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(54) **A VERTICAL DRYER SILO**

(57) A vertical hot air dryer silo or dry air dryer silo (29) has a circumferential silo wall (11a, 11b, 11), that delimits a drying chamber (10), is used in a vertical hot air drying apparatus (30) and in a method of drying pellets, granules, powder and/or particles. The vertical hot air dryer silo or dry air dryer silo (29) comprises an upper silo part (4), a lower conical silo part (5) in extension of the upper silo part (4), at least one loading inlet (8) for pellets to be dried, which at least one loading inlet (8) is provided at the top of the upper silo part (4), at least one discharge outlet (6) for dried pellets is provided at the bottom of the lower conical silo part (5), and at least one air inlet (30a, 30b) that is adapted for supplying heated air, dry hot air and/or dry air to the drying chamber (10) is provided in the lower conical silo part (5). A baffle member (34) is suspended in the lower conical silo part (5) above the at least one discharge outlet (6) to adjust the flow path of the falling moist pellets.

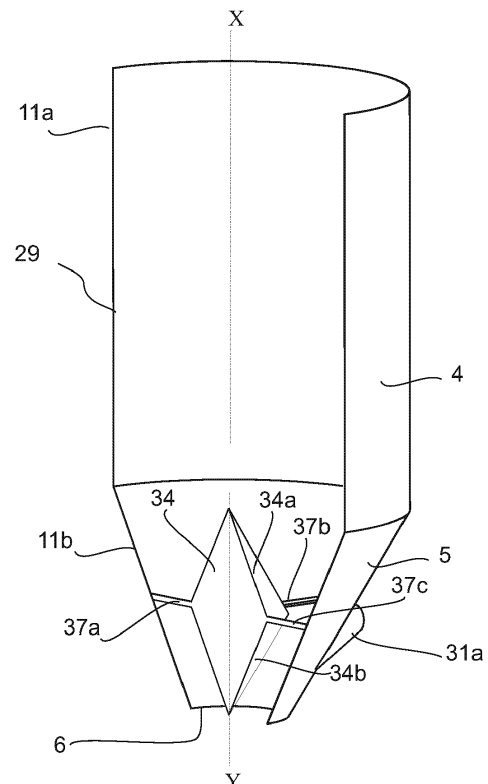


Fig. 8

Description

[0001] The present invention relates to the field of technology of hot air dryers and dry air dryers, such as a dryer for drying hygroscopic and non-hygroscopic plastic granules, in particular hot air dryers and dry air dryers for drying raw free-flowing plastic granules.

[0002] More specifically the present invention concerns a vertical hot air dryer silo and/or a vertical dry air dryer silo of the kind having a circumferential silo wall delimiting a drying chamber, wherein said vertical hot air dryer silo or vertical dry air dryer silo comprises

- an upper silo part,
- a lower conical silo part in extension of the upper silo part,
- at least one loading inlet for pellets, granules, powder and/or particles to be dried, which at least one loading inlet is provided at the top of the upper silo part,
- at least one discharge outlet for dried pellets, granules, powder and/or particles, which at least one discharge outlet is provided at the bottom of the lower conical silo part, and
- at least one air inlet adapted for supplying heated air, dry hot air, and/or dry air to the drying chamber.

[0003] Plastic pellets and plastic granules are the raw material which is pre-produced using the vertical hot air dryer and/or the vertical dry air dryer, and then melted down into "user plastics" at the manufacturing site for the melted plastic to be processed further to form plastic products.

[0004] For the sake of convenience pellets, granules, powder and/or particles are within the scope of the current application and invention, and despite differences in individual sizes and shapes amongst pellets, granules, powder and/or particles, in common and without intentions to be limiting, denominated "pellets" in the context of the description below of the present invention.

[0005] Within the scope of the present invention the term "air" means any kind of gas or combination of gases, including ambient air, and the term "heated" or "hot" means that the air has been subjected to a heating process to raise its temperature above room or ambient temperature, or is already so hot that that it is suited for drying out moisture from the pellets.

[0006] The maximum moisture content possible in air - at saturation - varies with temperature, and thus it varies how much moisture the heated air, dry hot air and/or dry air can take up from the moist pellets. Within the scope of the present invention the term "heated air", "dry hot air" and "dry air" may be used to cover atmospheric air, which at a room temperature approximates a relative humidity of below 5%, preferably the relative humidity approximates zero humidity. Dry air may have a lower temperature than heated or hot air, and dry air can be heated in the vicinity of the silo, e.g. if moist exhaust air is dehydrated and recycled, or hot air can be delivered without recycling. Combination of heated, hot, and dry air flows are within the scope of the present invention.

[0007] In hot air dryers and dry air dryers hygroscopic pellets must first be heated to allow the molecules of the moisture of the pellets, typically water molecules, to move freely. Then time must elapse for the water molecules to diffuse to the surface of hygroscopic pellets and then further time must elapse to fully dry the surface of the pellets. So similar as for non-hygroscopic pellets: the temperature of the heated air, dry hot air and/or dry air must be so that moisture evaporates from the surface so that the pellets are dry before packaging can take place.

[0008] Drying of non-hygroscopic materials, such as polyethylene and polystyrene can be carried out cost-effectively using simple hot air or dry air drying equipment, but more elaborate and complex drying methods are considered when using hygroscopic materials such as nylon, ABS, polycarbonate, cellulose and polymethacrylate. Extra caution is required when using type-6 nylon, as this material can absorb up to 9.5% of its weight in moisture. Just a tiny percentage too much moisture content is detrimental to the end result. On the one hand reducing moisture in plastic significantly improves overall quality, but on the other hand drying is the primary source of product failure and achieving the right drying level and process is a critical task. So optimum drying of moist plastic pellets is a challenging task.

[0009] The LHD series of the applicant's Hot Air Dryers is especially designed for drying the surface of free-flowing granular non-hygroscopic plastic materials. These known hot air dryers are made of stainless steel insulated by an insulation jacket of more than 25 mm, typically 50 mm, to save the heat loss and thus power. An LHD hot air dryer typically has, amongst other components, features, and functionalities in addition to the hot air dryer silo, a cleaning window for material change, PID temperature controller, over heat protection relay, a hopper loader mounting arrangement, and air heating equipment. Any or all of these components may also be part of the present invention.

[0010] The drying quality of the dried pellets is high when using these known hot air dryers. However the hot air is supplied to moist pellets in the drying chamber of the silo via an air inlet in the circumferential wall of the upper silo part. The injected hot air traverses the cross-section area of the drying chamber and is lead towards the lower conical silo part via an internal air pipe. A considerable inconvenience of the internal pipe is that it takes up space inside the drying chamber, and that the pellets cannot fall freely, resulting in that the heated air cannot spread evenly over the full portion

of the pellets falling inside the drying chamber.

[0011] Accordingly it is a main aspect of the present invention to remedy the short-comings of the known hot air dryers and dry air dryers.

[0012] In a further aspect the present invention provides a hot air dryer silo or a dry air dryer silo of the kind mentioned in the opening paragraph that serves to dry pellets, in particular plastic pellets, in a more uniform manner than hitherto known.

[0013] In a further aspect the present invention provides a hot air dryer silo or a dry air dryer silo of the kind mentioned in the opening paragraph that utilises the volume of the drying chamber at an optimum.

[0014] In another aspect of the present invention is provided an energy efficient hot air dryer silo or dry air dryer silo of the kind mentioned in the opening paragraph.

[0015] In another aspect of the present invention is provided a hot air dryer silo or a dry air dryer silo of the kind mentioned in the opening paragraph which hot air dryer silo or dry air dryer silo can be configured for drying a multiplicity of different pellet materials, including a multiplicity of different plastic pellet materials.

[0016] In another aspect of the present invention is provided a hot air dryer silo or a dry air dryer silo of the kind mentioned in the opening paragraph in which the drying process is easier to keep under control than in the prior art hot air dryer silos or dry air dryer silos.

[0017] In another aspect of the present invention is provided a drying apparatus incorporating the hot air dryer silo or the dry air dryer silo of the present invention.

[0018] In another aspect of the present invention is provided a method of drying pellets utilising the hot air dryer silo or the dry air dryer silo of the present invention.

[0019] In another aspect of the present invention is provided a batch of plastic pellets obtained by drying moist plastic pellets in the hot air dryer silo or the dry air dryer silo of the present invention.

[0020] The novel and unique features whereby these and other aspects are achieved according to the present invention consist in that the at least one air inlet is provided in the lower conical silo part and not in the upper silo part as in the known hot air dryer silo or dry air dryer silo.

[0021] By providing the at least one air inlet in the lower conical silo part the obstructions in the flow path of the falling pellets in conventional systems is no longer present and the majority or all pellets can fall by gravity and unobstructed towards the lower conical silo part. The heated air, dry hot air and/or dry air which is infused at the lower conical silo part does not lose thermal energy to the internal pipe but can instantaneously transfer thermal energy to and/or absorb water vapor from the moist pellets. Moreover, the longer, substantially straight path for the supplied heated air, dry hot air and/or dry air to travel on its way up the drying chamber, provides a longer residence time in the drying chamber, and accordingly a longer contact time with the moist pellets that flows in counter-current from the top of the hot air dryer silo or dry air dryer silo towards the bottom of the hot air dryer silo or dry air dryer silo where the dried pellets are discharged continuously via the at least one discharge outlet. Due to longer drying time the temperature of the heated air, dry hot air and/or dry air may be lower than in conventional hot air dryers or dry air dryers thereby saving costs for heating air and/or removing humidity from air. The heated air, dry hot air and/or dry air can, according to the present invention be infused or injected at higher speed than conventionally, thereby increasing production rates.

[0022] The heated air, dry hot air and/or dry air takes moisture from the moist pellets and leaves the upper silo part as moist air via an exhaust opening at the top of the hot air dryer silo or dry air dryer silo. The moist exhaust air may be dried and reused in some installations to achieve optimum control of the moisture content of the heated air, dry hot air and/or dry air that enters via the at least one air inlet.

[0023] In a preferred embodiment the lower conical silo part may have two air inlets to improve the spreading of the heated air, dry hot air and/or dry air inside the drying chamber. Optionally such two air inlets of the lower conical silo part can be arranged diametrically opposite each other to each cover half of the drying chamber with infused or injected heated air, dry hot air and/or dry air.

[0024] So according to the invention the vertical hot air dryer silo or vertical dry air dryer silo may not have any internal air pipes or internal air tubings inside the drying chamber for supplying heated air, dry hot air and/or dry air to moist pellets inside the drying chamber. This way the entire volume of the upper silo part is completely free of obstacles for the falling pellets and a larger space is available for receiving the pellets. The hot air silo dryer or dry air dryer silo can thus dry larger volumes of moist pellets than the conventional hot air dryers or dry air dryers, or combinations of those kinds of dryers, and the heated air, dry hot air and/or dry air can spread evenly when internal air pipes or internal air tubings are not in the way. The volume of moist pellets above the internal air pipe of the conventional hot air dryers or dry air dryers is not as easy for the heated air, dry hot air and/or dry air to reach as the moist pellets around or below the internal air pipe, thereby resulting in non-uniform drying of the moist pellets. This problem is eliminated by the present invention in which all internal components for supplying heated air, dry hot air and/or dry air to the drying chamber is removed from said drying chamber.

[0025] In the vertical hot air dryer silo or vertical dry air dryer silo of the present invention both the flow of the heated air, dry hot air and/or dry air rising up the drying chamber and the flow of pellets falling down the drying chamber can,

at least in the upper silo part, be kept laminar flows or substantially laminar flows due to the non-presence of internal air pipes or internal air tubings. Incidents of cross-currents perpendicular to the direction of flow, eddies or swirls are eliminated or substantially reduced, so the laminar flow of pellets contributes in minimizing collisions of pellets and thereby also to improving surface quality of resulting dry pellets.

[0026] The laminar flow and the supply of heated air, dry hot air and/or dry air at the bottom of the lower conical silo part improves the drying and ensures that each individual pellet is dried to a high level of homogeneity, thus moist pellets can be dried more uniform. However, due to the conical shape of the conical lower silo part pellets falling closer to the central axis of the vertical hot air dryer silo or vertical dry air dryer silo than to the circumferential wall of the vertical hot air dryer silo or vertical dry air dryer silo has a longer flow path than pellets falling closer to a central axis of the air dryer silo or the dry air dryer silo. Depending on the radius of the line of fall from the central axis of the air dryer silo or the dry air dryer silo pellets may have different residence time inside the drying chamber.

[0027] A baffle member suspended in the lower conical silo part above the at least one discharge outlet compensates for difference in the length of flow path of the falling pellets. The baffle member deflects the pellets hitting on it, and the design and dimensioning of the baffle member can be selected to obtain uniform residence time of pellets inside the drying chamber.

[0028] In a preferred embodiment of the vertical hot air dryer silo or the vertical dry air dryer silo of the present invention the baffle member may be a double cone consisting of an upper cone part having its apex facing towards the upper silo part and a lower cone part facing the at least one discharge outlet. The upper cone part are the part of the baffle member that the pellets hits on its way down the drying chamber to prolong residence time and thus drying time of the pellets closest to the circumferential wall of the hot air dryer silo or dry air dryer silo.

[0029] The baffle member may expediently be configured and arranged inside the drying chamber at the lower conical silo part in view of enabling all falling pellets to have the most uniform residence time and thus the closest to same drying time irrespective of where in the drying chamber they fall, typical only falling by gravity. The baffle member may conveniently be arranged inside the drying chamber so that a central baffle axis is coaxial with the central drying chamber axis and space is left around the baffle member to allow pellets to pass by towards the discharge outlet.

[0030] If an upper cone apex angle of the upper cone part of the baffle member is selected to match a lower silo apex angle of the lower conical silo part at least the majority of all pellets, granules, powder, and/or particles falling in the drying chamber get the substantially same drying and/or residence time irrespective of the radial position of the line or path of said falling pellets, granules, powder, and/or particles, thereby substantially eliminating deviations in dryness of the dried pellets and increasing the level of uniformness and homogeneity of dried pellets. The upper cone apex angle may simply be calculated in response to knowledge of the lower silo apex angle to approximate the best the falling time of all pellets to the same falling time.

[0031] Optionally a lower cone apex angle of the lower cone part of the baffle member can be the same or substantially the same as the lower silo apex angle of the lower conical silo part, so when the baffle member is suspended in the lower conical silo part no obstructions, constrictions or bottlenecks for dry pellets obstruct the smooth discharge of said dry pellets. A sufficient flow gap may thus be delimited between the baffle member and a circumferential wall of the lower conical silo part to expedite discharge of dried pellets and to prevent pellet aggregations.

[0032] An outer jacket, preferably an outer heat-insulating jacket, may surround at least the upper silo part and at least the upper portion of the lower conical silo part to keep a uniform heat distribution and heat gradient crosswise and lengthwise of the vertical hot air dryer silo or the dry air dryer silo.

[0033] Expediently the outer jacket can have a bottom jacket part with a bottom jacket hole so that at least a lower portion of the lower conical silo part can protrude out of the outer jacket, thereby arranging the at least one discharge outlet for dried pellets outside the outer jacket to facilitate discharge of dry pellets without the need to open the drying chamber at any stage, and without losing thermal energy and inducing temperature gradients and fluctuations that will be detrimental to the homogeneity of the drying and to the finish of the dried pellet products.

[0034] The pellets, granules, powder, and/or particles to be dried are typically non-hygroscopic, preferably non-hygroscopic plastic pellets, granules, or particles, however within the scope of the present invention hygroscopic pellets, granules, powder, and/or particles, are not excluded.

[0035] The heated air, dry hot air and/or dry air may have a temperature corresponding to or substantially corresponding to the dew point of the material of the pellets, granules, powder and/or particles to be dried.

[0036] Preferred plastic materials, and corresponding temperature and drying time process parameters, are conventional and known in the art. Some non-exhaustive examples of conventional process parameters for plastics are given in Table 1 below.

Table 1.

Plastic material	Temp. °C	Recommended drying time [h]
Acrylonitrile-butadiene-styrene (ABS)	80	2-3

(continued)

Plastic material	Temp. °C	Recommended drying time [h]
Polyoxymethylene (POM)	100	2
Polymethyl methacrylate (PMMA)	80	3
IONOMER	90	3-4
Nylon 6/66 copolymer (PA6/66)	75	4-6
Nylon 11 (PA11)	75	4-6
Nylon 12 (PA12)	75	4-5
Polycarbonate (PC)	120	2-3
Polyurethane (PU)	90	2-3
Polybutylene terephthalate (PBT)	130	3-4
Polyethylene (PE)	90	1
Polyethylene terephthalate (PET)	160	4-5
Polyphenylene oxide (PPO)	110	1-2
Polyimide (PI)	120	2
General purpose polystyrene (GPPS)	80	1
Polysulphone (PSU)	120	3-4
Polyvinyl chloride (PVC)	70	1-2
Styrene acrylonitrile (copolymer) (SAN)	80	1-2

[0037] Preferably the dimensions of the vertical hot air dryer silo or vertical dry air dryer silo may be sized and dimensioned in accordance with the kind and size of pellets, granules, powder, and/or particles to be dried.

[0038] The present invention also relates to a vertical hot air drying apparatus comprising the vertical hot air dryer silo or dry air dryer silo described above.

[0039] The hot air drying apparatus further comprise one or more of

- means for drying air,
- means for supplying heated air, dry hot air and/or dry air,
- means for controlling and monitoring the drying process, and
- means for suspending and/or erecting the vertical hot air dryer silo or dry air dryer silo above a surface.

[0040] The means for drying the air can be any suitable conventional heater, such as a heat exchanger, or be utilisation of waste heat from other productions processes, including waste heat from near by and remote other productions processes.

[0041] The means for drying the air may be the same or different from the means for heating the air, which is to be supplied to the vertical hot air dryer silo or dry air dryer silo. The means for drying and/or heating the heated air, dry hot air and/or dry air may also serve to dehydrate the moist exhaust air exiting the top of the hot air dryer silo or dry air dryer silo to reuse and recycle moist exhaust air as heated air, dry hot air and/or dry air. Dessicants can be used for drying the moist exhaust air or be part of such drying process.

[0042] The means for supplying heated air, dry hot air and/or dry air to the vertical hot air dryer silo or dry air dryer silo may be any suitable means, including but not limited to a pump, such as a vacuum pump, or a fan.

[0043] The means for controlling and monitoring the drying process may be or include electronic and mechanical means such as a humidity sensor, dry air velocity meter, pressure gauges, valve, thermometers, PDI controller, computers, etc. This list should not be construed as exhaustive. Such means are known to the skilled technician and will not be discussed further. Other means for controlling and monitoring the drying process are means for inspecting said drying process, such as an inspection windows in the outer jacket and in the vertical hot air dryer silo, sampling hatches, and samplers.

[0044] The means for suspending or erecting the vertical hot air dryer silo or vertical dry air dryer silo above a support surface may be a mount having legs to arrange the discharge outlet from the support surface to facilitate easy discharge

and provide space for discharge pipes or tubings, and for pumps to transport the dried pellets to a storage or to further processing, such as directly into an injection molding machine.

[0045] The present invention also relates to a method of drying pellets, granules, powder, and/or particles, which method comprises the steps of

- providing the vertical hot air drying apparatus described above,
- loading the drying chamber with a continuous flow of pellets, granules, powder and/or particles to be dried through the at least one loading inlet at the top of the upper silo part,
- continuously supplying to the drying chamber, in counter current with the flow of pellets, granules, powder and/or particles to be dried, a continuous flow of heated air, dry hot air and/or dry air through the at least one air inlet at the lower conical silo part,
- continuously discharging dried pellets, granules, or particles through the at least one discharge outlet at the bottom of the lower conical silo part.

[0046] A batch of highly uniformly dried pellets, granules, powder and/or particles can be obtained using the vertical hot air dryer silo, the vertical dry air dryer silo and/or the vertical hot air drying apparatus described above.

[0047] The present invention will now be described by way of references to the drawing, in which

fig. 1 is a perspective view of a conventional vertical hot air drying apparatus,

fig. 2 is a longitudinal sectional view inside the conventional vertical hot air drying apparatus seen in fig. 1 but without the circumferential wall of the outer jacket,

fig. 3 is a perspective view of a vertical hot air drying apparatus according to the present invention,

fig. 4 shows the same, slightly from the top but without the circumferential wall of the outer jacket,

fig. 5 is a perspective view from below of a vertical hot and dry air drying silo according to the present invention,

fig. 6 shows the same from below,

fig. 7 shows the same from above,

fig. 8 is a longitudinal sectional view inside the vertical hot and dry air drying silo of the present invention,

fig. 9 is a perspective view of the baffle member, and

fig. 10 is a longitudinal sectional view inside the vertical hot air drying apparatus according to the present invention.

[0048] The conventional vertical hot air drying apparatus 1, seen in figs. 1 and 2 has an outer jacket 2 surrounding a vertical hot air dryer silo 3, which, within the scope of the present invention also can be a dry air dryer silo, which vertical hot air dryer silo 3 or dry air dryer silo in the following is denominated "silo" for simplicity of reading.

[0049] The silo 3 has an upper silo part 4 and a lower conical silo part 5 in extension of the upper silo part 4. The lower conical silo part 5 has a discharge outlet 6 for dried pellets, and the top 7 of the upper silo part 4 has a loading inlet 8 and two air exhaust openings 9a,9b. The silo 3 delimits a drying chamber 10 by virtue of a circumferential silo wall 11, which circumferential silo wall 11 has an upper circumferential silo wall part 11a delimiting the upper silo part 4, and a lower circumferential silo wall part 11b that delimits the lower conical silo part 5 and tapers towards the discharge outlet 6.

[0050] An upper air inlet 12, which is provided in the upper circumferential silo wall part 11a, is arranged aligned with a corresponding upper jacket inlet 13. The aligned upper air inlet 12 and upper jacket inlet 13 is connected to and communicates with an exterior air pipe 14 arranged outside and through the upper circumferential silo wall part 11a and an internal air pipe 15 inside the drying chamber 10 for supplying heated or hot dry air to the drying chamber 10. The internal air pipe 15 that extends inside the drying chamber 10 bends into a vertical pipe section 16 in the direction towards the lower conical silo part 5. At the end 17 of the vertical pipe section 16 opposite the air inlet 10, the vertical pipe section 16 extends into a flared part 18 that spreads heated or hot dry air inside the lower conical section 5 above the discharge outlet 6. Radial struts 19a,19b at the upper silo part 4 serve to hold the vertical pipe section 16 substantially centred about the longitudinal central axis X of the silo 3.

[0051] The silo 3 and the outer jacket 2 are kept erected and supported by a frame mount 20 having legs 21, in the present frame mount 20 four spaced apart legs 21, thereby establishing a sufficient space below the discharge outlet 6

for tubings or containers for collecting the dried pellets (not shown).

[0052] A bottom jacket part 22 end caps the outer jacket 2 at the bottom and insulates the silo 3 from below, and a top jacket part 23 end caps the outer jacket 2 at the top and insulates the silo 3 from above. The top jacket part 23 has two respective exhaust jacket openings 24a,24b and a loading jacket inlet 25 aligned with the respective two exhaust openings 9a,9b and the respective loading inlet 10 of the silo 3. A hatch 26 is provided through the outer jacket 2 and the circumferential upper silo wall part 11a to gain occasional access to the drying chamber 10, e.g. for sampling and testing the pellets. A grid or mesh 27 is provided in the lower conical part 5 above the discharge outlet 6 to diffuse the dried pellets at the discharge outlet 6. A blow pipe 28 is positioned inside the vertical pipe section 16 and extends out of the flared part 18 and extends to the grid or mesh 27, to blow heated, hot and/or dry air onto said grid or mesh to further prevent that the discharge outlet 6 clogs. The blow pipe 28 expels heated, hot and/or dry air from the same source as used by the upper air pipe 14.

[0053] As can be seen from fig. 2: In particular the distribution system with the bend internal air pipe 15 and flared part 18 supplying the heated, hot and/or dry air takes up a lot of space inside the drying chamber 10.

[0054] The vertical hot air dryer silo 29, which is also suitable as a dry air dryer silo, and the vertical hot air drying apparatus 30 of the present invention are described in the following figs. 3 - 10. As for the conventional dryer silos discussed above the vertical hot air dryer silo and the dry air dryer silo are discussed in common and denominated "a silo". The silo 29 and the vertical hot air drying apparatus 30 of the present invention correspond to the conventional silo 3 and the vertical hot air drying apparatus 1 and for like parts same reference numerals are used. The silo 29 of the present invention however differs from the conventional silo 3 in the heated, hot and/or dry air supply system and in that a baffle member 34 is positioned inside the lower conical part 5. As such the silo 29 of the present invention does not have a bend internal air pipe 15 extending inside the drying chamber 10 and thus not an upper air inlet 12 provided in the upper circumferential silo wall part 11a, nor a corresponding upper jacket inlet 13, nor a flared part 18 above the discharge outlet 6.

[0055] The silo 29 differs from the conventional silo 3 in the position and arrangement of the air inlet(s) and in the baffle member 34. In the silo 29 of the present invention the air inlet(s) are lower air inlets 30a,30b provided in the lower circumferential wall 11b of the lower conical part 5 and having lower inlet pipes 31a,31b. As seen in e.g. figs. 3 - 5 heated, hot or dry air for drying pellets (not shown) inside the drying chamber 10 of the silo 29 is supplied at the lower conical part 5 of said silo 29 via lower air inlets 30a,30b, as indicated by arrows A1 and A2 in fig. 6. In the exemplary embodiment of a silo 29 two lower inlet pipes 31a,31b are provided, one at each respective air inlet 30a,30b, which air inlets 30a,30b are arranged opposite each other at the lower conical part 5, such as diametrically opposite each other, as seen best in the bottom view of fig. 6 and the top view of fig. 7. As seen in fig. 5 the two lower inlet pipes 31a,31b are also shown arranged at an acute angle in relation to the longitudinal axis X of the silo 29 but other angles are within the scope of the present invention. The angle of lower inlet pipes 31a,31b are convenient due to the little space in the gap 33 between lower circumferential silo wall part 11b and the outer jacket 2.

[0056] As seen in fig. 3 the outer jacket 2 has a lower jacket inlet pipe 35 provided at a lower jacket air inlet 32 for supplying heated air to the drying chamber 10 via the conical lower part 5. A manifold or branch pipe (not shown) is located inside the gap 33 between the lower conical part 5 and the outer jacket 2, which manifold or branch pipe connects the lower inlet pipes 31a,31b to the lower jacket air inlet 32, and thus to a source of heated or hot air. Said heated air can thus rise inside the silo 29 from two opposite locations to dry the moist pellets that flow in counter current.

[0057] Fig. 9 shows the baffle member 34 in perspective and fig. 8 shows the baffle member 34 positioned in the lower conical part 5 above the discharge opening 6.

[0058] The baffle member 34 is a double cone consisting of an upper cone part 34a having its upper cone apex 36a facing towards the upper silo part 5 and a lower cone part 34b having its lower cone apex 36b facing the discharge outlet 6.

[0059] The position of the baffle member 34 is secured by means of struts 37a,37b,37c,37d radiating from the middle of the double cone and engaging the interior surface of the lower conical part 5. The struts can radiate from other positions and the length of the struts 37a,37b,37c,37d can be adjusted to determine the appropriate height above the discharge opening. The baffle member 34 has a central baffle axis Y coaxial with the central drying chamber axis X, which central drying chamber axis X is the same as the longitudinal axis of the silo 29.

[0060] The baffle member 34 can be solid or hollow, have more or less tapered opposite apices, and have same or different upper and lower cone apices. However it is intended that the joining base faces 38a,38b have same area to avoid plateaus for accumulation and aggregations of pellets. Although the baffle member 34 is shown and described as a double cone other designs may also be within the scope of the present invention. The shape of the baffle member can e.g. be an octahedron or have domed parts, or be combinations of domed and flat-sided "cone parts". However it is preferred that the lower cone part 34b is similar to the lower conical silo part 5, thus having same shape but being reduced in size compared to the lower conical silo part 5.

[0061] In the vertical hot air drying apparatus 30 seen in fig. 6 the silo 29 is erected and suspended inside the outer jacket 2 so that a lower portion 38 of the lower conical silo part 5 protrudes out of a bottom jacket hole 39 of the bottom jacket part 22 whereby the discharge outlet 6 is accesible from outside the outer jacket 2.

[0062] The capacity of the heated, hot or dry air to absorb and carry away moisture determines the drying rate and establishes the duration of the drying cycle. Two elements essential to this process are inlet air temperature and air flow rate. The higher the temperature of the drying air, the greater its vapour holding capacity. The present invention optimises the drying process by optimising the flow path to be more uniform irrespective of cross-sectional area of the silo 29, and due to no internal pipings for supplying and distributing heated air occupy space inside the drying chamber 10 larger volumes of moist pellets per time unit can be dried than when using the conventional vertical hot air dryer silo.

Claims

1. A vertical hot air dryer silo and/or vertical dry air dryer silo (29) having a circumferential silo wall (11a,11b,11) delimiting a drying chamber (10), said vertical hot air dryer silo or vertical dry air dryer silo (29) comprising
 - an upper silo part (4),
 - a lower conical silo part (5) in extension of the upper silo part (4),
 - at least one loading inlet (8) for pellets, granules, powder, and/or particles to be dried, which at least one loading inlet (8) is provided at the top of the upper silo part (4),
 - at least one discharge outlet (6) for dried pellets, granules, powder, and/or particles, which at least one discharge outlet (6) is provided at the bottom of the lower conical silo part (5), and
 - at least one air inlet (30a,30b) adapted for supplying heated air, dry hot air and/or dry air to the drying chamber (10),**characterised in that**
 - the at least one air inlet (30a,30b) is provided in the lower conical silo part (5).
2. A vertical hot air dryer silo and/or vertical dry air dryer silo (29) according to claim 1, **characterised in that** the lower conical silo part (5) has two air inlets (30a,30b), optionally the two air inlets (30a,30b) of the lower conical silo part (5) are arranged diametrically opposite each other.
3. A vertical hot air dryer silo and/or vertical dry air dryer silo (29) according to claims 1 or 2, **characterised in that** the vertical hot air dryer silo and/or vertical dry air dryer silo (29) does not have any internal air pipes or air tubings inside the drying chamber (10) for supplying hot air to pellets, granules, or particles to be dried.
4. A vertical hot air dryer silo and/or vertical dry air dryer silo (29) according to any of the preceding claims 1, 2, or 3, **characterised in that** a baffle member (34) is suspended in the lower conical silo part (5) above the at least one discharge outlet (6).
5. A vertical hot air dryer silo and/or vertical dry air dryer silo (29) according to claim 4, **characterised in that** the baffle member (34) is a double cone consisting of an upper cone part (34a) having its upper cone apex (36a) facing towards the upper silo part (4) and a lower cone part (34b) having its lower cone apex (36b) facing the at least one discharge outlet (6).
6. A vertical hot air dryer silo and/or vertical dry air dryer silo (29) according to any of the preceding claim 4 or 5, **characterised in that** the baffle member (34) has a central baffle axis (Y) coaxial with the central drying chamber axis (X).
7. A vertical hot air dryer silo and/or vertical dry air dryer silo (29) according to any of the preceding claims 4, 5 or 6, **characterised in that** an upper cone apex (36a) angle of the upper cone part (34a) of the baffle member (34) is designed to match a lower silo apex angle of the lower conical silo part (5) so that pellets, granules, powder, and/or particles falling in the drying chamber (10) obtain same drying and/or residence time irrespective of the radial position of the fall path of said falling pellets, granules, powder, and/or particles.
8. A vertical hot air dryer silo and/or vertical dry air dryer silo (29) according to claim 7, **characterised in that** a lower cone apex (36b) angle of the lower cone part (5) of the baffle member (34) is the same or substantially the same as the lower silo apex angle of the lower conical silo part (5), and that a flow gap (33) is delimited between the baffle member (34) and a circumferential wall (11b) of the lower conical silo part (5).
9. A vertical hot air dryer silo and/or vertical dry air dryer silo (29) according to any of the preceding claims 1 - 8, **characterised in that** it has an outer jacket (2), preferably an outer heat-insulating jacket that surrounds at least

the upper silo part (4) and at least the upper portion of the lower conical silo part (5).

10. A vertical hot air dryer silo and/or vertical dry air dryer silo (29) according to claim 9, **characterised in that** the outer jacket (2) has a bottom jacket part (22) with a bottom jacket hole (39), and at least a lower portion (38) of the lower conical silo part (5) protrudes out of said bottom jacket hole (39).

11. A vertical hot air dryer silo and/or vertical dry air dryer silo (29) according to any of the preceding claims 1 - 10, **characterised in that** heated air, dry hot air and/or dry air has a temperature corresponding to or substantially corresponding to the dew point of the material of the pellets, granules, powder and/or particles to be dried, preferably said material is a plastic material.

12. A vertical hot air drying apparatus (30), **characterised in** comprising

- the vertical hot air dryer silo and/or vertical dry air dryer silo (29) according to any of the preceding claims 1 - 11, and one or more of
- means for drying air,
- means for supplying heated or hot air,
- means for controlling the drying process, and
- means for suspending and/or erecting the vertical hot air dryer silo (29) above a support surface.

13. A method of drying pellets, granules, powder and/or particles, **characterised in** comprising the steps of

- providing a vertical hot air drying apparatus (30) according to claim 12, a vertical hot air dryer and/or a vertical dry air dryer silo (29) according to any of the preceding claims 1 - 11,
- loading the drying chamber (10) with a continuous flow of pellets, granules, powder and/or particles to be dried through the at least one loading inlet (8) at the top of the upper silo part (4),
- continuously supplying to the drying chamber (10), in counter current with the flow of pellets, granules, powder and/or particles to be dried, a continuous flow of heated air, dry hot air and/or dry air through the at least one air inlet (30a,30b) at the lower conical silo part (5),
- continuously discharging dried pellets, granules, powder and/or particles through the at least one discharge outlet (6) at the bottom of the lower conical silo part (5).

14. A method according to claim 13, **characterised in that** at least in the upper silo part (4) the vertical flow of pellets, granules, powder and/or particles to be dried is laminar.

15. A batch of dry pellets, granules, or particles dried using the vertical hot air dryer silo and/or vertical dry air dryer silo (29) according to any of the preceding claims 1 - 12 or the hot air drying apparatus (30) according to claims 13 or 14.

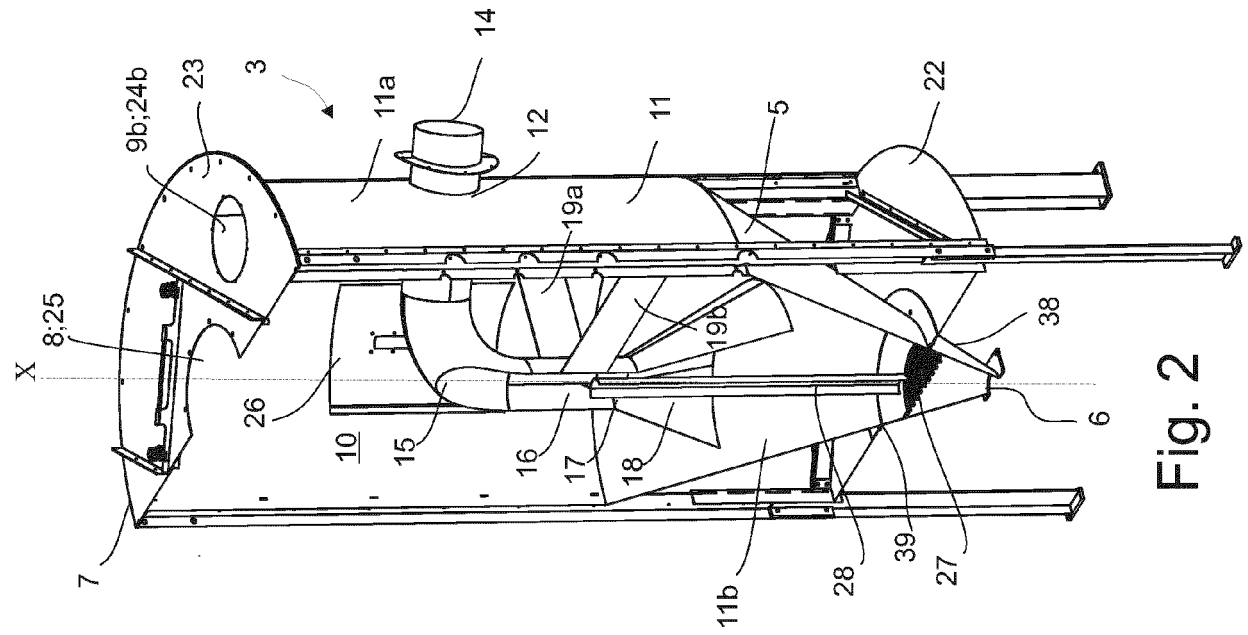


Fig. 1

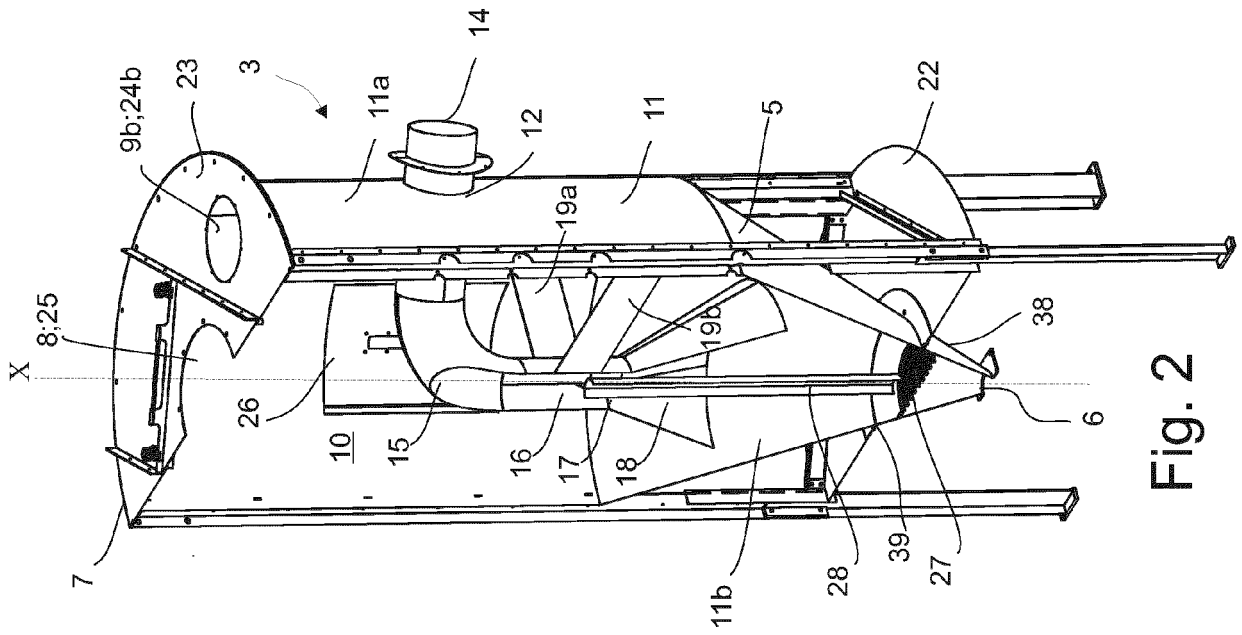


Fig. 2

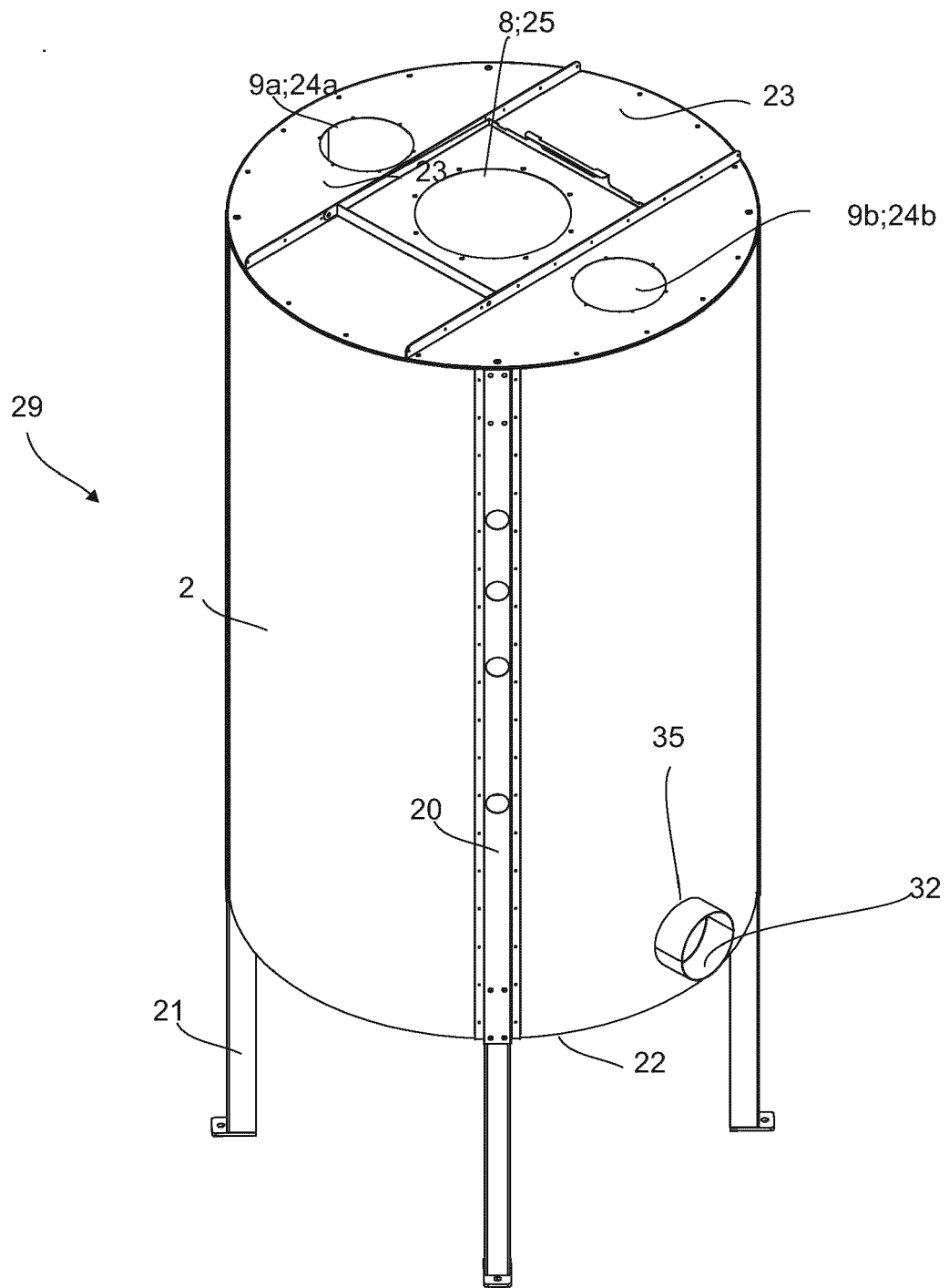


Fig. 3

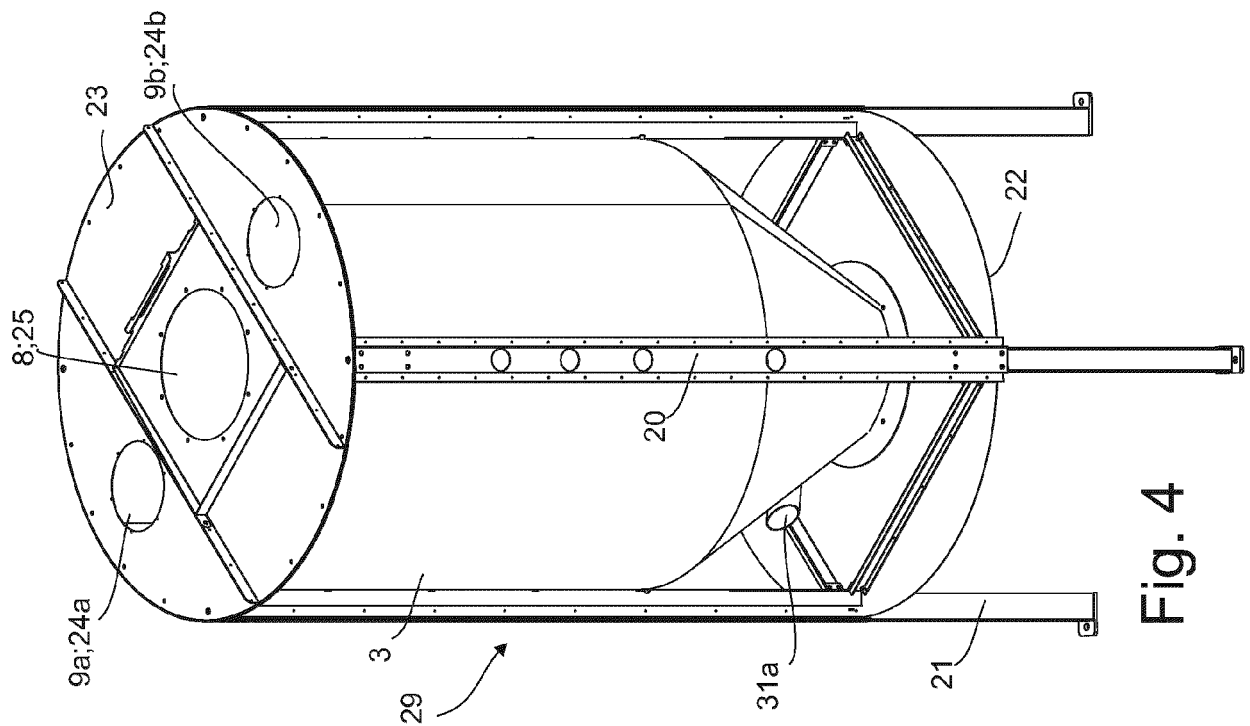


Fig. 4

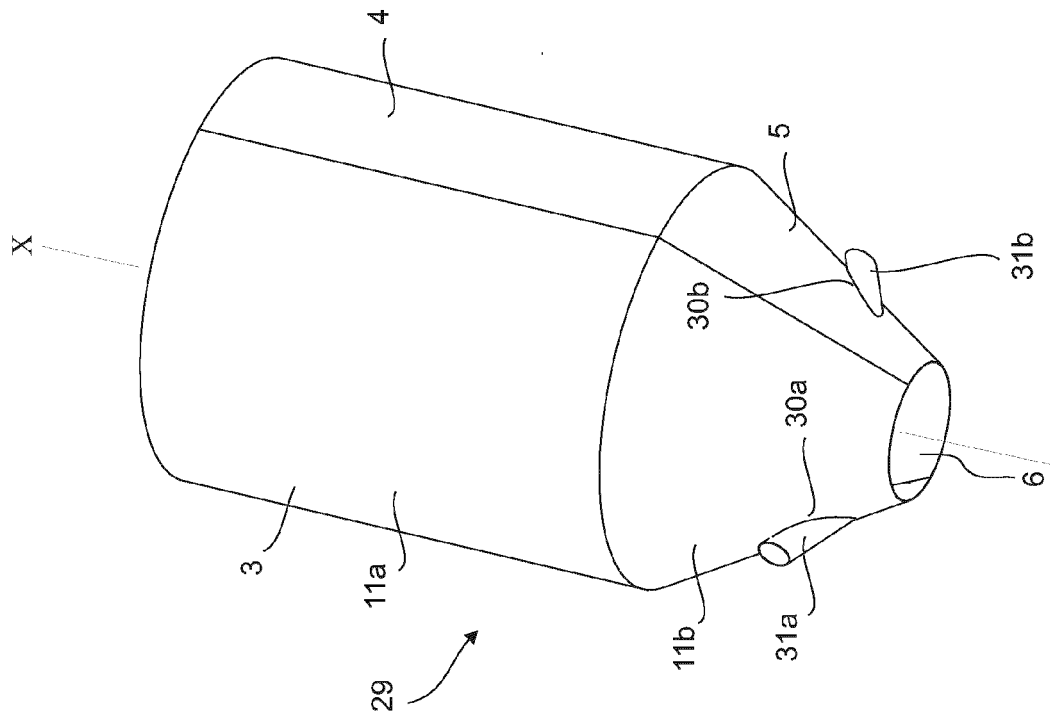


Fig. 5

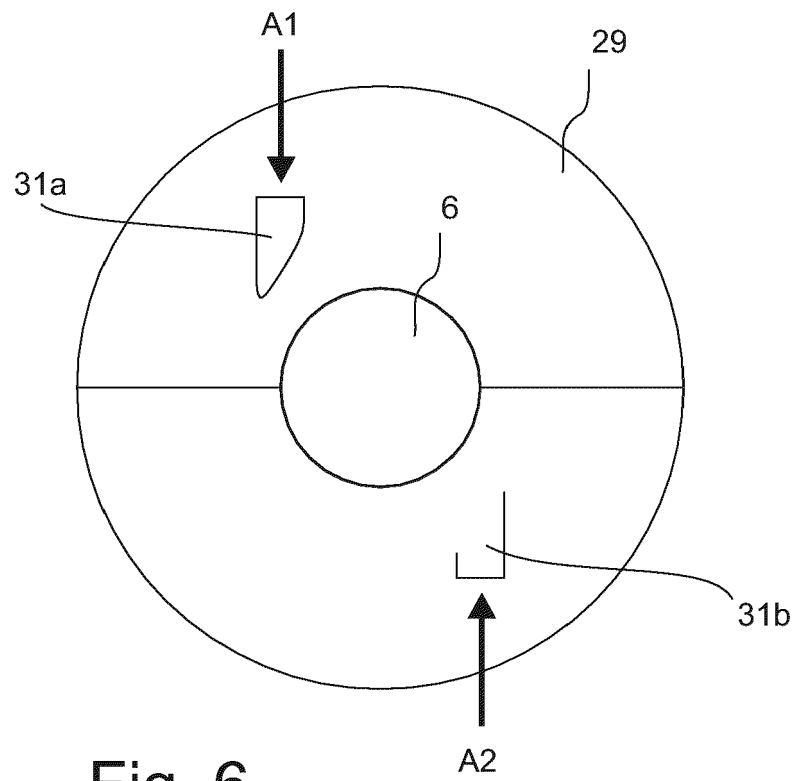


Fig. 6

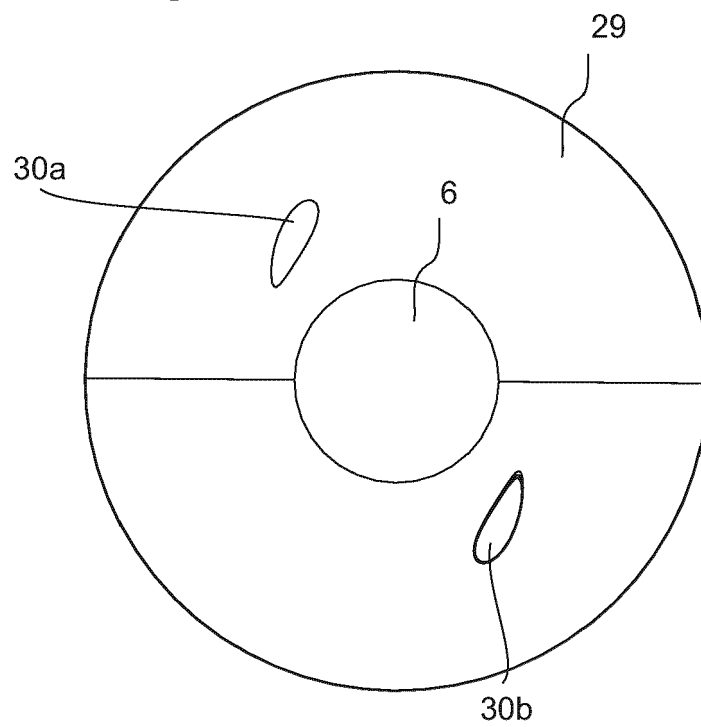
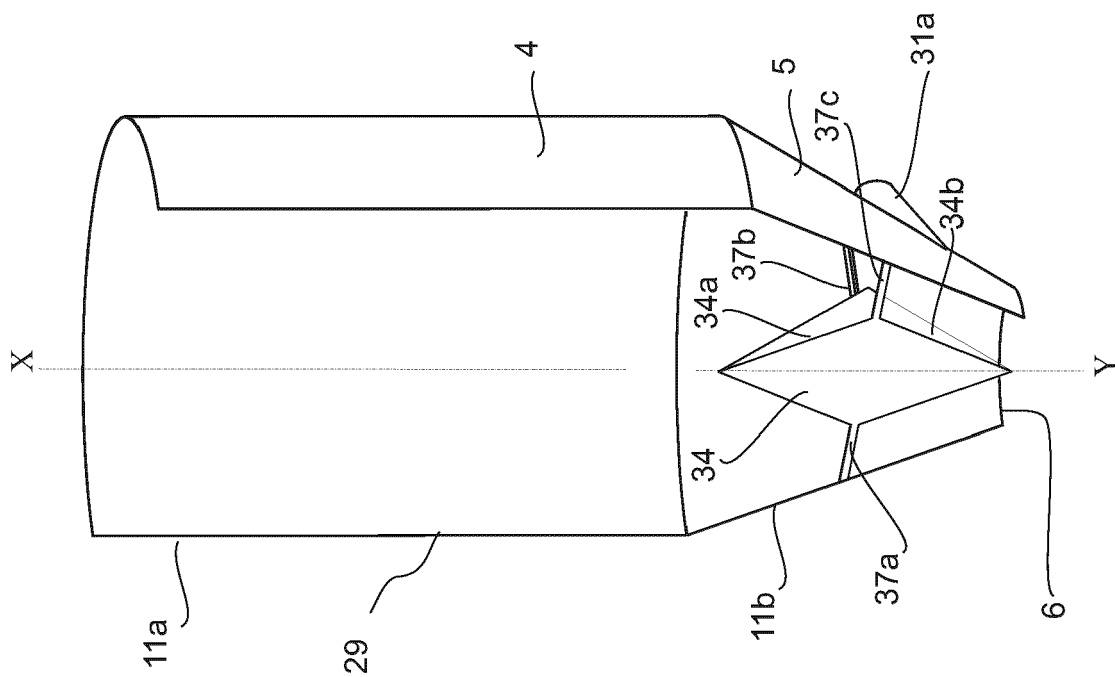


Fig. 7



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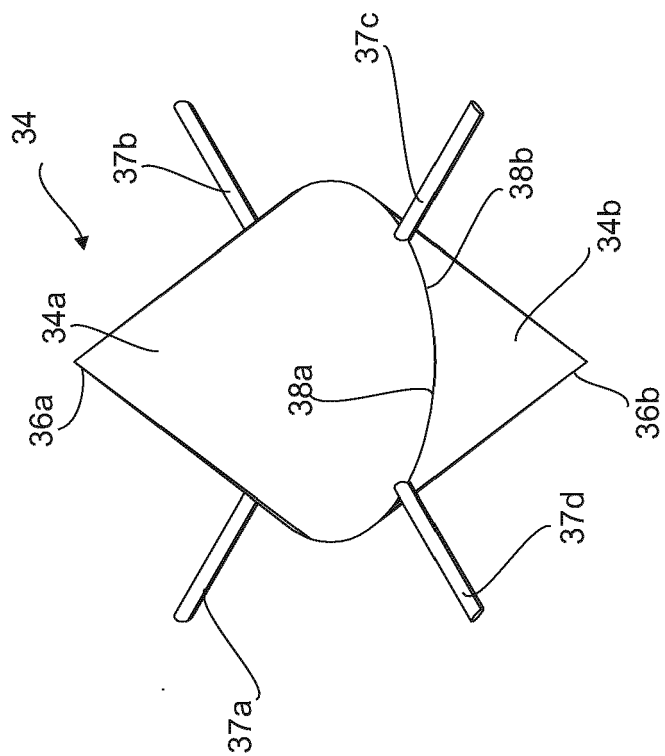


Fig. 9

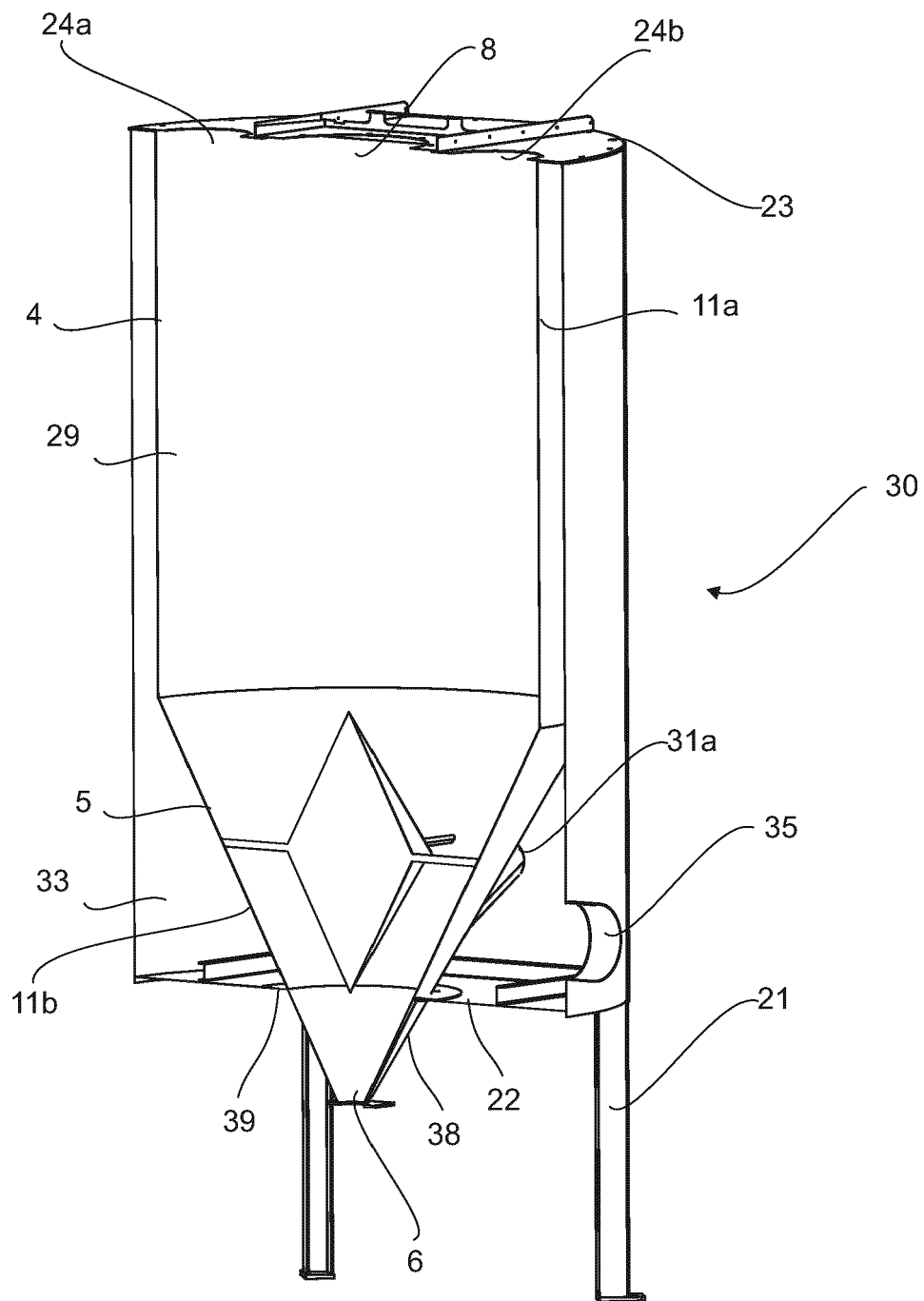


Fig. 10



EUROPEAN SEARCH REPORT

Application Number
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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 5 487 225 A (DOWNIE JOHN P [US]) 30 January 1996 (1996-01-30)	1,3,4,6,7,9,12-15	INV. F26B17/14
Y	* figures 1-3 *	8,10,11	
A	-----	2,5	
X	BE 737 249 A (VEB) 16 January 1970 (1970-01-16) * figures 1,4 *	1-7,9,12,15	
Y	----- US 2009/090019 A1 (MORETTO RENATO [IT]) 9 April 2009 (2009-04-09) * figures 1,5 *	8	
Y	----- US 4 325 192 A (LARSEN POUL ET AL) 20 April 1982 (1982-04-20) * column 6, line 15 - column 6, line 41 *	11	
Y	----- FR 1 517 161 A (EUROGRAIN ETS) 15 March 1968 (1968-03-15) * figure 1 *	10	
Y	----- FR 1 279 675 A (RAYMOND ALCITE MOREAU) 22 December 1961 (1961-12-22) * figure 1 *	10	TECHNICAL FIELDS SEARCHED (IPC) F26B
Y	----- DE 42 34 696 A1 (KOCH WERNER [DE]) 6 May 1993 (1993-05-06) * figure 1 *	10	
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 18 March 2021	Examiner Makúch, Milan
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 20 19 9823

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5487225 A	30-01-1996	AT 186006 T CA 2161311 A1 DE 69512992 T2 EP 0711641 A2 ES 2140627 T3 JP 3502212 B2 JP H08207044 A US 5487225 A	15-11-1999 15-05-1996 03-02-2000 15-05-1996 01-03-2000 02-03-2004 13-08-1996 30-01-1996
BE 737249 A	16-01-1970	NONE	
US 2009090019 A1	09-04-2009	CN 101408368 A EP 2048464 A2 KR 20090036536 A US 2009090019 A1	15-04-2009 15-04-2009 14-04-2009 09-04-2009
US 4325192 A	20-04-1982	AU 5396679 A BR 7908955 A DE 2953407 A1 DK 570778 A ES 8100955 A1 FR 2444910 A1 GB 2047397 A IT 1184722 B NL 7920176 A US 4325192 A WO 8001315 A1	26-06-1980 30-06-1981 08-01-1981 20-06-1980 16-12-1980 18-07-1980 26-11-1980 28-10-1987 31-10-1980 20-04-1982 26-06-1980
FR 1517161 A	15-03-1968	NONE	
FR 1279675 A	22-12-1961	NONE	
DE 4234696 A1	06-05-1993	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82