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(54) DEVICE FOR REMOVING PARTICLES FROM A MATERIAL IN MOVEMENT

(57) The present invention concerns a device (1) for removing particles from a material in movement, wherein said particles comprise or are made of a substance that is attracted by a magnet. In a practical embodiment, the device (1) is used to remove iron particles from a stream of flour, for example flour produced in a mill and being dropped by way of gravity through the device (1) of the invention. The device (1) comprises a trapping arrangement (7) that is movably connected with respect to the device (1) in such a manner that a first trapping area (7a) is in a trapping position inside a channel (4) of the device (1) while a second trapping area (7b) is in a release position, releasing trapped particles. The trapping arrangement (7) then moves such that said second area (7b) gets into the trapping position and the first area (7a) to the release position. The device is self-cleaning and allows continuous removal of iron particles.

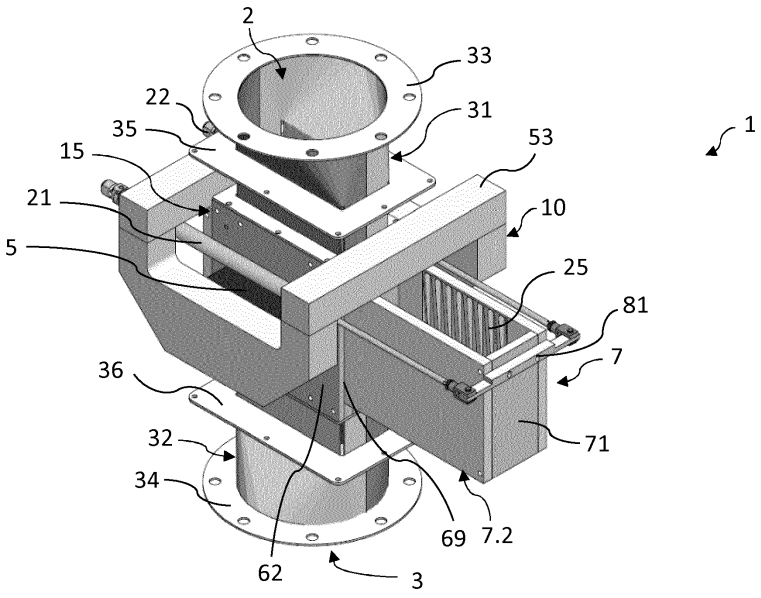

Figure 1

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Description

Technical Field

[0001] The present invention relates a method for removing particles from a material in movement and to a device for removing particles from a material in movement, wherein said particles comprise or are made of a substance that is attracted by a magnet.

Background Art and Problems Solved by the Invention

[0002] The present invention addresses the objective of removing undesired particles from a material, in particular a material in movement. In particular, the invention addresses the problem of removing undesired iron particles or particles comprising in general a substance that is attracted by magnetic forces.

[0003] A typical example of a material comprising undesired particles is cereal flour. It is known that flour produced by certain milling techniques comprises unwanted iron particles, which particles typically have a size in the micron to centimetre range. The flour is generally transported from the mill to an appropriate packaging or filling installation. For example, the flour is generally transported through a channel system transporting the flour to an appropriate packaging installation. In cereal mills, the cereals are typically inserted into the mill from the top, and the cereals move through the mill under the effect of gravity or vacuum. At the end of the mill, the flour obtained is dropped into a recipient, where it can be further processed and/or filled. It is an objective of the invention to remove the iron particles during the movement of the flour.

[0004] Similar examples where there is a need for removing iron and related particles from a powdered material are, for example, in the processing of cocoa, coffee, powdered ingredients, production of medicaments (pharma), and ceramic powders. Furthermore, iron or any para-, dia- or ferromagnetic particles may also be present in liquids, such as juice and other beverages. The invention also seeks to provide a solution that can be applied to various areas where undesired particles are to be removed, as long as said particles can be attracted or repulsed by magnetic forces.

[0005] Due to the use of cereal flour as food or food ingredient, such iron particles are undesired, there being possibly a risk of harm to the consumer of food containing such flour.

[0006] The problem of removing iron articles from flour has been addressed in the art. For example, US 8,474,629 B1 discloses a tramp metal separation device for removing contaminants from a stream of raw material that is being conveyed by a pneumatic conveying device. The device comprises a magnet drawer, which can be removed from a primary housing to secondary housing, where metallic contaminants are removed from the magnet drawer.

[0007] Other examples of devices are disclosed in FR2447228A1, FR2722120A1, US4157955A, US5740919A, and US8474629B1.

[0008] The devices disclosed in US 8,474,629 B1 and the other documents cited are not satisfactory for various reason. The main reason being that, for cleaning the device and/or removing the iron particles from the magnets, the operation of the device has to be stopped or the removal of iron particles is interrupted during the cleaning period. During the cleaning, iron particles are thus not removed from the stream of flour, which is why a certain amount of iron particles remains in the flour. In other prior art solutions, the entire milling process has to be stopped for cleaning the device and for removing iron particles that were collected by the device from the flour.

[0009] It is an objective of the invention to provide a device that is self-cleaning and that removes undesired particles continuously from a medium in movement, such as flour.

[0010] It is an objective of the invention to provide a device for removing undesired particles, such as iron particles or tramp metal particles, which device can be readily integrated in existing installation, for example existing milling and/or cereal processing installations.

[0011] Furthermore, many prior art devices rely on external power supply for operation. It is an objective to provide a device that remains operational and that uses comparatively little or less power in comparison to devices that use electric motors, for example. It is another objective of the invention to provide a device that does not require an electromagnet.

[0012] Undesired particles may be present in other materials or mediums, including liquid mediums. The present invention seeks to provide a device that can be used for removing the particles from any fluid, stream or fluid transporting a material containing such particles.

[0013] The present invention addresses the problems depicted above.

Summary of the Invention

[0014] Remarkably, the present inventors provide a device that is self-cleaning and/or that is capable of continuously removing particles from a material in movement.

[0015] In an aspect, the invention provides a device for removing particles from a material in movement, wherein said particles comprise or are made of a substance that is attracted by a magnet, the device comprising: an inlet opening and an outlet opening, a channel, wherein said inlet and outlet openings and said channel are arranged such that said material in movement can enter and/or is caused to enter said channel through said inlet opening and leave said channel through said outlet opening; one or more magnets, arranged in such a manner that magnetic flux lines extend in said channel such as to exert a force on said particles and to deviate a tra-

jectory of said particles in said moving material, a particle trapping arrangement, arranged such that particles in said moving material, the trajectory of which is deviated by said force, are at least temporarily retained on said trapping arrangement. Preferably, said trapping arrangement is mounted movably with respect to the channel and/or the device.

[0016] In another aspect, the invention provides a device for removing particles from a material in movement, wherein said particles comprise or are made of a substance that is attracted by a magnet, the device comprising: an inlet opening and an outlet opening, a channel, wherein said inlet and outlet openings and said channel are arranged such that said material in movement can enter and/or is can be made to enter said channel through said inlet opening and leave said channel through said outlet opening; one or more magnets, arranged in such a manner that magnetic flux lines extend in said channel such as to exert a force on said particles and to deviate a trajectory of said particles in said moving material, a particle trapping arrangement, arranged such that particles in said moving material, the trajectory of which is deviated by said force, are at least temporarily retained on said trapping arrangement, wherein said trapping arrangement comprises at least two trapping areas in the said trapping arrangement, a first trapping area and a second trapping area, and wherein said trapping arrangement is movably mounted on said device, in such a manner that a first trapping area can be moved from a first position or trapping position to a second position or release position, wherein, in said trapping position, the first trapping area is arranged with respect to said magnetic flux lines in such a manner that said particles are deviated towards and retained on said first trapping structure, and wherein, in said release position, said first trapping area is arranged with respect to said magnetic flux lines in such a manner that said particles are no longer retained on said first trapping area and can be removed or dropped from said first trapping area. Preferably, said trapping arrangement is arranged such that when said first trapping area is in said release position, said second trapping area, is in the trapping position.

[0017] Further aspects and preferred embodiments of the invention are defined herein below and in the appended claims. Further features and advantages of the invention will become apparent to the skilled person from the description of the preferred embodiments given below.

Brief Description of the Drawings

[0018] In the drawings,

Figure 1 is a top and lateral perspective view of a device in accordance with an embodiment of the invention. An external housing of the device is not visible for reasons of better illustration. Electronic circuitry of the device is not shown.

Figure 2 shows is a front perspective view of the device shown in Figure 1, with the housing being partially present. A front panel of the housing is removed for illustrating elements inside the housing.

Figure 3 is a bottom and lateral perspective view of the device shown in Figure 1.

Figure 4 is an exploded view of the device of Fig. 1.

Figures 5 A and **5 C** are longitudinal sections through the device shown in Fig. 1.

Figures 5 B is a top down view onto the device of Fig. 1.

Figure 5 D is an enlarged view of a support of the trapping arrangement of the device of Fig. 1.

Figure 6 shows some elements of the device in Fig. 1 partially disassembled for illustration

Figures 7 shows the magnets as well of a bridge structure and/or magnetic circuit of the device shown in Fig. 1.

Figures 8 shows magnetic flux lines of the magnet structure in the device shown in Fig. 1.

Figures 9 A and **9 B** show the operation of the device of Fig. 1 when removing iron particles from a stream of flour. As in Fig. 1, the housing and electronic circuitry of the device is not shown.

[0019] Hereinafter, preferred embodiments of the device of the invention are described with reference to the drawings, in order to illustrate the invention, without any intention to limit the scope of the present invention.

Detailed Description of Preferred Embodiments

[0020] The present invention generally relates to a device for removing particles from a material in movement, wherein said particles comprise or are made of a substance that is attracted by a magnet.

[0021] Said particles are preferably selected from particles that comprise and/or consist of a substance that has properties selected from paramagnetic, ferromagnetic properties and combinations thereof. Preferably, said particles are attracted by a magnet. In an embodiment, said particles comprises or consist of a metal that is attracted by a magnet. In a typical and preferred embodiment, said particles are iron particles. In some embodiments, said particles are tramp metal particles, in as far such particles are attracted by a magnet.

[0022] For the purpose of the present specification and in particular for illustrating the invention with reference to the figures herein below, said "particles that are at-

tracted by a magnet" are referred to as "particles". Iron particles are a particular embodiment of said particles.

[0023] The device of the invention is preferably suitable to remove said particles in as far as they are contained in or part of a material in movement. In a preferred embodiment, said material in movement is a fluid and/or a material suspended in a fluid. For example, said fluid may be air or a liquid, such as water, for example. The material from which particles are to be removed may be suspended in the fluid, or the material containing the particles may be the fluid itself.

[0024] In some preferred embodiments, the material is a powdered material, granulate and/or particulate material, for example, comprising said particles to be removed. For example, the material is a powdered food or food ingredient, such as a powdered material comprising starch powder, flour, cocoa powder, coffee powder, milk powder, and/or any powdered nutritional formula, such as an infant formula. In other embodiments, the material is a powdered formulation of a medicament, which is to be processed to pills, tablets, and so forth, for example. In yet other embodiments, the material is a powder intended for industrial use, such as a powder comprising ceramics or components of a ceramics, powdered organic polymer material, and so forth.

[0025] In a preferred embodiment, said material is flour, preferably cereal flour. The device of the invention may be integrated in a mill.

[0026] In some embodiments, the device shown in the figures may be adapted to the removal of particles from liquid fluids. Furthermore, the device can be adapted to the size of the particles to be removed, by choosing magnets having the appropriate strength, for example.

[0027] In some embodiments, the device of the invention is arranged for removing particles from a material in movement. The material may be caused to move in any appropriate way, for example by transporting on a conveyor belt. The device shown in the figures is particularly adapted to remove particles from a powdered material that is moving under the effect of gravity. In this embodiment, the powdered material is for some time suspended in air, while it falls through a channel, pipe or any zone arranged for the powdered material to fall through.

[0028] There is preferably a force acting on said material. In an embodiment, the device is arranged in such a manner that gravity or vacuum supply causes the material to be in movement. In other embodiments, the material may be transported or conveyed actively, for example by way of motors acting for example, on a conveyor belt on which the material is placed, or by applying a pressure on the material, for example in case of a liquid.

[0029] The device shown in the figures is arranged for removing particles from a powdered material that is falling under the effect of gravity. For this reason, the device comprises a substantially vertical orientation, with a substantially vertical channel extending through the device, and top and bottom openings 3, 4 aligned substantially vertically. However, the invention can be integrated into any type of channeling or transporting system and can be oriented in any desired way. Furthermore, the device may comprise tubing, channeling or guiding the material or for changing the direction of a material from which particles are to be removed.

[0030] For the purpose of the present specification, the expressions "rear", "front", "left", "right", "top," and "bottom" are used to describe the relative position of various structural parts of the device of the invention. These terms apply in particular to the device in a position as shown in Figure 2. These terms are arbitrarily chosen on the basis of the way the device is oriented in Figure 2 and should not be interpreted in a limitative manner with respect to the scope of the present invention.

[0031] In the exploded view of Figure 4, axis 82, 83 and 84 are shown to define space. The left to right direction extends along axis 82 from left to right as shown in Fig. 4. The rear to front direction extends along axis 83 from right to left as shown in Fig. 4. The top-down direction extends along axis 84 from top to down as shown in Fig. 4.

[0032] In the figures, except for Figure 2, an external casing or housing has been removed for better illustration. The housing can be seen partially in Figure 2. As can be seen from Figure 1, the device 1 comprises top inlet and bottom outlet openings 2, 3, respectively. The material from which particles are to be removed preferably enters the device through the inlet opening 2 and the material from which the particles have been removed exits the device 1 through outlet opening 3. The material preferably passes through the device when said particles are being removed. The device thus preferably comprises a channel 4, through which the material is guided, which channel can be seen when looking from the top onto said inlet opening, as in Fig. 5B, or in the section shown in Fig. 5C, for example.

[0033] The device preferably comprises a trapping arrangement, which is designated with reference numeral 7, as well as a magnet arrangement 5, 6, 10, comprising the magnets 5, 6 and a bridge structure 10.

[0034] In the embodiment shown, the inlet and outlet openings 2, 3 are formed by the top and bottom inlet and outlet modules 31, 32, which preferably comprise tubular or otherwise channeling parts, confining channel areas through which said material can pass. At their external or distal extremities, said inlet and outlet modules 31, 32 comprise flanges 33, 34, which are arranged for allowing the device to be fixed to an existing channeling or transporting system provided for transporting the material, thereby allowing the device to be conveniently integrated into such existing channeling system.

[0035] Furthermore, each opening module 31, 32 may comprise a second flange 35, 36, which is provided for attaching the housing to the entire device, in such a manner that the housing covers and/or protects the trapping arrangement 7 and the magnet arrangement 5, 6, 10, as well as the central channel 4. The flanges 33, 34; 35, 36 may comprise holes for allowing fixing of the device to

the existing channeling system and fixing the housing, respectively.

[0036] In Figure 2, the housing 30 is visible. The housing has an overall cuboid outer dimension and is basically composed of metal or plastic sheet. The housing has front and back, left and right and top and bottom panels. The front panel is removed in Fig. 2, such that some elements of the device inside the housing can be seen. Furthermore, two collectors 41 and 42 are shown in Figure 2. In the embodiment shown, the collectors are actually in the form of recipients that are open towards the top. The collectors 41, 42 are arranged on left and right sides of the device as shown in Fig. 2. They are preferably positioned so as to collect any dropping particles that are dropped from the trapping arrangement 7, in particular from those parts of the trapping arrangement that come to be positioned vertically above the collectors 41, 42. In Fig. 2, part of the trapping arrangement is positioned above the first collector 41, such as to collect particles dropping from the trapping arrangement, as will be described in more detail further below.

[0037] Instead of recipients, collectors 41, 42 could be different from a recipient. For example, the collector could be a tube or a conveyor, collecting and/or transporting particles that are removed from the trapping areas.

[0038] As can be seen in Figures 1, 2 and 3, the device comprises at least one magnet, preferably a first and a second magnet 5, 6. The device further preferably comprises a bridge structure or magnet circuit 10. The magnets 5, 6 are preferably permanent magnets. In other embodiments, the magnets may also be electromagnets. The latter, however, are less preferred, for example due to their need for electric power to be active.

[0039] The first and second magnets 5, 6 are arranged in such a manner that magnetic flux lines extend in the channel 4 so as to exert a force on said particles and to deviate a trajectory of said particles in said moving material. The channel 4 is inside the device, as indicated in Figures 5A-5C and 9B, and some of the structural elements that delimit the channel towards the outside are visible in Figs 1-3. In the embodiment shown, the channel 4 comprises and/or consists essentially of a cuboid space with two opposed openings where the channel is joined with the inlet and outlet modules 31, 32.

[0040] The magnetic flux lines between the first and second magnets 5, 6 are specifically illustrated in Figure 8, in which the channel arrangement 15 and the trapping arrangement 7 are not shown for better illustration. The first magnet 5 comprises a north pole 11, which is arranged to face a south pole 12 of said second magnet 6, thereby generating the magnetic flux lines 50 emanating from the north pole of the first magnet and extending to the south pole of the second magnet. The magnets are arranged such that magnetic flux lines between said north pole 11 and said south pole 12 traverse said channel 4. Of course, the poles of said magnets as shown in the figures could be inverted, such that the south pole of the first magnet 5 faces the north pole of the second magnet. Figure 8 shows one or two possible configurations.

[0041] For the purpose of the present specification, the "north pole" is preferably the pole that is repulsed by the north pole of another magnet, but attracted by the south pole of another magnet. Instead of "north pole" and "south pole", one may also refer to "first pole" and "second pole", respectively. In the device of the invention, the first and second magnets are preferably oriented such that two opposed poles, which attract each other, are position to face each other.

[0042] In a preferred embodiment, said one or more magnets are permanent magnets.

[0043] In an embodiment of the invention, a south pole 13 of said first magnet 5 is connected with a north pole 14 of said second magnet 6 by way of a material connection, such as a material bridge 10, which provides a magnetic circuit 10. The material bridge 10 may be made from iron, for example, or another material suitable to guide magnetic flux lines. Preferably, said material bridge 10 comprises or consists essentially of a magnetic, ferromagnetic and/or paramagnetic material. The purpose of the material bridge is to provide said magnetic circuit for directing or channelling the magnetic flux lines that emanate from the north pole 14 of the second magnet 6 and extend to the south pole 13 of the first magnet 5, thanks to said bridge 10.

[0044] The bridge 10 provides advantageous effects. For example, it prevents open magnetic flux lines that extend in any direction.

[0045] In this regard, in an embodiment of the device of the invention said one or more magnets 5, 6 are arranged so as to form a closed magnetic field.

[0046] In addition, the bridge 10, due to the way the magnets 5, 6 are arranged preferably outside the channel 4 and/or preferably on opposed sides of said channel, results in the controlled orientation of the magnetic flux lines caused by said magnets. In this manner, the magnetic flux lines are to a large extent confined in the channel 4 and their orientation in said channel is also controlled, so as to force particles entering the channel to move in a particular direction, namely towards said trapping arrangement 7. Since the magnetic lines from the north pole 14 of the second magnet 6 are channeled through the bridge 10 to the south pole 13 of the first magnet 5, they are not visible in Figure 8, since in this view the two lateral bridge bars 53, 54 are not shown in section.

[0047] In a preferred embodiment, the device of the invention comprises at least two magnets 5, 6, wherein said magnets 5, 6 are arranged on two opposed sides with respect to said channel 4, such that magnetic flux lines created by said magnets pass through said channel 4, preferably substantially perpendicularly with respect to an overall flow direction of a material in said channel. Preferably, the magnets are arranged or fixed outside the channel 4.

[0048] The bridge 10 forming the magnetic circuit is discussed in more detail with reference to Figs. 4, 6, 7

and 8. The magnetic circuit 10 comprises first and second main or base circuit structures or parts 51, 52, which are, respectively, arranged or connected on the outer sides of magnets 5 and 6, respectively. It is noted at this stage that the first and second magnets both have an overall cuboid shape, with substantially flat inner and outer sides or surfaces. The circuit structures 51, 52 have also inner and outer (front and rear) flat sides.

[0049] In this specification, the inner side of any respective magnet is the side that faces the channel 4, while the outer side is oriented away from said channel. In other words, in the embodiment shown, the inner sides of the magnets 5, 6 face each other. In particular, the inner side of the first magnet 5 harbors the north pole 11 of the first magnet, while the inner side of the second magnet 6 harbors the south (or opposed) pole 12 of the second magnet 6.

[0050] In the embodiment shown, the base structures 51 and 52 are identical in shape. Preferably, the base structures 51 and 52 comprise or are made from a ferromagnetic material. In the embodiment shown, they comprise each a main or body part 51c, 52c, which resembles the shape of an isosceles trapezoid.

[0051] The base structures 51, 52 comprise, on left and right, opposed ends of the upper side (corresponding to the larger side of said trapezoid) first and second teeth 51a, 51b and 52a and 52b, respectively.

[0052] When the bridge 10 is assembled, as shown in Figure 7, the first and second base structures 51, 52 are in contact with the outer sides of said first and second magnets 5, 6, respectively. Preferably, the surface of the main parts 51c, 52c of the base structures 51, 52 is at least sufficiently large to cover the entire outer surface of said first and second magnets, respectively. Preferably, the main or base structures 51, 52 extend at least laterally and/or on the top and/or bottom beyond the outer surfaces of the first and second magnets, for example for guiding magnetic flux lines accordingly, preferably away from the channel 4, as discussed below. This applies to magnetic flux lines that emanate or lead to the poles on the respective outer surfaces of the magnets.

[0053] The first and second main structures 51, 52 are connected with each other at their respective lateral and/or top teeth 51a, 51b and 52a, 52b, by way of first and second lateral bars 53, 54. These bars are preferably made from the same ferromagnetic material as said main structures 51, 52, for example from iron. In particular, a first lateral tooth 51a of the first main structure 51 is connected with a first lateral tooth 52a of the second main structure 52 by way of a first bar 53, and the same applies on the other lateral side to the second lateral teeth 51b, 52b and the second bar 54. Instead of teeth 51a, 51b and 52a, 52b, the main structures 51, 52 may comprise any other geometrical configuration suitable to connect the main structures to form a magnetic circuit. Indeed, the entire material bridge may be made from pieces and shapes different from those shown in the figures. For example, the bridge 10 may be made in one piece. Preferably, the magnetic bridge is constructed so as to physically connect opposed magnetic poles that are oriented outside, that is away from the inside of the channel 4.

[0054] As seen for example, in Figs 7 and 8, the first and second magnets and the magnetic circuit 10 form an overall closed magnetic field and/or circuit. As can further be seen from Figs 1, 2, 3,5A-5C, the magnetic circuit as provided by the bridge 10 extends next to and outside of channel 4. Preferably, the magnetic circuit 10 extends laterally and/or on the top or bottom with respect to a space defined by said channel 4. Preferably, the material bridge 10 is arranged outside and/or around the channel 4 and/or the channel arrangement 15, preferably extending at the periphery of the channel arrangement 15.

[0055] In particular, the first and second bars 53, 54 are arranged to extend laterally from said channel. In the embodiment shown, the bars 53, 54 extend on top of the space enclosed by said channel 4 and also above the trapping arrangement 7, which will be discussed below. In another embodiment, the bars 53, 54 may also extend below the channel 4 and/or trapping arrangement 7. The magnetic circuit 10 and in particular the bars 53, 54 preferably go around said channel 4 and/or said trapping arrangement 7. This is preferably arranged in such a manner that the magnetic circuit 10 and/or the bars 53, 54 do not interfere with or hinder the movement of the trapping arrangement 7.

[0056] In an embodiment, the device of the invention comprises two magnets 5, 6 and at least one bridge structure 10 connecting opposed poles of said two magnets, wherein said bridge structure 10 is arranged to extend next to and/or remain outside said channel 4. The material bridge structure 10 is interlinked with said magnets so as to assists in and favour the creation of a closed magnetic circuit.

[0057] The trapping arrangement 7 is preferably movably connected to the device 1, preferably the arrangement 7 is movably connected with respect to the channel 4. Below, the way the channel 4 is formed will be described first, for better understanding how the trapping arrangement is movably connected with respect to said channel 4.

[0058] In an embodiment, the channel 4 comprises or is formed by one or more wall elements. For the purpose of this specification, reference numeral 15 is used for designating the fixed structural elements contributing to forming the channel 4. These structural parts are summarily referred to as channel arrangement 15. In the embodiment shown, the channel arrangement is actually a channel assembly, formed from several structural elements that are connected with each other. The invention also encompasses that the channel arrangement 15 is made from one piece.

[0059] Said wall elements of the channel arrangement, and preferably the entire channel arrangement 15, including wall elements, guiding and fixing bars or struts and the like, preferably comprise a nonmagnetic material,

and preferably consists essentially of a nonmagnetic material. For example, the channel arrangement may comprise or consists of a nonmagnetic metal, such as aluminum, or plastics materials. The channel arrangement 15 is preferably not attracted or repulsed by the magnets used in the device and does not interfere with or affect substantially the magnetic flux lines produced by the magnets.

[0060] As can be understood from Figs 3, 4, 5 A and 6, the channel 4 comprises several wall elements 61, 62, 65, 66. The channel 4 has inlet and outlet openings, preferably on opposed ends of the channel, preferably on top and bottom ends of the channel 4. In the embodiment shown, the channel arrangement 15 is cuboid and comprises four wall elements 61, 62, 65, 66, forming rear and front walls 61, 62, and right and left wall elements 65, 66, connected to each other so as to form four flat sides of a cuboid, of which the top and bottom sides are open, thereby providing said inlet and out let openings. At the top and bottom open sides or extremities, the channel arrangement 15 is connected to said inlet and outlet modules 31, 32, respectively.

[0061] Preferably, in the assembled device, right and left walls 65, 66 are parallel with respect to each other. Rear and front walls 61, 62 are also parallel with respect to each other and perpendicular with respect to the lateral walls 65, 66, thereby forming said cuboid with open top and bottom faces, forming inlet and outlets of the channel 4.

[0062] The rear and front walls 61, 62 may comprise cutouts 63 in the form of a recess on their outer sides. These recesses have preferably an outline matching the flat surface of the respective magnets 5, 6 and are provided to allow precise positioning of the magnets on the respective rear and front wall, respectively. As mentioned elsewhere, the first and second magnets are preferably positioned in parallel and aligned so that opposed poles are positioned opposed to each other, while being spaced apart by the channel arrangement 15. The reduced thickness of the walls 61, 62 at the zone of the recess 63 also has the consequence that the wall is thinner in this zone, such that the effect of the wall on the magnetic flux lines is minimized. Preferably, the cutouts 63 in walls 61, 62 of the channel 4 are not through holes, but provide a defined zone of reduced thickness of said walls.

[0063] The channel arrangement 15 preferably comprises two pairs of rear and front spaceholder or guiding bars 67a, 67b and 68a, 68b, respectively. The rear bars 67a, 67b are fixed along the top and bottom edges, respectively, of the rear wall 61, and the front bars 68a, 68b, are fixed along the top and bottom edges, respectively, of the front wall 62. The bars are fixed on the inner or inside surfaces of said wall elements, as can be understood from Fig. 4. The left and right lateral walls 65, 66 are fixed in the channel arrangement 15 to be in contact with the guiding bars and not to be in direct contact with the rear and front walls 61, 62. In this manner, openings or slots are formed in the overall channel arrangement, which slots will be used to allow movement of the trapping arrangement 7 and to guide the latter to perform a linear, translational movement.

[0064] In the figures, the openings or slots formed in the channel arrangement 15 cannot be seen directly, because the rear and front trays 7.1, 7.2 of the trapping arrangement fit precisely in these slots and thereby "fill" the slots. In particular, the trays 7.1 and 7.2 move through these slots when the trapping arrangement 7 is caused to change position. In Figs 1 and 6 reference numeral 69 indicates the position of one of four slots formed in the channel arrangement 4. In particular, 69 indicates the longitudinal line which is an inner edge of the front wall 62, which is where the front (or second) tray 7.2 exits or extends through the slot. For the purpose of the present specification, reference numeral 69 is used to refer to any opening or slot provided in the channel arrangement for allowing entering and/or exiting of trapping areas.

[0065] As the skilled person will understand from the figures, there are two, left and right slots on the front side, and two, left and right slots on the rear side of the channel arrangement as shown in Fig. 1. There are thus overall four slots. During movement of the trapping arrangement, the front tray 7.2 will be moved in and/or through the two lateral slots on the front side, and the rear tray 7.1 will be moved through the two lateral slots on the rear side of the channel arrangement. The presence of the four slots enables the trapping arrangement to move left and right, that is, to move through the channel arrangement 15 on the right side and/or on the left side of the channel arrangement. Indeed, the trays 7.1 and 7.1 are sufficiently long so as to stay constantly within said slots, even when being moved, they do never entirely exit a slot, such that said slots remain closed at least towards the outside. The slots stay "filled" with the trays during any movement. Thanks to grooves 25 on the inner sides of the trays, particles can exit the channel through these slots with the trays, the particles stinging to the surface in these grooves.

[0066] In an embodiment, the trapping arrangement comprises supports 7.1, 7.2, on which one or more trapping areas are provided. In the embodiment shown, these supports are the first and second tray 7.1, 7.2. For the purpose of the present specification, the term "tray" is intended to mean any support suitable to provide and/or carry a trapping area. The term "tray" preferably encompasses flexible supports, for example, and/or supports that are not overall flat. In a preferred embodiment, said "tray" is indeed an overall flat, tray-like and/or rigid structure as shown in the figures, comprising two main opposed sides, on at least one of which at least one trapping area is provided.

[0067] In the embodiment shown, the trapping arrangement 7 also comprises four lateral wall elements forming an essentially cuboid wall arrangement, of which two sides are open, forming preferably top and bottom openings in said cuboid. The trapping arrangement 7

comprises the rear and front trays 7.1 and 7.2, which form rear and front walls of the cuboid, and lateral, left and right walls 72, 71, closing the cuboid laterally. The trays 7.1 and 7.2 are preferably substantially parallel with respect to each other, with flat surfaces facing each other on opposed sides of a cuboid containing said trays. The left and right walls 72, 71 are preferably substantially parallel with respect to each other with flat surfaces facing each other on opposed sides of a cuboid containing said walls 71, 72. Preferably, the walls 71, 72 are substantially perpendicular with respect to said trays 7.1, 7.2.

[0068] The dimensions of the trays and lateral walls 7.1, 7.2, 72, 71, are such that the cuboid formed by these walls can be guided in said slots and can perform said linear and/or translational movement with respect to the channel arrangement 15. This movement reminds remotely the movement of a drawer with respect to a commode or of a matchbox.

[0069] The lateral walls 71, 72 of the trapping arrangement are constantly outside the channel 4 formed by the channel arrangement. On the other hand, the lateral walls 65, 66 of the channel arrangement 4 form stationary abutment surfaces for the linear movement of the trapping arrangement 7.

[0070] As can be understood from looking at Fig. 6, when said trapping arrangement 7 moves from the position shown in Fig. 6 towards the left, wall 71 will eventually abut against wall 65, thereby preventing the trapping arrangement 7 from exiting completely the channel arrangement 4. The same applies when the trapping arrangement moves back from a position corresponding to that shown in Figs 5A or 9A to the position shown in Figs 6 or 9B, for example. Therefore, the trapping arrangement is 7 is arranged to be movable and in particular slidable with respect to the channel arrangement 15, but is at the same time confined by the latter with respect to that movement.

[0071] The trapping arrangement 7 is made to move by way of linear actuators 21, 22, which in Fig. 2 are fixed on rear and front sides with respect to the channel arrangement 15, for example on the outer sufaces of walls 61 and 62. The moving pistons 21a, 22a (Fig. 4) of the actuators are fixed to opposite ends of a transversal fixing piece or bar 81, which is connected rigidly to the trapping arrangement. In the embodiment shown, the fixing bar is fixed to right lateral wall 71 of the trapping arrangement 7 (Fig. 1). Of course, an attachment assembly may be provided on the left lateral wall 72, if actuators 21 and 22 are inverted.

[0072] In an embodiment, the device of the invention comprises at least one actuator 21, 22, preferably a pneumatic actuator, wherein said actuator 21, 22 is arranged so as to act on said trapping arrangement 7 and so as to move a trapping area 7a, 7b from a trapping position to a release position and/or from a release position to a trapping position.

[0073] In a preferred embodiment, the trapping areas 7a, 7b of the device of the invention comprise or consist essentially of a nonmagnetic material. Preferably, the support on which the trapping areas are provided comprise or consist essentially of a nonmagnetic material. In the embodiment shown, the support for the trapping areas is provided by the trays 7.1, 7.2. Preferably, the entire trapping arrangement 7 comprises or consists essentially of nonmagnetic material. The trapping arrangement includes the trays, side walls 71, 72, and optionally said connector or linker 81, allowing fixing the trapping arrangement with respect to the actuators 21, 22. The actuators may or may not comprise or consist essentially of nonmagnetic material. Nonmagnetic materials may be selected from nonmagnetic metals, such as aluminum and plastics, for example. The trapping arrangement 7 preferably does not interfere with the magnetic flux lines produced by the magnets.

[0074] In an embodiment, said actuators 21, 22 are pneumatic actuators. Of course, also other types of actuators may be used in accordance with the invention. Indeed, any type of actuator can be used. The device may also be operated with more than two actuators or with only one actuator. The actuators in the embodiment shown are preferably capable of moving actively in either of two linear directions, back and forward (or left and right, when referring to Fig. 2), and therefore are arranged to move the trapping arrangement back and forth (left and right).

[0075] In other embodiments of the invention, the trapping arrangement is caused to move by other propelling means, such as motors, for example electric motors. Indeed, the present invention is not limited to a particular way of causing the movement of the trapping arrangement 7. The device preferably comprises means for propelling the trapping arrangement 7.

[0076] It is worthwhile noting that the trays 7.1, 7.2 of the trapping arrangement 7 are guided through said slots in the wall arrangement, such that at least part of their surfaces are at some point inside the channel 4. More specifically, the trays 7.1, 7.2 are arranged in parallel, with their outer surfaces lying upon the inner surfaces of the rear and front walls 61, 62 of the channel arrangement, respectively. As a consequence, part of the inner surfaces of said trays 7.1, 7.2 face the inside of channel 4 and thereby form inside limitation of the channel 4 on the sides where the trays extend. The channel 4 is thus delimited towards the inside by inner faces of lateral walls 65 and 66 and the inner faces of trays 7.1, 7.2.

[0077] In an embodiment, said trapping arrangement 7 provides and/or replaces at least part of the inner surface of said channel 4. In an embodiment, the trapping arrangement provides or replaces at least an entire wall or an entire inner side wall surface of said channel 4. In an embodiment, said trapping arrangement provides at least part of two opposed inner walls of channel 4.

[0078] On their surfaces facing the inside of the channel 4, the trays 7.1, 7.2 comprise trapping or particle retaining areas 7a-7d. Trapping areas 7c and 7d provided on the second tray 7.2 are not directly visible in the fig-

ures, since they are oriented towards the rear side of the device. Their position is indicated in Fig. 5B and their construction can be deduced from the tray 7.1, which in the embodiment shown is mirror symmetrical. Each trapping area comprises structures 25, such as recesses, that preferably favor the retention of the particles while the trapping arrangement moves. For example, the recesses favor the retention laterally while the trapping arrangement moves. The recesses also allow particles captured in the trays to exit with the tray through the lateral slots as mentioned above. Furthermore, the trapping areas comprise a discharging area 26, favoring the discharge of the particles, preferably under the force of gravity, when the respective trapping area is in a release or discharge position.

[0079] Figure 5D provides an enlarged view of the first tray 7.1, as shown in Fig. 4. As discussed above, the second tray 7.2 is substantially identical or preferably mirror symmetrical to the first tray 7.1, so that the description herein also applies to the second tray and to the respective trapping areas 7c and 7d. The tray has an overall rectangular outline, delimited by four lateral sides 76-79, which lateral sides are preferably provided by straight, flat surfaces. The thickness (d) (not shown in the figures) of the tray 7.1 is defined by the extension of the tray along axis 83. It is further noted that the two trapping areas 7a and 7b are characterized by the presence of one or more recesses, such as grooves 25, extending here along the top-down direction. The recesses 25 define areas of reduced thickness of the tray, compared to the thickness along the lateral sides 76-79.

[0080] In the particular embodiment shown, each trapping area 7a, 7b also comprises a discharge zone 26, which provides a transition between the areas of reduced thickness and the bottom side 77 of the tray. This discharge zone may also be absent and may be replaced, in accordance with an embodiment, with an opening or cutout in the bottom side 77 of the tray.

[0081] In the embodiment shown, each trapping area is separated laterally (along axis 82 in Fig. 4) by areas or zones 73-76 that do not have said recesses and do thus not have said reduced thickness. These zones or areas 73-76 delimit the trapping areas laterally. In the embodiment shown, the delimitation zones 73-76 are in the form of rectangular surfaces, extending preferably in the form of bands along the top-bottom axis. The first trapping area 7a is delimited on the left and right lateral side by flat surfaces 73 and 74, and the second trapping area 7b is delimited on the left and lateral sides by flat surfaces 74 and 75 respectively. There is a flat surface 74 between said first and second trapping areas 7a, 7b, separating the latter along the left to right extension of the tray (along axis 82).

[0082] The one or more recesses 25, for example in the form of grooves 25 provided in the trapping areas of each tray 7.1, 7.2, provide one or more zones of reduced thickness of the flat surface of the tray facing the inside of the channel 4 in the assembled device. In an embodiment, said zone of reduced thickness defines and/or substantially corresponds to a trapping area.

[0083] The thickness of the tray 7.1 in zones 73-75 preferably defines the overall thickness (d) of the tray. This thickness (d) is adapted to fit into the slots 69 (Fig. 6) provided in the channel arrangement 15. The dimensions of the slots and the trays match each other, just to provide sufficient play allowing the trays to slide in the respective slot. Accordingly, the extension of the slots along front to rear axis 83 is just slightly larger than the thickness (d) of the trays 7.1, 7.2.

[0084] It is noted that in the embodiment shown, the overall device is preferably essentially symmetrical, that is, comprises two longitudinal planes of symmetry, if one ignores the electronic components, the actuators 21, 22 and the actuator fixing bar 81. The two planes of symmetry are perpendicular with respect to each other and extend along axis 82 and 83 (Fig. 4).

[0085] As a consequence of the symmetry, the two trays 7.1 and 7.2 are oriented in parallel and positioned or aligned so as to face each other, with a first trapping area 7a of the first tray 7.1 facing a first trapping areas 7c of the second tray 7.1, and the second trapping area 7b of the first tray 7.1 facing the second trapping area 7d of the second tray 7.2.

[0086] The first and second trapping areas 7a, 7b are arranged next to each other on the first tray 7.1, and the same applies two the two trapping areas 7c, 7d of the second tray 7.2.

[0087] In an embodiment, said first and second trapping areas 7a, 7b are connected one with respect to the other, preferably rigidly connected with each other.

[0088] In an embodiment, said first and second trapping areas 7a, 7b are arranged in the same plane and/or are aligned with respect to the same plane.

[0089] For removing for example iron particles from the material in movement, it is preferred that both trays 7.1, 7.2 comprise trapping areas, because the iron particles will always be attracted towards one of the two magnets and thus towards one of the two opposed trapping areas. The particles will thus be attracted towards one of the two supports 7.1, 7.2 and be retained on the trapping area on the respective support. Generally, the particle is attracted towards the trapping area which is closer to the particle passing through the channel. The arrangement preferably comprises two mirror symmetrical trays 7.1, 7.2 and preferably works independently from the two possible ways of attaching the magnets 5, 6.

[0090] In the embodiment shown, the trapping structures 25 of one trapping area comprise a plurality of recesses, preferably longitudinal grooves 25 aligned next to each other. Preferably, said first and second trapping areas 7a, 7b each comprises a plurality of longitudinal ribs and/or grooves 25.

[0091] The grooves are parallel and oriented in the sense of the movement of the material that passes the channel, that is, the grooves extend from the top of towards the bottom of the respective trapping area.

[0092] With the above description in mind, the function principle of the device of the invention becomes clear. As can be better understood from Figures 9 A and 9 B, the trapping arrangement 7 is arranged such as to move from a first position, shown in Fig. 9A, to a second position, shown in Fig. 9B. The movement is achieved by displacing the trays 7.1, 7.2 through the respective slots in the channel arrangement 15 by activating the actuators 21, 22 accordingly. In the embodiment as shown in Figs 9A and 9B, the movement of the trapping arrangement 7 is a movement from the left to the right and *vice versa*, whereas the material in movement (here cereal flower) moves from the top to the bottom through the channel 4. In other words, the reciprocating movement of the trapping arrangement is substantially perpendicular to the movement of the flour in the particular embodiment illustrated. In the view Figs 9A and 9B, the second tray 7.2 is not seen.

[0093] A particularity of the embodiment shown is that there is always at least one and preferably at least two trapping areas in a trapping position, while the respective other (e.g. second) is in a release or discharge position. In Fig. 9 A, the trapping arrangement is shown in its extreme left position, and is arrested for a certain time in this position. The first trapping area 7a (of the first tray 7.1) is outside channel 4 and thus in a release position. It does not trap any particles, since it is outside the channel 4 and not in contact with the flour 80 moving from the top to the bottom, through said channel. In this particular embodiment shown, the flour may be moved under the effect of gravity. The flour 80 enters the channel 4 through the inlet 2 and enters the same through outlet 3 (Fig. 1). The flour is indicated as a white fuzzy, cloud-like material in Figs 9A and 9B. The white arrows indicate the direction of the movement of the flour 80, indicating further where the flour enters the device and exits the device.

[0094] In Fig. 9A, the second trapping area 7b of the first tray 7.1 is inside the channel and forms, as described above, an inner wall of the channel 4, preferably an inner side (rear) wall. Under the force of the magnets, the trajectory of iron particles contained in the flour are pushed (or attracted) towards the second trapping area 7b (or towards the trapping area 7d on the second tray 7.2), where they stay attached due to the magnets. After a predetermined amount of time, the trapping arrangement moves towards the right until it reaches the position shown in Fig. 6 or Fig. 9B.

[0095] During the movement from the position shown in Fig. 9A to the position shown in Fig. 9B, the second trapping area 7b exits the channel 4 through the lateral slot as described elsewhere. Thanks to the longitudinal ribs or grooves 25, the particles blocked on the second trapping area 7b follow the lateral movement of the trapping arrangement, but as long as a particle is still in the channel 4 and in particular under the effect of the magnets, it remains attached to the second trapping area 7b. Particles trapped on the fourth trapping area 7d (not shown) on the second tray 7.2 will also drop now. Thanks to the recesses 25 on the trapping areas, the particles do not obstruct the slot through which the second trapping area 7b exits the channel 4.

[0096] The magnets are arranged in such a manner that, once the second trapping area 7b has exited the channel 4 to come to the second position shown in Fig. 9B, the particles 70 on the second trapping area 7b (and on the fourth trapping area 7d) are no longer under the effect of said magnets. Indeed, the magnets are arranged so as not to have a strong retaining effect on the particles once the particles have been moved outside the channel on their respective trapping area. Therefore, in the position shown in Fig. 9B, the particles 70 drop from the second trapping area 7b under the effect of gravity, as indicated with the black arrow in Fig. 9 B. The particles 70 can be collected below the trapping area 7b (and 7d) by way of a collector entity 41, 42 (Fig. 2), for example a suitable recipient arranged so as to collect the dropping particles.

[0097] In an embodiment of the device, in said trapping position, said second trapping area 7b is inside said channel 4, and in said release position, it is outside said channel 4.

[0098] In an embodiment, the device comprises at least two release positions provided on two lateral sides, respectively, of said channel 4.

[0099] In an embodiment, the device comprises at least one collector 41, 42, arranged so as to collect particles that drop under the force of gravity from a trapping area 7a, 7b while the trapping area is in a release position. In other embodiments, the particles may be removed by way of other forces, in addition or instead to gravity. For example, the device may comprise a brush which removes the particles by brushing, or a second magnet arrangement, disposed to act of the particles once they are outside the channel 4 and/or separated from the material in movement. A still other possibility would be an aspirating device, removing particles by vacuum/aspiration.

[0100] It is interesting to note that, while the second trapping area 7b is now in a release position (Fig. 9B), the first trapping area 7a is in a trapping position, in particular inside the channel 4 and providing a trapping surface inside the channel 4. In the embodiment shown, the first trapping area 7a forms an inner surface of channel 4 as did the second area 7b in the position shown in Fig. 9A. The first trapping area 7a was moved to the position that the second trapping area 7b had before the displacement. When, after a predetermined time the trapping arrangement 7 moves back to the position shown in Fig. 9A, the first trapping area 7a will be again in the release position and will be releasing particles captured when it was inside channel 4.

[0101] It is also noted that, while the trapping arrangement 7 as a whole is arranged and/or displaced such as to be prevented from moving entirely outside the channel 4, individual trapping areas 7a-7e are arranged and/or displaced so as to move entirely outside the channel 4,

for reaching the discharge position where particles can be released. While one individual trapping area is outside the channel, at least one other trapping area of preferably the same trapping arrangement is inside the channel, attracting particles under the force of said magnets. Preferably, trapping areas enter and exit the channel 4 pairwise (7a and 7c; 7b and 7d) as can be understood from the mirror symmetric construction of the trapping arrangement and preferably the channel arrangement (Fig.5C).

[0102] In accordance with an embodiment of the invention, there is at least one trapping entity or area 7a or 7b disposed so as to capture or trap particles, while another trapping entity or area 7b or 7a, respectively, is cleaned and/or particles are removed from that entity or area. In this manner, particles are continuously removed from the material in movement, such a material in a stream. Furthermore, the device is preferably self-cleaning, in that particles are automatically removed from trapping entities 7a, 7b while the devices operates and continuously removes particles. It is noted that the above indicated also applies to trapping areas 7c and 7d, which are not visible in Figs 9A and 9B. Preferably, there is at least one pair of trapping entities or areas 7a, 7c disposed so as to capture or trap particles, while another pair trapping entities or areas 7b, 7d, respectively, is cleaned and/or particles are removed from that pair of entities or areas.

[0103] The positions of Figs 9A and 9B show the "end point" or "stop" positions of the movement of said trapping arrangement 7. In these positions, the trapping arrangement 7 is stopped from moving and/or immobilized for a predefined time period, so as to allow complete release of particles and, on the other hand, proceed with trapping particles on the one or more trapping areas that are inside the channel 4. When moving, the trapping arrangement switches between the two positions shown relatively rapidly. In a preferred embodiment, the time during which the trapping area is immobilized is longer than the time during which the trapping arrangement is displaced for switching the position, for example, twice or more as long.

[0104] It is noted that, in said stop positions, the slots 69 provided in the channel arrangement 15 are closed and/or filled by the respective tray, in particular by zones 73-75 of the tray, which are positioned in the very slots once the tray is immobilized after displacement/switching. In the embodiment shown, these zones are characterized in that they provide flat, smooth surfaces lacking recesses and that they have a thickness (d) corresponding substantially to the thickness of the openings 69.

[0105] As can be understood from Figs 5 A and 9 A, zone 74 is placed precisely in the slot on the rear left side of the channel arrangement, thereby "closing", sealing and/or clogging the slot. In this position, the slot on the rear right side is closed by the flat zone 75 (not visible in Figs 5A and 9A, since inside the channel arrangement 15). Of course, the same applies accordingly to the second tray 7.2 and the corresponding slots towards the front side of the device.

[0106] The closing of the slots in the stop positions of the trapping arrangements makes sure that the material in movement does not exit the device through these slots.

[0107] In the position shown in Fig 9 B, which may be referred to as the second "stop position", the second trapping area 7b is in a release position. Starting from the position shown in Fig. 9A, the second trapping area 7b was moved through rear right slot to get to the position shown in Fig. 9B. In this position, the central zone 74 on the tray 7.1 blocks or closes the slot. The rear left slot is closed by zone 73, not visible in Fig. 9B but visible in Fig. 9A. The same applies with respect to the second tray 7.2 and the slots on the front side.

[0108] In some embodiments, the device is configured to displace the trapping arrangement 7 in discrete steps and/or during defined periods of time, followed by intervals where the trapping arrangement is immobilized. These intervals can be referred to as the "trapping and release interval". The trapping and release interval is succeeded by short displacement events, where the one or more trapping areas move with respect to channel 4 and/or channel arrangement 15, preferably as described elsewhere in this specification. It is also noted that even during the displacement, particle trapping continues to take place on surfaces or parts of trapping areas of the trays that are still inside the channel 4 while moving out of the channel, and on surfaces or parts of trapping areas that are already inside the channel while moving into the channel.

[0109] In an embodiment, the trapping arrangement 7 comprises closure zones 73, 74, 75, which are arranged so as to close openings provided in the channel arrangement 15, as indicated above, said openings or slots 69 are preferably provided for allowing moving of trapping areas 7a-7d in and out channel 4 and thereby allow the displacement or movement of the trapping arrangement 7 with respect to the channel arrangement 15. Preferably, said closure zones 73-75 are provided to close said openings while the trapping arrangement is in a stop or end point position. As specified above, thanks to the recesses 25 provided in the trapping areas, the particles trapped on a trapping area do not obstruct the displacement of the trapping arrangement 7 through the slots in the channel arrangement.

[0110] In view of the description hereinabove, the following embodiments become apparent.

[0111] In a preferred embodiment, the device of the invention is self-cleaning, and/or allows removal of particles from the trapping structure without interrupting the particle removal process and/or without opening the machine. Preferably, the device allows removal of particles without stopping the machine.

[0112] In an embodiment, the displacement of the trapping arrangement and/or the trapping areas do not interfere with and/or do not prevent the material in movement from passing through the channel. The trapping arrangement is constructed such that its movement, including

movements from trapping to release positions does not change substantially the channel 4's properties with respect to channeling or guiding a material in movement 80.

[0113] In a preferred embodiment, while any trapping area 7a, 7c is in the release position, at least one other trapping area 7b, 7d is in the trapping position, such that said particles are continuously trapped on at least one of said trapping areas 7a, 7b, or on at least part of a trapping area, and/or while said material is in continuous movement through said device. Preferably, particles are trapped on a pair of trapping areas 7a, 7c and 7b, 7d provided on two separate supports 7.1, 7.2, preferably two supports that face each other and/or form opposed inner side walls of said channel 4.

[0114] In an embodiment, said first trapping area 7a is arranged such as to move from said first or trapping position to said second or release position while said material in movement traverses and/or passes through said channel 4.

[0115] In a preferred embodiment, said trapping arrangement 7 comprises a first support 7.1 and a second support 7.2, said first and second supports being rigidly connected one with respect to the other, wherein said first support 7.1 comprises said first and second trapping areas 7a, 7b, and wherein said second support 7.2 comprises a third trapping area 7c and a fourth trapping area 7d, wherein said first and third trapping areas 7a, 7c and said second and fourth trapping areas 7b, 7d, respectively, are arranged in parallel and opposite one with respect to the other.

[0116] In a preferred embodiment, the trapping arrangement 7 is arranged to conduct a reciprocating movement between two reciprocating positions, wherein, in a first reciprocating position, said first trapping area 7a is in a trapping position in the channel 4, while the second trapping area 7b is in a release position outside said channel 4, and wherein in a second reciprocating position said second trapping area 7b is in said trapping position and said first trapping area 7a in said release position.

[0117] In an embodiment, said trapping arrangement 7 is arranged such as to conduct a linear movement.

[0118] In an embodiment, the channel 4 of the device of the invention comprises at least one insert opening or slot 69, and wherein said first and/or said second trapping area 7a, 7b are arranged so as to enter into said channel 4 through said insert opening 69.

[0119] In embodiments, disclosed above, the trapping arrangement is configured to conduct a back and forth (or left and right) movement, during which the direction is changed regularly. The invention also encompasses devices in which the trapping arrangement is not necessarily arranged to conduct a reciprocating movement, but possibly another type of movement, including a closed-loop, for example a substantially circular movement or a continuous linear movement in the same direction. In an embodiment (not shown), the channel may comprise an entry opening and an exit opening (or pairs of entry and exit openings), and trapping areas enter successively the channel through said entry slot and exit the channel though said exit slot. Possibly, there may be more than two trapping surfaces. In an embodiment, the trapping arrangement forms a closed loop, or a pair of closed loops, rotating in a particular defined direction, where particles are removed once a trapping area exits the channel or trapping zone, where the material in movement passes. Trapping areas may be defined on a belt-like structure, for example.

[0120] In some embodiments, the invention comprises one continuous trapping area, in which said first trapping area 7a and said second trapping area 7b correspond to first and second parts of said continuous trapping area, such that a first part of the trapping area is in a trapping position while the second part is in a release position.

[0121] In the embodiment shown in the figures, the actuators are powered by compressed air. They are thus preferably connected with a system providing said compressed air. In accordance with this or other embodiments, the actuators are not powered by electricity. Accordingly, the electronic circuit for operating and running the device is the only part of the device that requires electricity. The electric power may be provided by a battery comprised in the device, for example inside the housing of the device. The battery may be a rechargeable battery. The device of the invention may thus be independent from an external power supply. This applies for example also to embodiments where the magnets are permanent magnets, which also renders the device independent of the external power supply.

[0122] The electronic system is preferably used to send signals to the actuators so as to make them move the trapping arrangement 7 in the appropriate direction or possibly to change the sense of the movement. Preferably, the electronic components require comparatively little electric power.

[0123] The invention also encompasses that the device is branched to an external power supply and may, for example, lack a battery. The device may be powered by and connected to the external power supply. For example, the invention does not exclude and hence encompasses in some embodiments that the trapping arrangement is moved by way of one or more motors, for example electric motor. Furthermore, the invention does not exclude and hence encompasses that electromagnets are used instead of permanent once as shown in the figures.

[0124] The device of the invention may be adapted to remove particles from any material in movement. In some embodiments, the device of the invention is configured to remove particles from a liquid in movement, such as a beverage, an industrial liquid or a medicament provided in liquid form, for example a suspension or solution of a medicament in a liquid. The liquid may be moved through liquid channeling system in which the device of the invention is integrated. In case of liquids, the material in movement may be caused to move by applying a pressure on the liquid such as to cause it to move through the device of the invention, for example.

[0125] In some embodiments, the device of the invention is adapted and/or configured to trap and/or remove particles that are repulsed by a magnet, such as diamagnetic particles.

[0126] While certain of the preferred embodiments of the present invention have been described and specifically exemplified above, it is not intended that the invention be limited to such embodiments. Various modifications may be made thereto without departing from the scope and spirit of the present invention, as set forth in the following claims.

Claims

1. A device (1) for removing particles from a material in movement, wherein said particles comprise or are made of a substance that is attracted by a magnet, the device comprising:

    - an inlet opening (2) and an outlet opening (3),
    - a channel (4), wherein said inlet and outlet openings (2, 3) and said channel (4) are arranged such that said material in movement can enter said channel (4) through said inlet opening (2) and leave said channel (4) through said outlet opening (2);
    - one or more magnets (5, 6), arranged in such a manner that magnetic flux lines extend in said channel (4) such as to exert a force on said particles and to deviate a trajectory of said particles in said moving material,
    - a particle trapping arrangement (7), arranged such that particles in said moving material, the trajectory of which is deviated by said force, are at least temporarily retained on said trapping arrangement (7),
    - wherein said trapping arrangement (7) comprises at least two trapping areas (7a, 7b) in the said trapping arrangement (7), a first trapping area (7a) and a second trapping area (7b), and wherein said trapping arrangement (7) is movably mounted on said device (1), in such a manner that a first trapping area (7a) can be moved from a first position or trapping position to a second position or release position,

        - wherein, in said trapping position, the first trapping area (7a) is arranged with respect to said magnetic flux lines in such a manner that said particles are deviated towards and retained on said first trapping structure (7a), and wherein, in said release position, said first trapping area (7a) is arranged with respect to said magnetic flux lines in such a manner that said particles are no longer retained on said first trapping area (7a) and can be removed or dropped from said first trapping area (7a), and wherein,
        - wherein said trapping arrangement (7) is arranged such that when said first trapping area (7a) is in said release position, said second trapping area (7b), is in the trapping position.

2. The device of claim 1, wherein in said trapping position, said first trapping area (7a) is inside said channel (4), and in said release position, it is outside said channel (4).

3. The device of any one of claims 1-2, wherein said first trapping area (7a) is arranged such as to move from said first to said second position while said material in movement traverses said channel (4).

4. The device of any one of the preceding claims 1-3, wherein, while any trapping area (7a, 7b) is in the release position, at least one other trapping area (7b, 7a) is in the trapping position, such that said particles are continuously trapped on at least one of said trapping areas (7a, 7b) or at least on part of a trapping area and/or while said material is in continuous movement through said device.

5. The device of any one of the preceding claims, comprising at least two magnets (5, 6), wherein said magnets (5, 6) are arranged on two opposed sides with respect to said channel (4), such that magnetic flux lines created by said magnets pass through said channel (4), preferably substantially perpendicularly with respect to an overall flow direction of a material in said channel.

6. The device of any one of the preceding claims, wherein said one or more magnets (5, 6) are permanent magnets (5, 6).

7. The device of any one of the preceding claims, wherein said one or more magnets (5, 6) are arranged so as to form a closed magnetic circuit.

8. The device of any one of claims 5-7, wherein a south pole (13) of said first magnet (5) is connected with a north pole (14) of said second magnet (6) by way of a material bridge, in particular a magnetic circuit (10).

9. The device of any one of the preceding claims, comprising at least one actuator (21, 22), preferably a pneumatic actuator, wherein said actuator (21, 22) is arranged so as to act on said trapping arrangement (7) and so as to move a trapping area (7a, 7b) from a trapping position to a release position and/or from a release position to a trapping position.

10. The device of any one of the preceding claims, wherein said trapping arrangement (7) is arranged

such as to conduct a linear movement.

11. The device of any one of the preceding claims, wherein at least two release positions are provided on two lateral sides, respectively, of said channel (4).

12. The device of any one of the preceding claims, comprising at least one collector (41, 42), arranged so as to collect particles that drop under the force of gravity from a trapping area (7a, 7b) while it is in a release position.

13. The device of any one of the preceding claims, wherein said trapping arrangement (7) comprises a first support (7.1) and a second support (7.2), said first and second supports being rigidly connected one with respect to the other, wherein said first support (7.1) comprises said first and second trapping areas (7a, 7b), and wherein said second support (7.2) comprises a third trapping area (7c) and a fourth trapping area (7d), wherein said first and third trapping areas (7a, 7c) and said second and fourth trapping areas (7b, 7d), respectively, are arranged in parallel and opposite one with respect to the other.

14. The device of any one from the preceding claims, wherein said material in movement is a fluid and/or a material suspended in a fluid.

15. The device of any one of the preceding claims, which is self-cleaning and/or which allows removal of ferromagnetic or paramagnetic particles from the trapping structure without interrupting the particle removal process and/or without opening the device.

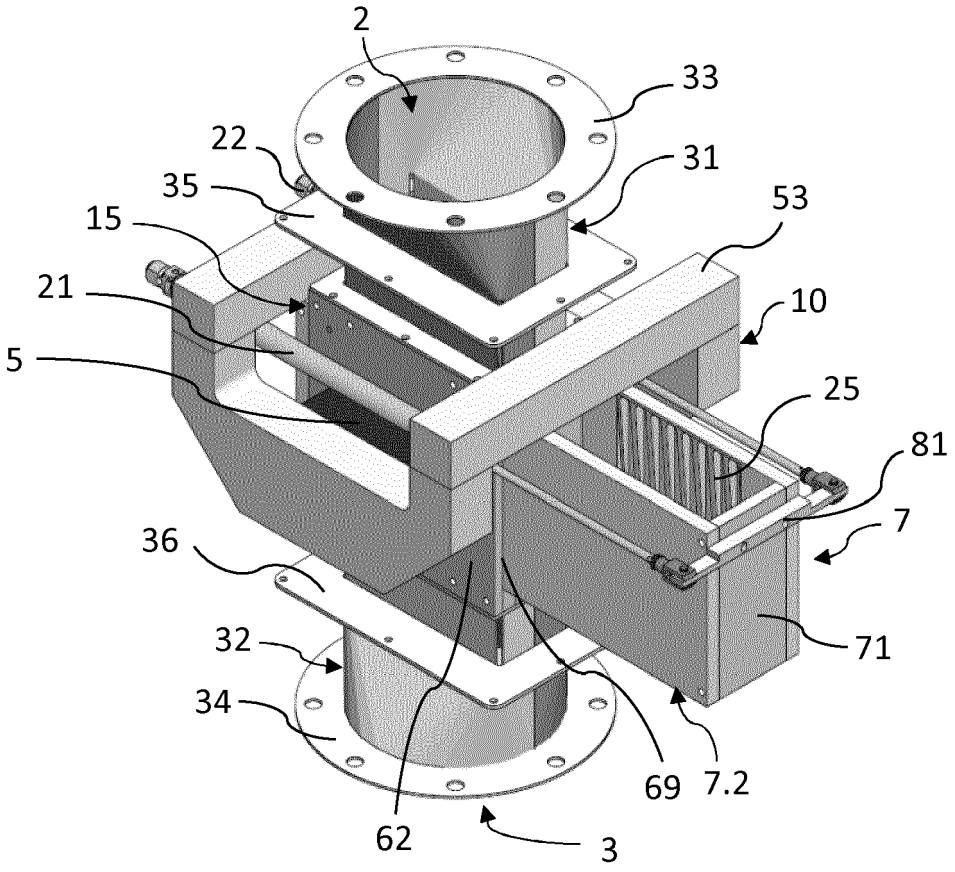


Figure 1

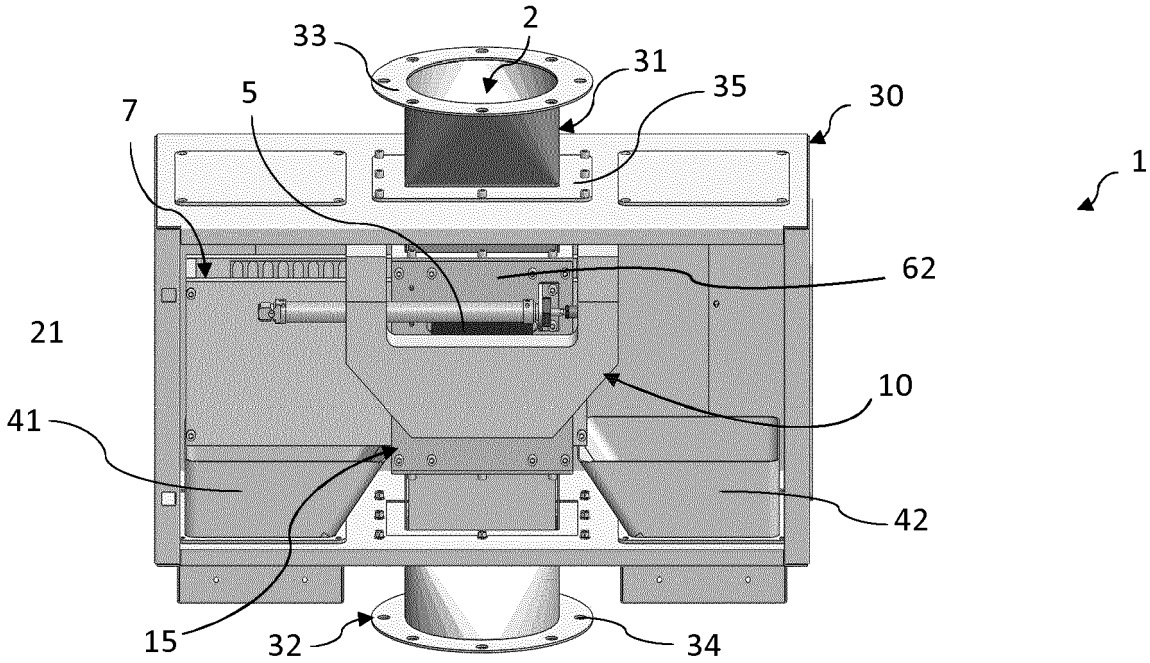


Figure 2

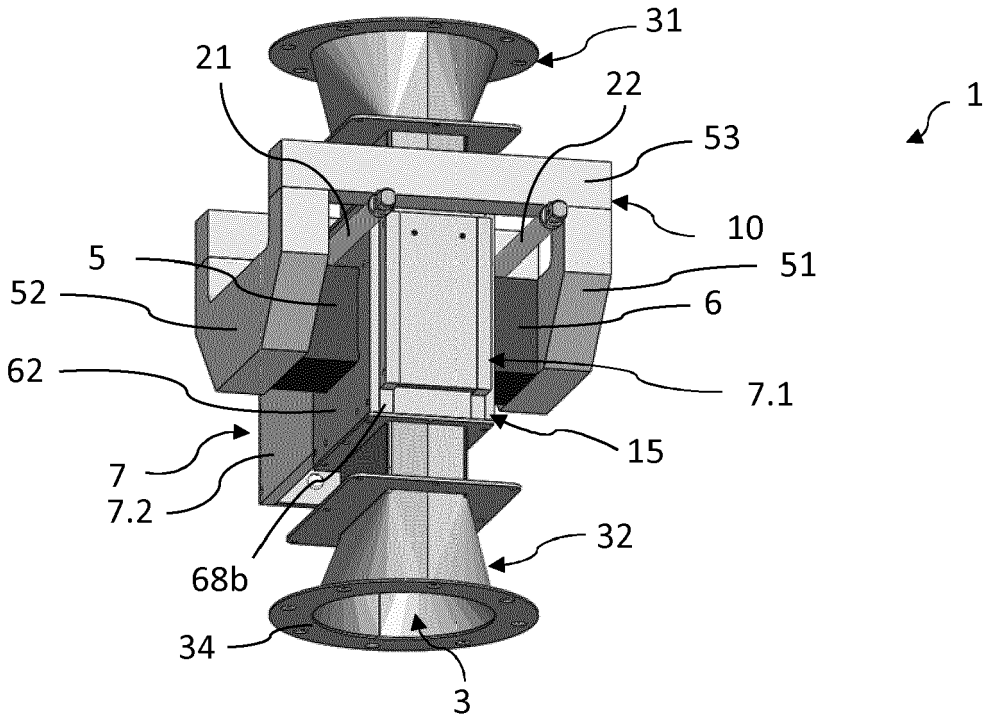


Figure 3

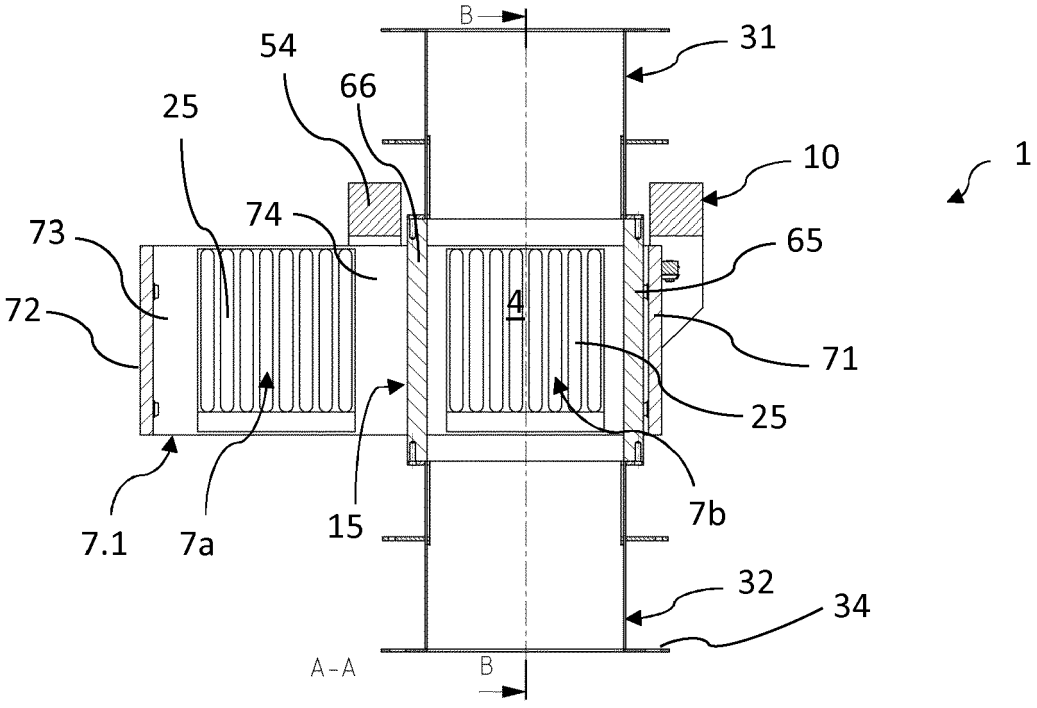
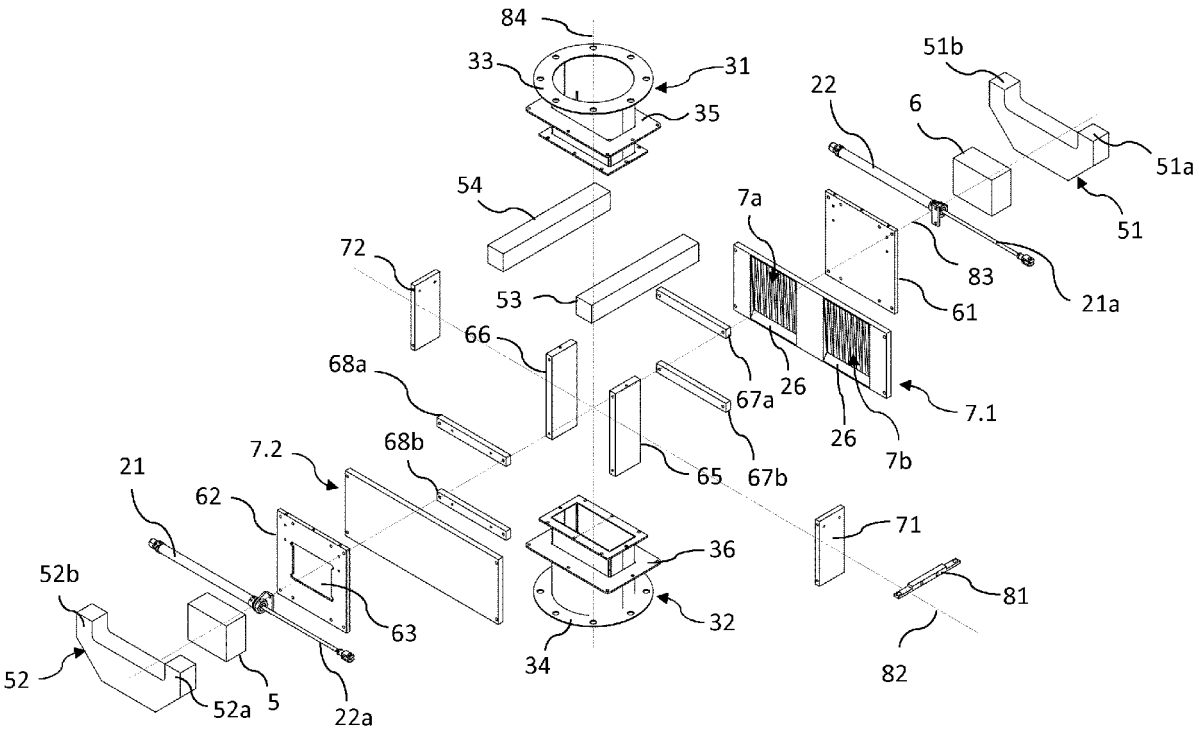


Figure 5 A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7b
65
67b

Figure 4

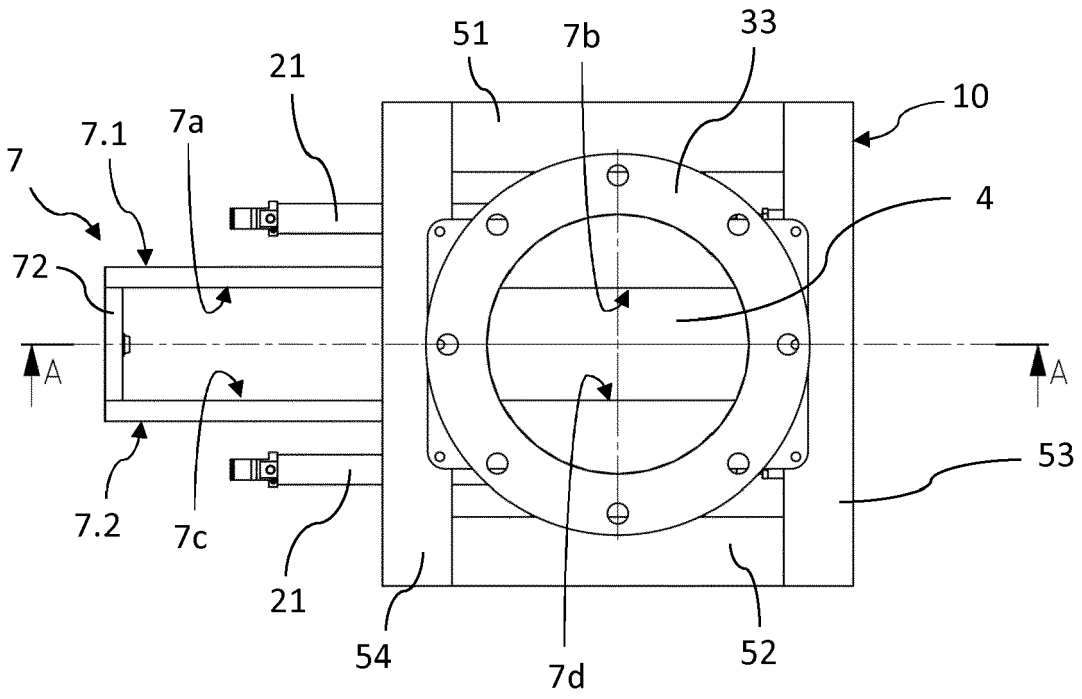

Figure 5 B

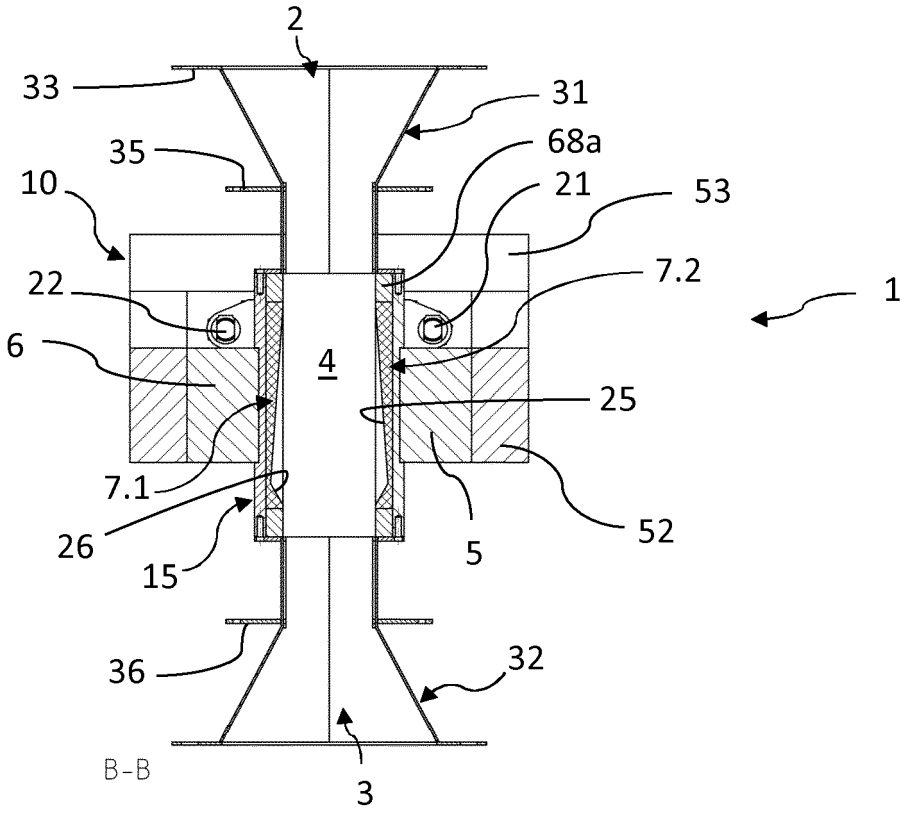

Figure 5 C

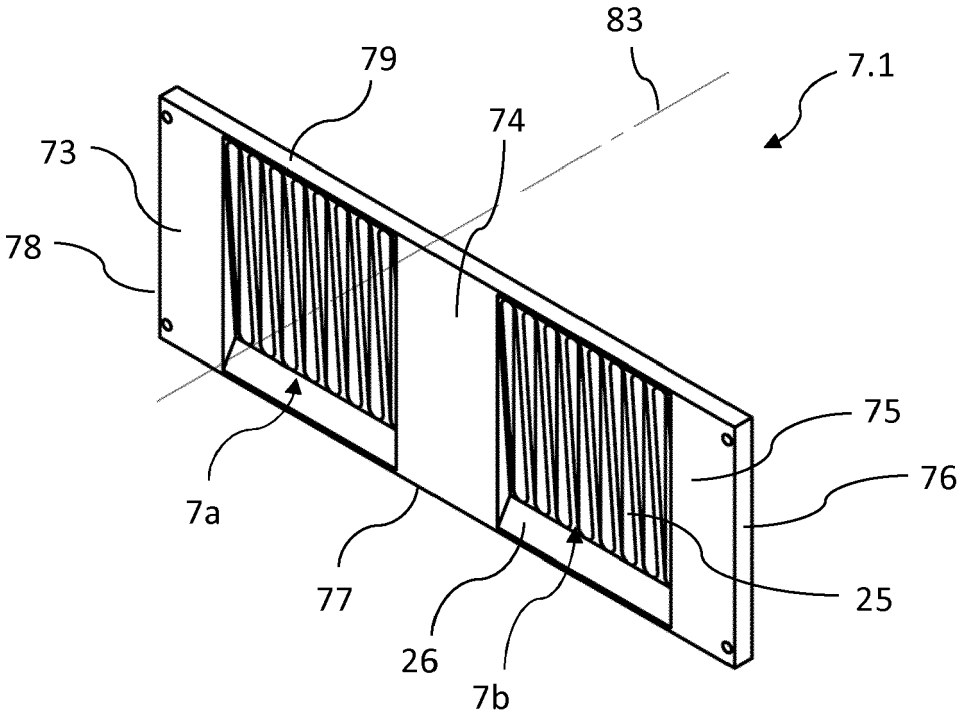

Figure 5 D

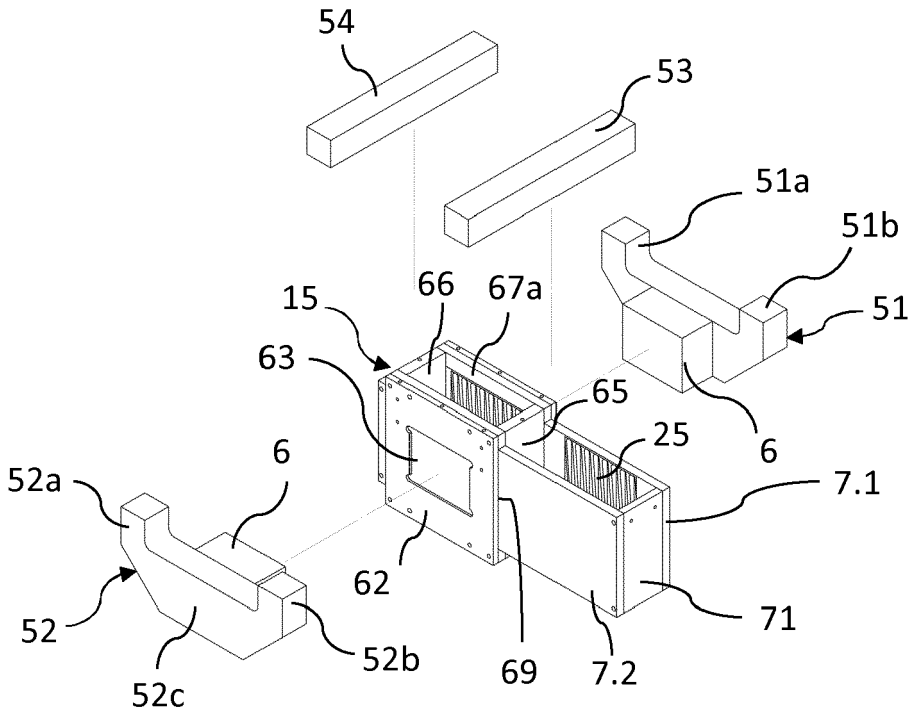

Figure 6

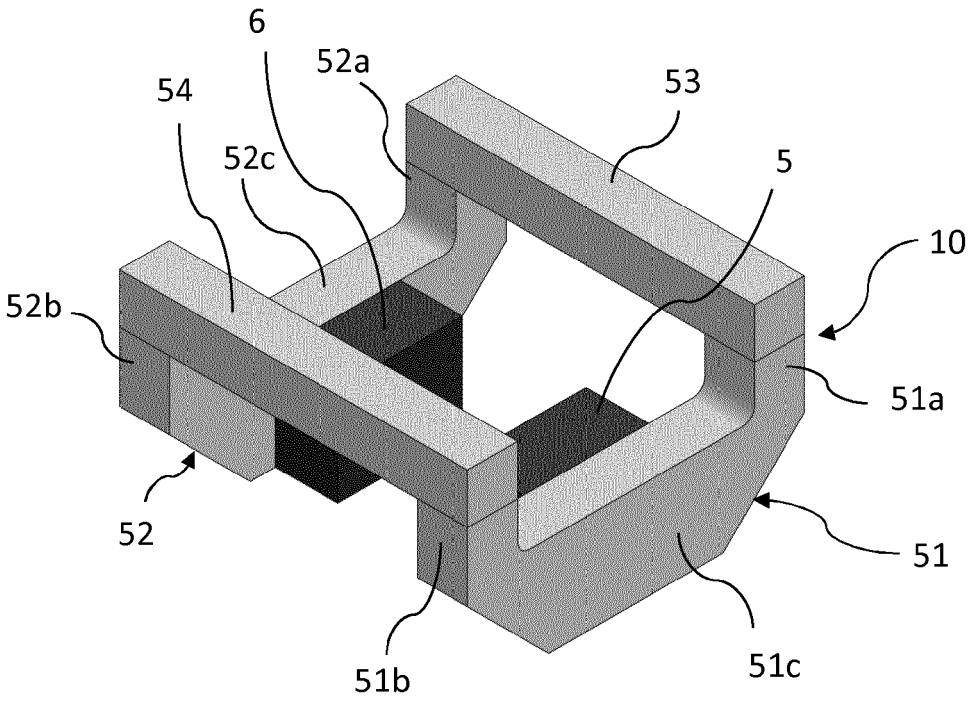

Figure 7

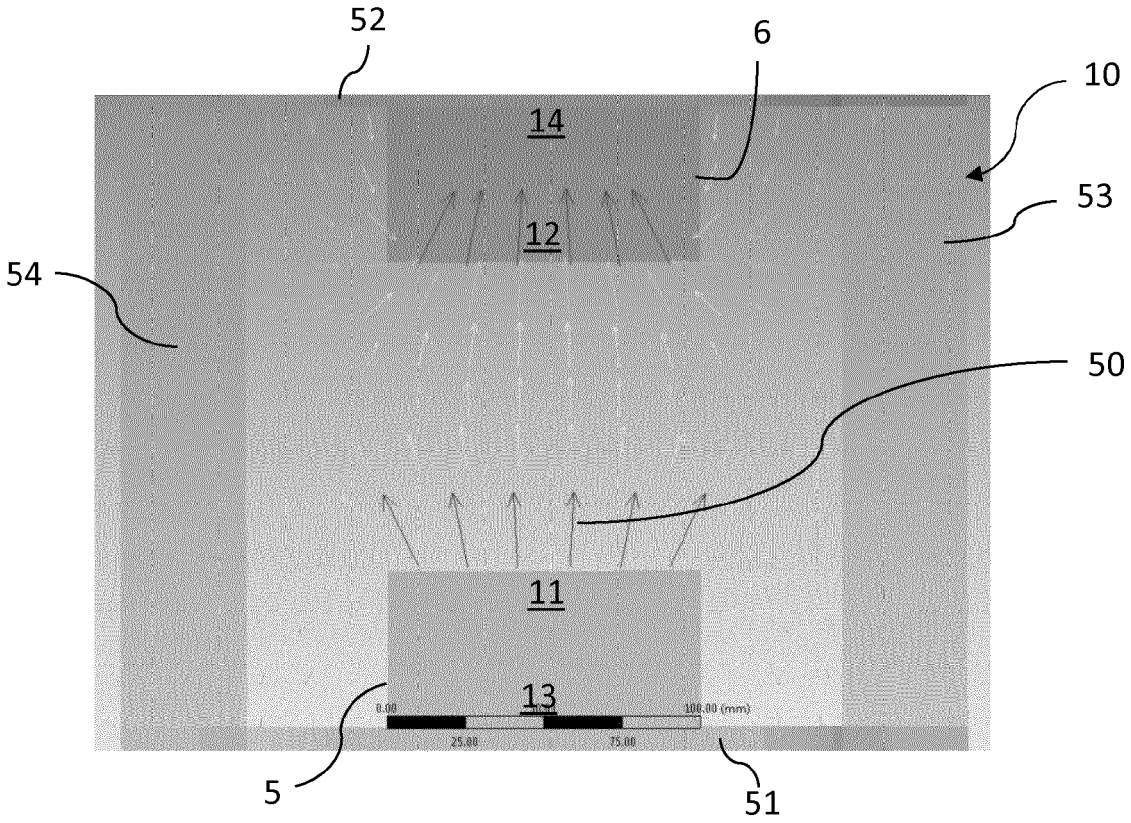

Figure 8

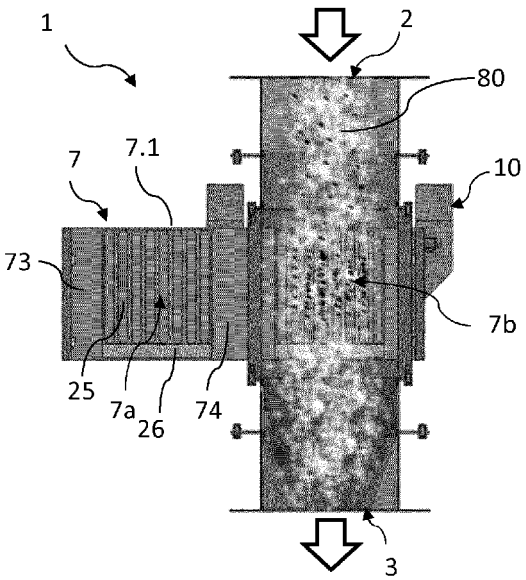

Figure 9 A

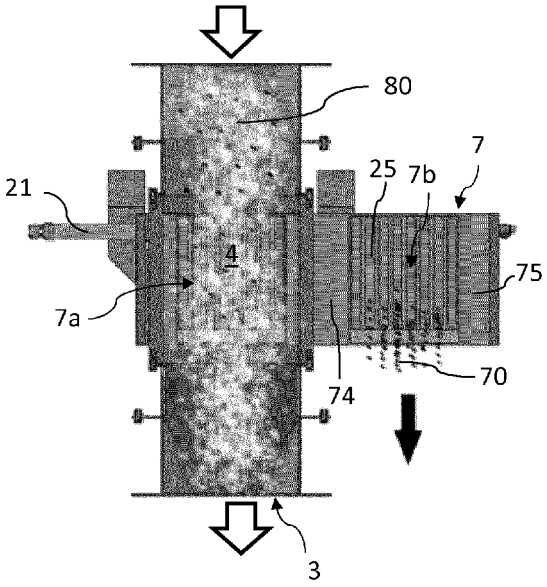

Figure 9 B

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EUROPEAN SEARCH REPORT

Application Number
EP 16 18 3005

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 5 932 096 A (SAHO NORIHIDE [JP] ET AL) 3 August 1999 (1999-08-03) * figures 1-3,7 * * column 4, line 49 - column 9, line 52 * * column 12, line 8 - line 34 * * column 1, line 4 - line 9 *	1-15	INV. B03C1/027 B03C1/033 B03C1/034 B03C1/28
X	DE 26 55 140 B1 (KLOECKNER HUMBOLDT DEUTZ AG) 9 February 1978 (1978-02-09) * figure 3 * * column 5, line 65 - column 6, line 25 *	1-15	
X	JP S61 118112 A (NEC CORP) 5 June 1986 (1986-06-05) * figure 1 *	1-15	
X	CN 2 274 532 Y (CHANGSHA MINING AND METALLIZIN [CN]) 18 February 1998 (1998-02-18) * figures 1,2 *	1-15	
X	CN 204 892 115 U (ZHENGZHOU INST MULTIPURPOSE UTILIZATION MINERAL RESOURCES CAGS) 23 December 2015 (2015-12-23) * figures 1,2 * * paragraph [0023] - paragraph [0027] *	1-15	TECHNICAL FIELDS SEARCHED (IPC) B03C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	7 February 2017	Menck, Anja

CATEGORY OF CITED DOCUMENTS

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

REFERENCES CITED IN THE DESCRIPTION

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