperture (9) arranged on the outer surface (3) of the cooling tower, means for feeding cooling air to the inlet aperture and further to the cooling space of the cooling tower,
   - liquid feed equipment (11), comprising means for feeding the liquid (10) to be cooled to the cooling space (6),
   - exhaust air discharge equipment (12),
   - as well as means (13) for removing the cooled liquid, **characterized** in that the cooling air feed equipment (8) and the exhaust air discharge equipment (12) are arranged, with respect to the cooling tower (2), so that both the flowing direction of the cooling air (7) from the inlet aperture (9) to the cooling space (6) and the flowing direction of the exhaust air (14) from the discharge equipment (12) is horizontal and parallel to the tangent (15) of the outer surface (3) of the cooling tower.

2. Cooling equipment according to claim 1, **characterized** in that the exhaust air discharge equipment (12) includes a housing element (19), provided with at least four outlet apertures (16) arranged vertically with respect to the horizontal cross-section of the cooling tower (2).

3. Cooling equipment according to claim 1 or 2, **characterized** in that the housing element (19) of the exhaust air discharge equipment (12) is provided with eight outlet apertures (16), arranged equidistantly in the housing element, so that each plane (17) parallel to the surface of the

outlet aperture forms an equally large angle (B) with the tangent (15) of the outer surface of the cooling tower (2).

4. Cooling equipment according to claim 2 or 3, **characterized** in that in each outlet aperture (16), there is installed in the vertical direction at least one droplet separator element (18) for separating liquid droplets from the exhaust air.

5. Cooling equipment according to claim 4, **characterized** in that the droplet separator element (18) is formed of at least two adjacently installed, air-permeable vertical plates with a corrugated profile.

6. Cooling equipment according to any of the preceding claims, **characterized** in that the exhaust air discharge equipment (12) is arranged in the upper part (4) of the cooling tower (2), and the cooling air feed equipment (8) is arranged in the vicinity of the bottom part (5).

7. Cooling equipment according to claim 2, 3 or 4, **characterized** in that the ratio of the height (22) of the outlet aperture (16) and the height (23) of the cooling tower in the vertical direction is advantageously 1:5.

8. Cooling equipment according to claim 1, **characterized** in that the liquid feed equipment (11) comprises at least one liquid nozzle (24), installed in the upper part (4) of the cooling tower, underneath the exhaust air discharge equipment (12).

9. Method for cooling liquid in a cooling equipment (1), comprising:
   - a cooling tower (2) that is mainly cylindrical in the vertical direction, having an outer surface (3), an upper part (4) and a bottom part (5) of the cooling tower, defining the cooling space (6),
   - cooling air feed equipment (8), comprising at least one inlet aperture (9) arranged on the outer surface (3) of the cooling tower,

means for feeding cooling air to the inlet aperture and further to the cooling space of the cooling tower,

- liquid feed equipment (11), comprising means for feeding the liquid (10) to be cooled to the cooling space (6),
- exhaust air discharge equipment (12),
- as well as means (13) for removing the cooled liquid, **characterized** in that cooling air (7) is fed horizontally and in parallel with the tangent (15) of the outer surface of the cooling tower to the cooling space (6), where the cooling air meets the liquid (10) fed against the current, which air flows out of the cooling space, so that its flowing direction is horizontal and parallel to the tangent (15) of the outer surface (3) of the cooling tower.

10. Method according to claim 9, **characterized** in that the exhaust air (14) is conducted in the horizontal direction to the discharge equipment (12), where the air flows through at least one droplet separator element (18) arranged in the vertical direction, in which case from the air, there is separated liquid, which is then circulated back to the cooling tower (2).

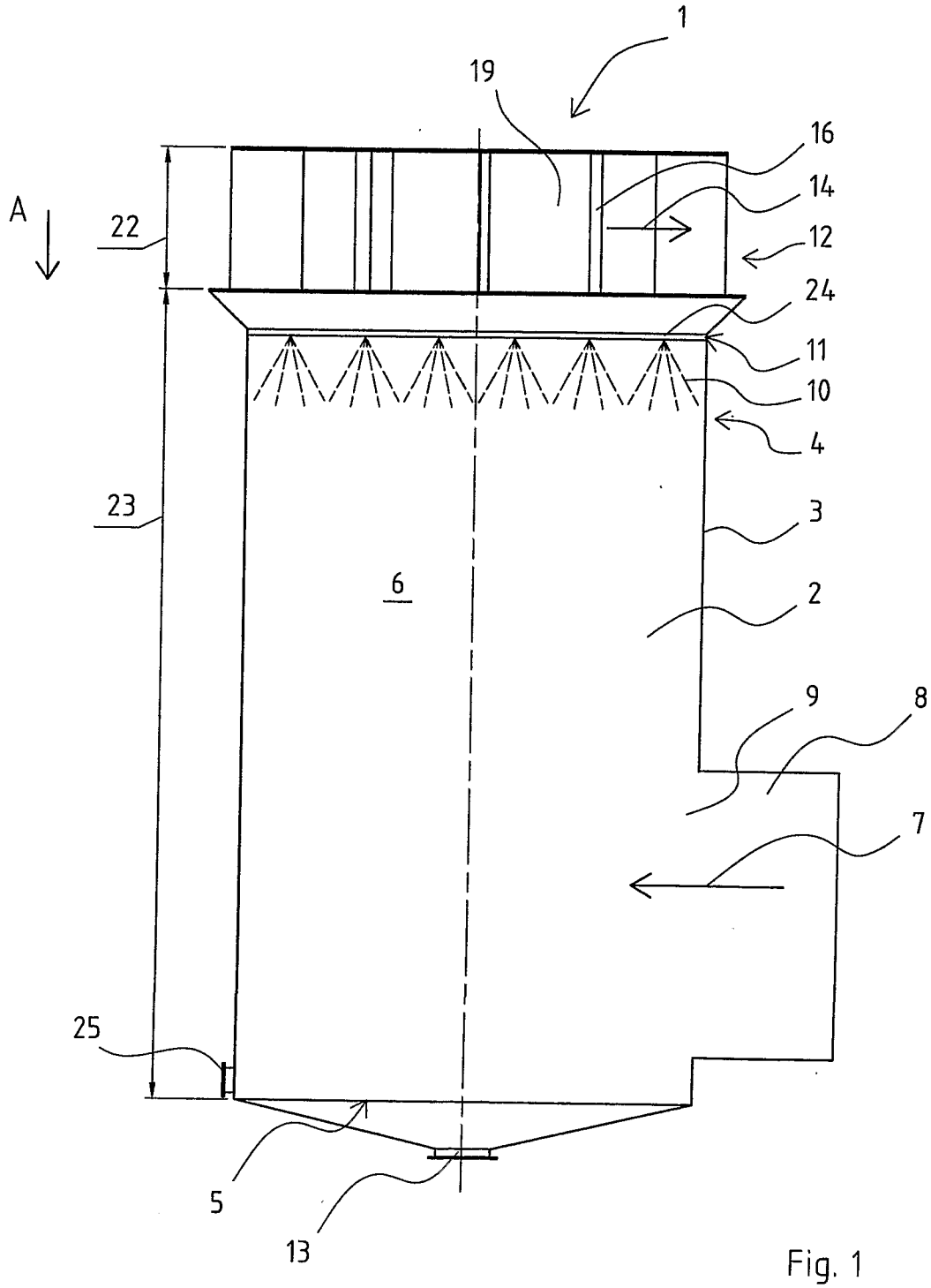


Fig. 1

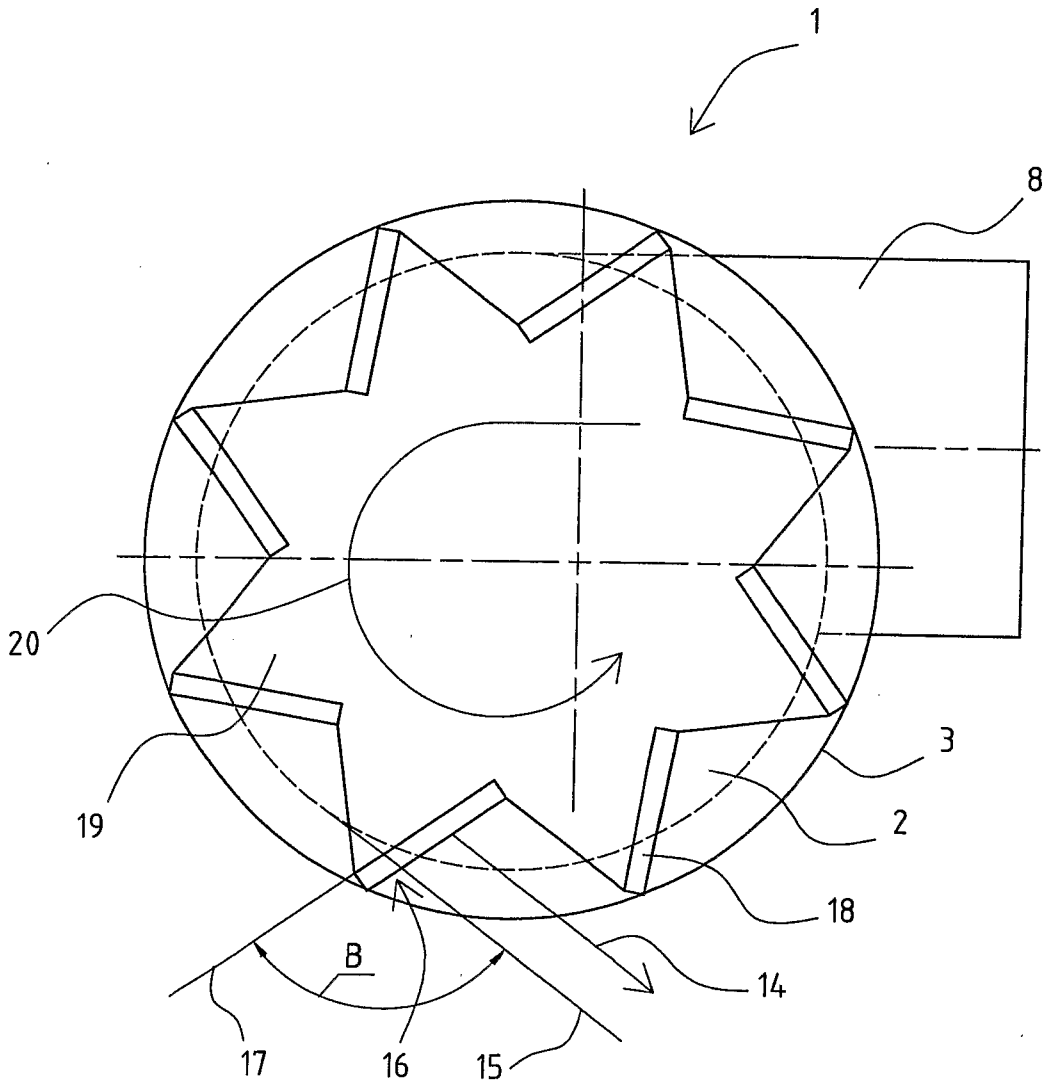


Fig. 2

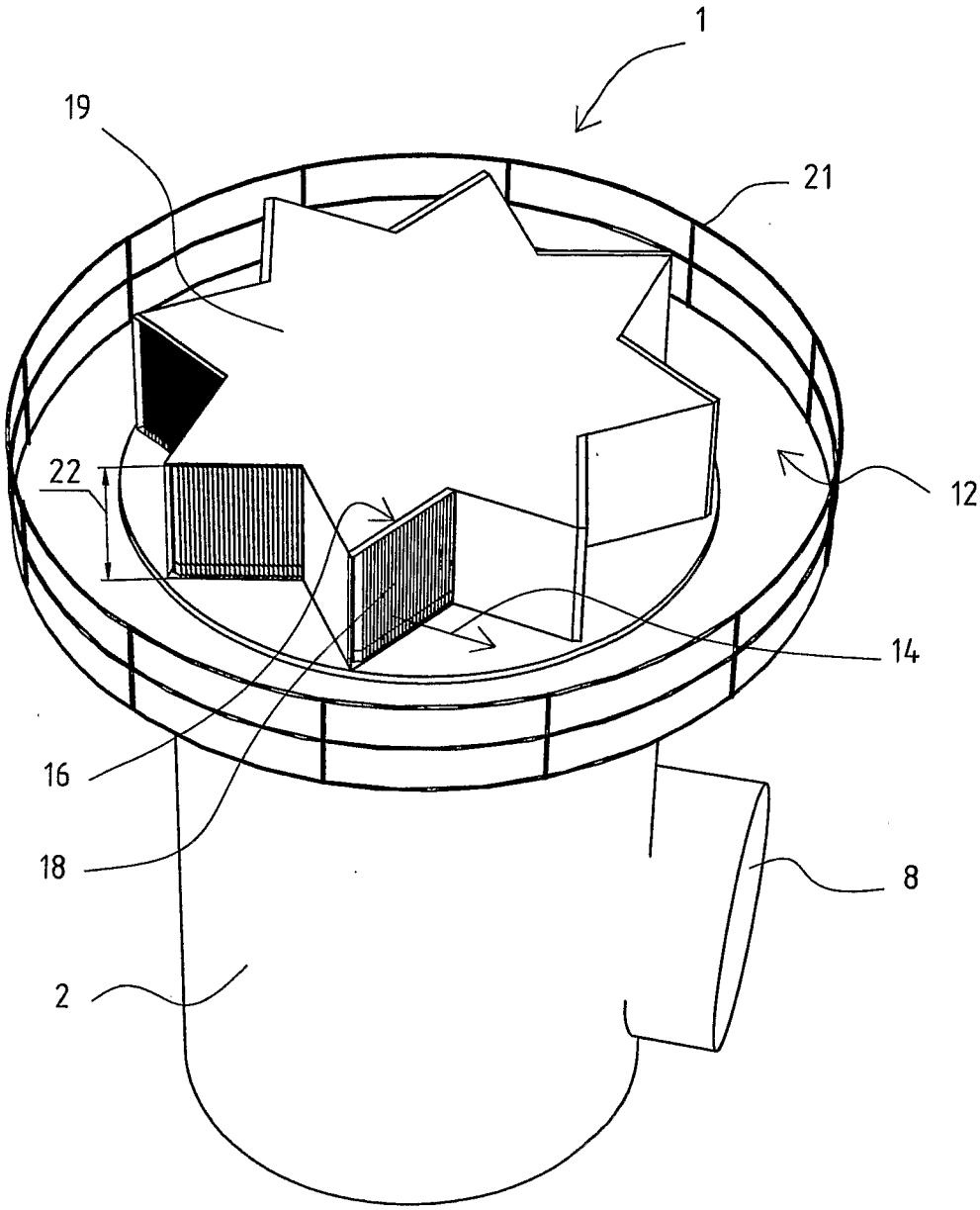


Fig. 3