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(54) Title: By-product fuel delivery assembly

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"By-product fuel delivery assembly"

Introduction

This invention relates to a by-product fuel delivery assembly. In particular, the present invention relates to an assembly for delivering by-product fuel to a fluidised bed boiler of an energy conversion system.

Fluidised bed units are used in fluidised bed boilers. Fluidised bed units are capable of thermally treating by-product fuels that are normally difficult to thermally treat using other technologies, in a very efficient manner. Fluidised bed units also have low emission rates of Nitrous Oxide (N_2O), Sulfur Oxide (SO_x) and Carbon Dioxide (CO_2) which is beneficial to the environment. Fluidised bed units can be used with an associated heat exchanger to provide a fluidised bed boiler which is used to heat a liquid, typically water, or a gas which is then stored for subsequent use.

The conditions for efficient combustion within the fluidised bed unit are sensitive and it can be difficult to maintain the fragile conditions without a steady and sufficient supply of by-product fuel into the fluidised bed unit. Too little by-product fuel will cause the fluidised bed unit to combust the by-product fuel in non-optimal conditions, leading to inefficient operation of the fluidised bed unit. Often, an auxiliary combustion unit has to be employed in these conditions which is undesirable. Similarly, too much by-product fuel also causes the fluidised bed unit to combust the by-product fuel in non-optimal conditions, again leading to inefficient operation of the fluidised bed unit resulting in emission problems and possibly a complete shut down of the entire system.

It is thus important to deliver by-product fuel into the fluidised unit in a controlled and optimised manner.

It is a goal of the present invention to provide an apparatus that overcomes at least one of the above mentioned problems.

Statements of Invention

The present invention is directed to a by-product fuel delivery assembly for delivering by-product fuel to a fluidised bed unit, the by-product fuel delivery assembly comprising a fuel hopper, a fuel conveyer and a fuel metering device, wherein, the fuel hopper comprises a substantially planar base having side walls, a front wall and a back wall projecting upwardly from the base; the front wall comprising a discharge slot substantially adjacent the planer base; the by-product fuel delivery system further comprising an actuator located external the fuel hopper to operate a by-product fuel feed mechanism located internal the fuel hopper; wherein, the fuel hopper comprises a plurality of laterally arranged stop bars that are mounted on the base of the fuel hopper; and, intermediate the plurality of stop bars, the by-product fuel feed mechanism comprises a plurality of laterally arranged push bars that lie over the base of the fuel hopper; whereby, in operation, the laterally arranged push bars of the by-product fuel feed mechanism are moved in a reciprocating fashion in a longitudinal direction of the fuel hopper, whereby the push bars are moved back and forth intermediate the stop bars, so as to cooperate with the stop bars to advance by-product fuel in the fuel hopper towards the discharge slot on each forward stroke of the by-product fuel feed mechanism.

The advantage of providing a by-product fuel feed mechanism that comprises a plurality of laterally arranged push bars and a plurality of laterally arranged stop bars is that the by-product fuel in the hopper may be relatively easily feed from the fuel hopper onward to the energy conversion system. By moving the by-product fuel feed mechanism in a reciprocating fashion in a longitudinal direction over the base of the hopper, the push bars and stop bars co-operate to feed by-product fuel sitting on the base of the fuel hopper along the base of the fuel hopper towards the discharge slot of the fuel hopper. This reciprocating movement can be relatively easily implemented by an actuating means such as a pneumatic ram, a hydraulic ram, or the like, and therefore provides a simple, effective, low-cost and low maintenance solution to the problem of feeding by-product fuel from the fuel hopper.

A problem with fuel hoppers is that the by-product fuel within the hopper can become compacted if the by-product fuel has been sitting in the fuel hopper for an extended period of time due to the weight of the by-product fuel at the top of the fuel hopper

acting down on the by-product fuel beneath it. The by-product fuel becomes difficult to break up and thus difficult to deliver to the fluidised bed unit. This is particularly true for by-product fuel that has a high moisture content, wherein, the problem is exacerbated. Existing methods and apparatus for breaking up compacted by-product fuel are felt to be high energy users and are also complicated. The arrangement of the present invention has been found to be particularly useful when the by-product fuel sitting on the base of the fuel hopper has a high moisture content and/or has been compacted due to the by-product fuel above it.

Furthermore, the by-product fuel delivery assembly provides suitable amounts of by-product fuel for efficient combustion within the fluidised bed unit, which is sensitive as it can be difficult to maintain the fragile conditions without a steady and sufficient supply of by-product fuel into the fluidised bed unit, particularly for smaller fluidised beds where the fuel intake is between 80 kilograms and 500 kilograms per hour.

In a further embodiment, the by-product fuel feed mechanism comprises a spine arranged longitudinally in the fuel hopper having the plurality of push bars protruding perpendicularly therefrom; and, the spine is connected to the actuating means.

In a further embodiment, the plurality of push bars protruding perpendicularly from the spine are arranged in pairs, one on either side of the spine that are co-linear with each other.

In a further embodiment, the plurality of push bars protruding perpendicularly from the spine are arranged in pairs, one on either side of the spine that are offset with respect to each other in a non-linear manner.

In a further embodiment, the by-product fuel feed mechanism comprises a pair of longitudinally arranged support bars that run substantially adjacent the side walls of the fuel hopper, having the plurality of push bars connected laterally between the support bars; and, at least one of the support bars is connected to the actuating means.

In a further embodiment, the stop bars have a substantially triangular cross-section, each bar comprising a flat vertical face arranged toward the discharge slot, and a

sloped face on an opposing side of the bar.

In a further embodiment, the push bars have a substantially triangular cross-section, each bar comprising a flat vertical face arranged toward the discharge slot, and a sloped face on an opposing side of the bar.

The advantage of having a sloped face on the push bars is that the bars will dig in under any by-product fuel on the back stroke, and thus will prevent by-product fuel from becoming stuck in the fuel hopper. This is a particularly efficient embodiment of the fuel hopper which reduces by-product fuel waste and also ensures that no by-product fuel becomes stuck on the base of the fuel hopper which could potentially cause the fuel hopper to malfunction.

In a further embodiment, the actuating means is a pneumatic ram.

In a further embodiment, the fuel metering device comprises a fuel feed auger which is provided exterior the fuel hopper and adjacent the discharge slot; wherein, the fuel feed auger comprises a fuel feed auger casing having two augers mounted side by side within the casing; wherein, the two augers are arranged to contra-rotate away from one another with respect to each other.

The advantage of arranging the two augers to contra-rotate away from one another with respect to each other is that the by-product fuel will be much less likely to bridge over the rotating augers as a result of this rotational arrangement of the twin augers.

In a further embodiment, the fuel metering device comprises a fuel feed auger which is provided exterior the fuel hopper and adjacent the discharge slot; wherein, the fuel feed auger comprises a fuel feed auger casing having two augers mounted side by side within the casing; wherein, the two augers are arranged to contra-rotate toward one another with respect to each other.

In a further embodiment, the fuel feed auger further comprises a baffle plate mounted within the casing and above a discharge outlet of the fuel feed auger casing.

In a further embodiment, the fuel feed auger is controlled by a system controller to vary the amount of by-product fuel being feed out of a discharge outlet of the fuel feed auger.

In a further embodiment, the fuel metering device comprises a fuel feed auger which is provided adjacent the fluidised bed unit; wherein, the fuel feed auger comprises a fuel feed auger casing having two augers mounted side by side within the casing; wherein, the two augers are arranged to contra-rotate with respect to each other.

The advantage of arranging the two augers to contra-rotate with respect to each other is that the by-product fuel will be much less likely to bridge over the rotating augers as a result of this rotational arrangement of the twin augers. The fuel feed auger unit is used to meter the amount of by-product fuel that is being feed into the fluidised bed unit. As the auger could become jammed with by-product fuel and cut-off the steady and continuous supply of by-product fuel that is vital to the efficient operation of the fluidised bed unit, contra-rotating twin augers are used to prevent "bridging" from occurring, wherein the by-product fuel in the fuel feed auger unit slightly compacts to bridge over the rotating augers and no by-product fuel can be delivered out of the fuel feed auger unit causing disruption to the operation of the fluidised bed unit.

A further advantage of this embodiment is that as the fuel metering device is provided adjacent the fluidised bed unit, the fuel conveyer does not need to be sealed, and is thus easier to construct, operate and maintain. Air ingress into the fluidised bed unit is still prohibited by the fuel metering device, but this arrangement allows for a simpler overall construction.

In a further embodiment, the fuel feed auger further comprises a baffle plate mounted within the casing and above a discharge outlet of the fuel feed auger casing.

In a further embodiment, the fuel feed auger is controlled by a system controller to vary the amount of by-product fuel being feed out of a discharge outlet of the fuel feed auger.

In a further embodiment, the fuel conveyer comprises a box-shaped conduit having a substantially flat floor and a proximal end adjacent the fuel hopper and a distal end adjacent the fluidised bed unit; wherein, a continuous link chain looped around a pair of end sprockets is located within the conduit, and the link chain mounts a plurality of by-product fuel moving paddles thereon; wherein, the fuel conveyer further comprises a plurality of intermediary sprockets, having a smaller diameter than the end sprockets, which engage a lower section of the looped link chain to guide the lower section of the looped link chain and hold the corresponding by-product fuel moving paddles substantially in abutment against the flat floor of the fuel conveyer.

The advantage of providing a plurality of intermediary sprockets is that the by-product fuel moving paddles along a lower section of the continuous looped link chain are kept substantially in abutment against the flat floor of the fuel conveyer. This will improve the continuous delivery of by-product fuel to the fluidised bed and will reduce the possibility that the conveyer will malfunction or break due to clogged by-product fuel become caught beneath the lower section of the looped link chain and the corresponding by-product fuel moving paddles. This will prevent by-product fuel from becoming trapped beneath the arms and the link chain, causing the fuel conveyer to malfunction, which is disadvantageous as this could lead to an insufficient supply of by-product fuel to the fluidised bed unit, or, in particularly bad cases, the by-product fuel build-up could be such as to cause the link chain to break, thus forcing a shut-down of the entire fluidised bed unit and associated heat exchanger system.

In a further embodiment, the fuel conveyer further comprises a sensor to confirm normal operation of the fuel conveyer by detecting rotation of one or more of the shafts for the end sprockets.

In a further embodiment, the fuel conveyer further comprises a sensor to confirm normal operation of the fuel conveyer by detecting rotation of one or more of the shafts for the intermediary sprockets.

In a further embodiment, the by-product fuel moving paddles are constructed of a heavy duty plastics.

This is advantageous as the heavy duty plastic is sufficient rigid to drag portions of by-product fuel along the conduit, but the plastic will not wear down a metallic floor of the conduit.

In a further embodiment, the conduit is constructed of mild steel.

In a further embodiment, the conduit of the fuel conveyer is sealed to prevent air ingress into the by-product fuel delivery system.

In a further embodiment, on each stroke of the by-product fuel feed mechanism, by-product fuel is advanced through the discharge slot of the fuel hopper and into the fuel metering device; the fuel metering device comprises a fuel feed auger which is provided external the fuel hopper and adjacent the discharge slot; the fuel feed auger comprises a fuel feed auger casing having two augers mounted side by side within the casing; wherein, the two augers are arranged to contra-rotate away from one another with respect to each other and to feed by-product fuel through a discharge outlet of the fuel metering device and onto the fuel conveyer; the fuel conveyer comprises a box-shaped conduit having a substantially flat floor and a proximal end adjacent the fuel hopper and a distal end adjacent the fluidised bed unit; wherein, a continuous link chain looped about a pair of end sprockets is located within the conduit, and the link chain mounts a plurality of by-product fuel moving paddles thereon; the fuel conveyer further comprises a plurality of intermediary sprockets, having a smaller diameter than the end sprockets, which engage a lower section of the looped link chain to guide the lower section of the looped link chain and hold the corresponding by-product fuel moving paddles substantially adjacent to the flat floor of the fuel conveyer; and, in operation, by-product fuel is dragged along the conduit by the by-product fuel moving paddles from the proximal end of the fuel conveyer to the distal end of the fuel conveyer; wherein, the by-product fuel is passed into a fluidised bed unit fuel feed auger which feeds the by-product fuel into the fluidised bed unit.

In a further embodiment, on each forward stroke of the by-product fuel feed mechanism, by-product fuel is advanced through the discharge slot and into a fuel conveyer feed auger; the by-product fuel passed into the fuel conveyer feed auger is

then feed onto the fuel conveyer; the fuel conveyer comprises a box-shaped conduit having a substantially flat floor and a proximal end adjacent the fuel hopper and a distal end adjacent the fluidised bed unit; wherein, a continuous link chain looped about a pair of end sprockets is located within the conduit, and the link chain mounts a plurality of by-product fuel moving paddles thereon; the fuel conveyer further comprises a plurality of intermediary sprockets, having a smaller diameter than the end sprockets, which engage a lower section of the looped link chain to guide the lower section of the looped link chain and hold the corresponding by-product fuel moving paddles substantially adjacent to the flat floor of the fuel conveyer; and, in operation, by-product fuel is dragged along the conduit by the by-product fuel moving paddles from the proximal end of the fuel conveyer to the distal end of the fuel conveyer; wherein, the by-product fuel is passed into a fuel metering device which comprises a fuel feed auger and is provided adjacent the fluidised bed unit; the fuel feed auger comprises a fuel feed auger casing having two augers mounted side by side within the casing; wherein, the two augers are arranged to contra-rotate away from one another with respect to each other and to feed by-product fuel through a discharge outlet of the fuel metering device and into the fluidised bed unit.

In a further embodiment, the by-product fuel delivery assembly further comprises a system controller which receives monitoring data regarding the operational parameters of the fluidised bed unit and an associated heat exchanger, and, varies the amount of by-product fuel being fed to the fluidised bed unit by controlling the operation of one or more of the fuel hopper, the fuel metering device and/or the fuel conveyer.

Detailed Description of Embodiments

The invention will be more clearly understood from the following description of some embodiments thereof, given by way of example only with reference to the accompanying drawings, in which:

Fig. 1 is a perspective view of an energy conversion system in accordance with the present invention;

Fig. 2 is a perspective view of a by-product fuel delivery system that forms part of

the energy conversion system of Fig. 1;

Fig. 3 is a perspective view of a fuel hopper that forms part of the by-product fuel delivery system of Fig. 2;

Fig. 4 is a side elevation view of a push bar in the fuel hopper of Fig. 3;

Fig. 5 is a plan view of the fuel hopper of Fig. 3;

Fig. 6 is a perspective view of a fuel metering device that forms part of the by-product fuel delivery system in accordance with the present invention;

Fig. 7 is a plan view of a fuel metering device of Fig. 6;

Fig. 8 is a cross-sectional view of the fuel metering device along line VII-VII of Fig. 7;

Fig. 9 is a perspective view of a fuel metering device in accordance with a further embodiment of the present invention;

Fig. 10 is a perspective view of a fuel conveyer that forms part of the by-product fuel delivery system of Fig. 2;

Fig. 11 is a cross-sectional view of the fuel conveyer along line X-X of Fig. 10; and,

Fig. 12 is a perspective view of a by-product fuel feed auger unit.

Referring to the drawings and initially to Figure 1 thereof, there is shown an energy conversion system, indicated generally by the reference numeral 1, comprising a fluidised bed unit 3, a by-product fuel feed system 5 feeding the fluidised bed unit 3, a heat exchanger 7 operatively coupled to the fluidised bed unit 3, an exhaust filter 9 operatively coupled to the heat exchanger 7 and a negative pressure system. The negative pressure system comprises a forced draught fan 11 and an

induction draught fan 13 which are operable to maintain a flow of exhaust gases in the direction from the fluidised bed unit 3 through the heat exchanger 7.

The fluidised bed unit 3 further comprises a charging inlet 15 for fuel delivered by the by-product fuel feed system 5, a diesel burner (not shown) connected to a burner inlet 17 and a furnace sump 19 containing fluidised bed media. The furnace sump 19 tapers inwardly towards the bottom of the furnace sump 19 where there is a clinker extraction unit, in this case a furnace ash removal auger 21 located at the bottom of the furnace sump 19. The fluidised bed unit 3 further comprises an air introducer assembly most of which is mounted substantially in the furnace sump 19 for delivering air up through the fluidised bed media in the sump. The air introducer further comprises the forced draught fan 11 from the negative pressure system. Above the furnace sump 19 is the furnace freeboard 23.

The by-product fuel feed system 5 comprises a hopper 25, a variable speed auger 27 and a fuel conveyor 29 to deliver fuel from the hopper to the charging inlet 15 of the fluidised bed unit 3. The variable speed auger 27 is operated to deliver a desired amount of fuel from the hopper 25 onto the fuel conveyor 29.

The heat exchanger 7 comprises a pair of heat exchanger units, an upper heat exchanger unit 31 and a lower heat exchanger unit 33. The lower heat exchanger unit 33 is provided with a cold water flow pipe 35 and the upper heat exchanger unit 31 is provided with a hot water return pipe 37. The upper heat exchanger unit 31 further comprises a heat exchanger soot blower 32 mounted across the upper heat exchanger unit 31 and extending between a plurality of tubes (not shown) of the upper heat exchanger unit 31. The heat exchanger soot blower 32 is rotatably mounted on the upper heat exchanger unit 31. Below the lower heat exchanger unit 33 is a heat exchanger sump 39 which is provided with a heat exchanger ash removal auger 41 to remove ash from the heat exchanger sump. The heat exchanger 7 is operatively coupled to the fluidised bed unit 3 by way of a freeboard interconnector 34. The freeboard interconnector 34 is provided with a plurality of pulsed blower nozzles 36 arranged substantially in line with the floor of the freeboard interconnector 34. Pressurised air is periodically passed through the pulsed blower nozzles 36 to dislodge any settled ash from the floor of the

freeboard interconnector 34. A heat exchanger exhaust conduit 43 operatively couples the heat exchanger 7 to the exhaust filter 9.

In further embodiments (not shown), the heat exchanger 7 may be alternatively replaced with or augmented by a steam generation unit or an electricity generation unit.

The exhaust filter 9 is a bag filter having a plurality of bags to catch the fly ash from the exhaust gases. The exhaust filter 9 comprises an ash extractor auger 45 located at the bottom of the exhaust filter 9. The induction draught fan 13 is coupled to the exhaust filter 9 and draws exhaust gases through the energy conversion system from the fluidised bed unit 3, through the heat exchanger 7 and through the exhaust filter 9.

With reference to Figure 2, the by-product fuel delivery assembly 5 comprising the fuel hopper 25, the fuel metering device 27 and the fuel conveyor 29 is shown.

With reference to Figures 3 to 5 inclusive, the fuel hopper 25 comprises a fuel hopper base 47, a fuel hopper back wall 49, a fuel hopper front wall 51 and fuel hopper side walls 53. The fuel hopper front wall 51 comprises a fuel hopper discharge slot 59 which runs in a horizontal direction across the width of the fuel hopper front wall 51 at a lowest portion of the fuel hopper front wall 51, adjacent the fuel hopper base 47. A by-product fuel feed mechanism 71 is located within the interior cavity of the fuel hopper 25. The by-product fuel feed mechanism 71 lies substantially over and along the fuel hopper base 47. The by-product fuel feed mechanism 71 comprises a plurality of push bars 55 and a plurality of fixed bars 57. The push bars 55 are moveable and connected to a fuel hopper actuator 73 which moves the push bars 55 in unison. The fixed bars 57 are fixedly connected to the fuel hopper base 47 so as to be substantially in parallel with and intermediate the push bars 55. The fuel hopper actuator 73 is a pneumatic ram which acts to move the by-product fuel feed mechanism 71 in a reciprocating fashion over the fuel hopper base 47 in a longitudinal direction relative to the fuel hopper toward and away from the fuel hopper discharge slot 59 as indicated by the bidirectional arrow A in Figure 5. In an alternative embodiment, a hydraulic ram or a motor rotating a cam may be used as the actuator 73.

With reference to Figure 4, each of the push bars 55 and each of the fixed bars 57 are triangular or wedge shaped in cross-section. The push bars 55 and fixed bars 57 comprise a sloped, rearward directed face 63, a substantially vertical forward directed face 65, and a substantially horizontal underside 67. The plurality of push bars 55 are perpendicularly connected to a central spine 69. The central spine 69 is connected to the actuator 73. The forward stroke of the by-product fuel feed mechanism 71 is such as to move the push bar 55 so that its vertical forward directed face 65 is moved toward being substantially adjacent the sloped, rearward directed face 63 of a fixed bar 57. In an analogous manner, during the reverse stroke of the by-product fuel feed mechanism 71, the push bar 55 is moved so that its vertical, forward directed face 65 is moved away from being substantially adjacent the sloped rearward directed face 63 of a fixed bar 57 to a point where the sloped rearward directed face 63 of the push bar 55 is adjacent the vertical, forward directed face 65 of a fixed bar 57. It will be understood that in a further embodiment, the dimensions and construction of the by-product fuel feed mechanism 71 are chosen with respect to the properties of poultry litter such as the average weight, density, consistency, moisture content and the like.

Referring to Figure 3, it is shown that the fuel hopper 25 is supported by a plurality of support legs 61. It will be understood that various supports such as blocks or a skid may be used in place of the legs 61.

Referring to Figures 6 to 8, there is shown the fuel metering auger 27. The fuel metering auger 27 comprises a pair of contra-rotating augers 75, 77 which rotate away from one another with respect to each other as indicated by arrows B and C respectively in Figure 8. The pair of augers 75, 77 are mounted within a fuel metering auger casing 79 on a pair of respective shafts 81, 83. The fuel metering auger casing 79 comprises an outlet 87 having a discharge outlet 85 at one end of the fuel metering auger casing 79. The diameter of the augers 75, 77 is such that the augers 75, 77 are mounted in close proximity to the side walls 89, 91 and the base 88 of the fuel metering auger casing 79. The base 88 may comprise a raised rail 90 extending along the longitudinal length of the base 88 and located substantially between the pair of augers 75, 77 to assist with directing the by-product fuel (not shown) along the fuel metering auger 27 to the exit point 85. The rail 90 will also prevent fuel from becoming

clogged inside the fuel metering auger casing 79 over time.

The fuel metering auger 27 may be hermetically sealed to components of the by-product fuel delivery system 5 to form part of the air tight section of the by-product fuel delivery system 5. In one embodiment, the fuel metering auger 27 is hermetically sealed to the discharge slot 59 of the fuel hopper 25 and to the fuel conveyer 29. In a further embodiment, the fuel metering auger 27 is hermetically sealed to the fuel conveyer 29 and to the charging inlet 15 of the fluidised bed boiler 3. In Fig. 9, a further embodiment of the fuel metering auger 27 is shown wherein, an anti-clogging auger 86 is situated above the pair of contra-rotating augers 75, 77 so as to further assist with the prevention of clogging within the fuel metering auger 27. The anti-clogging auger 86 may be linked to the pair of contra-rotating augers 75, 77 by a geared mechanism such as a simple drive chain so that the rotational speed of the anti-clogging auger 86 would be relative to the rotational speeds of the pair of contra-rotating augers 75, 77.

In a further embodiment (not shown), the pair of contra-rotating augers 75, 77 may be arranged to contra-rotate toward one another as this will also assist with preventing the by-product fuel to bridge over the auger 27.

Referring to Figures 10 and 11, there is shown the fuel conveyer 29. The fuel conveyer 29 comprises a link chain 95 which is looped about a lower end sprocket 99 and an upper end sprocket 101 to form a chain drive system indicated generally by reference numeral 96. The chain drive system 96 is housed within a fuel conveyer casing 98. The fuel conveyer casing comprises a base 100 and a top cover 102, and has an inlet 105 and an outlet 107, as indicated in Fig. 10. A plurality of fuel moving paddles 97 are connected to the link chain 95 at regular intervals to form part of the chain drive system 96. The chain drive system 96 comprises a length of link chain 95 having a plurality of fuel moving paddles 97 which runs adjacent the base 100 to form a delivery portion of the chain drive system 96, and, the chain drive system 96 comprises a length of link chain 95 having a plurality of fuel moving paddles 97 which runs adjacent the top cover 102 of the fuel conveyer casing 98 to form a return portion of the chain drive system 96. A plurality of intermediate retaining sprockets 103 are located within the fuel conveyer casing 98 and are used to retain the delivery portion of the chain drive system 96 adjacent to and in abutment with the base 100 of the fuel conveyer casing

98. The intermediate retaining sprockets 103 are of a lesser diameter than the lower end sprocket 99 and the upper end sprocket 101. In this manner, the intermediate retaining sprockets 103 only contact the link chain 95 on the delivery portion of the chain drive system 96. This greatly improves the robustness of the chain drive system 96. A motor (not shown) drives at least one of the sprockets 99, 101, 103.

In use, by-product fuel (not shown) will enter the inlet 105 as indicated by reference arrow D and one of the plurality of fuel moving paddles 97 will scoop some of the by-product fuel that has entered through the inlet 105 and the fuel will be held in the gaps 109 between adjacent fuel moving paddles 97. The fuel moving paddles will push the by-product fuel along the base 100 of the fuel conveyer 29 to the outlet 107 and the by-product fuel will be expelled from the fuel conveyer 29 from the outlet 107 as indicated by reference arrow E.

In a preferred embodiment, the fuel conveyer 29 may move approximately 100kgs of by-product fuel per hour.

With reference to Figure 12, wherein like parts previously described have been assigned the same reference numerals, there is provided a fuel feed auger 111. The fuel feed auger 111 comprises an auger 113 that is mounted within a fuel feed auger casing 79 on a shaft 115. The fuel feed auger casing 79 is substantially similar to the fuel metering auger casing 79 and comprises an outlet 87 having an exit point 85 at one of its ends. The diameter of the auger 113 is such that the auger 113 is mounted in close proximity to side walls 89, 91 of the fuel feed auger casing 79. As before, the fuel feed auger 111 may be hermetically sealed to components of the by-product fuel delivery system 5 to form part of an air tight section of the by-product fuel delivery system 5. Alternatively, the fuel feed auger 111 may be open and allow air ingress to occur depending on the set-up of the by-product fuel delivery system 5.

Throughout the preceding specification, the term "operational parameters" in relation to the fluidised bed unit and associated heat exchanger shall be understood to encompass parameters such as pressure within the freeboard of the fluidised bed unit, pressure within the heat exchanger, temperature within the fluidised bed, temperature within the freeboard of the fluidised bed unit, temperature within the heat exchanger,

temperature of the liquid passing through and exiting the heat exchanger in addition to parameters relating to the temperature, pressure and measurable characteristics of the ash, exhaust and other expended materials from the overall energy conversion system.

It is envisaged that the fuel metering auger 27 could comprise a single auger instead of two contra-rotating augers 75, 77. The augers may contra-rotate toward each other in a further embodiment.

It will be readily appreciated that although the fuel conveyer 29 in Figs. 9 and 10 has been shown with a top cover 102, the fuel conveyer may not require to be hermetically sealed, and thus the top cover 102 may not be provided on the fuel conveyer 29, thus improving the access to the innards of the fuel conveyer 29, easing maintenance work. It will be further understood that a pair of link chains 95 could be used instead of the one link chain 95 shown in Figs. 9 and 10. The pair of link chains could be located adjacent the side walls of the casing 98 and would mount the fuel moving paddles 97 intermediate their lengths. Additional sprockets would be required to accommodate this double link chain embodiment. In a further embodiment, it is envisaged to use rope or other known means instead of the link chain.

The by-product fuels that may be used in the fluidised bed units may be poultry litter, mushroom compost, meat and bone meal and other similar animal and vegetation waste. It should be understood that references to waste and to by-product fuel in this specification are inter-changeable, and, that both of the terms have been used so as to encompass the different types of waste and non-waste, or by-product fuel, which are so categorised by different regulatory bodies in different jurisdictions.

It will be further understood that references to a hopper in this specification encompasses any type of storage area for holding by-product fuel to be subsequently delivered from the hopper for further processing. Thus, the term "hopper" comprises a stand-alone container, a pit and the like. It will be appreciated that if a pit is used to store the by-product fuel, then the by-product fuel feed mechanism may be located on the ground inside the pit so as to facilitate the feed of by-product fuel from the pit for further processing.

It will be further understood that references to "thermally treating" the by-product fuel, or any grammatical variations thereof, should be interpreted as incinerating, burning, combusting, cremating, igniting and/or an oxidising reaction with the by-product fuel.

The terms "comprise" and "include" and any variations thereof required for grammatical reasons are to be considered as used interchangeable and accorded the widest possible interpretation.

The invention is not limited to the embodiments hereinbefore described which may be varied in both construction and detail within the scope of the appended claims.

CLAIMS

1. A by-product fuel delivery assembly (5) for delivering by-product fuel to a fluidised bed unit (3), characterised in that,

the by-product fuel delivery assembly comprises a fuel hopper (25), a fuel conveyer (29) and a fuel metering device (27), wherein,

the fuel hopper comprises a substantially planar base (47) having side walls (53), a front wall (51) and a back wall (49) projecting upwardly from the base;

the front wall comprising a discharge slot (59) substantially adjacent the planer base;

the by-product fuel delivery system further comprising an actuator (73) located external the fuel hopper to operate a by-product fuel feed mechanism (71) located internal the fuel hopper;

the fuel hopper comprises a plurality of laterally arranged stop bars (57) that are mounted on the base of the fuel hopper; and,

intermediate the plurality of stop bars, the by-product fuel feed mechanism comprises a plurality of laterally arranged push bars (55) that lie over the base of the fuel hopper; whereby,

in operation, the laterally arranged push bars of the by-product fuel feed mechanism are moved in a reciprocating fashion in a longitudinal direction of the fuel hopper, whereby the push bars are moved back and forth intermediate the stop bars, so as to cooperate with the stop bars to advance by-product fuel in the fuel hopper towards the discharge slot on each forward stroke of the by-product fuel feed mechanism.

2. A by-product fuel delivery assembly as claimed in claim 1, wherein,
the fuel metering device comprises a fuel feed auger which is provided

exterior the fuel hopper and adjacent the discharge slot; characterised in that, the fuel feed auger comprises a fuel feed auger casing (79) having two augers (75, 77) mounted side by side within the casing; wherein,
the two augers are arranged to contra-rotate away from one another with respect to each other.

3. A by-product fuel delivery assembly as claimed in claim 1, characterised in that,

the fuel metering device comprises a fuel feed auger which is provided adjacent the fluidised bed unit;

the fuel feed auger comprises a fuel feed auger casing having two augers mounted side by side within the casing; and,

the two augers are arranged to contra-rotate with respect to each other.

4. A by-product fuel delivery assembly as claimed in claim 1, characterised in that,

the fuel conveyer comprises a box-shaped conduit having a substantially flat floor and a proximal end adjacent the fuel hopper and a distal end adjacent the fluidised bed unit; wherein,

a continuous link chain (95) looped around a pair of end sprockets (99, 101) is located within the conduit, and the link chain mounts a plurality of by-product fuel moving paddles (97) thereon; and,

the fuel conveyer further comprises a plurality of intermediary sprockets (103), having a smaller diameter than the end sprockets, which engage a lower section of the looped link chain to guide the lower section of the looped link chain and hold the corresponding by-product fuel moving paddles substantially in abutment against the flat floor of the fuel conveyer.

5. A by-product fuel delivery assembly as claimed in claim 1, wherein,

on each stroke of the by-product fuel feed mechanism, by-product fuel is advanced through the discharge slot of the fuel hopper and into the fuel metering device;

the fuel metering device comprises a fuel feed auger which is provided external the fuel hopper and adjacent the discharge slot;

the fuel feed auger comprises a fuel feed auger casing having two augers mounted side by side within the casing; wherein,

the two augers are arranged to contra-rotate away from one another with respect to each other and to feed by-product fuel through a discharge outlet of the fuel metering device and onto the fuel conveyer;

the fuel conveyer comprises a box-shaped conduit having a substantially flat floor and a proximal end adjacent the fuel hopper and a distal end adjacent the fluidised bed unit; wherein,

a continuous link chain looped about a pair of end sprockets is located within the conduit, and the link chain mounts a plurality of by-product fuel moving paddles thereon;

the fuel conveyer further comprises a plurality of intermediary sprockets, having a smaller diameter than the end sprockets, which engage a lower section of the looped link chain to guide the lower section of the looped link chain and hold the corresponding by-product fuel moving paddles substantially adjacent to the flat floor of the fuel conveyer; and,

in operation, by-product fuel is dragged along the conduit by the by-product fuel moving paddles from the proximal end of the fuel conveyer to the distal end of the fuel conveyer; wherein,

the by-product fuel is passed into a fluidised bed unit fuel feed auger which feeds the by-product fuel into the fluidised bed unit.

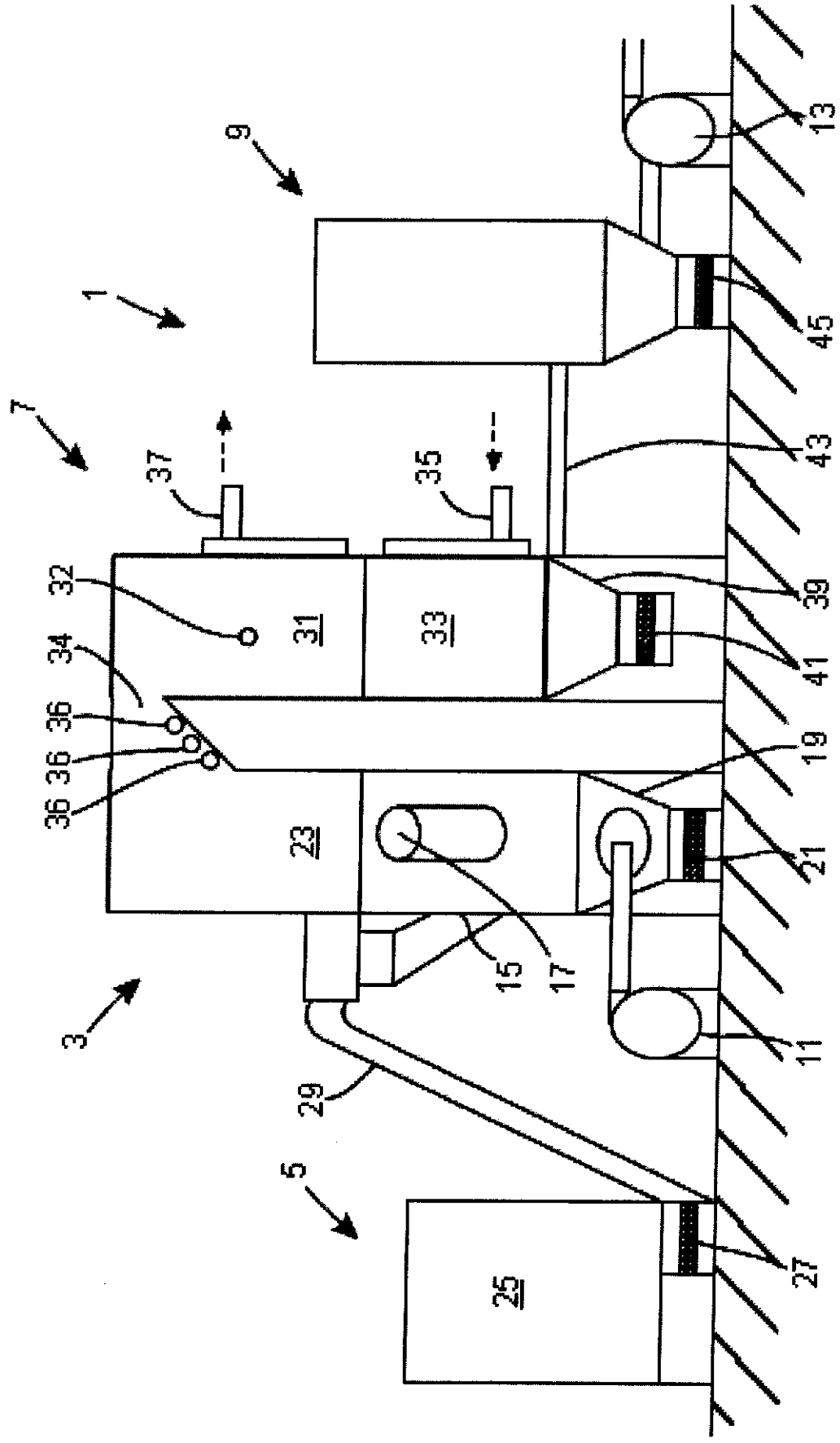
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Fig. 1

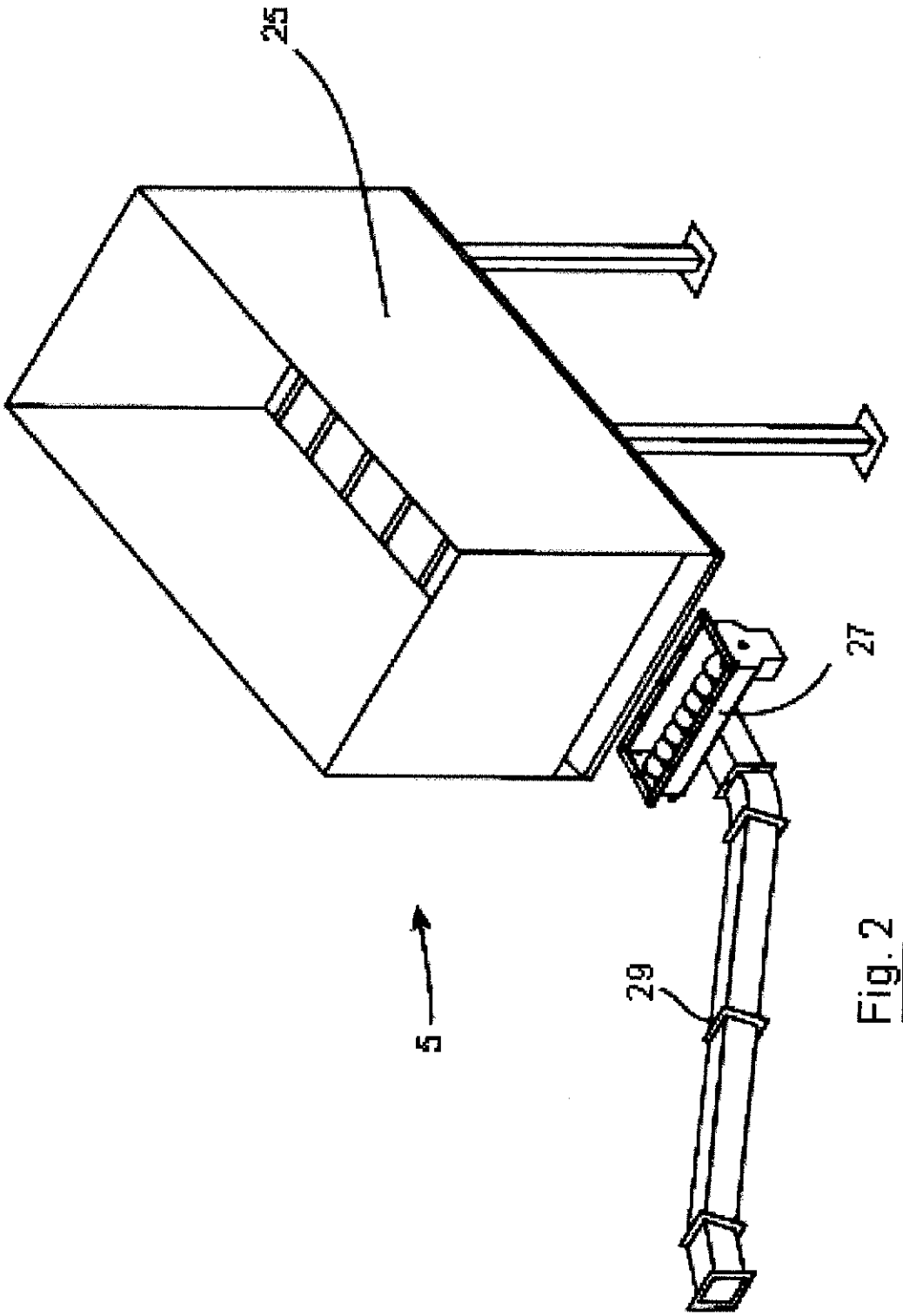

Fig. 2

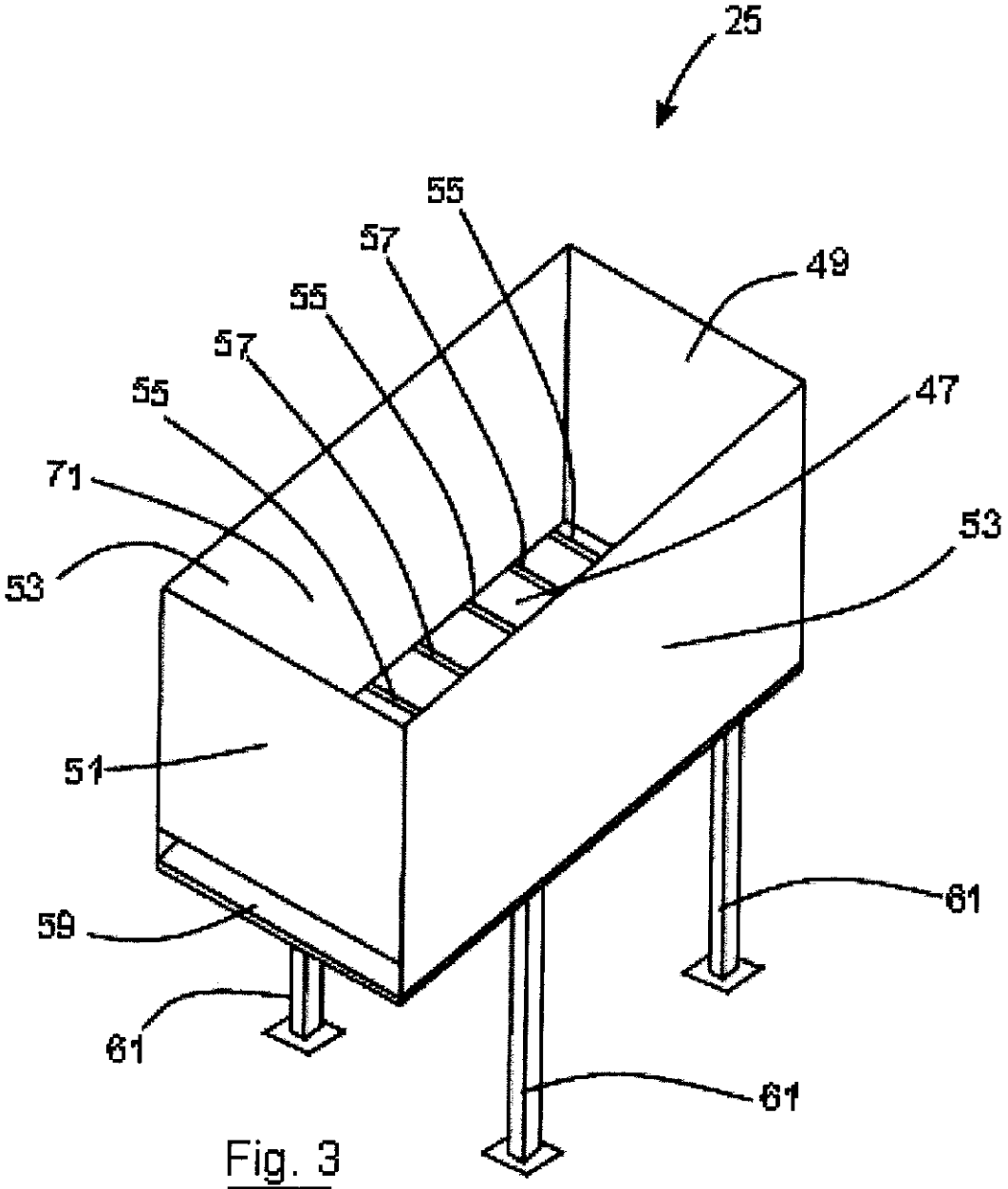

Fig. 3

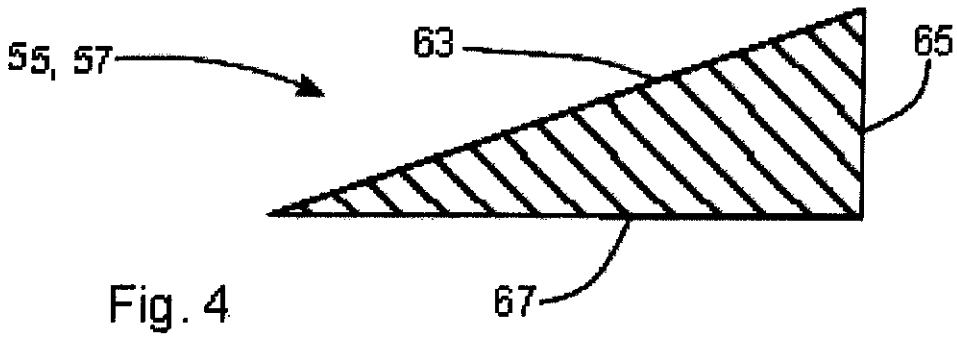

Fig. 4

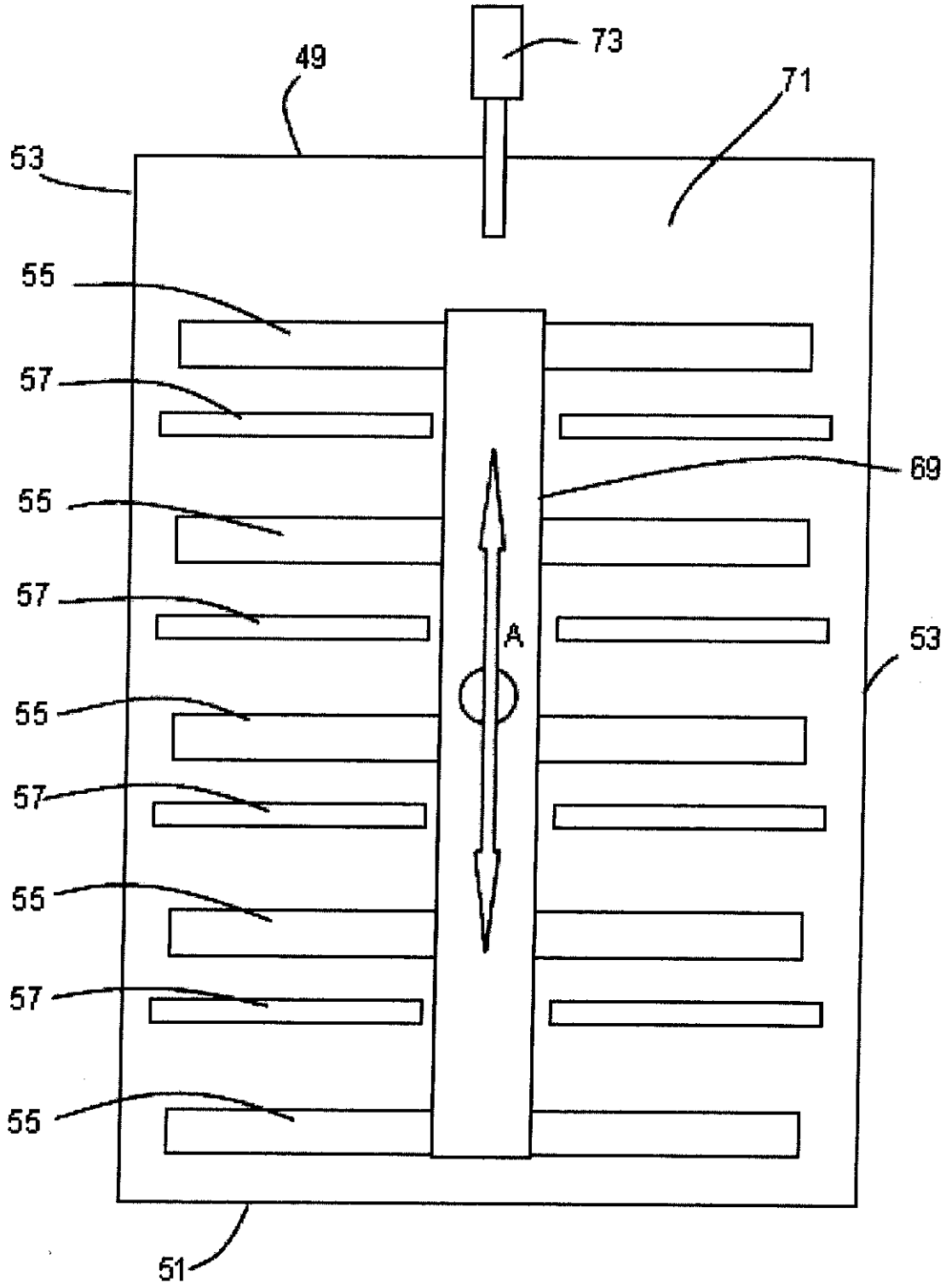

Fig. 5

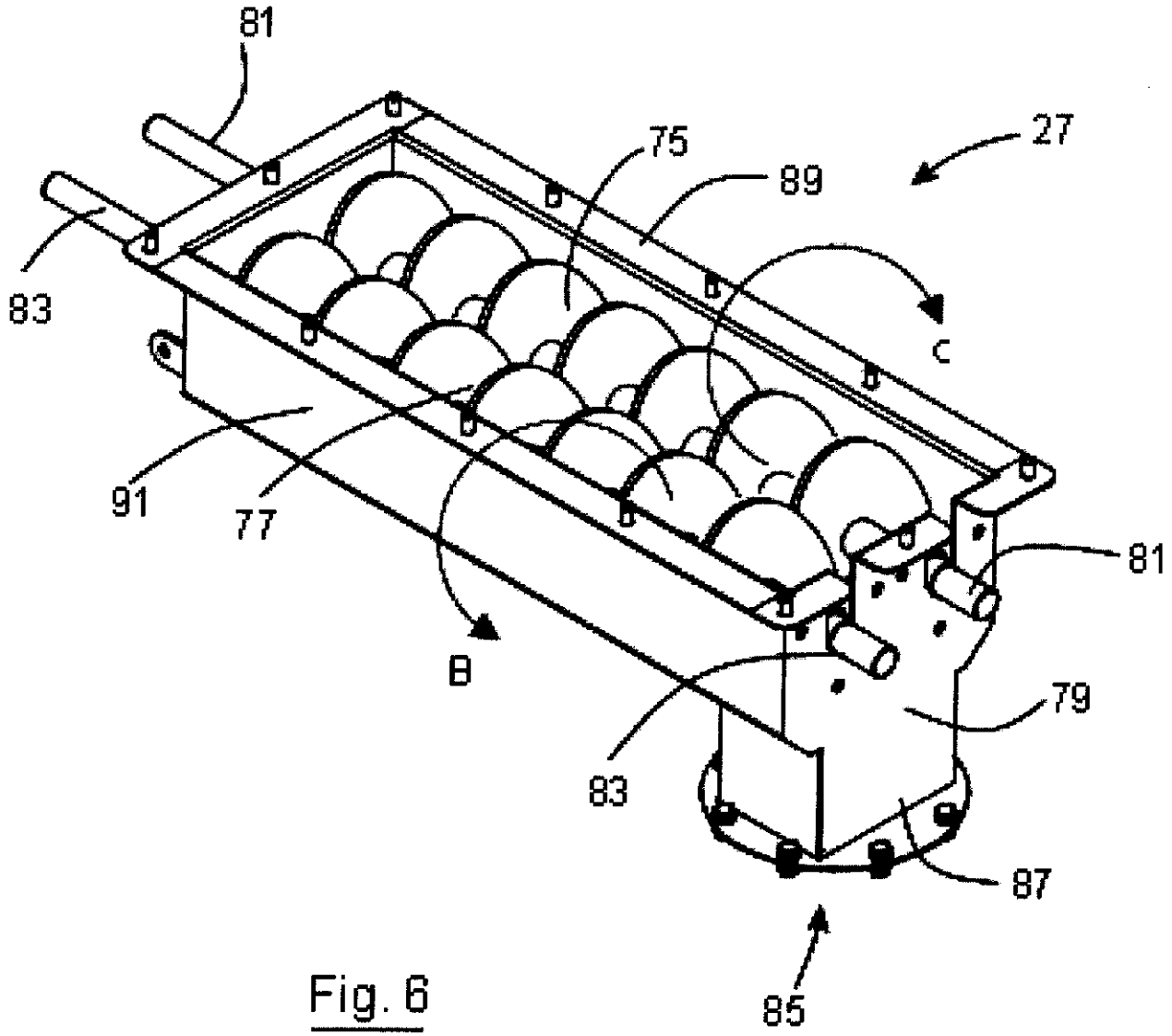

Fig. 6

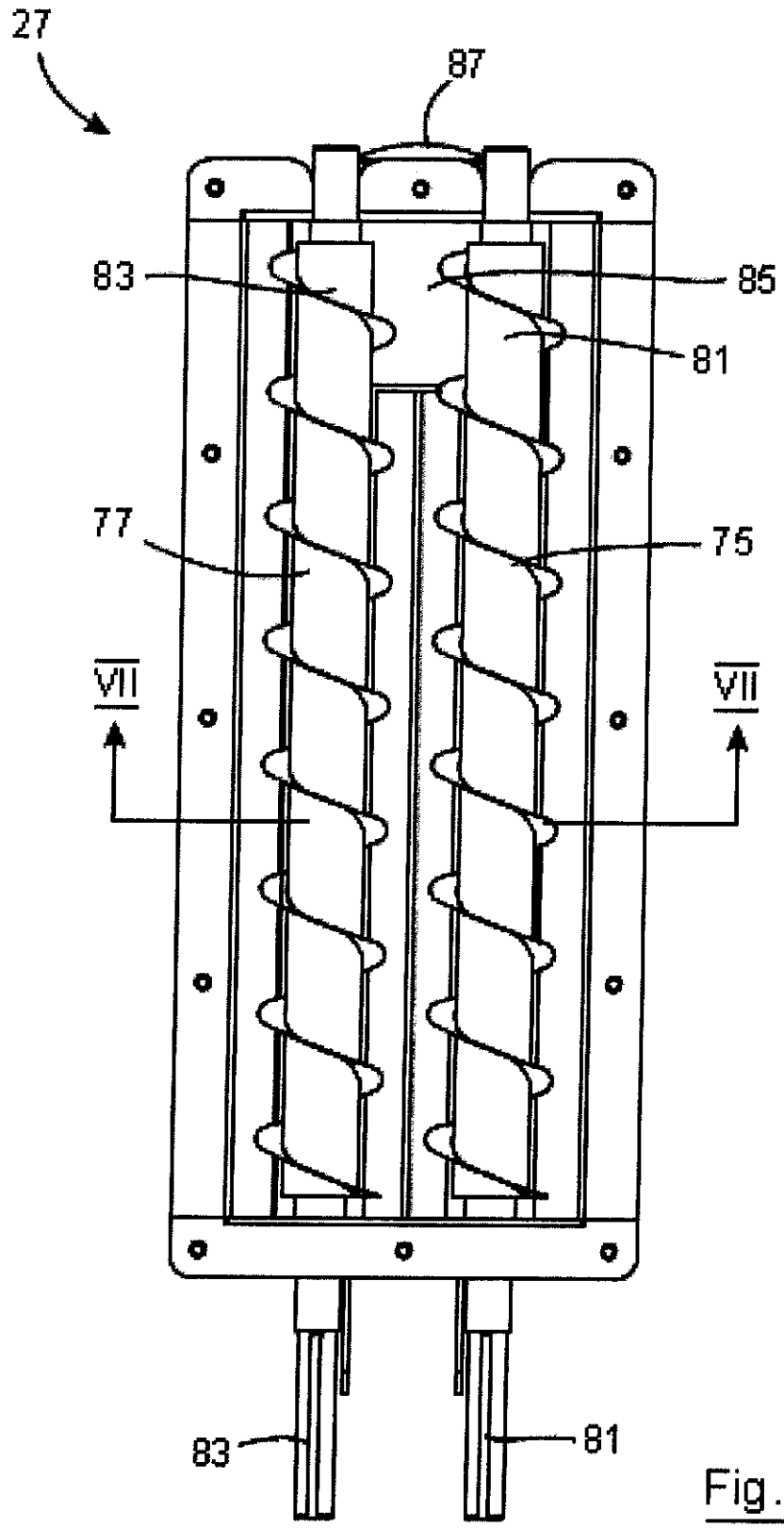

Fig. 7

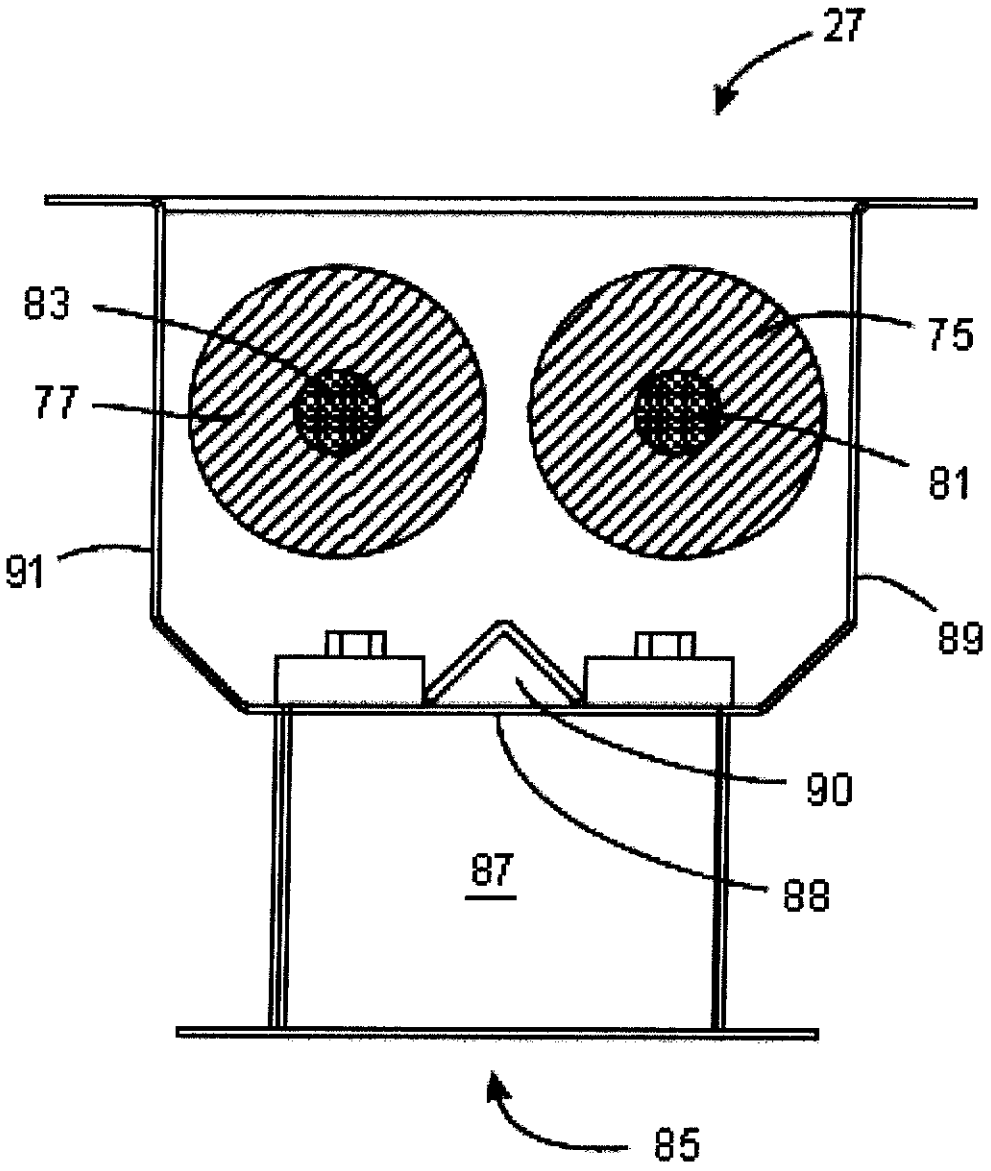

Fig. 8

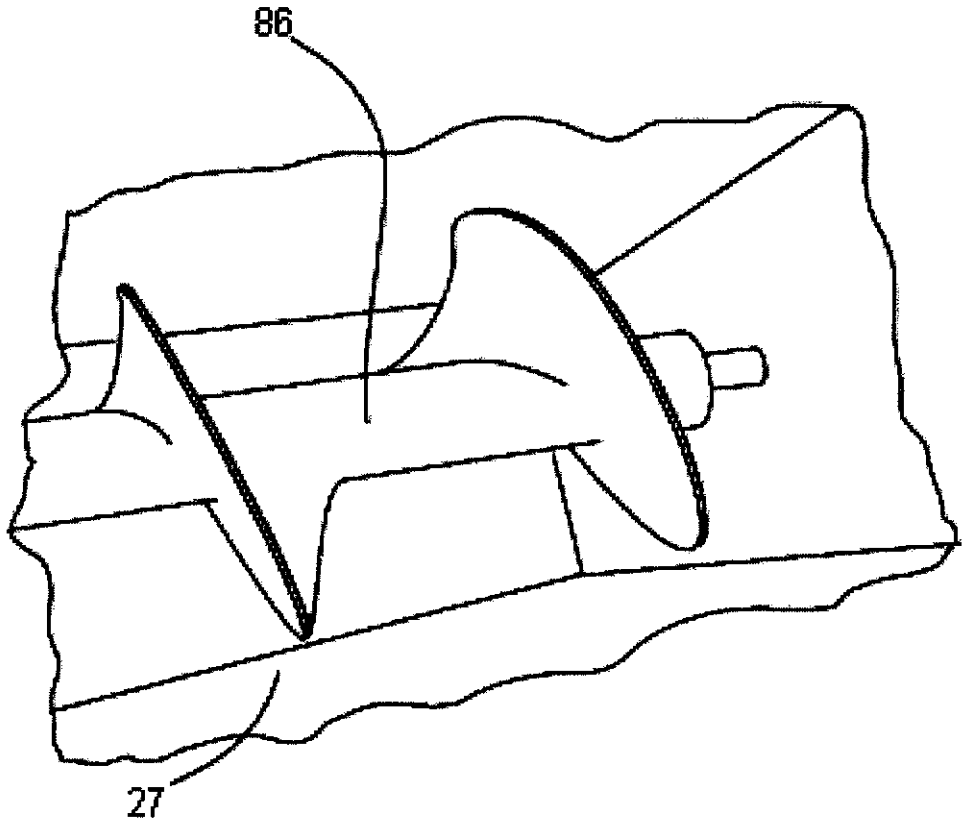

Fig. 9

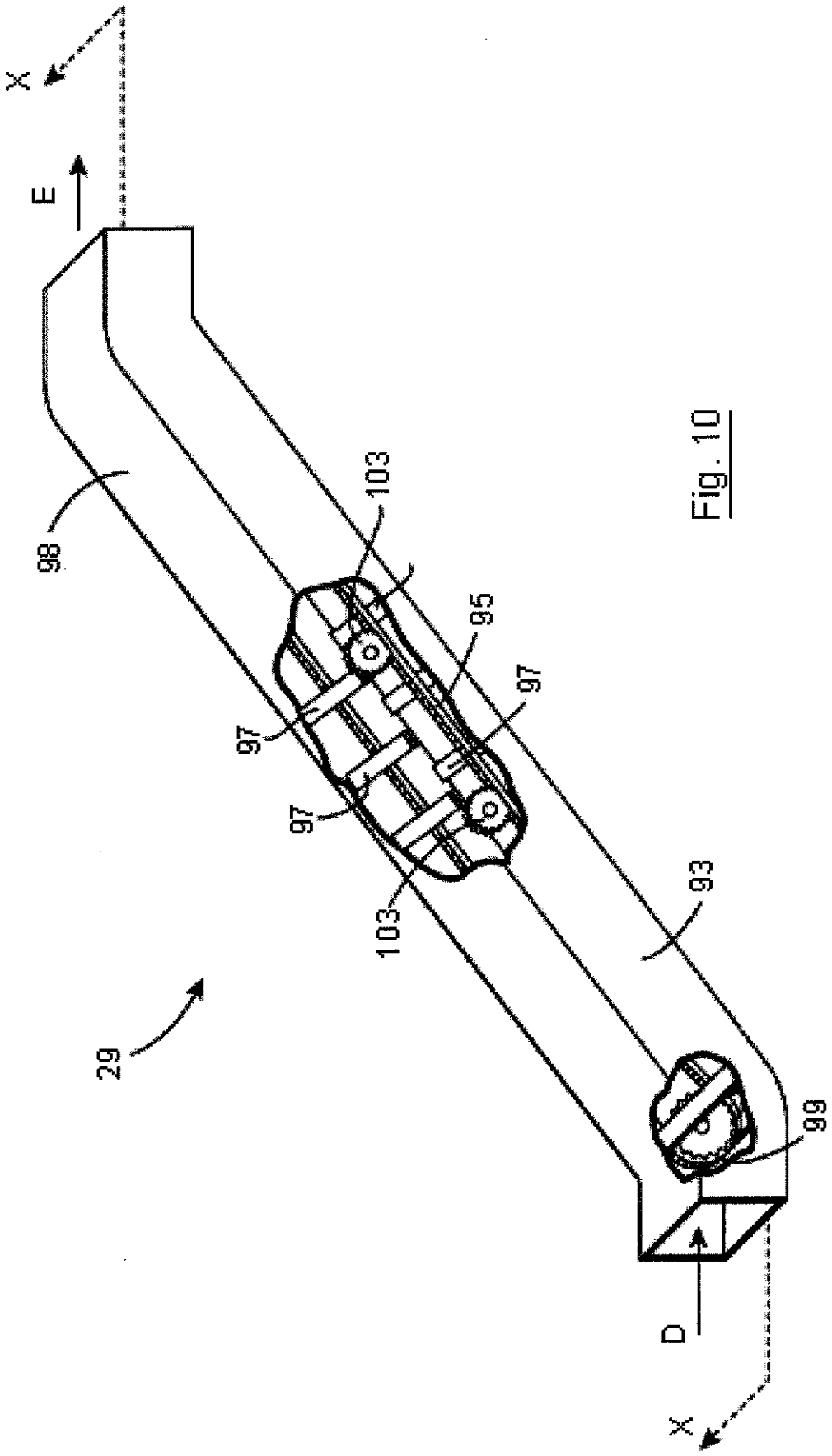

Fig. 10

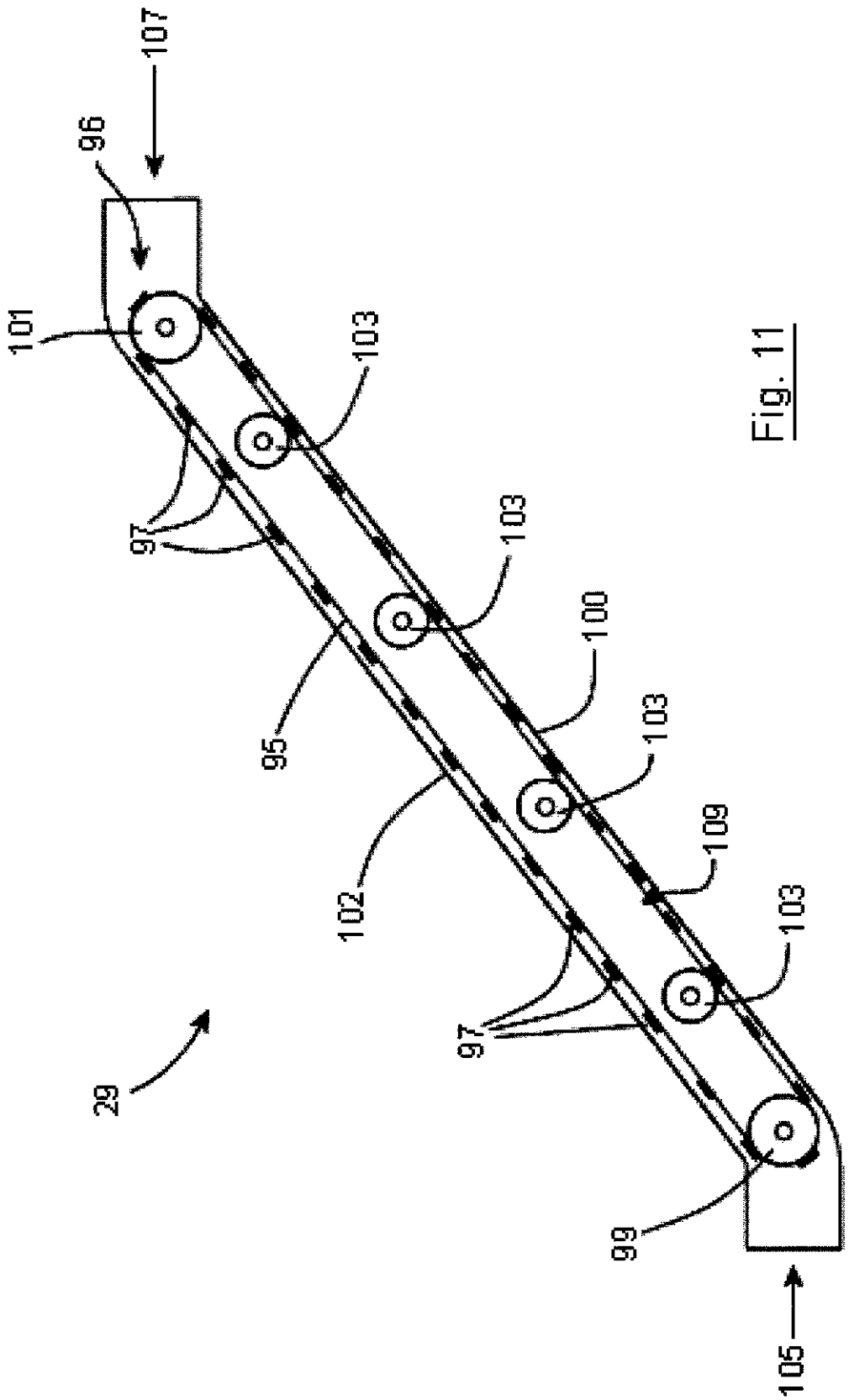

Fig. 11

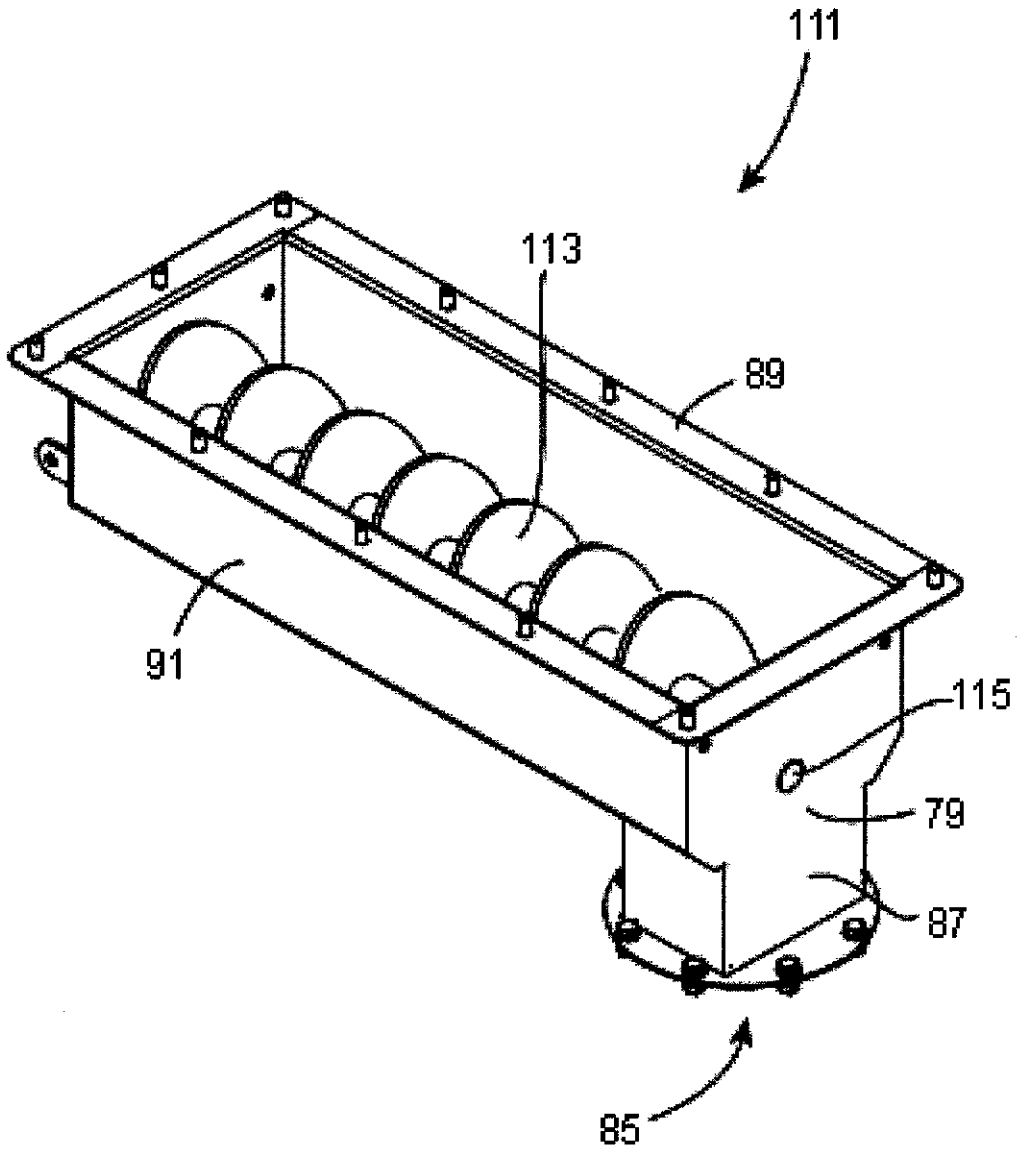

Fig. 12