(19) Europäisches Patentamt
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(11) **EP 4 741 544 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
13.05.2026 Bulletin 2026/20

(21) Application number: **25214451.4**

(22) Date of filing: **07.11.2025**

(51) International Patent Classification (IPC):
D01B 1/10 *(2006.01)* *D01B 1/22* *(2006.01)*
D01B 1/24 *(2006.01)* *D01B 1/38* *(2006.01)*
B02C 13/04 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
D01B 1/10; D01B 1/22; D01B 1/24; D01B 1/38

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH LA MA MD TN

(30) Priority: **12.11.2024 US 202463719224 P**

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(54) APPARATUS AND METHOD FOR EXTRACTING FIBERS FROM A FIBROUS MATERIAL

(57) An apparatus and method for extracting fibers from a fibrous material in which the fibers are mixed with other constituents. The apparatus comprises a chassis (18) having a housing (22) in which a rotor (20) spins at relatively high speed. The housing (22) has a first and a second chambers (30, 32) defined by a disc (35) of the rotor splitting the housing (22) in two. On one side, the disc (35) has a set of protrusions (54) that cooperate with another set of static protrusions (34) in the second chamber (32). On the other side, the disc (35) has vanes (36). When the rotor (35) spins, fibrous material is introduced in the second chamber (32) where it is broken by the cooperating sets of protrusions (34, 54). Simultaneously, ambient air is drawn in the first chamber (30) by the rotation of the vanes (36) and compressed. The compressed air is injected in the second chamber (32), expelling separately the detached fibers and the other constituents.

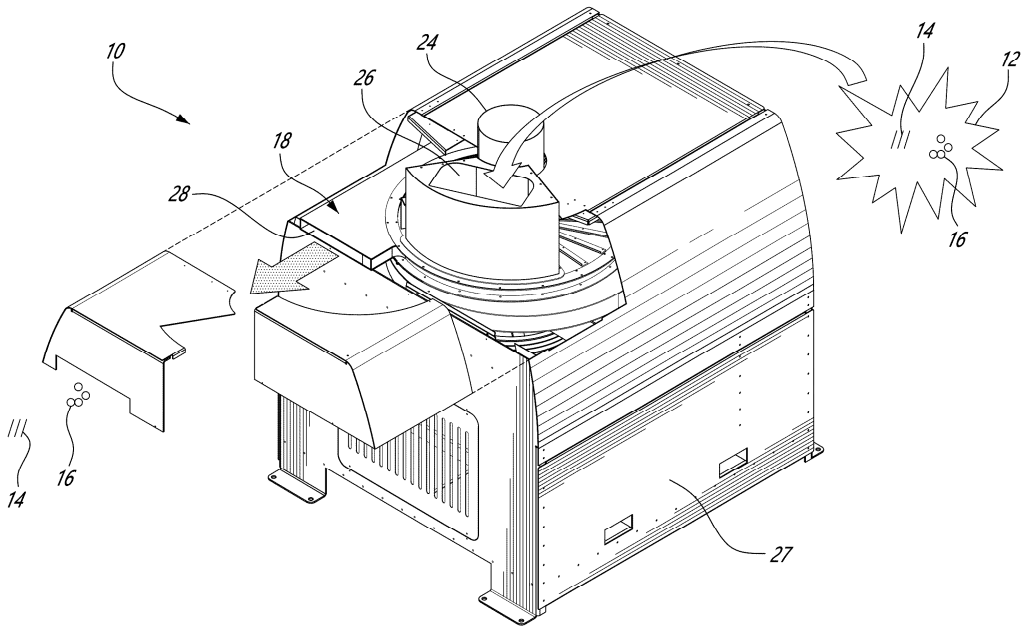

Fig. 1

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Description

FIELD OF THE INVENTION

[0001] The present invention generally relates to the field of separation of fibers from a fibrous material. More specifically, the invention relates to an apparatus and method for extracting fibers from a fibrous material, for example for extracting hemp fiber from hemp stalks.

BACKGROUND OF THE INVENTION

[0002] Whether it is during the first processing steps of raw materials or during recycling of a manufactured product at its end of life, it is often required to separate such product in its constituents. For example, for manufacturing a product using fibers, it may be required as a first step of the manufacturing process to extract such fibers from a plant that has been harvested.

[0003] More particularly, hemp has been used for centuries in the manufacturing of fabrics, paper, ropes and clothing and other products advantageously using its durability and strength properties. Nowadays, hemp is also used in the construction industry and in the manufacturing of different components. Hemp has gained increasing attention also because it is a sustainable material.

[0004] For all its qualities, however, hemp has one drawback: extracting its fibers at an industrial scale requires expensive machinery that mostly works by hammering the hemp stalks to break it and split the hemp fibers from the hemp hurds. Although automated, these processes struggle to yield an industrial amount of processed hemp fiber so that the use of hemp fibers at an industrial scale is still challenging.

[0005] There is therefore a need for a method and equipment to more efficiently extract fibers from a fibrous material, and particularly for extract hemp fibers from hemp stalks.

SUMMARY OF THE INVENTION

[0006] It is an object of the present invention to provide an apparatus for extracting fibers from a fibrous material containing the fibers mixed with other constituents that overcomes or mitigates one or more disadvantages of known such apparatuses or at least provides a useful alternative.

[0007] The invention provides the advantages of potentially providing a higher processing rate than known solutions.

[0008] In accordance with an embodiment of the present invention, there is provided an apparatus for extracting fibers, also known as an extractor, from a fibrous material in which the fibers are mixed with other constituents. The apparatus comprises a chassis and a rotor. The chassis has a housing, an air intake, a material inlet and an outlet. The housing has a first chamber, a second chamber and a first set of protrusions projecting inwardly into the second chamber. The air intake fluidly connects to the first chamber. The first chamber is fluidly connected to the second chamber. The material inlet, adapted to receive the fibrous material, is fluidly connected to the second chamber. The outlet is fluidly connected to the second chamber. The rotor has a disc and is adapted to spin on a shaft within the housing. The disc divides the housing in the first chamber and in the second chamber. The disc has vanes extending in the first chamber and has a second set of protrusions protruding in the second chamber. The second set of protrusions face the first set of protrusions and is radially offset from the first set of protrusions so as to closely cooperate with the first set of protrusions when the rotor spins. When in use, the rotor is spun, the fibrous material is introduced in the material inlet and therefrom into the second chamber where the fibrous material is shred into the detached fibers and the other constituents by the cooperating action of the first set of protrusions with the spinning second set of protrusions. Air is drawn in the first chamber of the housing by the spinning vanes of the rotor, thereby creating compressed air in the first chamber. The compressed air is routed to the second chamber so as to expel the detached fibers and the other constituents.

[0009] In accordance with an embodiment of the present invention, there is provided an apparatus for extracting fibers from a fibrous material in which the fibers are mixed with other constituents. This apparatus is also known as an extractor. The apparatus comprises a chassis and a rotor. The chassis has a housing, an air intake, a material inlet and an outlet. The housing has a cavity and a first set of protrusions projecting inwardly into the cavity. The air intake is fluidly connected to the cavity. The material inlet, adapted to receive the fibrous material, is fluidly connected to the cavity. The outlet is fluidly connected to the cavity. The rotor, which is adapted to spin on a shaft within the housing, has a disc equipped with a second set of protrusions protruding into the cavity. This second set of protrusions faces the first set of protrusion and is radially offset from the first set of protrusions so as to closely cooperate with the first set of protrusions when the rotor spins. In use, the rotor is spun by source of power and the fibrous material is introduced in the material inlet and therefrom into the cavity. In the cavity, the fibrous material is shred into the detached fibers and the other constituents by the cooperating action of the first set of protrusions with the spinning second set of protrusions. The detached fibers and the other constituents being are expelled through the outlet.

[0010] Optionally, the apparatus may comprise an air propulsion system connected to the cavity so as to expel the detached fibers and the other constituents through the outlet. This air propulsion system may be selected from the group consisting of an air compressor, a fan and a turbine.

[0011] Optionally, the cavity may be divided into a first chamber and a second chamber by the disc. The first

chamber is then fluidly connected to the second chamber. The disc may comprise vanes extending in the first chamber for compressing air. The first set of protrusions and the second set of protrusions protrude into the second chamber. The air intake is fluidly connected to the first chamber. The material inlet and the outlet are fluidly connected to the second chamber. In use, the rotor is spun, the fibrous material is introduced in the material inlet and therefrom into the second chamber where the fibrous material is shred. Air is drawn in the first chamber of the housing by the spinning vanes of the rotor, thereby creating compressed air in the first chamber of the housing. The compressed air is routed to the second chamber so as to expel the detached fibers and the other constituents through the outlet.

[0012] Optionally, the air compressed by the apparatus is operative to expel the detached fibers at a first distance from the outlet and to expel the other constituents at a second distance from the outlet, the first distance being substantially different from the second distance.

[0013] Optionally, a motor may be used for spinning the rotor.

[0014] The housing may be cylindrical. The second set of protrusions may extend radially on a face of the disc. The first set of protrusions may extend radially on an inner face of the housing.

[0015] A channel may connect the first chamber to the second chamber.

[0016] The second set of protrusions may be distributed over 360 degrees on the face of the disc while the first set of protrusions may be distributed over at least 90 degrees on the inner face of the housing.

[0017] The first set of protrusions may be distributed over less than 180 degrees on the inner face of the housing.

[0018] The distance between the inner face of the housing and the face of the disc may be adjustable.

[0019] The first set of protrusions and the second set of protrusions may each contain a plurality of teeth.

[0020] The teeth of each set may be disposed facing each other and offset to each other so that first peaks and first valleys of the first set of protrusions respectively coincide with second valleys and second peaks of the second set of protrusions.

[0021] The first set of protrusions and/or the second set of protrusions may be replaceable.

[0022] The disc may comprise holes for fluid communication between the air intake and the second chamber.

[0023] The air intake may be coaxial with the shaft.

[0024] The outlet may be tangential with the disc.

[0025] The fibrous material may be selected from the group consisting of: a plant, a fabric and a diaper.

[0026] The fibrous material may be hemp and the other constituents may comprise hemp chaff.

[0027] In accordance with an embodiment of the present invention, there is provided a method for extracting fibers from a fibrous material in which the fibers are mixed with other constituents. The method comprises:

providing the apparatus as previously described;

spinning the rotor at a speed of at least 250 rpm;

introducing the fibrous material in the second chamber through the material inlet;

shredding the fibrous material, thereby detaching the fibers from the other constituents by the cooperating action of the first set of protrusions with the spinning second set of protrusions

drawing air in the first chamber of the housing by creating a vacuum in the air intake using the spinning vanes, thereby creating compressed air in the first chamber;

routing the compressed air to the second chamber through the channel;

expelling the detached fibers at a first distance from the outlet; expelling the other constituents at a second distance from the outlet substantially different from the first distance.

[0028] Optionally, the speed may be less than 3000 rpm, for example, between 500 rpm and 1000 rpm.

[0029] The introducing the fibrous material may comprise introducing hemp stalks.

[0030] The expelling may comprise substantially separating the detached fibers from the other constituents by expelling the detached fibers at a first distance from the outlet and expelling the other constituents at a second distance from the outlet substantially different from the first distance.

BRIEF DESCRIPTION OF DRAWINGS

[0031] These and other features of the present invention will become more apparent from the following description in which reference is made to the appended drawings wherein:

Figure 1 is a perspective partially exploded view of an apparatus for extracting fibers from a fibrous material in accordance with an embodiment of the present invention;

Figure 2A is an perspective view showing the chassis of the apparatus of Figure 1;

Figure 2B is an perspective view showing the chassis and the rotor of the apparatus of Figure 1;

Figure 2C is an perspective view showing the chassis, the rotor and a cover of the apparatus of Figure 1;

Figure 2D is an perspective view showing the chas-

sis, the rotor and an arrangement of cooperating protrusions of the apparatus of Figure 1;

Figure 3A is a top view of the rotor of the apparatus of Figure 1;

Figure 3B is a side cross-section view along lines 3B-3B of the rotor of Figure 3A;

Figure 3C is an perspective cross-section view along lines 3C-3C of the rotor of Figure 3A;

Figure 3D is a cross-sectional top view along lines 6D-6D of the rotor of Figure 3B;

Figure 4 is an perspective cross-section view along lines 4-4 of the chassis and rotor of Figure 2C;

Figure 5 is a detailed front view of the cross-section of Figure 4;

Figure 6A to 6C are different teeth profiles for first and second sets of protrusions in accordance with another embodiment of the present invention; and

Figure 7 is a perspective view of the chassis and housing of an apparatus for extracting fibers from a fibrous material in accordance with another embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0032] The present invention relates to an apparatus and a method for extracting fibers from a fibrous material containing the fibers mixed with other constituents.

[0033] Figure 1 shows an apparatus, also known as an extractor 10, for extracting fibers from a fibrous material 12 in which the fibers 14 are mixed with other constituents 16. Such fibrous materials may range from raw products such as plants, to barely processed materials such as wood chips, to manufactured products such as fabrics or even diapers. The extractor 10 comprises a chassis 18 covered by a body 27.

[0034] In particular, the fibrous material may be hemp, in which the fibers are intended to be separated from hemp chaff which, in that example, represents the other constituents.

[0035] Figures 2A to 2D, now concurrently referred to, depict internal components of the extractor 10 at various stages of assembly so as to show how the internal components are stacked together.

[0036] In Figure 2A, the body 27 is removed to reveal the bare chassis 18. The chassis 18 has a cylindrical housing 22 defining a cavity 23. The housing 22 has a curved side wall 29 and bottom wall 33. The cavity 23 is designed to receive a rotor 20, best shown in Figure 2B.

[0037] Whereas the housing 22 is static, the rotor 20 is designed to spin inside the cavity 23, drawing air from the air intake 24 aligned with the fan hub 50 and expelling it through the outlet 28. The rotor 20 is provided with a set of removable static protrusions 54 on its upper surface.

[0038] Figure 2C shows that a cover 25 partially closes the cavity 23, thereby constituting a top wall for the cavity 23. The cover 25 is provided with a set of removable static protrusions 34 protruding inside the cavity 23 and facing the removable static protrusions 54 of the rotor 20. The cover 25 is also provided with an opening 44 through which the fibrous material 12 enters the cavity 23.

[0039] Figure 2D shows a material inlet 26 in place, being connected to the cover 25 so as to be fluidly connected to the opening 44. In Figure 2D, the cover 25 is shown in transparency, except for its static protrusions 34 which are shown in place to better illustrate how the dynamic protrusions 54 of the rotor 20 cooperate with the static protrusions 34 of the cover 25.

[0040] Figures 3A to 3D are concurrently referred to. The rotor 20 comprises a disc 35, first and second disc walls 37, 39, a shaft 48 and fan hub 50. The disc 35 is also equipped with vanes 36, best shown in Figure 3D, extending between a first disc wall 37 and a second disc wall 39, thereby defining a compressor stage 56 therebetween. The vanes 36 may have different shapes and pitch between them. The rotor 20 comprises radial holes 38 in a peripheral wall 58 of the fan hub 50. The dynamic protrusions 54 are attached to the first disc wall 37, opposite the vanes 36. The rotor 20, including the disc 35 attached to the shaft 48, is designed to spin inside the housing 22 on bearings 52 under the power of motor 64. The motor 64, preferably an electric motor, can drive the rotor 20 either directly or indirectly, for example through a transmission with gears or using one or more belts.

[0041] Figures 4 and 5 are now concurrently referred to. The air intake 24, shaped like a tube, is coaxially aligned with the fan hub 50 so as to be fluidly connected with the compressor stage 56 through holes 38. When the rotor 20 spins, ambient air is drawn by the vanes 36 from the environment into the air intake 24, directed to the fan hub 50 and then through the holes 38 into the compressor stage 56.

[0042] The rotor 20, and more particularly the first disc wall 37, divides the housing 22 into a first chamber 30 and a second chamber 32. In other words, the whole disc 35 resides almost completely within the first chamber 30, the first disc wall 37 dividing the first chamber 30 from the second chamber 32. The compressor stage 56 is fluidly connected to the first chamber 30.

[0043] The first chamber 30 is fluidly connected to the second chamber 32 through channel or conduit 46. This conduit 46 may adopt different shapes of cross-sections, inasmuch as it does not create too much pressure drop in the pressure of the compressed air coming from the first chamber 30.

[0044] Whereas the compressor stage 56 in the first chamber 30 serves to compress air, the second chamber 32 is where the fibrous material 12 is treated to separate the fibers 14 from other constituents 16. The fibrous

material 12 is introduced in the second chamber 32 via the material inlet 26, which is fluidly connected to the second chamber 32 through a material receiving area or plenum 42. The fibrous material 12 falls or is drawn in the second chamber 32 through the opening 44 of the material receiving area 42.Whereas the bottom wall 33 and side wall 29 of the housing 22 adopt a rather smooth surface, the cover 25, defining the top wall of the housing 22, is equipped with static protrusions 34 which project inwardly into the second chamber 32. This set of static protrusions 34 typically extends radially across the cover 25, although other arrangements may be used (for example, curvilinear, staggered, etc). It has been found that arranging the static protrusions 34 in a plurality of radial lines distributed over 90 to 120 degrees of the surface of the cover 25 performs adequately, although a narrower or broader distribution may also perform adequately.

[0045] Facing the static protrusions 34, the first disc wall 37 of the disc 35 is provided with the matching set of dynamic protrusions 54 which also protrudes within the second chamber 32 so as to cooperate with the dynamic protrusions 34 of the rotor 20. This set of dynamic protrusions 54 faces the first set of static protrusion 34 and is radially offset from the set of static protrusions 34 so as to closely cooperate with it when the rotor 20 spins.

[0046] The dynamic protrusions 54 are typically evenly distributed over 360 degrees on the face of disc 35. Even distribution of the dynamic protrusions 54, and of the vanes 36, ensures an even balancing of the rotor 20.

[0047] Since both sets of protrusions 34, 54 are removable, they can be replaced when worn, when a different fibrous material having different characteristics is treated, or when a different treatment of the same fibrous material is required. Indeed, both sets of protrusions 34, 54 each use a plurality of knives or teeth 60. The teeth 60 of each set of protrusions 34, 54 are disposed facing each other and offset to each other so that peaks and valleys of one set of protrusions respectively coincide with valleys and peaks of the other set of protrusions. The distance between the cover 25 of the housing 22 and the facing first disc wall 37 may be adjustable so that a gap 62 between the facing teeth 60 is adjusted. This gap 62 influences the treatment of the fibrous material 12.

[0048] The size, shape, quantity and pitch of teeth 60 also influence the treatment of the fibrous material 12. For example, the pitch between each tooth influences fiber length. Different sizes and shapes of teeth 60, such as those shown in Figures 6A to 6C, may be used depending on how the fibrous material 12 is to be treated. For example, square (Figure 6A), sinusoidal (Figure 6B) or triangular (Figure 6C) are the most common shape of teeth 60 used. For example, when hemp is the fibrous material to be treated, it has been found that triangular teeth are better at separating fibers from the hemp stalks, whereas rounded or sinusoidal teeth are better at softening an already treated fibrous material. Each set of protrusions, or teeth 34, 54 are replaceable when they are worn, or when required for treating a different material. Materials used for the teeth 60 are steel, hardened steel or other wear resistant materials such a ceramics. These materials can also be coated to prevent wear and extend their useful life.

[0049] The outlet 28 is fluidly connected to the second chamber 32. More particularly, the outlet 28 is placed tangentially to the side wall 29 of the housing 22.

[0050] When in use, the rotor 20 is driven by the motor 64 so as to spin between 250 rpm and 3000 rpm, preferably between 400 rpm and 2000 rpm and more preferably between 500 rpm and 1000 rpm. Spinning, the vanes 36 of the disc 35 draw ambient air through the air intake 24 and through the holes 38 and compress this air in the first chamber 30. This compressed air is then directed to the second chamber 32 through the conduit 46. Simultaneously, the fibrous material 12, for example hemp stalks, is introduced in the extractor 10 using the material inlet 26, from which it falls into the plenum or receiving area 42 and into the second chamber 32 through the opening 44. By the relative movement between the static and dynamic sets of protrusions or teeth 34, 54, the fibrous material 12 is shred at high speed into detached fibers 14 and other constituents 16. Under the centrifugal forces developed by the rotational movement of the spinning disc 35, combined with the compressed air entering the second chamber 32, the fibers 14, now detached from the other constituents, are expelled from the tangential outlet 28.

[0051] Advantageously, the fibers 14 typically have a form factor that is different from that of the other constituents 16 so that both are expelled at a different distance from the outlet 28 because of different resistance to air, allowing a certain separation of both constituents of the fibrous material 12. For example, when hemp is treated, the hemp fibers 14 are expelled farther from the outlet 28 than the hemp chaff because the hemp chaff has a higher drag coefficient and does not fly as far as the hemp fibers. This primary separation is however not perfect and a subsequent separation step, for example by filtering or sieving, may be required to fully isolate fibers from other constituents

[0052] For resistant materials, such as hemp, the high rotational speed of the rotor 20 is a determining factor for the successful separation of the fibers 14. At low speeds, (e.g. lower than 100rpm), there is a higher risk that the fibers 14 of the fibrous material 12 do not get properly separated and cut so that they wrap around the rotor 20. At a certain higher speed, this phenomenon stops from occurring and the fibers 14 get properly cut and separated from the other constituents 16.

[0053] In accordance with another embodiment of the invention, it is possible to do without the vanes 36 on the disc 35 so that the fibers 14 and the other constituents 16 are expelled under the kinetic action of the dynamic protrusions 54.

[0054] In accordance with another embodiment of the invention, it is possible to do without the vanes 36 on the disc 35 and to optionally assist the expulsion of the fibers

14 and the other constituents 16 by using an external forced air propulsion system 66 connected to the cavity 23. This external air propulsion system 66 helps to expel the detached fibers 14 and the other constituents 16 through the outlet 28 at higher speeds. Such air propulsion systems 66 may be an air compressor, a fan or a turbine, which are connected to the extractor 10. For example, many plants are equipped with compressed air lines running in many areas of the plant. The extractor 10 is then connected directly to one of these compressed air lines through a compressed air hose 68.

[0055] In this embodiment, the extractor 10 is provided with a compressed air outlet 70 in the cavity 23. The compressed air outlet 70 may be oriented tangentially to the side wall 29 of the cavity. Alternatively, the compressed air outlet 70 may be placed in the cover 25, whatever position works better for expelling the specific fibers 14 and the other constituents 16 of a given fibrous material 12.

[0056] The present invention has been described with regard to preferred embodiments. The description as much as the drawings are intended to help the understanding of the invention, rather than to limit its scope. The invention is defined by the claims that follow.

Claims

1. An apparatus for extracting fibers from a fibrous material in which the fibers are mixed with other constituents, the apparatus being **characterized in that** it comprises:

   a chassis (18) having:

   a housing (22) having a cavity (23), the housing (22) having a first set of protrusions (34) projecting inwardly into the cavity (23);
   an air intake (24) fluidly connected to the cavity (23);
   a material inlet (26) adapted to receive the fibrous material, the material inlet (26) being fluidly connected to the cavity (23); and
   an outlet (28) fluidly connected to the cavity (23); and

   a rotor (20) adapted to spin on a shaft (48) within the housing, the rotor (20) having a disc (35), the disc (35) having a second set of protrusions (54) protruding into the cavity (23) so that the second set of protrusions (54) faces the first set of protrusion (34) and is radially offset from the first set of protrusions (34) so as to closely cooperate with the first set of protrusions (34) when the rotor (20) spins,
   wherein in use, the rotor (20) is spun, the fibrous material is introduced in the material inlet (26) and therefrom into the cavity where the fibrous material is shred into the detached fibers and the other constituents by the cooperating action of the first set of protrusions (34) with the spinning second set of protrusions (54), the detached fibers and the other constituents being expelled through the outlet (28).

2. The apparatus of claim 1, further comprising an air propulsion system (66) connected to the cavity (23) so as to expel the detached fibers and the other constituents through the outlet (28).

3. The apparatus of claim 1 or claim 2, **characterized in that**:

   the cavity (23) is divided into a first chamber (30) and a second chamber (32) by the disc (35);
   the first chamber (30) is fluidly connected to the second chamber (32);
   the disc (35) comprises vanes (36) extending in the first chamber (30) for compressing air;
   the first set of protrusions (34) and the second set of protrusions (54) protrude into the second chamber (32);
   the air intake (24) is fluidly connected to the first chamber (30);
   the material inlet (26) is fluidly connected to the second chamber (32); and
   the outlet (28) is fluidly connected to the second chamber (32); and
   wherein in use, the rotor (20) is spun, the fibrous material is introduced in the material inlet (26) and therefrom into the second chamber (32) where the fibrous material is shred, air is drawn in the first chamber (30) of the housing (22) by the spinning vanes (36) of the rotor (20), thereby creating compressed air in the first chamber (30), the compressed air being routed to the second chamber (32) so as to expel the detached fibers and the other constituents through the outlet (28).

4. The apparatus of any one of claims 1 to 3, wherein the housing (22) is cylindrical, the second set of protrusion (54) extends radially on a face of the disc (35) and the first set of protrusions (34) extends radially on an inner face of the housing (22).

5. The apparatus of claim 4, wherein the second set of protrusions (54) is distributed over 360 degrees on the face of the disc (35) and wherein the first set of protrusions (34) is distributed over at least 90 degrees, preferably less than 180 degrees, on the inner face of the housing (22).

6. The apparatus of any one of claims 1 to 5, wherein the distance between the inner face of the housing (22) and the face of the disc (35) is adjustable.

7. The apparatus of any one of claims 1 to 6, wherein the first set of protrusions (34) and the second set of protrusions (54) each contain a plurality of teeth (60).

8. The apparatus of claim 7, wherein the teeth (60) of each one of the first set of protrusions (34) and the second set of protrusions (54) are disposed facing each other and offset from each other so that first peaks and first valleys of the first set of protrusions (34) respectively coincide with second valleys and second peaks of the second set of protrusions (54).

9. The apparatus of any one of claims 1 to 8, wherein the first set of protrusions (34) and/or the second set of protrusions (54) are replaceable.

10. The apparatus of any one of claims 1 to 9, wherein the disc (35) comprises holes (38) for fluid communication between the air intake (24) and the second chamber (32).

11. The apparatus of any one of claims 1 to 10, wherein the air intake (24) is coaxial with the shaft (48) and wherein the outlet (28) is tangential to the disc (35).

12. A method for extracting fibers from a fibrous material in which the fibers are mixed with other constituents, the method being **characterized in that** it comprises:

providing the apparatus of any one of claims 1 to 11;
spinning the rotor (20) at a speed of at least 250 rpm;
introducing the fibrous material in the second chamber (32) through the material inlet (26);
shredding the fibrous material, thereby detaching the fibers from the other constituents by the cooperating action of the first set of protrusions (34) with the spinning second set of protrusions (54);
drawing air in the first chamber (30) of the housing (22) by creating a vacuum in the air intake (24) using the spinning vanes (36), thereby creating compressed air in the first chamber (30);
routing the compressed air to the second chamber (32); and
expelling the detached fibers and the other constituents from the outlet (28).

13. The method of claim 12, wherein the expelling comprises expelling the detached fibers at a first distance from the outlet (28) and expelling the other constituents at a second distance from the outlet (28) substantially different from the first distance.

14. The method of claim 12 or 13, wherein the spinning comprises spinning the rotor (20) at a speed less than 3000 rpm, preferably between 500 rpm and 1000 rpm.

15. The method of any one of claims 12 to 14, wherein the introducing the fibrous material comprises introducing hemp stalks.

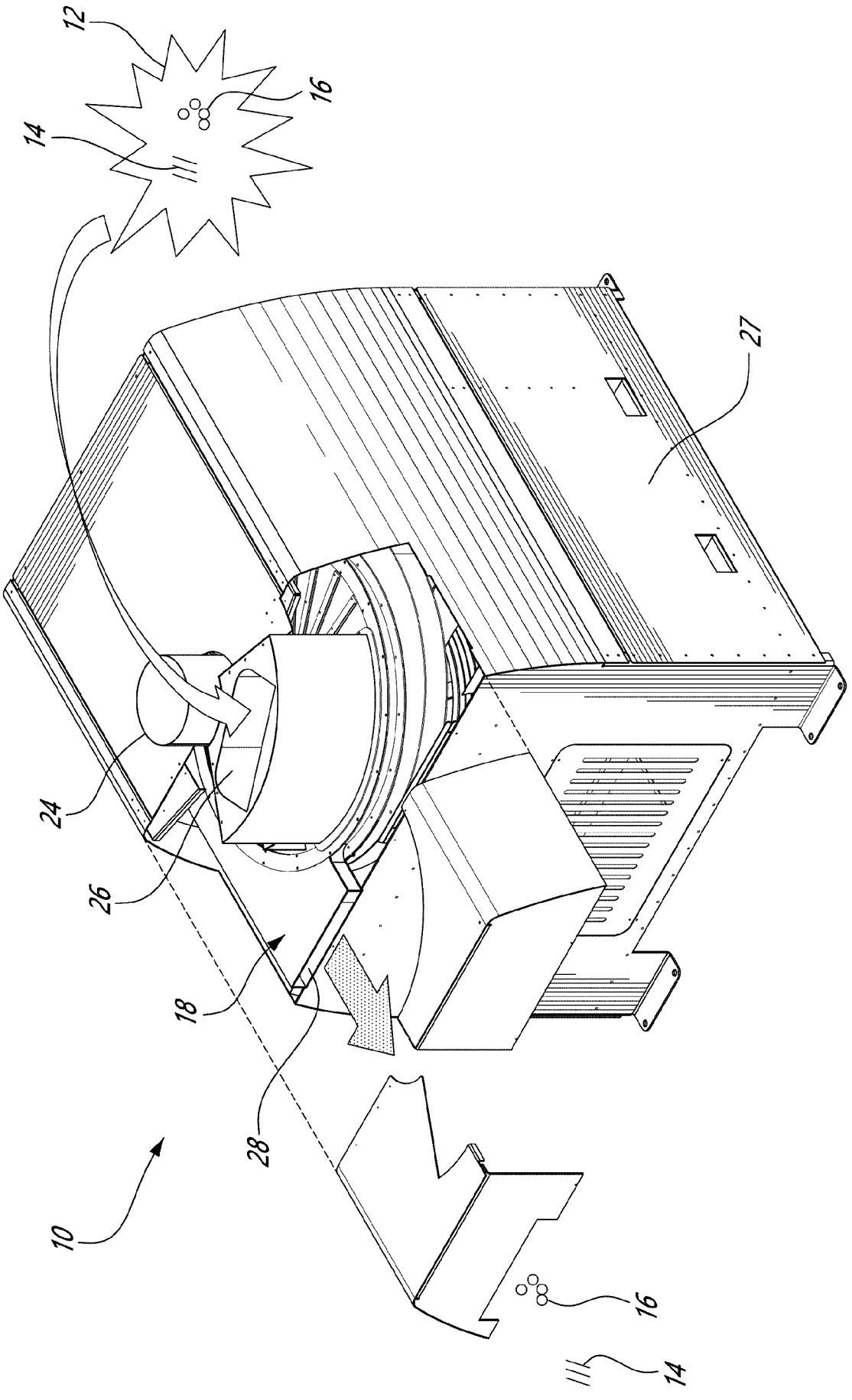


FIG. 1

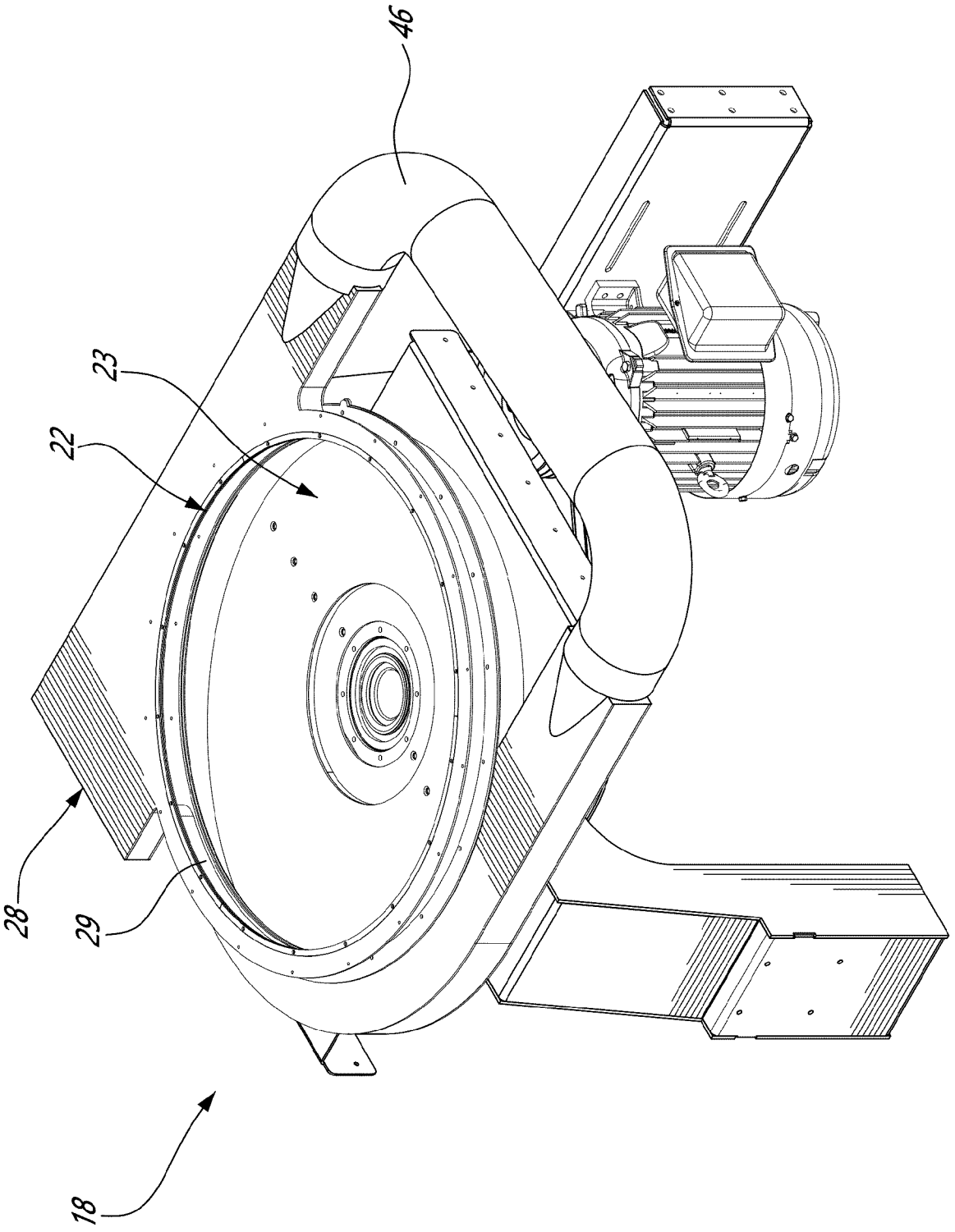


Fig. 2A

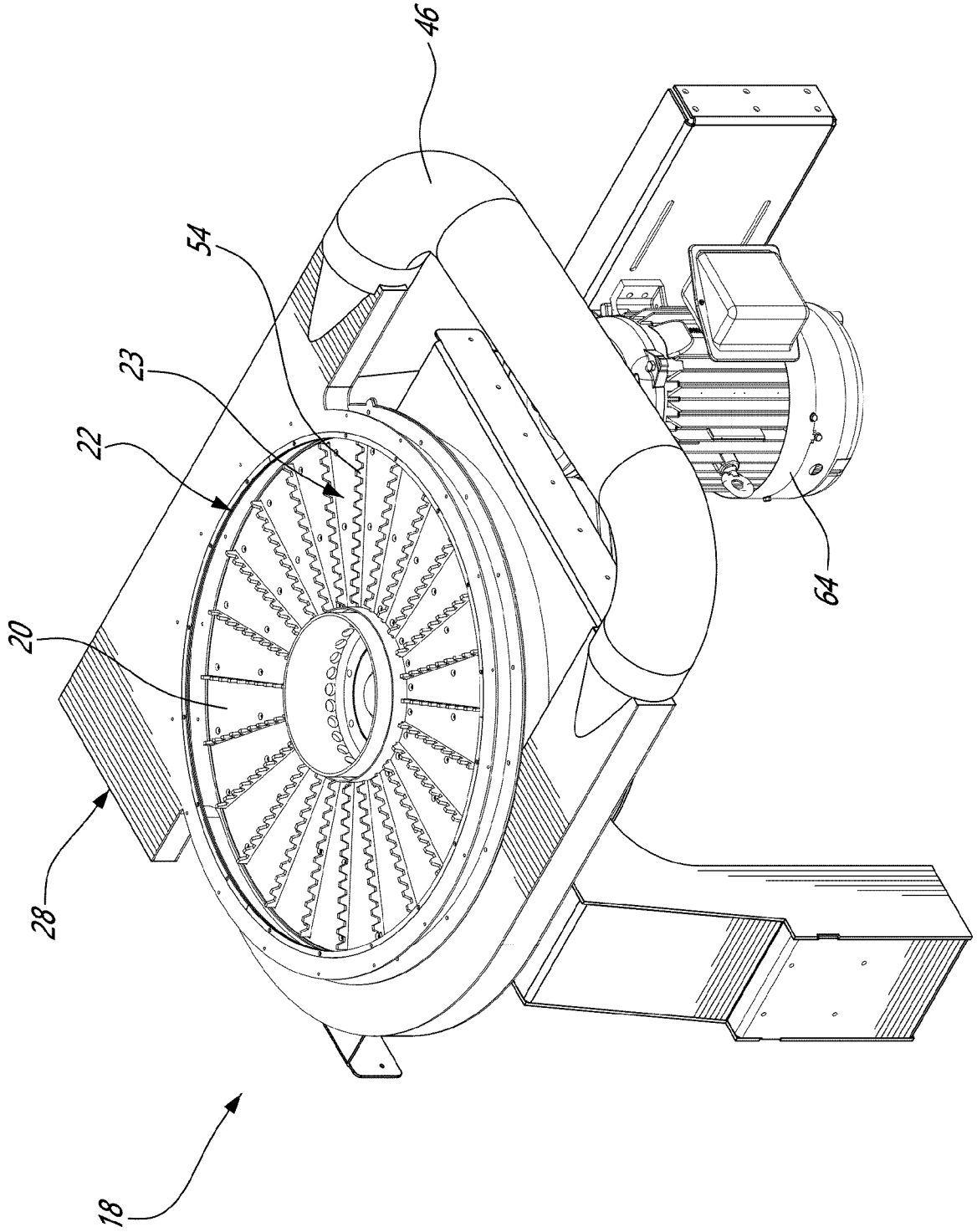


Fig. 2B

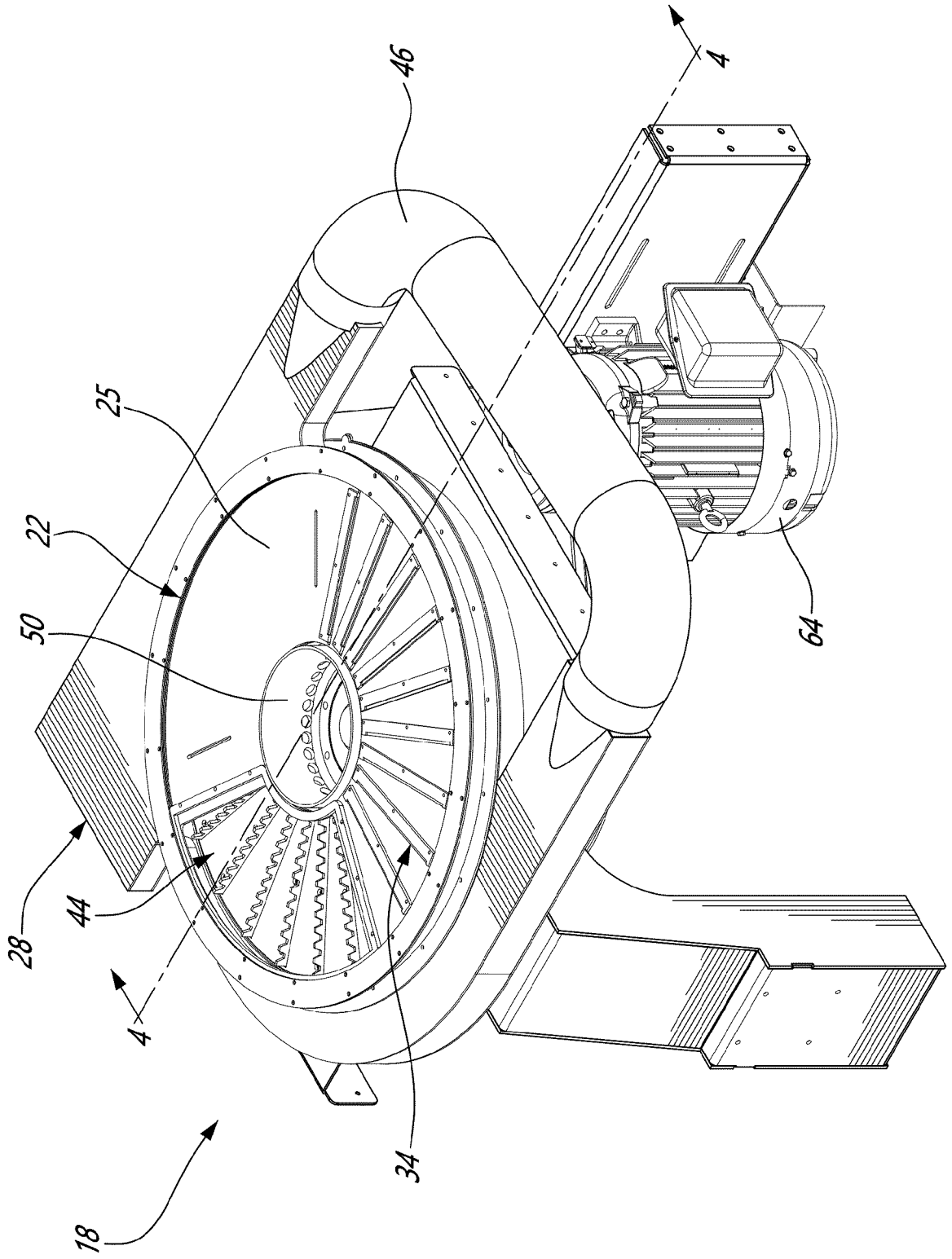


Fig. 2C

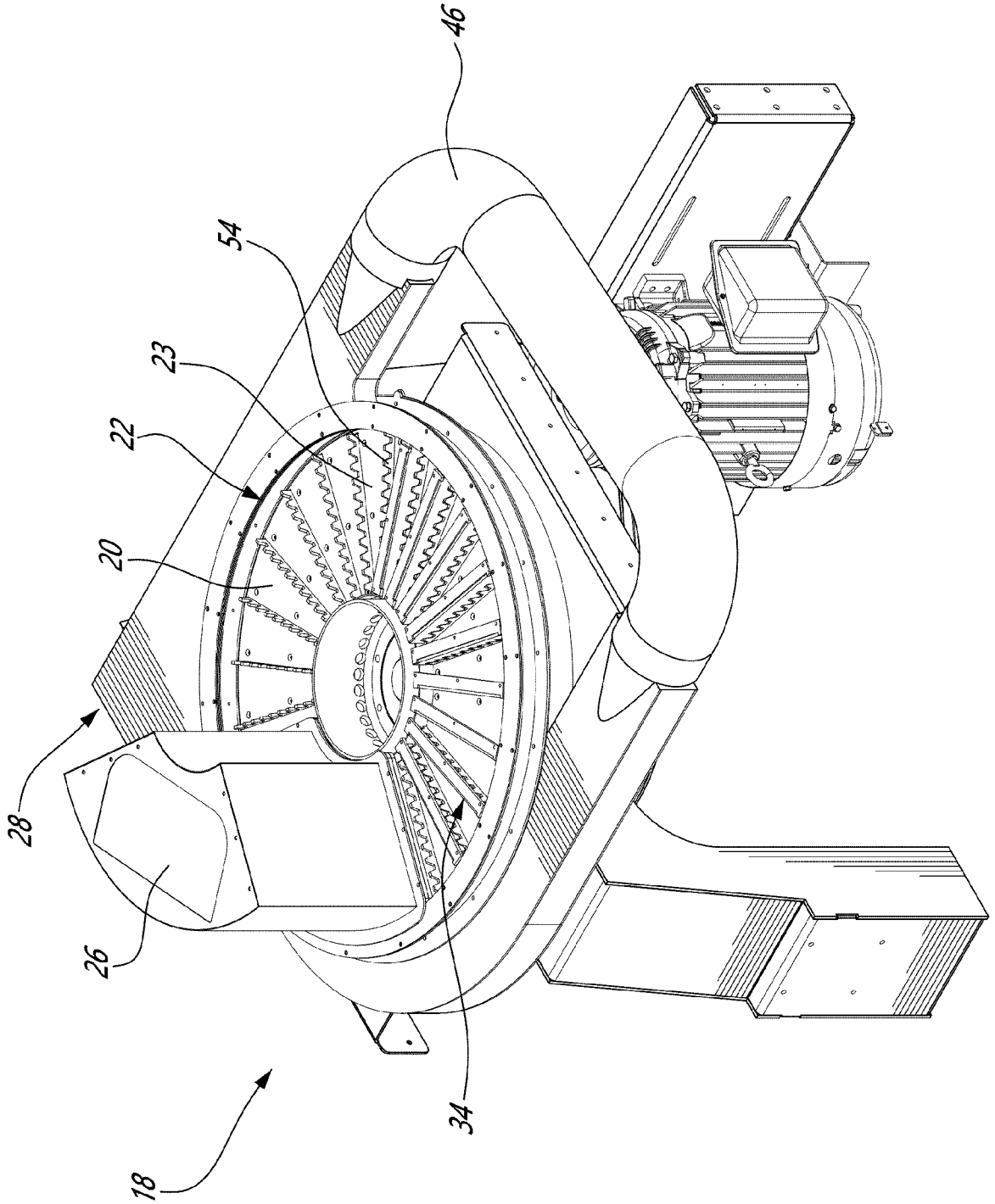
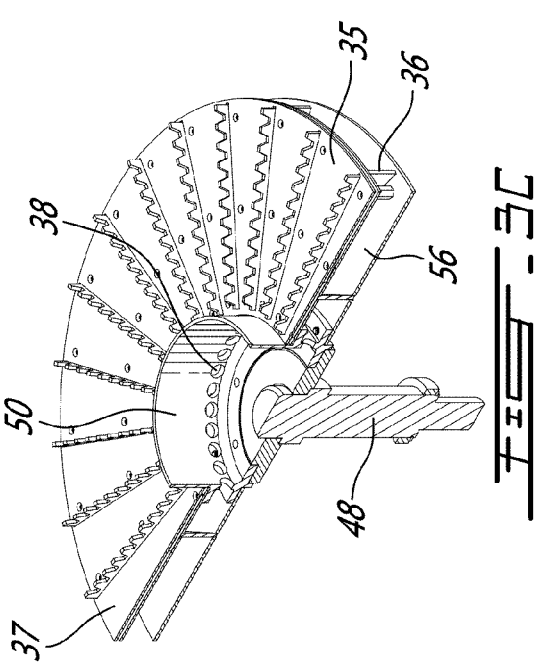
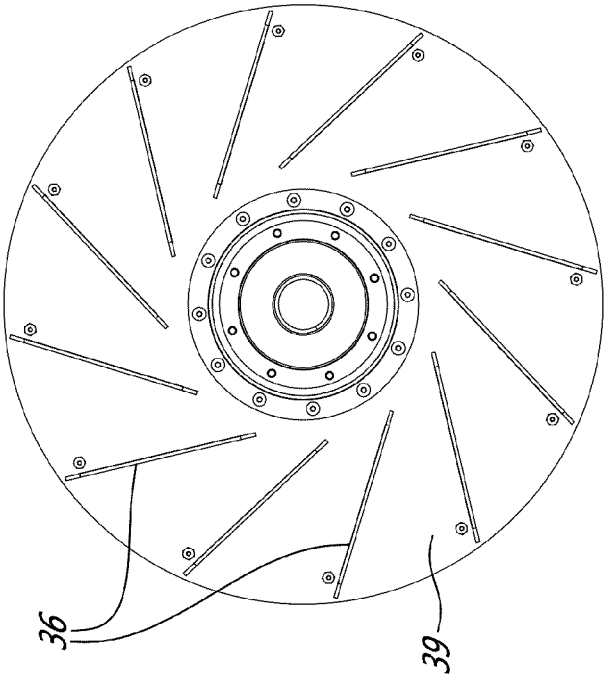


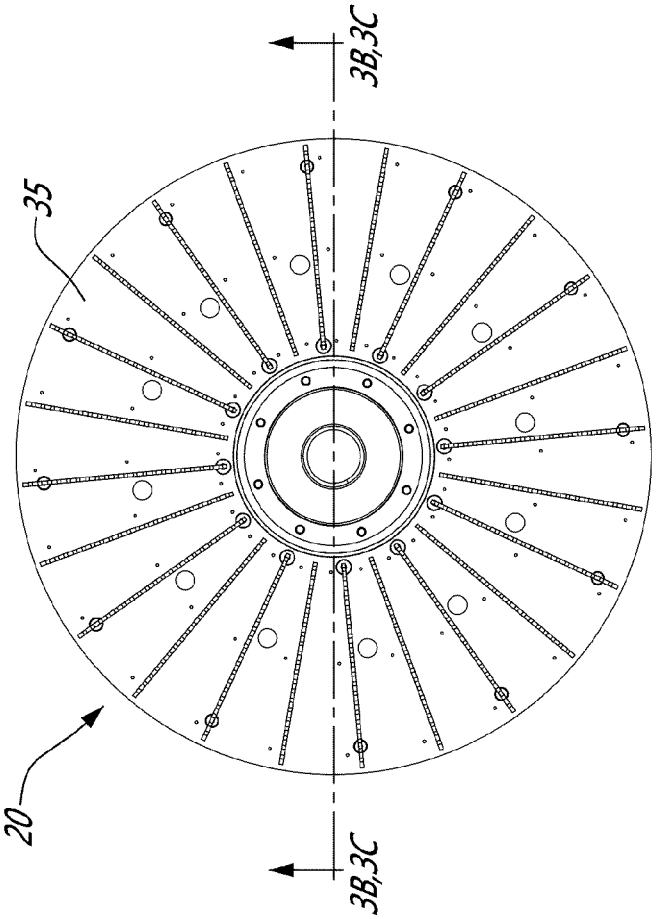
FIG. 20



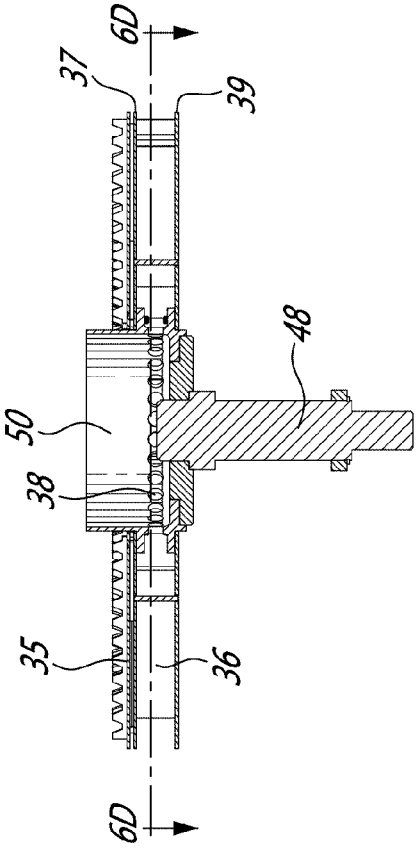
Фиг. 3С



Фиг. 3D



Фиг. 3A



Фиг. 3B

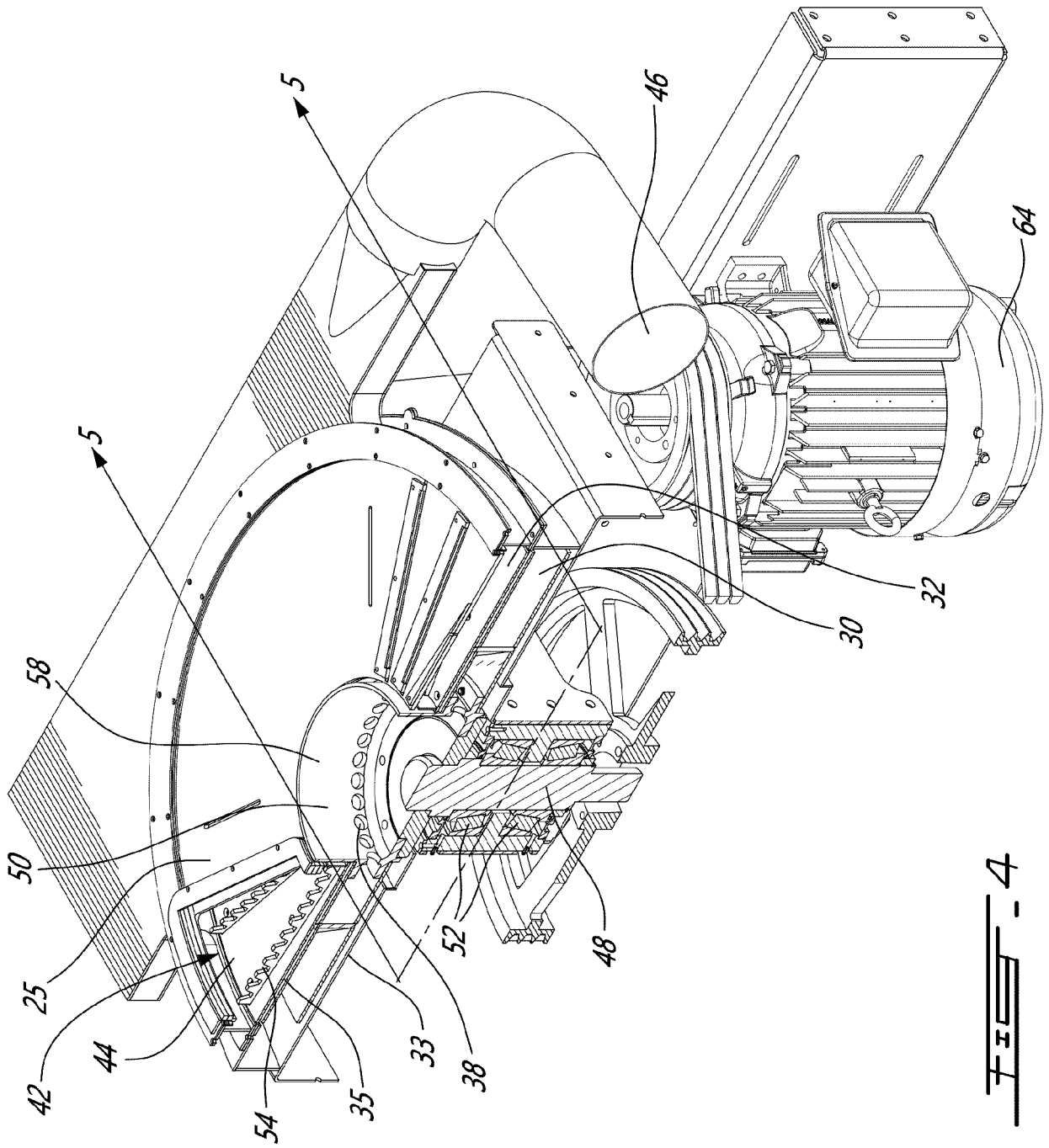


Fig. 4

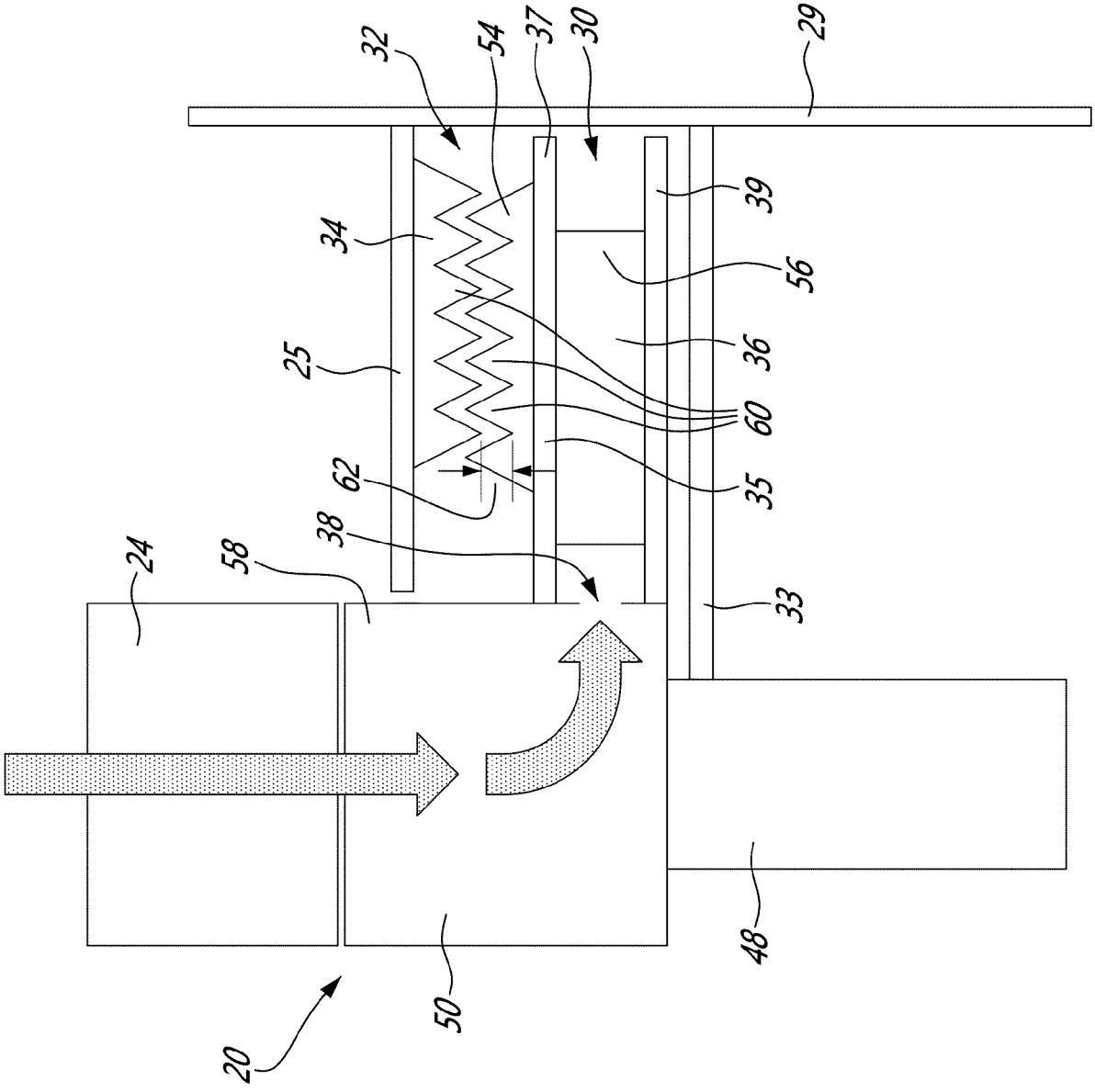


Fig. 5

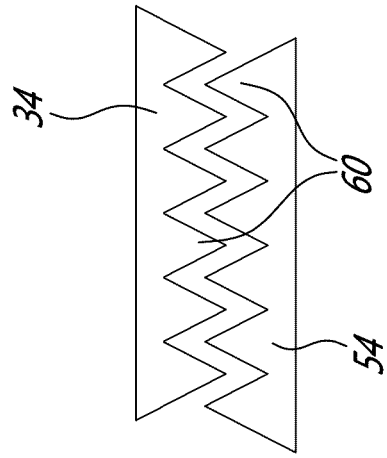


FIG. 6C

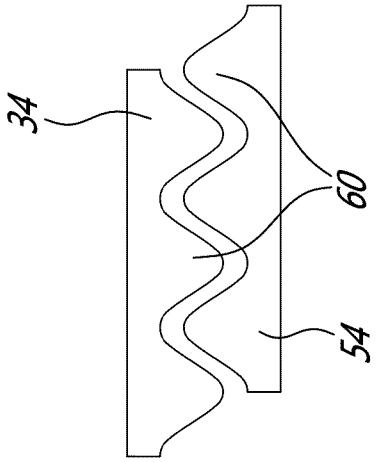


FIG. 6B

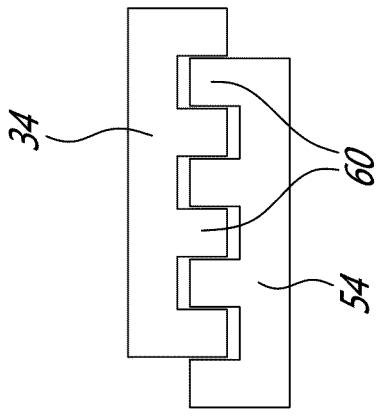


FIG. 6A

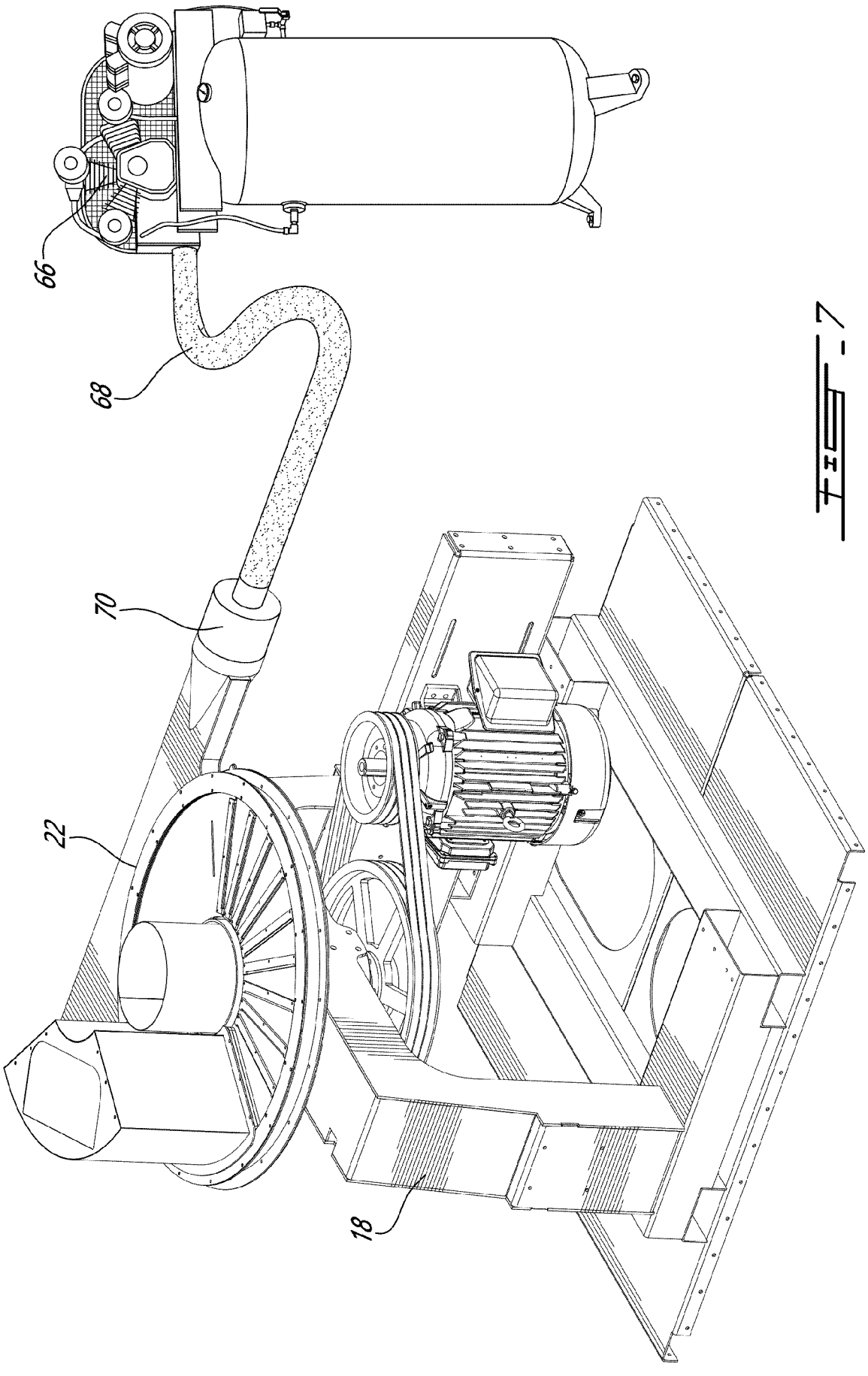


Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 25 21 4451

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D01B
D01G
B02C
B02B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	5 March 2026	Clivio, Eugenio

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