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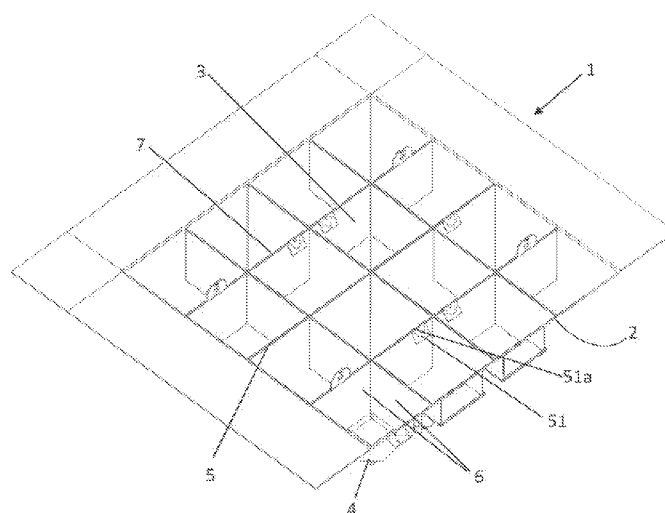


Fig. 2

(57) Abstract: The present invention is directed to drawdown cone (1) with a convergent housing (2) comprising a main material inlet (3) on a top side of the drawdown cone (1) and a main material outlet (4) on a bottom side of the drawdown cone (1). At least one rooftop-shaped divider (5, 6) is arranged inside the drawdown cone (1), dividing the drawdown cone (1) into at least two sub-sections.

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DRAWDOWN CONE

FIELD OF THE INVENTION

The present invention relates to a drawdown
5 cone for granular material, specifically sand.

SUMMARY OF THE INVENTION

According to the present invention, a
drawdown cone is provided, with a convergent housing,
10 a main material inlet on a top side of the drawdown
cone and a main material outlet on a bottom side of
the drawdown cone.

The main material outlet is smaller than the
main material inlet, meaning it has a smaller area, a
15 smaller diameter and/or a smaller width than the main
material inlet. Hence the housing is converging from
the top side to the bottom side.

The words top side and bottom side refer to
the normal use of the drawdown cone, where the cone
20 is oriented with the bottom side towards the earth's
center of mass. Hence, the main axis of the drawdown
cone, which leads from the center of the main
material inlet to the center of the main material
outlet, is oriented parallel to the gravitational
25 field. Therefore, the granular material in the
drawdown cone travels from the main material inlet
towards the main material outlet due to the
gravitational force.

Drawdown cones are for example used in
30 fluidized bed combustion and/or gasification systems,
to drawdown the bed of sand in order to clean and
recycle the sand back into the reactor. When the sand
or other granular material is removed from the

drawdown cone through the main material outlet, so called rat holing can occur. This means that the granular material directly above the main material outlet will move towards the main material outlet with a higher speed of travel than the granular material near the edge of the drawdown cone, forming a sink over the main material outlet.

In fluidized bed combustion and/or gasification systems it is very important that all of the bed of grain material is drawn down at some even rate during operation so that it may be cleaned and recycled back into the furnace of the fluidized bed reactor. If dead areas exist, tramp material or other inert material can build up and eventually cause the facility to shut down for cleaning.

It is known to arrange a second smaller inner cone inside of the drawdown cone, which is arranged centrally over the main material outlet and that has several openings in the side wall to leak sand out to the outer cone. These openings create hang up points for tramp material being drawn down with the sand. Eventually, this plugs the whole drawdown cone and the entire system must be shut down and cleaned. Also with such a design there are dead areas, where the grain material does not get drawn down at all.

It is therefore the object of the present invention to provide a drawdown cone that can ensure a homogeneous drawdown of the grain material, while minimizing the shutdown time due to plugs in the drawdown cone.

The object is solved by a drawdown cone according to claim 1, with a convergent housing, a main material inlet on a top side of the drawdown

cone and a main material outlet on a bottom side of the drawdown cone. According to the invention, at least one rooftop-shaped divider is arranged inside the drawdown cone, dividing the drawdown cone into at least two sub-sections.

Due to the rooftop-shaped form of the divider, the granular material travelling through the drawdown cone gets redirected, leading to a more homogeneous distribution of the travelling speeds of the granular material. It is especially possible to avoid dead areas, where the granular material does not move at all or only with a very low speed. Hence the formation of plugs due to the build-up of tramp or inert material is avoided.

According to a preferred embodiment, the at least one rooftop-shaped divider has a top edge facing the material inlet and at least one bottom edge, facing towards the material outlet and/or away from the main material inlet.

Most preferably, the rooftop-shaped divider has a constant slope. The slope of the rooftop-shaped divider, however, can also increase from the top edge to the bottom edge, leading to a streamlined form.

Alternatively, the slope of the rooftop-shaped divider can also decrease from the top edge to the bottom edge or be a combination of increasing, decreasing and/or constant parts.

The rooftop-shaped divider can be arranged symmetrical to the main axis of the drawdown cone or be tilted with respect to the main axis. By selecting the appropriate form and orientation, the rooftop-shaped divider can be adapted to the used grain

material, drawdown speeds and other parameters of the facility.

According to a further preferred embodiment, the rooftop-shaped divider comprises two wings joined together at the top edge. The profile of the rooftop-shaped divider can be that of an upside-down letter V, where the two wings are constructed as flat plates. The angle α between the two wings should preferably be smaller than 106° , preferably between 30° and 106° , more preferably between 50° and 90° , more preferably about 70° . When the rooftop-shaped divider is arranged symmetrical to the main axis of the drawdown cone, an angle of 106° corresponds to a slope γ of the rooftop-shaped divider with regard to the horizontal of 37° , which is the angle of repose of sand. Hence, sand or similar material will not plug the drawdown cone. With an angle α of 70° , the slope of the rooftop-shaped divider is 55° with regard to the horizontal, which is well above the angle of repose of sand, thereby ensuring that no plugs occur. In other words, the angle α of the divider has a relationship to the slope γ of the rooftop-shaped divider in the following manner:

$$\gamma = 90^\circ - \frac{\alpha}{2}$$

25

According to a further preferred embodiment, the at least one rooftop-shaped divider comprises two rooftop-shaped dividers that are arranged perpendicular to each other and intersect directly above the main material outlet, dividing the drawdown cone in four sub-sections or quadrants.

30

"Directly above the main material outlet", in the sense of the present invention, means that the intersection lies between the main material outlet on the bottom side and the main material inlet on the topside of the drawdown cone. Preferably, the intersection point of the top edges of the two rooftop-shaped dividers lies on the main axis from the center of the main material inlet to the center of the main material outlet.

The rooftop-shaped dividers redirect the grain material away from the point directly above the main material outlet, where rat-holing would appear. Hence, the division of the drawdown cone prevents one big rat hole from forming in the center by drawing the sand equally from each quadrant of the drawdown cone.

Preferably, the rooftop shaped divider has a larger width than the main material outlet. In that case, no direct path exists between the main material inlet and the main material outlet. Therefore, all of the grain material has to travel sideways at some point in the drawdown cone, which avoids rat-holing at the edge of the rooftop-shaped dividers and leads to a more even drawdown of the grain material.

In a preferred embodiment, a sub-cone is formed in the at least one sub-section or quadrant by part of the wall of the convergent housing and/or parts of the at least one rooftop-shaped divider. The length of the wings of the rooftop-shaped divider, from the top edge to the bottom edge, is such that a gap remains between the bottom edge and the housing. Therefore, the sub-cone comprises a sub-outlet, formed by the at least one bottom edge of the

rooftop-shaped divider. Thus, the inventive drawdown cone is split up into littler cone shaped areas, forcing the grain material to follow a specific path.

Preferably, the drawdown cone has a square
5 base and thus has the form of a pyramidal frustum. Such a drawdown cone can be easily manufactured out of flat metal plates. In that case, the sub-cones formed in the four quadrants also have the form of pyramidal frustums, which are smaller versions of the
10 main cone.

In a particularly preferred embodiment, the at least one rooftop-shaped divider comprises two more rooftop-shaped dividers that are arranged perpendicular to each other, intersecting directly
15 over the sub-outlet of the sub-cone formed in at least one quadrant.

These additional rooftop-shaped dividers therefore further divide the respective quadrant in even smaller sub-sections. The additional dividers
20 act in the same way for the sub-cone as the main dividers intersecting above the main material outlet do for the whole drawdown cone. Hence, the additional dividers prevent a rat-hole from forming in the center of the quadrant over the sub-outlet by drawing
25 the sand equally from each smaller sub-section of the quadrant.

Preferably, the additional rooftop shaped dividers have a larger width than the sub-outlet in order to avoid rat-holing at the edge of the
30 additional rooftop-shaped dividers. Also in the smaller sub-sections sub-cones are formed by part of the wall of the housing and/or parts of the main and additional rooftop-shaped dividers.

Preferably the top edge of the additional rooftop shaped dividers lies in the same plane as the top edge of the main dividers.

Effectively, when every quadrant is further
5 divided by two additional rooftop-shaped dividers,
the drawdown of the bed of grain material acts like
it has sixteen small cones underneath it instead of
one big one. That is basically the case, but the
sixteen small cones are within four bigger cones
10 which are within one big cone. This means, the
drawdown cone has one easy manageable outlet for
sixteen cones worth of bed drawdown.

Preferably, the length of the wings of the
additional rooftop-shaped dividers is smaller than
15 the length of the wings of the main rooftop-shaped
dividers. Hence, when the top edges of the dividers
lie in the same plane, the sub-outlets of the even
smaller sub-cones lie on a different level than the
sub-outlets of the quadrants, forming multiple stages
20 of cones inside the drawdown cone.

This principle can be repeated for even more
stages by further dividing the sub-sections in
smaller sub-sections by additional rooftop-shaped
dividers. The principle works best for decreasing
25 sizes of the rooftop-shaped dividers. Thereby, the
drawdown cone can be divided down to subsections of
the desired size. While more and thus smaller sub-
sections lead to a more homogeneous drawdown of the
granular material, the subsections must be large
30 enough that tramp material can pass the drawdown cone
without causing a plug.

According to a preferred embodiment, the rooftop-shaped dividers divide the drawdown cone in sub-sections that are larger than 10" (0.254 m) x 10" (0.254m) and smaller than 30" (0.762 m) x 30" (0.762 m), preferably larger than 15" (0.381 m) x 15" (0.381m) and smaller than 25" (0.635 m) x 25" (0.635 m), more preferably about 20" (0.508 m) x 20" (0.508 m).

"About" is to be understood as with normal technical deviations, for example plus or minus 5%. These sizes are small enough to minimize dead areas where no drawdown of the grain materials occurs. The size may be chosen so as to integrate into a combustion system or a gasification system. For example, the dividers may divide the drawdown cone in subsections of 24" (0,610 m) x 24" (0,610 m).

According to a preferred embodiment, the sub-outlets are larger than 4" (0.102 m) x 4" (0.102 m) and smaller than 10" (0.254 m) x 10" (0.254 m), preferably larger than 6" (0.152 m) x 6" (0.152 m) and smaller than 10" (0.254 m) x 10" (0.254 m), more preferably about 8" (0.203m) x 8" (0.203 m). With sub-outlets sized 8" (0.203 m) x 8" (0.203 m), there is a minimum clearance distance of 6" (0.152 m), which is enough room to handle any tramp material smaller than 4" (0.102 m).

The sub-outlets may have the same size in every stage. This is especially beneficial in ensuring a large enough clearance to pass tramp or inert materials, and, at the same time, ensuring a small enough clearance to be able to control the process accurately.

In an embodiment, the sub-outlets in different stages may also have different sizes. This may be especially advantageous in achieving different flow effects of the materials.

5 According to a preferred embodiment, the opening angle β of the convergent housing is smaller than 106° , preferably between 30° and 106° , more preferably between 50° and 90° , more preferably about 70° . With an angle smaller than 106° , the slope γ of
10 the drawdown cone with regard to the horizontal is larger than the angle of repose of sand of 37° . Hence, sand or similar material will not plug the drawdown cone. An opening angle β of 70° leads to a slope of the drawdown cone of 55° . In the case of a
15 square drawdown cone, this results in a 45° valley angle in the corners of the cone. Hence also the valley angle is well above the 37° needed for the sand to smoothly travel through the drawdown cone, thereby avoiding the formation of plugs in the cone
20 corners. In other words, the angle β of the divider has a relationship to the slope γ of the rooftop-shaped divider in the following manner:

$$\gamma = 90^\circ - \frac{\beta}{2}$$

25 According to a preferred embodiment, the opening angle α of the convergent housing is the same as the angle β between the two wings of the rooftop-shaped dividers. Hence, the slope of the different parts of the drawdown cone is uniform throughout the
30 entire cone, leading to a homogeneous drawdown of the grain material.

According to another preferred embodiment of the invention, at least one ram device is mounted inside the drawdown cone, such that it can be moved in and out of at least one sub-outlet.

5 Even though the design of the drawdown can handle even large tramp material, the chance that the cones will plug at some point during operation still exists. In that case, the ram device can poke into one of the sub-outlets of the sub-cones to break up
10 potential plugs.

Preferably, the ram device is a swinging ram device, which is axially mounted inside the drawdown cone, such that it can be rotated in and out of the sub-outlets. The ram device may be operated manually.
15 Alternatively, the ram device may be operated automatically, for example by a pneumatic or hydraulic cylinder, or by a motor, such an electric motor.

In a preferred embodiment, the housing of the
20 drawdown cone comprises a feedthrough, wherein the ram device passes through that feedthrough. Hence, it is possible to externally operate the ram device, without accessing the drawdown cone and therefore remove even major plugs without requiring a plant-
25 wide shutdown.

In a preferred embodiment, the ram device has a standby position, in which it is completely concealed under one of the rooftop-shaped dividers. This means that there is no line of sight between the
30 ram device and the main material inlet, such that during normal operation, the grain material does not directly pass the ram device. The ram device does

thus not form an obstacle for the grain material, when in the stand-by position.

According to another preferred embodiment, the housing comprises a door for accessing the
5 drawdown cone. Via said door the drawdown cone can be accessed for inspection and maintenance purposes.

According to a preferred embodiment, coolant medium is arranged to be introduced into the drawdown cone via inlets arranged into the housing, and
10 removed via outlets arranged into the housing.

When handling heated granular material comprising inert materials which also are heated, it may be problematic to cool the materials to a temperature in which the materials can be efficiently
15 handled or managed. In the drawdown cone according to the invention, the design is such that the drawdown cone 1 will only fill to 50 % of its total volume with the granular material, and the remaining 50 % of the volume of the drawdown cone 1 is void.

Coolant medium, for example air or other gas, may be introduced, that is pumped, compressed or otherwise led into the void volume to further cool the granular material. By void herein is meant a total volume of pockets or such sub-volumes of the
20 drawdown cone 1 that are not filled with the granular material. It is therefore to be understood that the drawdown cone 1 may comprise several such voids, and at the same time several areas of the total volume filled with the granular material in-between the
25 voids.
30

The embodiments of the invention described herein may be used in any combination with each other. Several of the embodiments may be combined

together to form a further embodiment of the invention. An apparatus, to which the invention is related, may comprise at least one of the embodiments of the invention described herein.

5

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and constitute a part of this specification, illustrate embodiments of the invention and together with the description help to explain the principles of the invention. In the drawings:

Fig. 1 shows an isometric view of the inventive drawdown cone,

Fig. 2 shows an isometric view of the drawdown cone in a slightly different angle,

Fig. 3 shows a top view of the isometric drawdown cone,

Fig. 4 shows a simplified sectional view of the inventive drawdown cone,

Fig. 5 shows another sectional view of the inventive drawdown cone,

Fig. 6 shows another sectional view of the inventive drawdown cone, and

Fig. 7 shows another simplified sectional view of the inventive drawdown cone.

DETAILED DESCRIPTION OF THE INVENTION

The invention will now be described in more detail on the basis of the following description of preferred embodiments and the drawings. All features described or illustrated form the subject matter of the invention, independent of their combination in the claims or their back reference.

Figures 1 to 3 show the inventive drawdown cone 1, which has the main form of a square frustum. The drawdown cone 1 comprises a converging housing 2, which in turn comprises four side walls 2a. At the top side, the drawdown cone 1 comprises a main material inlet 3, which has the form of a square. Opposite of the main material inlet 3, at the bottom side, is a main material outlet 4. The drawdown cone 1 further comprises a door 12 in its housing 2 for accessing the drawdown cone 1.

The principle function of the drawdown cone 1 is that the grain material, for example sand, enters the drawdown cone 1 through the main material inlet 3, travels through the drawdown cone 1 and exits through the main material outlet 4, which is smaller than the main material inlet 3. In order to homogenize the speed of travel of the grain material that enters the drawdown cone 1 at different positions of the main material inlet 3 the drawdown cone 1 comprises several dividers 5, 6, which divide the drawdown cone 1, and especially the main material inlet 3 of the drawdown cone 1, into several sub-sections.

The drawdown cone 1 comprises two main dividers 5 that each reach from the middle of one side wall of the housing 2 to the middle of the opposite side wall of the housing 2 and are perpendicular to each other.

The two main dividers 5 intersect in the center of the main material inlet 3 directly above the main material outlet 4, thereby dividing the drawdown cone 1 into four approximately identical sub-sections called quadrants.

The drawdown cone 1 further comprises two small dividers 6 in every quadrant, which are arranged perpendicular to each other and which further divide the drawdown cone 1 into in total sixteen smaller sub-sections (four sub-sections per quadrant).

In each of the four quadrants, the sidewalls of the housing 2 together with the main dividers 5 form a medium-sized cone with a sub-inlet, corresponding to one fourth of the main material inlet 3 of the drawdown cone 1. The medium-sized cones formed in each quadrant further comprise a sub-outlet 9 defined by the bottom edges 8 of the main dividers 5. The sub-outlet 9 is not visible in Fig. 2 since the two small dividers 6 are arranged directly above the sub-outlet 9 of the quadrant and have a larger width than the sub-outlet 9.

The two small dividers 6 in every quadrant intersect directly above the sub-outlet 9 of the medium-sized cone formed in the respective quadrant. The small dividers 6 in the quadrant further divide each quadrant into four smaller sub-sections, such that the drawdown cone 1 is equally divided into sixteen sub-sections. In each of the sixteen smaller sub-sections the dividers 5, 6 and/or the side walls of the housing 2 form small cones with a sub-inlet corresponding to one sixteenth of the main material inlet 3 and a sub-outlet 10 facing towards the main material outlet 4.

The drawdown cone 1 may also comprise field adjustment caps 51 arranged to receive temperature probes (not shown in the figures) that can be passed through holes 51a arranged into the field adjustment caps 51 for monitoring the temperature of the material passing through the drawdown cone 1. The field adjustment caps 51 may be placed in other positions as well, and they may be used to receive other measurement equipment besides temperature probes, as well.

Alternatively or in addition, the drawdown cone 1 may also comprise additional holes inside its structure for enabling access and inspection of the drawdown cone 1 while out of operation (not shown in the figures). These holes do not have contact with the material treated in the drawdown cone 1.

Alternatively or additionally, the drawdown cone 1 may further comprise inlets 52a and outlets 52b arranged into the housing 2. The inlets 52a and outlets 52b may be utilized in cooling the material handled in the drawdown cone 1.

A coolant medium, such as air or other suitable gas, may be introduced into a void volume or void volumes within the housing 2 as infeed via the inlets 52a, using any suitable conduits, such as pipes or tubes, arranged to run via the inlets 52a.

Similarly, removal of the coolant medium as an outfeed may be arranged via the outlets 52b in the same manner. The size and/or location within the housing 2 of the inlets 52a and outlets 52b may vary depending on the type of coolant medium and/or the amount of cooling capacity required. In figure 1, an embodiment of such an arrangement is shown.

The infeed and/or outfeed of the coolant medium is preferably achieved by pumping or compressing cool air or other gas into the inlets. The coolant medium may be removed by venting and/or recycling the coolant medium in a safe and/or controlled manner out of the system.

As can best be seen in figures 2 and 4, the dividers 5, 6 are rooftop-shaped. Specifically, they have a profile, formed like an upside-down letter V, with two wings 11 joined together at an upper edge 7 facing the main material inlet 3 and with their bottom edges 8 facing towards the main material outlet 4. The angle α between the two wings 11 of the rooftop-shaped dividers 5, 6 is approximately identical to the opening angle β of the drawdown cone 1. Basically, the slope of the rooftop-shaped dividers 5, 6 is the same as that of the exterior wall of the main cone.

The wings 11 of the small dividers 6 are smaller than the wings 11 of the main dividers 5, meaning that they do not extend as far towards the main material outlet as the wings 11 of the main dividers 5. Hence, the bottom edge 8 of the main dividers 5 lies on a different level or height than the bottom edge 8 of the small dividers. Therefore, the sub-outlet of the medium sized cones in every quadrant lies on a different level or height than the sub-outlets 10 of the small cones in the sixteen sub-sections. Hence, the drawdown cone 1 comprises three stages of cones, wherein the size of the cones increases from the topside to the bottom side. The first stage is constituted by the sixteen small cones.

The second stage is formed by the four medium-sized cones, with always four sub-outlets 10 of the small cones leading into every one of the four medium-sized cones of the second stage. The sub-outlets 9 of the medium sized cones of the second stage in turn lead to the lower part of the housing 2 as the main cone and hence back together towards the main material outlet 4.

Since the angles α of the rooftop-shaped dividers 5, 6 are approximately identical to the opening angle β of the drawdown cone 1, the four medium-sized cones formed in each quadrant and the sixteen small cones formed in each sub-section are symmetrical and geometrically similar to the drawdown cone 1 as a whole.

When grain material, for example sand or the like, enters the drawdown cone 1, depending on its position, it enters into one of the small cones of the first stage and travels through the small cone towards the sub-outlet 10 of that cone. It leaves the small cone and thereby the first stage through that sub-outlet 10 and reaches a medium-sized cone of the second stage. The sand of four sub-sections of the first stage flows together into one quadrant of the second stage and moves towards the sub-outlet 9 of the medium-sized cone formed in the respective quadrant. The sand then leaves the second stage through the sub-outlet 9 of the medium-sized cone of the second stage and reaches the lowest part of the drawdown cone 1, where all the sand from every sub-section is merged together again, and finally leaves the drawdown cone 1 through the main material outlet 4.

As can be seen in Fig. 7, three swinging ram devices 20 are axially and pivotably mounted inside the drawdown cone 1. As shown in Fig. 4 and 5, the ram devices 20 each comprise a main rod 21, which is
5 pivotably mounted on one side of the housing 2 and mounted on the opposite side in a feedthrough 22 of the housing 2, such that the main rod 21 passes through the feedthrough 22 to the outside of the drawdown cone 1. Hence, the main rod 21 can be
10 actuated from the outside, when the drawdown cone 1 is in use and for example filled with sand. The ram device 20 may further comprise arms 23 protruding from the main rod 21 that can poke in and out of at least one sub-outlet 9, 10, when the ram device 20 is
15 pivoted. The ram device 20 may be operated either manually or automatically.

A first ram device 20 is depicted in Fig. 5 which is arranged in the center of the drawdown cone 1 directly above the main material outlet 4. This ram
20 device 20 has two protruding arms 23 that can poke in the sub-outlets 9 of the second stage cones. As shown in Fig. 6, the first ram device 20 is concealed below one of the main dividers 5 when in a standby position.

25 When the first ram device 20 is pivoted in a first direction, the two protruding arms 23 each poke in a sub-outlet 9 of one of the quadrants breaking up the potential plugs in the two sub-outlets 9 at once. For the sub-outlets 9 of the remaining two quadrants
30 on the other side of the ram device 20, the ram device 20 is pivoted in the opposite direction, whereby the two protruding arms 23 poke into the sub-outlets 9 of the other two quadrants.

Fig. 6 shows one of the two further ram devices 20 that are arranged such that they pass through the center of the four quadrants directly above the sub-outlets 9 of the medium-sized cones formed in the quadrants. The two further ram devices 20 preferably
5 each comprise four protruding arms 23, which are shorter than the two protruding arms 23 of the center ram device 20 and that can poke in the sub-outlets 10 of the small cones formed in each sub-section of the
10 first stage.

As can best be seen in Fig. 6, the further ram devices 20 are completely concealed under the small dividers, when they are in their stand-by positions. The right ram device 20 shown in Fig. 6 is depicted
15 in its stand-by position. When rotated in a first direction, the four protruding arms 23 of the further ram devices 20 can each poke in one sub-outlet 10 of the small cones formed in each sub-section, thereby breaking up potential plugs in four sub-outlets at
20 once.

The left ram device 20 shown in Fig. 7 is depicted in a position, where it pokes the sub-outlet 10. When rotated in the opposite direction, the four protruding arms poke into the sub-outlets 10 of the
25 small cones of four more sub-sections on the other side of the ram device 20.

Hence the inventive drawdown cone provides for a homogeneous drawdown of the grain material, while avoiding plugs inside the drawdown cone. The
30 inventive drawdown cone further provides means for breaking up potential plugs in the drawdown cone, reducing the need to shut down the facility for cleaning purposes.

Additionally, the high-temperature granular material can be efficiently cooled down to improve the manageability of the material to be treated.

While the present invention has been described
5 in relation to the drawdown of sand and tramp material in a fluidized bed combustion or gasification system, it is readily apparent that the invention can just as well be used for the drawdown
of other bulk material or in any other process
10 requiring the drawdown of bulk material through a cone.

Reference numbers

	1	drawdown cone
	2	housing
5	2a	side walls
	3	main material inlet
	4	main material outlet
	5	main divider
	6	small divider
10	7	top-edge
	8	bottom edge
	9	sub-outlet second stage
	10	sub-outlet first stage
	11	divider wing
15	12	door
	20	ram device
	21	main rod
	22	feedthrough
	23	protruding arm
20	51	field adjustment cap
	51a	hole
	52a	inlet
	52b	outlet
25	α	opening angle of dividers 5, 6
	β	opening angle of housing 2

CLAIMS

1. Drawdown cone with a convergent housing (2), a main material inlet (3) on a top side of the drawdown cone (1) and a main material outlet (4) on a bottom side of the drawdown cone (1), **characterized in that** at least one rooftop-shaped divider (5, 6) is arranged inside the drawdown cone (1), dividing the drawdown cone (1) into at least two sub-sections.

2. Drawdown cone according to claim 1, **characterized in that** the at least one rooftop-shaped divider (5, 6) has a top edge (7) facing the main material inlet (3) and at least one bottom edge (8) facing towards the main material outlet (4).

3. Drawdown cone according to claim 2, **characterized in that** the rooftop-shaped divider (5, 6) comprises two wings (11) joined together at the top edge (7), wherein the angle (α) between the two wings (11) is smaller than 106° , preferably between 30° and 106° , more preferably between 50° and 90° , even more preferably about 70° .

4. Drawdown cone according to any of the preceding claims, **characterized in that** the at least one rooftop-shaped divider (5) comprises two rooftop-shaped dividers (5) that are arranged perpendicular to each other and intersect directly above the main material outlet (4).

5. Drawdown cone according to any of the claims 2 to 4, **characterized in that** a sub-cone is

formed in the at least one sub-section by the housing (2) and/or the at least one rooftop-shaped divider (5, 6), whereby a sub-outlet (9, 10) is formed by the at least one bottom edge (8) of the rooftop-shaped divider (5, 6).

6. Drawdown cone according to claim 5, **characterized in that** the at least one rooftop-shaped divider (6) comprises two additional rooftop-shaped dividers (6) that are arranged perpendicular to each other, intersecting directly above the sub-outlet (9).

7. Drawdown cone according to any of the preceding claims, **characterized in that** the rooftop-shaped dividers (5, 6) divide the drawdown cone in sub-sections that are larger than 10" (0.254 m) x 10" (0.254 m) and smaller than 30" (0.762 m) x 30" (0.762 m), preferably larger than 15" (0.381 m) x 15" (0.381 m) and smaller than 25" (0.635 m) x 25" (0.635 m), more preferably about 20" (0.508 m) x 20" (0.508 m).

8. Drawdown cone according to any of the claims 5 to 7, **characterized in that** the sub-outlets (9, 10) are larger than 4" (0.102 m) x 4" (0.102 m) and smaller than 10" (0.254 m) x 10" (0.254 m), preferably larger than 6" (0.152 m) x 6" (0.152 m) and smaller than 10" (0.254 m) x 10" (0.254 m), more preferably about 8" (0.203 m) x 8" (0.203 m)

9. Drawdown cone according to any of the preceding claims, **characterized in that** the opening angle (β) of the convergent housing (2) is smaller than 106°, preferably between 30° and 106°, more

preferably between 50° and 90° , even more preferably about 70° .

10. Drawdown cone according to any of
5 the claims 3 to 9, **characterized in that** the opening angle (β) of the convergent housing (2) is the same as the angle (α) between the two wings (11) of the rooftop-shaped divider (5, 6).

10 11. Drawdown cone according to any of the preceding claims, **characterized in that** at least one ram device (20) is movably, preferably pivotably, mounted inside the drawdown cone (1) so that it can be moved in and out of at least one sub-outlet (9,
15 10).

12. Drawdown cone according to any of the preceding claims, **characterized in that** the housing (2) comprises a feedthrough (22), wherein the
20 ram device passes (20) through that feedthrough (22).

13. Drawdown cone according to any of the preceding claims, **characterized in that** the ram device (20) has a standby position, in which it is
25 completely concealed under the rooftop-shaped divider (5, 6).

14. Drawdown cone according to any of the preceding claims, **characterized in that** the
30 housing (2) comprises a door (12) for accessing the drawdown cone (1).

15. Drawdown cone according to any of the preceding claims, **characterized in that** coolant medium is arranged to be introduced into the drawdown cone (1) via inlets (52a) arranged into the housing (2), and removed via outlets (52b) arranged into the housing (2).

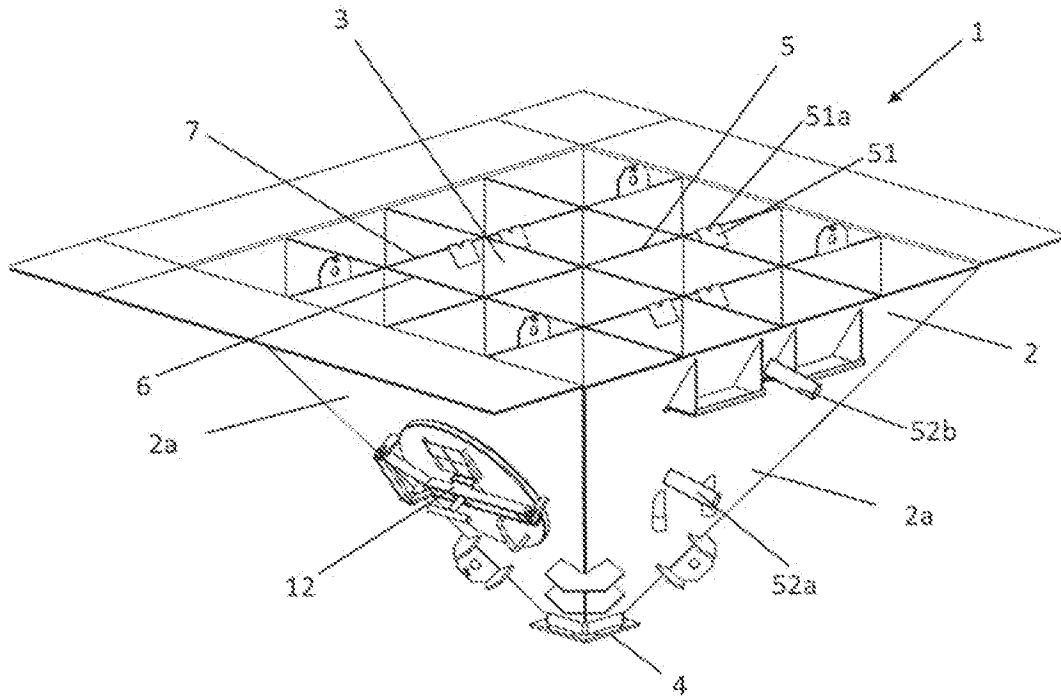


Fig. 1

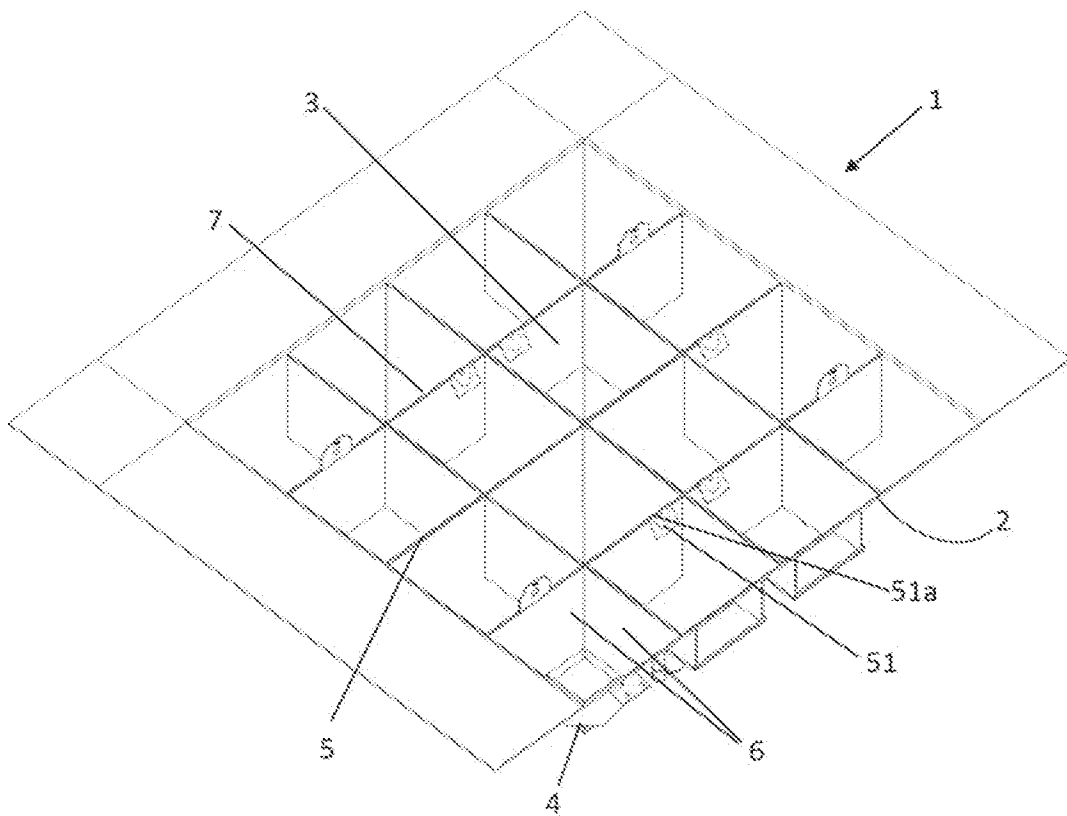


Fig. 2

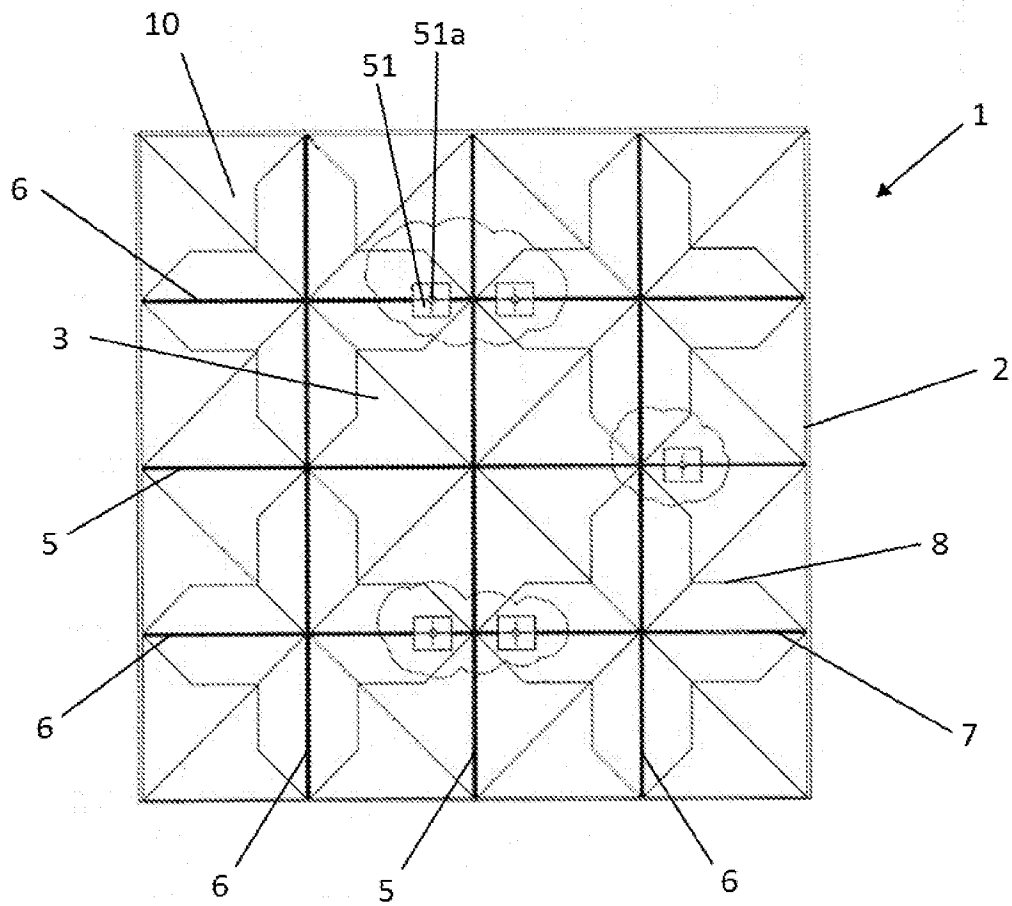


Fig. 3

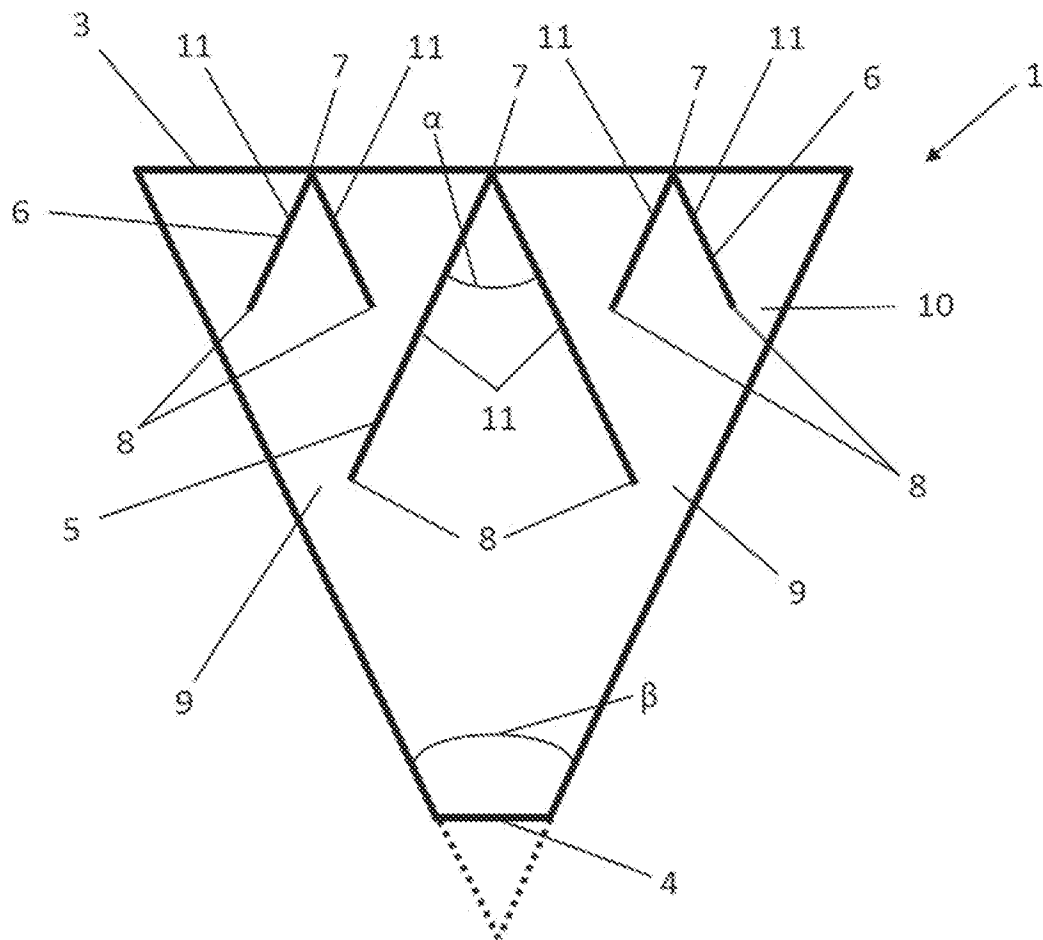


Fig. 4

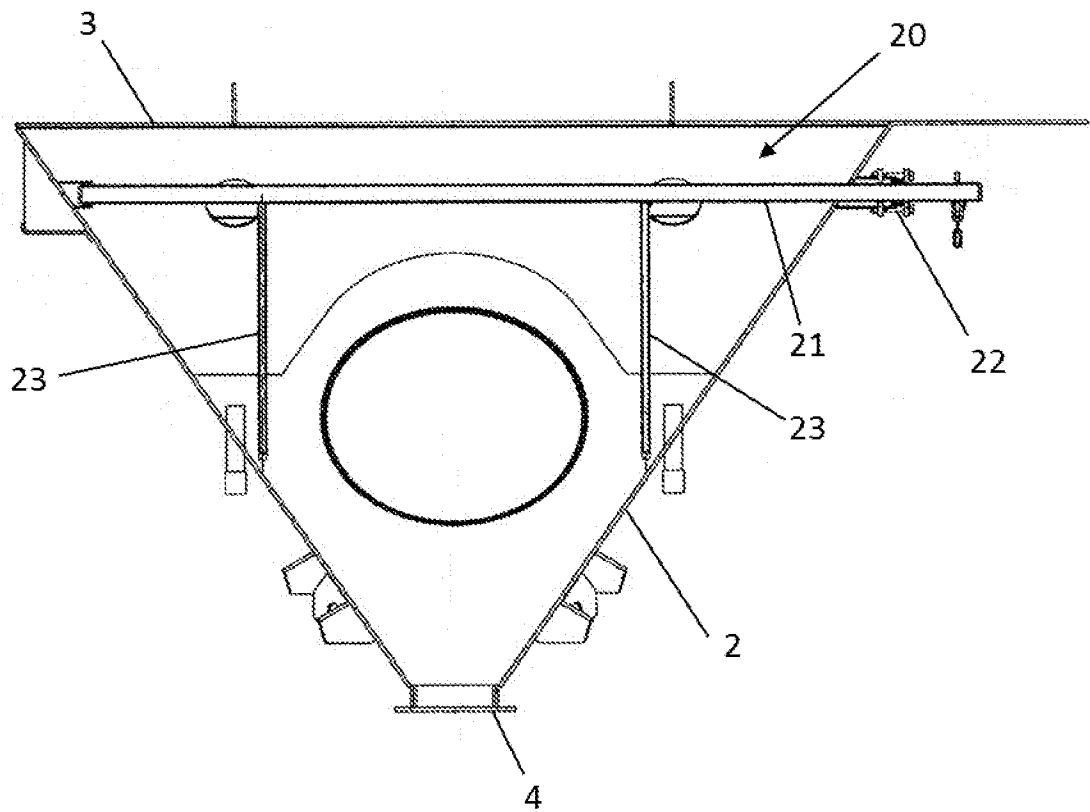


Fig. 5

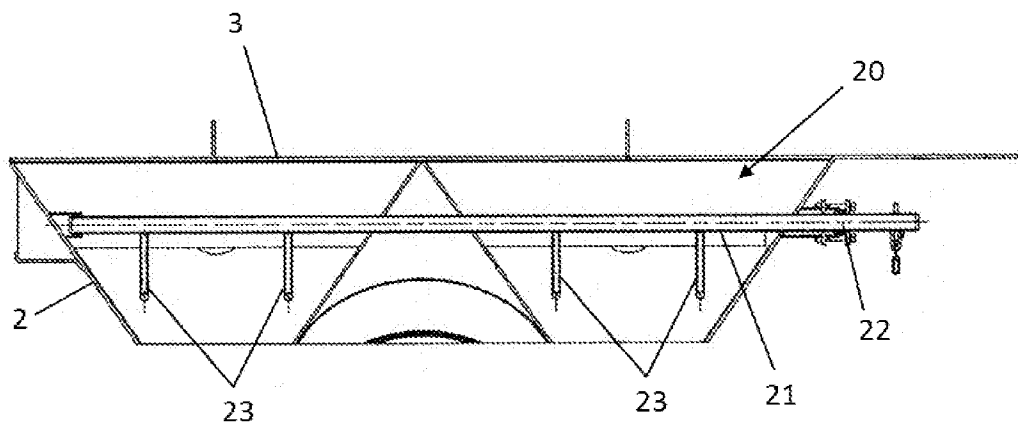


Fig. 6

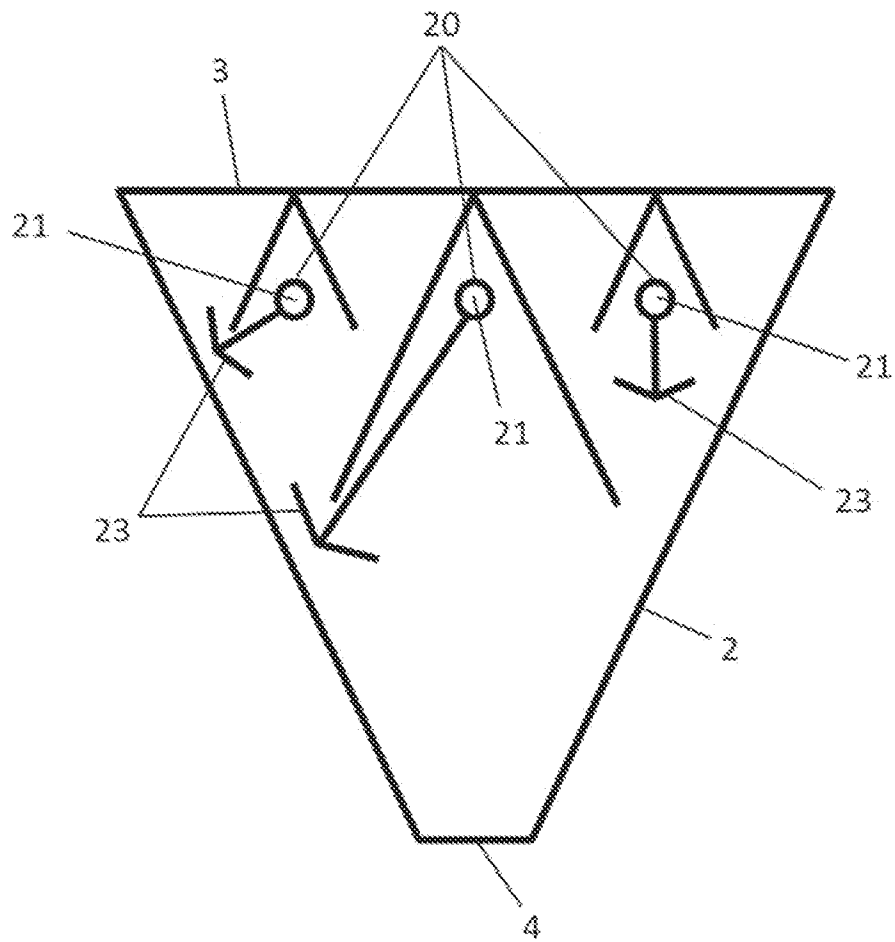


Fig. 7

INTERNATIONAL SEARCH REPORT

International application No

PCT/FI2017/050550

A. CLASSIFICATION OF SUBJECT MATTER
 INV. F23J3/06 F23C10/24
 ADD.

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)
 F23J F23C B65D F23B

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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 1 278 358 A (BUEHLER AG GEB [CH]) 21 June 1972 (1972-06-21)	1-10,14, 15
Y	page 2, line 68 - page 4, line 24 figures 1-14	11,12
X	JP 2006 242454 A (BABCOCK HITACHI KK) 14 September 2006 (2006-09-14) figures 1, 2, and the relating passages of the description	1,2,4-6, 15
X	CN 106 287 689 A (BEIJING NOWVA ENERGY TECH CO LTD) 4 January 2017 (2017-01-04) figures 1-3 and the relating passages of the description	1-3,9
Y	US 3 985 244 A (GESSLER HANS ET AL) 12 October 1976 (1976-10-12)	11,12
A	column 2, line 2 - column 6, line 44 figures 1-11	1-10, 13-15



Further documents are listed in the continuation of Box C.



See patent family annex.

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search

4 April 2018

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/FI2017/050550

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 1278358	A	21-06-1972	AT 285451 B 27-10-1970
		BE 740963 A 29-04-1970	
		BG 17614 A3 10-11-1973	
		CH 498019 A 31-10-1970	
		CS 166718 B2 29-03-1976	
		DE 1952468 A1 19-11-1970	
		FR 2021846 A1 24-07-1970	
		GB 1278358 A 21-06-1972	
		IL 33179 A 29-10-1972	
		JP S4916312 B1 20-04-1974	
		NL 6915689 A 04-05-1970	
		RO 56507 A 29-04-1974	

JP 2006242454	A	14-09-2006	NONE

CN 106287689	A	04-01-2017	NONE

US 3985244	A	12-10-1976	BE 822839 A 01-04-1975
		CH 589551 A5 15-07-1977	
		DD 114381 A5 05-08-1975	
		DE 2356054 A1 15-05-1975	
		FR 2250690 A1 06-06-1975	
		JP S5079067 A 27-06-1975	
		JP S5727033 B2 08-06-1982	
		SU 704450 A3 15-12-1979	
		US 3985244 A 12-10-1976	
