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(54) **BIOMASS BOILER AND METHOD OF USING A BIOMASS BOILER**

(57) Rasping device for use in a boiler using biomass fuel of the type using bales of compressed straw as biomass fuel, where said rasping device comprises one or more cutting or rasping teeth or knives, such that in use said cutting or rasping teeth or knives engage and disintegrate a surface of a bale, where said cutting or rasping teeth or knives are moveable.

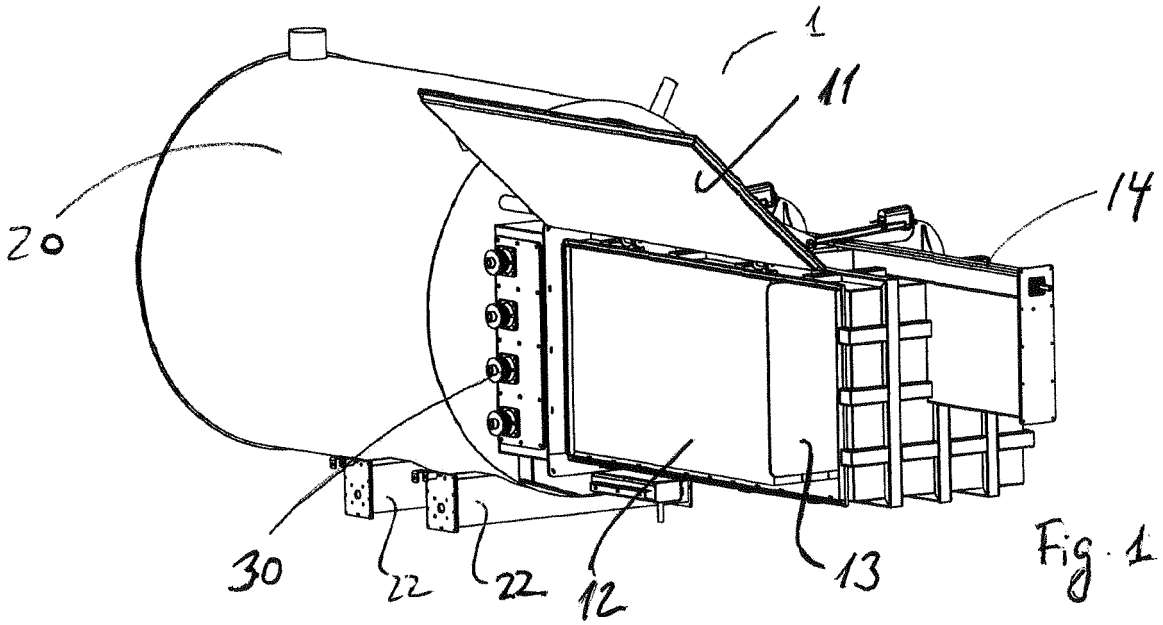


Fig. 1

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Description

Field of the Invention

[0001] The present invention relates to a biomass boiler, and in particular to a rasping device used in order to free biomass material from a bale of biomass material.

Background of the Invention

[0002] It is well-known to use biomass as fuel and particularly compressed straw bales as fuel in boilers having various configurations.

[0003] In DK157099 is disclosed a boiler having a feeding chamber. In the feeding chamber a rectangular size bale may be introduced. A pushing mechanism thereafter forces the bale into the first combustion chamber. In the first combustion chamber the surface of the bale facing the first combustion chamber is ignited and will burn such that straw, i.e. biomass material is turned into heat energy which is used further downstream in a heat exchange device in order to heat for example water or the like.

[0004] The speed of combustion and thereby the effect of the device is determined by the first combustion chamber's ability to burn the surface of the bale.

[0005] In another prior art construction disclosed in FR2295347 it is suggested to increase the capacity of the burner by in the same manner as described above with reference to DK157099 also forcing a bale of straw into a combustion chamber, but in order to enhance the burning of the surface of the bale, extra air is blown onto the bale either one-sided or double-sided in order to force the combustion thereby accelerating the burning action.

[0006] In DE3025565 a similar problem is addressed in that the inventor has realized that in order to expedite the burning of straw, particularly when using compressed bales of straw it is desirable to loosen the bales before the straw is burnt. DE 3025565 therefore provides a screw device which will screw itself into a surface of a bale which is forwarded towards the combustion chamber. The screw device rotates faster than the bale is transported towards it such that top layers of the bale are loosened and even become loose and thereby introduced as loose straw into the combustion chamber.

[0007] Due to increased transportation costs, particularly of bales of straw, these bales are now being compressed much more than they were when the prior art above was conceived. In 1980 when the invention according to DE3025565 was conceived, a compressed bale weighed about 2-300 kg (1,2 * 1,2 * 2,4 m). Today the same size compressed bale weighs 5-700kg due to the much harder pressing action by the modem balers.

[0008] For these reasons it is still desirable to create as good a combustion as possible, but also to provide control of how much straw is being introduced into the combustion chamber in order to utilize the combustion chamber to its capacity and at the same time to ensure a clean and stable combustion of the straw such that unnecessary emissions containing dust, tar and poisonous gasses is avoided.

Object of the Invention

[0009] It is therefore an object of the present invention to provide a device and a biomass burner which can handle the hard compressed bales which are used nowadays in such a manner that the capacity of the burner is utilised in the most optimum way and at the same time a high capacity is provided.

Description of the Invention

[0010] The invention addresses this by providing a biomass boiler using compressed bales of straw or other compressed biomass material as fuel, where said biomass boiler has a feeding chamber, said chamber having a door mechanism for allowing bales of straw to be placed in said chamber, said door closing off the feeding chamber from the ambient surroundings, and in which feeding chamber a pushing mechanism is arranged for forcing the bale of straw in a direction against a rasping device said rasping device arranged in a side of a first combustion chamber facing the feeding chamber, such that rasped off straw material is directly combusted in said first combustion chamber.

[0011] The rasping device engages the surface of the bale which is facing the combustion chamber. By rasping on the surface of the highly compressed bales of straw, loose pieces of straw become undone from the bale and as such will be directly burnt in the combustion chamber.

[0012] As the cutting or rasping teeth are working on the surface of the bale at the same time as the surface is burning inside the first combustion chamber, it is possible effectively to work even highly compressed bales and thereby increase the availability of straw in the first combustion chamber. This is due to the fact that the combustion (burning of straw) in the chamber cleans the rasping device (by also burning any straw material adhering tio the rasping device) which is also placed inside the primary combustion chamber.

[0013] A standard bale of hay/straw which is 1.2 x 1.2 x 2.4 m will have a weight of about 450 kg per bale. However, with new machinery it is possible to increase the weight of the bale up to approx. 550-600 kg per bale. This of course reduces the transportation costs per kilo, but on the other hand provides for a very dense and compact bale which is very difficult to disintegrate and hence the rasping device of the present invention.

[0014] With the Hesston bales used it is known to disintegrate the bales outside the burner and then by means of a screw conveyor or auger conveyor transport the disintegrated straw into the burner. However, this method has a very limited effect in that particularly if the straw is slightly moist, the disintegrated straw will cling to the cutters and will jam the cutting device, and the auger or snail conveyors. With the present invention as the rasping of

the front surface of the bale takes place inside the combustion chamber, any loose straw will immediately be ignited and combusted not leaving any residue on the rasping device which will remain clean and therefore effective in loosening the surface of the straw bale.

[0015] A further advantage is that with prior art devices there is a tendency during the combustion of the straw bale that an uneven temperature coefficient will be present across the surface of the bale, such that in some places the bales will burn as intended whereas in other places the bale is hardly burning. This situation especially arises if the boiler in which the bale in introduced is not working at full capacity such that incomplete combustion occurs on the surface of the bale or due to the inconsistencies in the compaction of the bale itself.

[0016] Under these conditions it is normal that charred and tarred surface areas will be created which are very difficult to combust in a proper manner afterwards when the capacity is increased and as such a very high energy loss is created due to the insufficient combustion of all available biomass material. At the same time an incomplete combustion also gives rise to detrimental side effects such as an exaggerated high amount of dust and various NOx gasses. These drawbacks are avoided with the present device as the rasping device may be activated or deactivated according to the desired capacity such that only the amount of straw is loosened and burnt which is desirable at that particular time due to demand for energy.

[0017] Further embodiments are disclosed in the dependent claims.

[0018] In an embodiment of the invention the one or more cutting or rasping teeth or knives are arranged on one or more rotatable axles arranged with their respective rotation axes parallel in a first plane, where said axles are arranged in a frame, and means are provided for rotating said axles. With this arrangement, simply by rotating the axles, the knives or teeth will engage the front surface of the bale which is burning, and consequently rasp off any material from the bale which is needed in order to provide the capacity which is desired in the first combustion chamber.

[0019] Usually bales in these types of installations are pushed forward towards the combustion chamber in a manner for example as illustrated in DK157099 or FR2295349. Therefore, by adjusting the speed with which the bales are forwarded towards the rotating axles also the amount of loosened biomass material can be controlled.

[0020] In an alternative embodiment the one or more cutting or rasping teeth or knives are arranged on one or more beams, in use the cutting or rasping teeth or knives will be facing the bale, said beams being arranged in a first plane, where said beams are arranged in a frame, and means are provided for moving said beams in said first plane. As was the case with the previous embodiment of the invention the movement of the beams foresees that the surface of the bale is rasped/cut such that loose bale material is provided for the ignition and combustion processes inside the boiler.

[0021] Traditionally, rectangular Hesston bales or round bales are used in boilers of this type using biomass fuel in the shape of compressed straw. It is therefore desirable to have the rasping means defined in a single common plane such that an even wear on the surface of the bale which is introduced in to the first combustion chamber is achieved.

[0022] In a still further advantageous embodiment the one or more cutting or rasping teeth or knives are arranged on one or more rotating wheels, the wheels' rotation axis being orthogonal to the wheels' plane in use, such that the one or more cutting or rasping teeth or knives engages a surface of a bale, where said wheels are arranged in a common first plane, and by means of a suitable lattice structure arranged in a frame.

[0023] Again, as is the case with the previous embodiments mentioned above the movement of the teeth or knives across the surface loosens the material such that even for very dense and compact bales of compressed straw loose and readily ignitable and combustible biomass material will be the result of the rasping device's action on the surface of the bale.

[0024] The same is true for a further advantageous embodiment where the cutting or rasping teeth or knives are provided on an open mesh conveyor belt, where said conveyor belt is arranged for rotation or reciprocating movement around two axles, said axles being arranged in a frame, and where the axles are parallel and arranged in a first plane.

[0025] Under some circumstances, especially with high capacity, the temperature inside the first combustion chamber may be so elevated that it is necessary to cool the rasping device. This may for example be carried out as set out in a further embodiment by allowing water or other cooling medium to circulate inside the rasping device.

[0026] In a further advantageous embodiment of the invention the axles or beams are movably in the frame such that they individually can be moved relative to the first plane, but their axes of rotation remain parallel.

[0027] In some instances it might be desirable to change the size of the first combustion chamber in that the volume of the first combustion chamber also determines the capacity of the boiler, i.e. how many kilowatts it is able to generate. Also, in some instances it may be advantageous to arrange the axles or beams outside the first plane in order to obtain an uneven surface of the first bale or a surface at an oblique angle. For example with a surface having an oblique angle it might be desirable to rasp off more material in the bottom than in the top such that the fire on the surface of the bale will have a tendency to burn into the bale as the fire moves upwards. The same is achieved in a further embodiment of the invention where the frame in which the axles or beams are mounted is provided with multiple holders for the axles, such that the axles may be arranged in holders out-

side said first plane but the axles remain parallel.

[0028] In order to be able to change the size of the first/primary combustion chamber the frame in use is movable back and forth orthogonal to a plane defined by the cutting or rasping teeth or knives.

[0029] The biomass boiler may in an advantageous embodiment have a closure member arranged between the feeding chamber and the rasping device or between the feeding chamber and the first combustion chamber, said closure member separating the first combustion chamber from the feeding chamber.

[0030] This closure member is particularly advantageous in installations or constructions of the biomass boiler where it is not possible to have a continuous string of bales lined up such that continuous combustion may be achieved as is for example the case in FR2295349 and will be the normal way of operating the device. However, when single bales are combusted one at a time it is desirable to be able to screen off the first combustion chamber while a new, fresh compressed bale of straw is inserted into the feeding chamber. In this manner the temperature in the combustion chamber may be kept relatively high while the next bale of straw is positioned inside the feeding chamber.

[0031] The method of using the biomass boiler including a rasping device according to any of the embodiments mentioned above is also part of the invention and does achieve and enjoy the same advantages as already recited above.

Description of the Drawing

[0032] The invention will now be explained with reference to the accompanying drawing wherein

Figure 1	illustrates an embodiment of the invention shown in perspective
Figure 2	illustrates a cross-section through the boiler installation 1 in front of the rasping device
Figure 3	illustrates a cross-section through the rasping device 30 and the boiler unit
Figure 4A-D	illustrate schematically other examples of rasping devices
Figure 5	illustrates schematically a side view of the frame of the rasping device

Detailed Description of the Invention

[0033] In figure 1 is illustrated an embodiment of the invention shown in perspective. Generally the boiler installation 1 in this embodiment comprises a biomass feeding unit 10 as well as a boiler unit 20. Between the biomass feeding unit 10 and the boiler unit 20 is arranged a rasping device 30 according to the present invention.

[0034] The biomass feeding unit 10 comprises a pivotable door 11 such that after biomass material for example in the shape of a bale of straw is placed in the cavity of the feeding chamber 12 the pivotable door 11 is closed. At this stage the bale of straw (not illustrated) is forced towards the rasping device by a pushing plate (13). The pushing plate 13 is connected to an actuator 14 such that the pushing plate continuously will force the biomass material against the rasping device 30.

[0035] In this embodiment the biomass feeding unit 10 is illustrated as being suitable to accommodate rectangular shaped bales of straw/hay, for example known as Heston bales, but it is also possible to shape the biomass feeding unit in order to be able to accommodate circular bales. For the sake of completeness any type of compressed biomass material may be used with the present invention, and the invention is not limited to straw or hay.

[0036] In figure 2 is illustrated a cross-section through the boiler installation 1 in front of the rasping device 30.

[0037] In this particular embodiment the rasping device comprises four rotating axles 31-34 where each axle 31-34 is equipped with a plurality of cutting or rasping teeth or knives 35. The rotating axles 31-34 are arranged in a frame 36 such that they will be arranged in a common plane in the frame 36 and be able to rotate independently in this plane.

[0038] As the biomass material is forced against the rasping device due to the force of the actuator 14 pushing the pushing plate 13 against the biomass material the biomass material will engage the rasping device 30. Due to the rotation of the axles 31-34 and the action of the rasping or cutting teeth or knives 35 the front face of the bale, i.e. the part of the bale of straw material being forced against the rasping device will be disintegrated due to the action of the rasping or cutting teeth or knives and more or less loose straw material/biomass material will be introduced into the burner as will be described below.

[0039] Furthermore, as the primary combustion chamber is directly connected to the rasping device 30 the loose straw will be ignited and combusted immediately and at the same time any biomass material which will otherwise be caught, stuck or otherwise adhered to the rotating axles will be burnt/ignited and combusted during operation such that the rasping or cutting teeth or knives at all times will be substantially free from foreign matter and able to create clean and efficient cutting into the biomass material, i.e. a bale of hay. In this manner it is ensured that no clogging of the rasping device occurs as the combustion in the primary combustion chamber will also burn any biomass material which may become stuck on the rotating axles and the rasping or cutting teeth or knives. In figure 3 is illustrated a cross-section through the rasping device 30 and the boiler unit 20.

[0040] In this embodiment the frame 36 has a certain extent in the direction in which the biomass material is forced into the boiler. The ends of the axles 31-34 are arranged in suitable bearings and provided with means for rotating the axles which will not be discussed in this description as they are considered trivial in the art. However, as is evident from figure 3 the axles 31-34 are arranged in a common plane indicated by the dashed line

37 such that the common plane is substantially vertical and orthogonal to the direction in which the biomass material is forced towards the rasping device 30.

[0041] As indicated also in figure 3 a second common plane 37' may also be provided which means such that the axles 31-34 may be arranged in this common plane 37' instead of the common plane indicated by the arrow 37. The reason for this is the fact that as the rasping device 30 is connected to the first combustion chamber 21 a part 38 of the rasping device is also a part of the first combustion chamber 21. Consequently, by arranging the axles 31-34 in the second common plane 37' the first combustion chamber is enlarged, i.e. has a larger volume and as such will be able to produce a higher effect when the biomass material is introduced into the first combustion chamber 21 plus the section of the rasping device 30 which is an integrated part of the combustion chamber.

[0042] During combustion of biomass material an amount of ash will be produced and due to gravity the ash will accumulate at the bottom of the boiler unit 20, particularly in the first combustion chamber 21. In order to be able to remove the ashes from the first combustion chamber 21 a snail removal device 22 is arranged at the bottom of the combustion chamber 21 such that ashes and other debris may be removed from the boiler installation as such.

[0043] In the embodiment described above with reference to figures 1-3 the rasping device comprises four rotating axles on which axles 31-34 a plurality of rasping or cutting teeth or knives 35 are arranged for engagement and disintegration of a front face of for example a straw bale forced into the rasping device.

[0044] Turning to figure 4A-D, other examples of rasping devices being able to engage and disintegrate the biomass material prior to being introduced into the combustion chamber enjoying the same advantages as described above with respect to the rotating axles are also disclosed in a schematic manner.

[0045] In figure 4A an alternative embodiment is illustrated. In the embodiment a construction with only three axles 31, 32, 33 is illustrated, but any number of axles may be used in any of the embodiments including axles.

[0046] The axles 31, 32, 33 are arranged in a secondary frame member 41 which secondary frame member 41 may move relative to the frame 36 of the rasping device 30. The secondary frame 41 is provided with actuator means 42, 43 such that when a bale is forced against the rasping device 30 the axles will rotate as already discussed above, but at the same time they will be moved in a reciprocating manner indicated by the arrow 45 up and down such that the entire face of the bale will be worked by the teeth (not illustrated) arranged on the axles 31, 32, 33.

[0047] In figure 4B is illustrated a further alternative where the axles 31, 32, 33 are provided with separate actuators 42', 43', 44' such that the axles 31, 32, 33 as they rotate in contact with the biomass material the actuators 42', 43', 44' will create a reciprocating motion indicated by the arrow 45' and in this manner biomass material will be loosened from the bale in the combustion chamber.

[0048] Both with respect to the embodiment illustrated with reference to figure 4A and figure 4B it is also contemplated that the axles 31, 32, 33 may be replaced by beams, i.e. members that do not rotate, but due to the reciprocating movement created by the actuators 42, 43, 42', 43', 44' a rasping work on the face of the biomass material will occur in order to loosen the material in the combustion chamber.

[0049] With respect to figure 4C the rasping device 30 is provided with a substantially centrally arranged beam 46. In the illustrated embodiment the beam 46 is illustrated as being mounted substantially horizontally in the frame 36 of the rasping device 30, but the beam may have any orientation. The purpose of the beam 46 is to provide support for a rasping wheel 47 which either rotates around an axle 48 arranged in the beam 46 or reciprocates back and forth as illustrated by the arrow 45". The rasping wheel 47 is provided with a plurality of cutting teeth or knives such that as the wheel 47 is rotated or reciprocated and biomass material is brought into contact with the rasping wheel 47, material will be loosened from the bale directly into the combustion chamber in the same manner as described above.

[0050] Turning to the embodiment illustrated with reference to figure 4D two axles 51, 52 are arranged in the rasping device 30 for rotation relative to the frame 36. The two axles 51, 52 serve as drive axle 51 and power axle 52 respectively for a conveyor belt 53 which will be rotated in a common plane defined by the axles 51, 52. The conveyor belt is typically made from steel and in particular stainless steel of the open mesh type, i.e. the conveyor belt 53 has a very open structure, and furthermore the side of the conveyor belt 53 facing the biomass material, i.e. for example a bale of straw is provided with cutting teeth or knives such that as engagement occurs between the conveyor belt 53 and the biomass material, cutting devices mounted on the side of the conveyor belt facing the bale of straw will loosen material on the bale.

[0051] Due to the open mesh structure of the conveyor belt 53 the loosened biomass material will have access to the combustion chamber and as such be loosened in the same manner as discussed above with the other embodiments.

[0052] In figure 5 is schematically illustrated a side view of the frame 36 of the rasping device 30. The frame 36 is provided with elongated substantially horizontal slits 54, 55, 56 such that the bearings of the axles 31, 32, 33 may be selected steplessly within the slits 54, 55, 56 in order to adjust the axles' 31, 32, 33 position relative to the biomass material forced against the rasping device 30.

[0053] In all embodiments the rasping device and in particular the axles may be provided with cooling means for example by circulating a cooling liquid, in particular

water, inside the axles in order to retain the temperature of the axles at a level where deformation of the axles will occur.

Claims

1. Biomass boiler (1) using compressed bales of straw or other compressed biomass material as fuel, where said biomass boiler (1) has a feeding chamber (12), said chamber (12) having a door mechanism (11) for allowing bales of straw to be placed in said chamber (12), said door (11) closing off the feeding chamber (12) from the ambient surroundings, and in which feeding chamber (12) a pushing mechanism (13) is arranged for forcing the bale of straw in a direction against a rasping device (30) said rasping device (30) arranged in a side of a first combustion chamber (21) facing the feeding chamber (12), such that rasped off straw material is directly combusted in said first combustion chamber (21).

2. Biomass boiler (1) according to claim 1 wherein the rasping device (30) comprises one or more cutting or rasping teeth or knives (35), such that in use said cutting or rasping teeth or knives (35) engage and disintegrate a surface of a bale, where said cutting or rasping teeth or knives (35) are moveable.

3. Biomass boiler (1) according to claim 2 wherein said one or more cutting or rasping teeth or knives (35) are arranged on one or more rotatable axles (31-34) arranged with their respective rotation axes parallel in a first plane (37,37'), where said axles (31-34) are arranged in a frame (36), and means are provided for rotating said axles (31-34).

4. Biomass boiler according to claim 2 or 3 wherein said one or more cutting or rasping teeth or knives (35) are arranged on one or more beams, in use the cutting or rasping teeth or knives (35) will be facing the bale, said beams being arranged in a first plane, where said beams are arranged in a frame, and means (41,45,42',43',44') are provided for moving said beams in said first plane.

5. Biomass boiler according to claim 2 or 3 wherein said one or more cutting or rasping teeth or knives (35) are arranged on one or more rotating wheels (47), the wheels' rotation axis (48) being orthogonal to the wheels' plane in use, such that the one or more cutting or rasping teeth or knives (35) engages a surface of a bale, where said wheels (47) are arranged in a common first plane, and by means of a suitable lattice structure (46) arranged in a frame.

6. Biomass boiler according to claim 2 or 3 wherein the cutting or rasping teeth or knives (35) are provided on an open mesh conveyor belt (53), where said conveyor belt (53) is arranged for rotation or reciprocating movement around two axles (51,52), said axles (51,52) being arranged in a frame (36), and where the axles are parallel and arranged in a first plane.

7. Biomass boiler according to claim 3 wherein the axles (31,32,32,51,52) are movably mounted in the frame (36) such that they individually can be moved relative to the first plane, but their axes of rotation remain parallel.

8. Biomass boiler according to claim 2 or 3 wherein the frame in which the axles are mounted is provided with multiple holders for the axles, such that the axles may be arranged in holders outside said first plane but the axles remain parallel.

9. Biomass boiler according to claim 1 wherein a closure member (60,60') is arranged between the feeding chamber (12) and the rasping device (30) or between the feeding chamber (12) and the first combustion chamber (21), said closure member (60,60') separating the first combustion chamber (21) from the feeding chamber (12).

10. Method of combusting straw bales in a biomass boiler, where a straw bale is arranged in a feeding chamber (12), where a pushing mechanism (13) is arranged for pushing the straw bale against a rasping device (30) wherein the rasping device (30) comprises one or more cutting or rasping teeth or knives (35), such that in use said cutting or rasping teeth or knives (35) engage and disintegrate a surface of a bale, where said cutting or rasping teeth or knives (35) are moveable, where the teeth or knives (35) arranged on the rasping device (30) grate pieces of straw off the surface of the straw bale facing the rasping device (30), said pieces of straw being burned in a primary combustion chamber (21), thereby creating a heated gas in said primary combustion chamber (21).

11. Method of combusting straw bales in a biomass boiler according to claim 10, where the heated gas from the primary combustion chamber (21) is transferred to a secondary combustion chamber, and the remaining ashes in the first combustion chamber (21) is removed by ash removing means (22) arranged in the bottom of the first combustion chamber (21), and where the flue gas from the second combustion chamber after passing a heat exchanging unit is discarded.

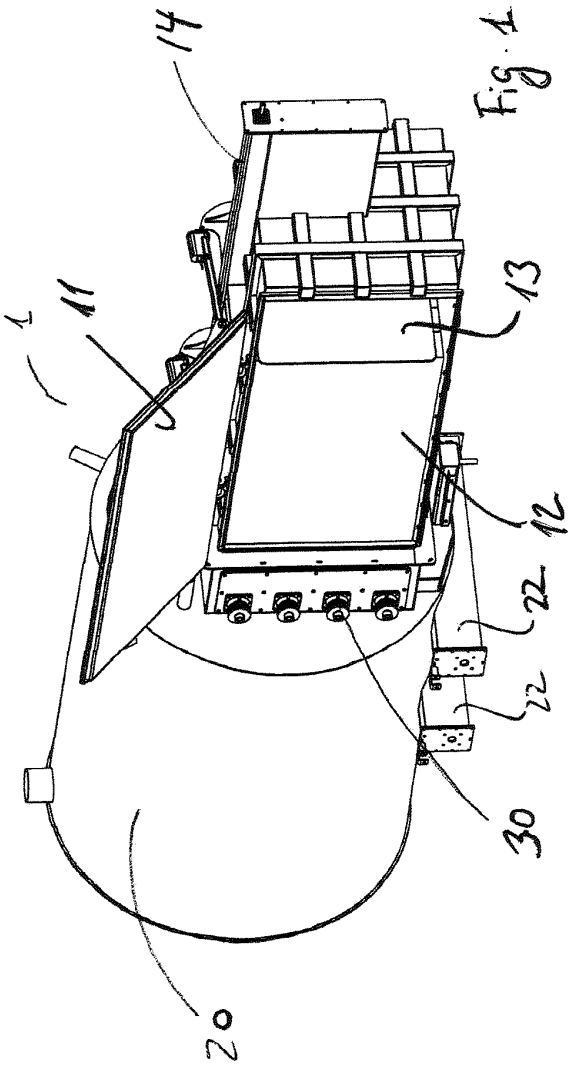


Fig. 1

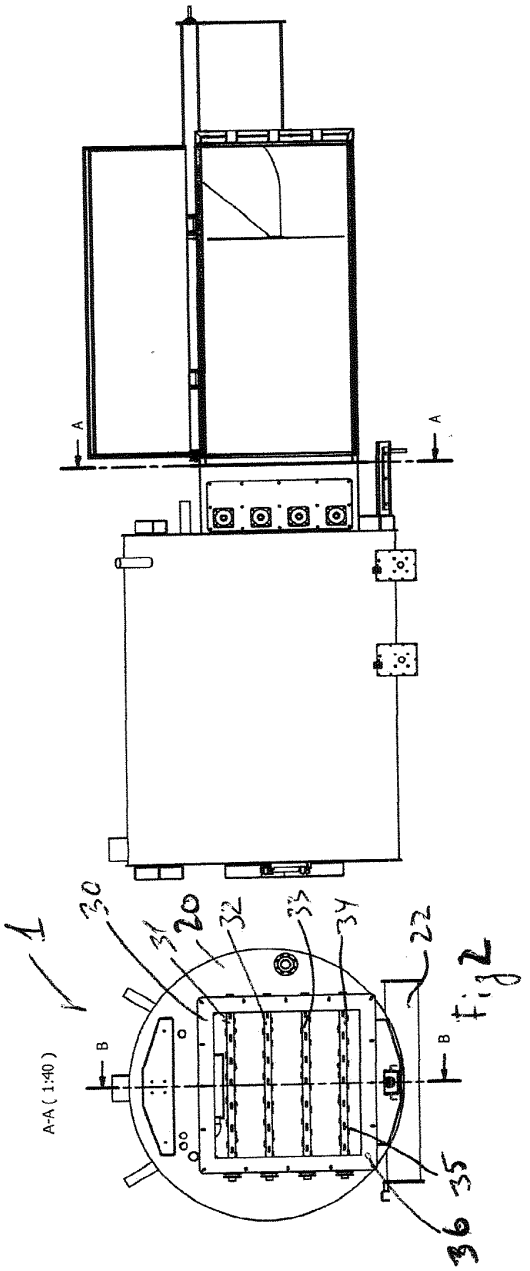


Fig 2

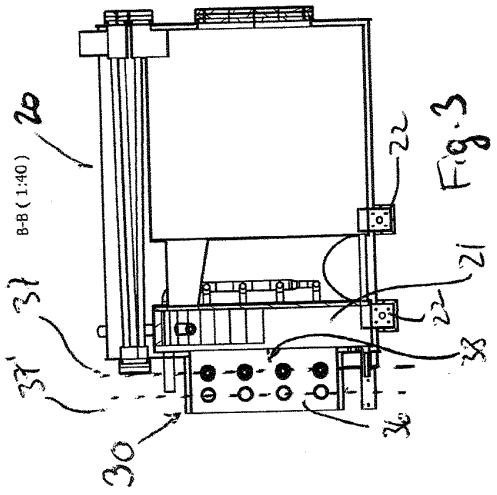


Fig. 3

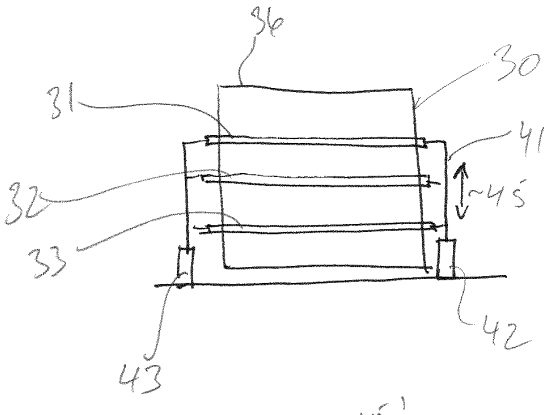


Fig. 4A

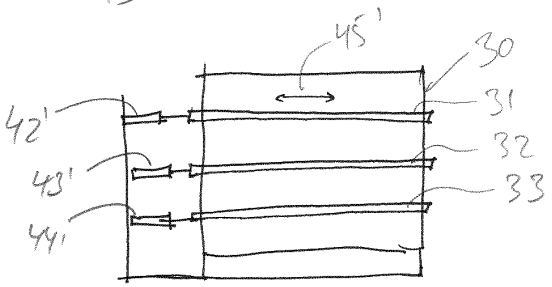


Fig 4B

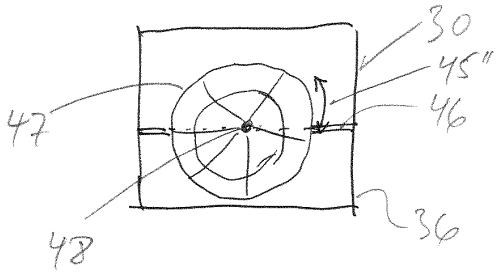


Fig 4C

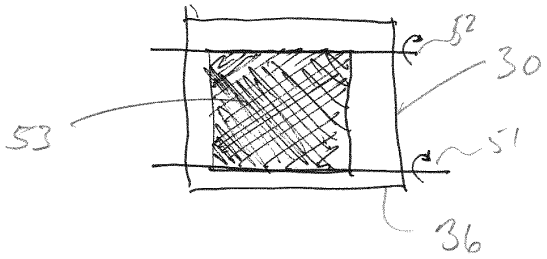


Fig. 4D

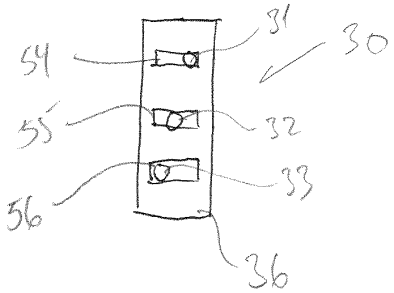


Fig 5

Europäisches Patentamt
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EUROPEAN SEARCH REPORT

Application Number
EP 17 18 7696

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	WO 86/00390 A1 (BOLLMANN HEINRICH SEN [DE]; BOLMANN HEINRICH JUN [DE]) 16 January 1986 (1986-01-16)	10,11	INV. F23G5/44 F23G7/10
Y	* page 1, line 1 - line 9; figures 1-8 * * page 2, line 29 - page 3, line 22 * * page 5, line 13 - page 6, line 26 * * page 7, line 14 - line 21 * * page 8, line 1 - line 11 *	1,2,5	
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