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(54) **ELECTROSTATIC FILTER FOR A FLUE DUCT OUTLET FROM A COMBUSTION CHAMBER, EQUIPPED WITH AN IMPROVED CLEANING**

(57) Electrostatic filter (4) for flue duct outlets from a combustion chamber, comprising a hollow manifold (8) having an inner side wall (12) delimiting a volume (16) for the passage and conveying of fumes, from an inlet end (20) of the fumes to an outlet end (24) of the fumes, said inlet end (20) and outlet end (24) being offset with respect to a vertical rising direction (Y-Y) of the fumes, said inner side wall (12) being lapped by said fumes, at least one electrode (28), housed at least partially in said volume (16) and/or in a side duct (32) fluidly connected to said volume (16), and configured so as to ionize the fumes crossing said volume (16) so as to adhere the particulate transported by the fumes to said inner side wall (12), and a cleaning device (44) configured so as to at least partially abrade said inner side wall (12) so as to remove the particulate attached thereto. The cleaning device (44) comprises at least one movable frame (48) within the volume (16), operatively connected to motor means (52), the frame (48) being provided with a plurality of brushes (56) configured so as to flap and clean said inner side wall (12), wherein said movable frame (48) comprises vertical sections (50), parallel to the vertical direction Y-Y, provided with said brushes (56).

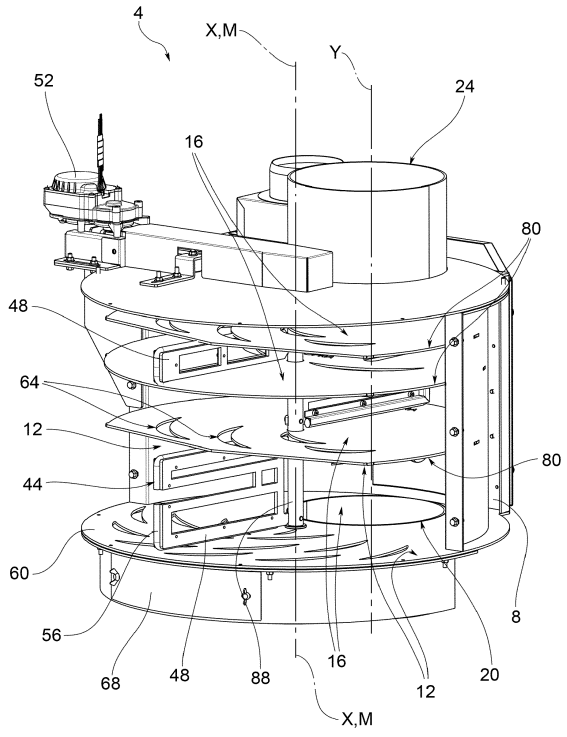

FIG.1

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Description

FIELD OF APPLICATION

[0001] The present invention relates to an electrostatic filter for a flue duct outlet from a combustion chamber, provided with an improved cleaning system.

PRIOR ART

[0002] As is well known, flue ducts are hollow containers that convey away the combustion fumes produced by a combustion chamber arranged upstream thereof.

[0003] Inevitably, combustion fumes carry combustion residues in the form of particulates, dust, soot, ash and the like which, in order to limit polluting emissions, must be filtered out of said fumes before they are emitted into the atmosphere.

[0004] Such particulate matter may be captured by means of the use of electrostatic filters comprising a charged high-voltage electrode that ionizes the air and consequently the fumes crossing the duct.

[0005] The particulate suspended in the fumes is in turn electrostatically charged, with a generally negative but also positive charge, and attracted towards the inner metallic walls of the duct which are grounded, thus attracting the electrostatic charges of the fumes by means of a potential difference. The inner walls of the flue therefore become surfaces for the deposition of particulate which may accumulate, also in large quantities, within a few hours of combustion chamber operation.

[0006] The accumulated particulate matter must obviously be removed, since the accumulation thereof may lead to numerous problems, such as for example:

- a decrease in particulate filtration efficiency over time,
- accelerated and localized fouling of those flue walls that are near to the filter,
- the need for more frequent periodic cleaning of the flue section affected by the filtration,
- the formation of coarse particulate matter that detaches from the walls and is emitted into the atmosphere along with the fumes (a phenomenon that we will define for simplicity as "reentering"),
- the possibility of flue fire phenomena.

[0007] The phenomenon of "reentering" emits coarse particulate matter into the atmosphere which presents fewer problems for human health than ultrafine particulate matter. Notwithstanding this, reentering is a problem during product emission sampling tests. Emission tests are in fact performed using a gravimetric sample, which involves drawing in combustion fumes and passing them through a filter. Reentering therefore significantly increases the weight of the filter.

[0008] To solve those problems relating to the presence of the particulate deposited in the flue, known in the art are manifolds with an automatic cleaning system for the removal of the collected particulate.

[0009] Such known solutions include, for example, an auger with an integrated brush that removes, by abrasion, the particulate that accumulates along the inner walls of the flue.

[0010] The known solutions have some drawbacks and disadvantages.

[0011] In fact, these known solutions do not ensure complete cleaning of the inner surface of the flue and are also cumbersome. Furthermore, also the auger itself accumulates particulate upon the surface thereof that cannot be cleaned.

[0012] Furthermore, the cleaning, i.e. the removal of the particulate matter, is not thorough, since known brushes with metal bristles cannot remove all of the encrustation that accumulates on the walls, not even at those points that are reached by the same. This is also due to the fact that the geometry of the flue ducts is not particularly precise, and therefore known brushes cannot exert a constant mechanical action upon all portions of the inner surface of the flue duct.

[0013] Finally, the known solutions, during cleaning, are quite noisy: this aspect is by no means negligible and constitutes a considerable drawback since users do not appreciate the noises of the cleaning phase (especially for combustion plants that are installed within domestic environments).

DISCLOSURE OF THE INVENTION

[0014] The need to solve the drawbacks and limitations mentioned with reference to the prior art is therefore felt.

[0015] This requirement is met by an electrostatic filter for a flue duct outlet from a combustion chamber, provided with a cleaning system, perfected in accordance with claim 1.

DESCRIPTION OF THE DRAWINGS

[0016] Further features and advantages of this invention will become more apparent from the following detailed description of preferred, non-limiting embodiments thereof, wherein:

- Figure 1 shows an axonometric view of an electrostatic filter for a flue duct outlet from a combustion chamber in accordance with one embodiment of the present invention, wherein the side wall of the filter has been partially removed;
- Figure 2 shows a side sectional view of the electrostatic filter in Figure 1;
- Figure 3 shows an upper sectional view of the electrostatic filter in Figure 1;
- Figure 4 shows a plan view from above of the bottom of the electrostatic filter in Figure 1;
- Figure 5 shows a partial enlarged view of a movable frame that supports brushes for cleaning the filter, in

accordance with possible variations of one embodiment of the present invention;
Figure 6 shows views of a movable frame that supports brushes for cleaning the filter, in accordance with a further possible embodiment of the present invention.

[0017] Elements or parts of elements common to the embodiments described hereinafter will be indicated with the same numerical references.

DETAILED DESCRIPTION

[0018] With reference to the above figures, reference sign 4 has been used to indicate an overall view of an electrostatic filter for flue duct outlets from a combustion chamber. For the purpose of the present invention, the type of combustion chamber whereto the electrostatic filter 4 is applied is not relevant. In general, the present invention applies, in a broad sense, to any type of combustion chamber, including for example also wood-burning fireplaces, wood-burning ovens or in general biomass combustion equipment. The size or power of said combustion chambers does not matter either.

[0019] The electrostatic filter 4 comprises a hollow manifold 8 having an inner side wall 12 delimiting a volume 16 for the passage and conveying of fumes, from an inlet end 20 of the fumes to an outlet end 24 of the fumes.

[0020] Said inlet ends 20 and outlet ends 24 are offset with respect to a vertical rising direction Y-Y of the fumes. With the term offset it is meant that said inlet ends 20 and outlet ends 24 are at different heights with respect to the vertical direction Y-Y. In one specific embodiment, the inlet ends 20 and outlet ends 24 are coaxial with respect to the vertical direction Y-Y. The inner side wall 12 is lapped by said fumes.

[0021] In general, the definition of inner side wall 12 is to be understood in a broad sense: in other words, not only the wall that delimits the volume laterally, but also the opposing lower and upper faces which enclose said side wall. In other words, the term inner side wall 12 refers to any surface facing or inserted into said volume 16 and lapped by the fumes produced by the combustion chamber, introduced therein by means of the inlet end 20.

[0022] The hollow manifold 8 may have any type of geometry; preferably, but not necessarily, the hollow manifold 8 is cylindrical and axially symmetrical with respect to an axis of vertical symmetry X-X, parallel to said vertical direction Y-Y.

[0023] Usually, but not necessarily, the inlet end 20 and the outlet end 24 are aligned with each other, with respect to said vertical direction Y-Y.

[0024] Said inlet ends 20 and outlet ends 24 may have any geometry, for example a circular or elliptical geometry, typically counter-shaped with respect to the geometry of the pipe or flue whereto they are fluidly connected.

[0025] The electrostatic filter 4 comprises at least one electrode 28, housed at least partially in said volume 16 and/or in a side duct 32, fluidly connected with said volume 16, and configured so as to ionize the fumes crossing said volume 16 so as to adhere the particulate transported by the fumes to said inner side wall 12. The at least one electrode 28 is therefore essential in order to allow the particulate to cling onto the inner side wall 12 of the hollow manifold 8; this particulate must then be removed using suitable removal means that are better described below.

[0026] In accordance with one possible embodiment, the electrostatic filter 4 comprises two electrodes 28 at least partially superimposed along the vertical direction Y-Y.

[0027] The use of multiple electrodes 28 allows for more effective ionization of the fumes, and therefore efficient filtration of the particulate that adheres to the inner side wall 12 of the hollow manifold 8 and/or the elements contained therein and that will not be expelled from the outlet end 24 together with the fumes.

[0028] Preferably, in the embodiment comprising two electrodes 28, said electrodes 28 have different cantilevered sections 36 within said volume 16. Said cantilevered sections 36 are preferably oriented parallel to a plane perpendicular to said vertical direction Y-Y.

[0029] For example, said electrodes 28 each comprise a coating sleeve 40 made of insulating material, typically a ceramic material, which electrostatically insulates them near said inner side wall 12 of the manifold 8.

[0030] The electrostatic filter 4 further comprises a cleaning device 44 configured so as to at least partially abrade said inner side wall 12 so as to remove the particulate attached thereto.

[0031] Said cleaning device 44 comprises at least one movable frame 48 within the volume 16, which frame is operatively connected to motor means 52. Preferably, said motor means 52 comprise electric motors with relative motion transmission elements.

[0032] The movable frame 48 may provide various movement trajectories. According to one possible embodiment, said movable frame 48 is a frame which is rotatable around said axis of vertical symmetry X-X. It is also possible for the movable frame 48 to have a translation movement or even a rotation-translation movement, within said volume 16, so as to reach those portions of the inner side wall 12 that are to be cleaned.

[0033] Advantageously, the frame 48 is provided with a plurality of brushes 56 configured so as to flap and clean said inner side wall 12.

[0034] In accordance with one possible embodiment, said brushes 56 comprise silica fiber and/or basalt fiber and/or ceramic fiber.

[0035] Preferably, said movable frame 48 comprises vertical sections 50, parallel to the vertical direction Y-Y, provided with said brushes 56.

[0036] In accordance with one possible embodiment, the movable frame 48 comprises a plurality of cantilevered portions 54 that are discrete and separated from

each other, provided with said vertical sections 50.

[0037] According to one possible embodiment, said cantilevered portions 54 are radial elements, provided with a main extension along a radial direction R-R, perpendicular to the vertical direction Y-Y. Said cantilevered portions may be parallel or angled with each other and may also be arranged in diametrically opposite positions to each other with respect to an axis of rotation of the frame 48, parallel to said vertical direction Y-Y.

[0038] According to one embodiment, said cantilevered portions 54 have a height 53, measured parallel to the vertical direction Y-Y, less than a width 55, measured perpendicular to the vertical direction Y-Y.

[0039] In accordance with one possible embodiment, said inlet ends 20 and outlet ends 24 are coaxial with respect to said vertical rising direction Y-Y of the fumes.

[0040] For example, said brushes 56 have a cantilevered height with respect to the movable frame 48 of between 1 mm and 20 mm, preferably between 3 mm and 10 mm.

[0041] The manifold 8 comprises a bottom plate 60 having a plurality of discharge holes 64 for the particulate that are connected to an underlying collection compartment 68 for the particulate. In other words, the particulate, once removed from the brushes 56, is pushed by the latter to the discharge holes 64, arranged at the bottom plate 60, wherethrough the particulate may precipitate, thus being collected within the collection compartment 68.

[0042] In accordance with one possible embodiment, said discharge holes 64 are on the side opposite the inlet end 20 of the fumes, with respect to a vertical centerline plane M-M of the hollow manifold 8.

[0043] In accordance with one possible embodiment, said discharge holes 64 have an arched elongated configuration that prevents the fibers of the brushes 56 from being damaged and/or detaching from the frame 48. In other words, such a configuration prevents the brushes from becoming caught, even partially, in the discharge 64 holes during the handling of the movable frame 48 and thus being damaged by, for example, tearing, ripping, or breaking.

[0044] Preferably, said discharge holes 64 have tapered ends 72 with respect to an enlarged central body 76.

[0045] According to one possible embodiment, said discharge holes 64 have a predominantly circumferential orientation with respect to an axis of vertical symmetry X-X of the hollow manifold 8 having a cylindrical shape.

[0046] Preferably, said at least one movable frame 48 comprises a plurality of brushes 56 configured so as to flap and clean said bottom plate 60 during the movement of the frame 48 itself.

[0047] Preferably, the hollow manifold 8 comprises at least one separation plate 80, arranged perpendicular to said vertical direction Y-Y within the volume 16, so as to create a forced path for said fumes along a horizontal direction O-O perpendicular to said vertical direction Y-Y.

[0048] Said separation plate 80 is provided with at least one discharge hole 64 for the particulate. Preferably, the discharge holes 64 of the separation plate 80 have the same configuration as the discharge holes 64 of the bottom plate 60.

[0049] Preferably, said movable frame 48 is counter-shaped so as not to interfere with the separation plate 80 during the movement thereof within the volume 16. In other words, the movable frame 48 itself must not collide with the separation plate 80 during the movement thereof.

[0050] Preferably, the movable frame 48 comprises a plurality of brushes 56 configured so as to flap and clean said separation plate 80 during the movement of the frame 48. The brushes 56 are therefore designed to be interfaced for sliding against the separation plate 80.

[0051] According to one possible embodiment, said at least one electrode 28, housed at least partially in said volume 16, is positioned at least partially cantilevered within the volume 16 of the hollow manifold 8 and said movable frame 48 is counter-shaped with respect to the electrode 28 so as not to interfere with the electrode 28 during the movement thereof within the volume 16. In other words, the movable frame 48 must not strike the electrode 28 during the movement thereof within the volume 16.

[0052] In accordance with one possible embodiment, the movable frame 48 comprises a plurality of brushes 56 configured so as to flap and clean the at least one electrode 28 during the movement of the frame 48 within the volume 16.

[0053] According to a possible embodiment, said frame 48 comprises at least one elastic element 84 configured so as to elastically influence the brushes 56 in abutment against said inner side wall 12 of the hollow manifold 8.

[0054] In other words, it is possible to envisage an embodiment wherein elastic elements 84 are provided between the movable frame 48 and the brushes 56. In this case, only the elastic elements 84 elastically press the brushes 56 in abutment against the inner side wall 12.

[0055] For example, said at least one elastic element 84 elastically influences the brushes 56 in a radial direction R-R, perpendicular and incident to a vertical axis of rotation of the frame 48 and/or in said vertical direction Y-Y. The elastic forces exerted by said elastic elements 84 are schematically shown with the references 'F' in Figure 5.

[0056] Furthermore, said movable frame 48 is counter-shaped so as not to interfere with said electrodes 28 during the movement thereof.

[0057] The operation of an electrostatic filter according to this invention will now be described.

[0058] In particular, the combustion fumes produced within the combustion chamber enter the electrostatic filter 4, through the inlet end 20, and follow a path that is preferably serpentine due to the presence of shelves, i.e., of the at least one separation plate 80, within the

hollow manifold 8. On each shelf or separation plate 80 there are frames, which are for example integral with a central shaft 88, which allows for the synchronous rotation of the movable frames 48 themselves. Brushes 56 comprising a temperature-resistant ceramic fiber are applied to the external part of the frames 48, which makes it possible to clean the surfaces of the inner side wall 12 of the manifold 8 when the cleaning system is set in motion.

[0059] When the cleaning device 44 is activated, the frames 48 turn within the manifold 8 and the brushes 56 make it possible to clean the surfaces of the inner side wall 12 of the same.

[0060] The agglomerated particulate falls between the various surfaces or plates via the appropriate discharge holes 64, which are preferably slotted or tapered, until terminating within a tank or collection compartment 68 which is positioned at the base or bottom plate 60 of the hollow manifold 8 and easily accessible for seasonal cleaning of the collected soot.

[0061] The frames are equipped with ceramic and/or silicon and/or basalt fiber brushes 56, which resist temperatures above 700°C (the temperatures of the fumes within the manifold may reach 400°C).

[0062] As may be appreciated from that which has been described, the present invention overcomes the drawbacks of the prior art.

[0063] In particular, the present invention makes it possible to thoroughly clean those surfaces that are reached by the brushes. In fact, the brushes, by virtue of the envisaged geometry and material, adapt perfectly to the not completely regular geometry of the inner walls of the hollow manifold 8 (due to the inevitable machining tolerances that are significant within the sector).

[0064] Furthermore, the present invention, unlike the known solutions, makes it possible to increase the deposition surfaces of the particulate and to clean up to 90% of these surfaces lapped by the fumes of the manifold 8, where, due to the electrostatic effect and serpentine passageways, most of the particulate is deposited.

[0065] In this way, the phenomenon of reentering is avoided, or else the periods of filter operating time are significantly lengthened before having to perform special maintenance.

[0066] The solution of the present invention also has reduced dimensions.

[0067] The noise level of the solution according to the present invention is particularly low with respect to the known solutions, whereby there are no problems or inconveniences as regards locating the boiler and flue within enclosed spaces.

[0068] Advantageously, by virtue of the particular geometry of the slots 64 themselves, the brushes do not fit into the slots that are provided for the evacuation of the removed particulate.

[0069] The present invention, as seen, applies broadly and generally to any boiler, wood-burning fireplace, wood-burning oven or biomass combustion equipment.

[0070] A person skilled in the art, for the purpose of satisfying contingent and specific needs, may make numerous modifications and variations to the solutions described above.

[0071] The scope of protection of the invention is defined by the following claims.

Claims

1. Electrostatic filter (4) for flue duct outlets from a combustion chamber comprising

   - a hollow manifold (8) having an inner side wall (12) delimiting a volume (16) for the passage and conveying of fumes, from an inlet end (20) of the fumes to an outlet end (24) of the fumes, said inlet ends (20) and outlet ends (24) being offset with respect to a vertical rising direction (Y-Y) of the fumes,
   - at least one electrode (28), housed at least partially in said volume (16) and/or in a side duct (32) fluidly connected with said volume (16), and configured so as to ionize the fumes crossing said volume (16) so as to adhere the particulate transported by the fumes to said inner side wall (12),
   - a cleaning device (44) configured to at least partially abrade said inner side wall (12) so as to remove the particulate attached thereto,
   - wherein the cleaning device (44) comprises at least one movable frame (48) within the volume (16), operatively connected to motor means (52), the frame (48) being provided with a plurality of brushes (56) configured to flap and clean said inner side wall (12),

   wherein said movable frame (48) comprises vertical sections (50), parallel to the vertical direction (Y-Y), wherein the movable frame (48) comprises a plurality of cantilevered portions (54), discrete and separated from each other, provided with said vertical sections (50).

2. Electrostatic filter (4) according to claim 1, wherein said cantilevered portions (54) are radial elements, provided with a main extension along a radial direction (R-R), perpendicular to the vertical direction Y-Y.

3. Electrostatic filter (4) according to claim 1 or 2, wherein said cantilevered portions (54) have a height (53), measured parallel to the vertical direction (Y-Y), less than a width (55), measured perpendicular to the vertical direction (Y-Y).

4. Electrostatic filter (4) according to any one of claims 1 to 3, wherein said brushes (56) comprise silica and/or basalt fibre and/or ceramic fibre.

5. Electrostatic filter (4) according to any one of claims 1 to 4, wherein the hollow manifold (8) is cylindrical and axial-symmetrical with respect to an axis of vertical symmetry (X-X), parallel to said vertical direction (Y-Y), wherein said frame (48) is rotatable around said axis of vertical symmetry (X-X).

6. Electrostatic filter (4) according to any one of claims 1 to 5, wherein said brushes (56) have a cantilevered height with respect to the frame comprised between 1 mm and 20 mm, preferably between 3 mm and 10 mm.

7. Electrostatic filter (4) according to any one of claims 1 to 6, wherein the hollow manifold (8) comprises a bottom plate (60) having a plurality of discharge holes (64) for the particulate connected with an underlying collection compartment (68) of the particulate, wherein said discharge holes (64) are on the side opposite the inlet end (20) of the fumes, with respect to a vertical centreline plane (M-M) of the manifold (8).

8. Electrostatic filter (4) according to claim 7, wherein said discharge holes (64) have an arched elongated configuration.

9. Electrostatic filter (4) according to claim 7 or 8, wherein said discharge holes (64) have tapered ends (72) with respect to an enlarged central body (76).

10. Electrostatic filter (4) according to any one of claims 1 to 9, wherein the manifold (8) comprises at least one separation plate (80), arranged perpendicular to said vertical direction (Y-Y) within the volume (16), so as to create a forced path for said fumes along a horizontal direction (O-O) perpendicular to said vertical direction (Y-Y).

11. Electrostatic filter (4) according to claim 10, wherein said separation plate (80) is provided with at least one discharge hole (64) for the particulate.

12. Electrostatic filter (4) according to claim 10 or 11 in combination with claim 7 or 8, the movable frame (48) comprises a plurality of brushes (56) configured so as to flap and clean said bottom plate (80) during the movement of the frame (48), wherein said brushes (56) are configured so as to flap and clean said bottom plate (60) during the movement of the frame (48).

13. Electrostatic filter (4) according to any one of claims 1 to 12, wherein said frame (48) comprises at least one elastic element (84) configured so as to elastically influence the movable frame (48) and/or the brushes (56) in abutment against said inner side wall (12) of the hollow manifold (8).

14. Electrostatic filter (4) according to any one of claims 1 to 13, wherein the filter (4) comprises two electrodes (28) at least partially superimposed along the vertical direction (Y-Y).

15. Electrostatic filter (4) according to any one of claims 1 to 14, wherein said electrodes (28) each comprise a coating sleeve (40) made of insulating material which electrostatically insulates them near said inner side wall (12) of the hollow manifold (8).

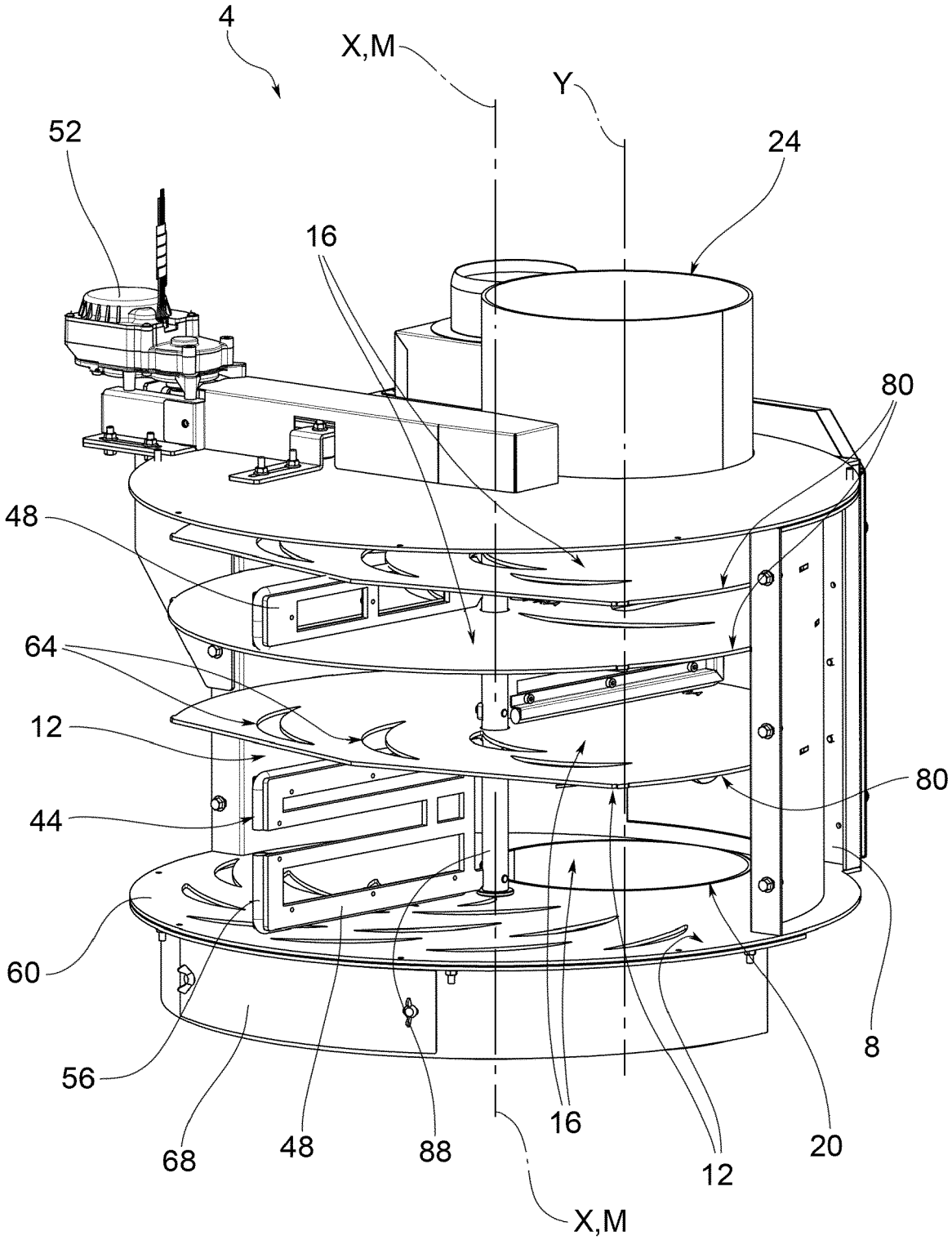

FIG.1

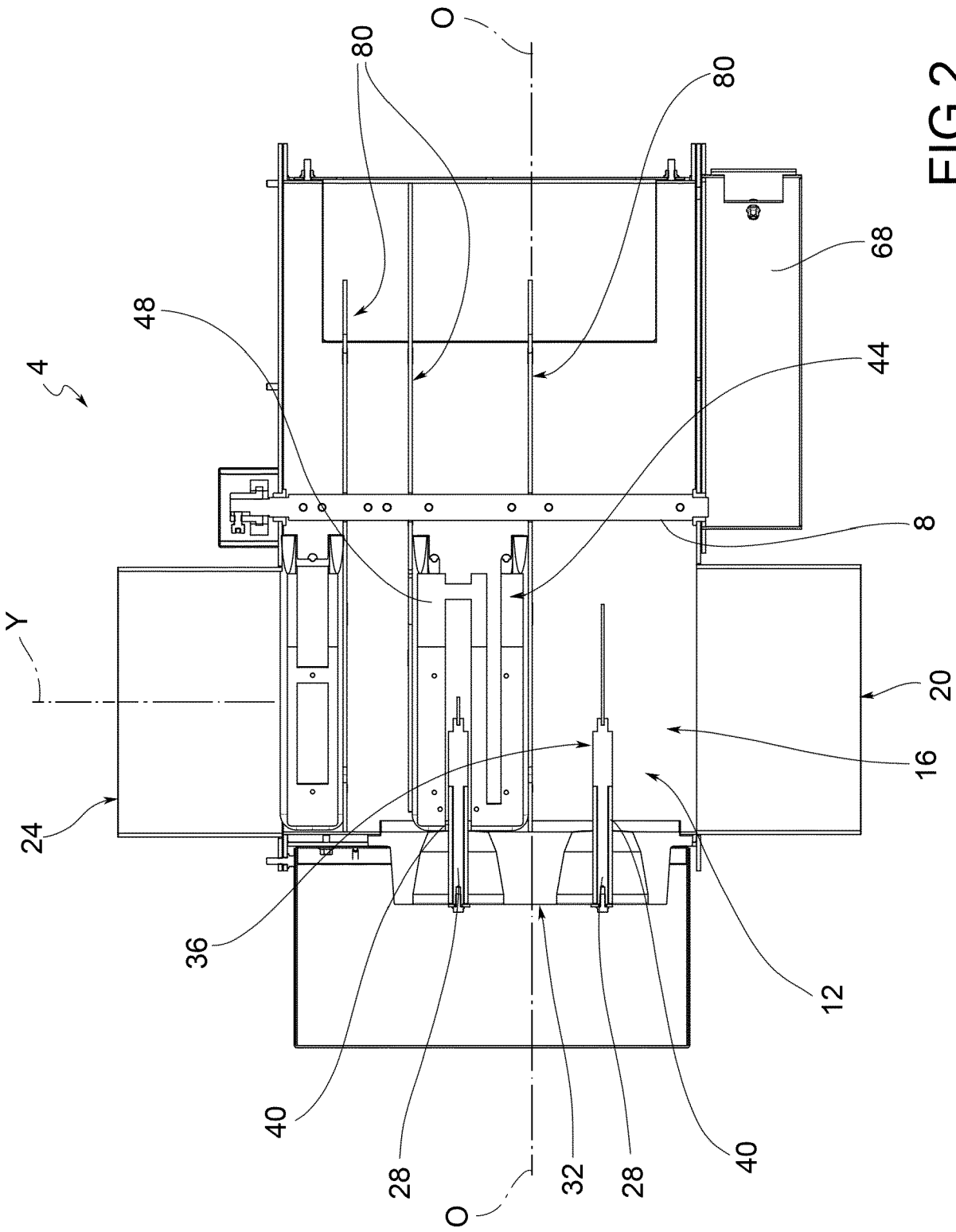

FIG.2

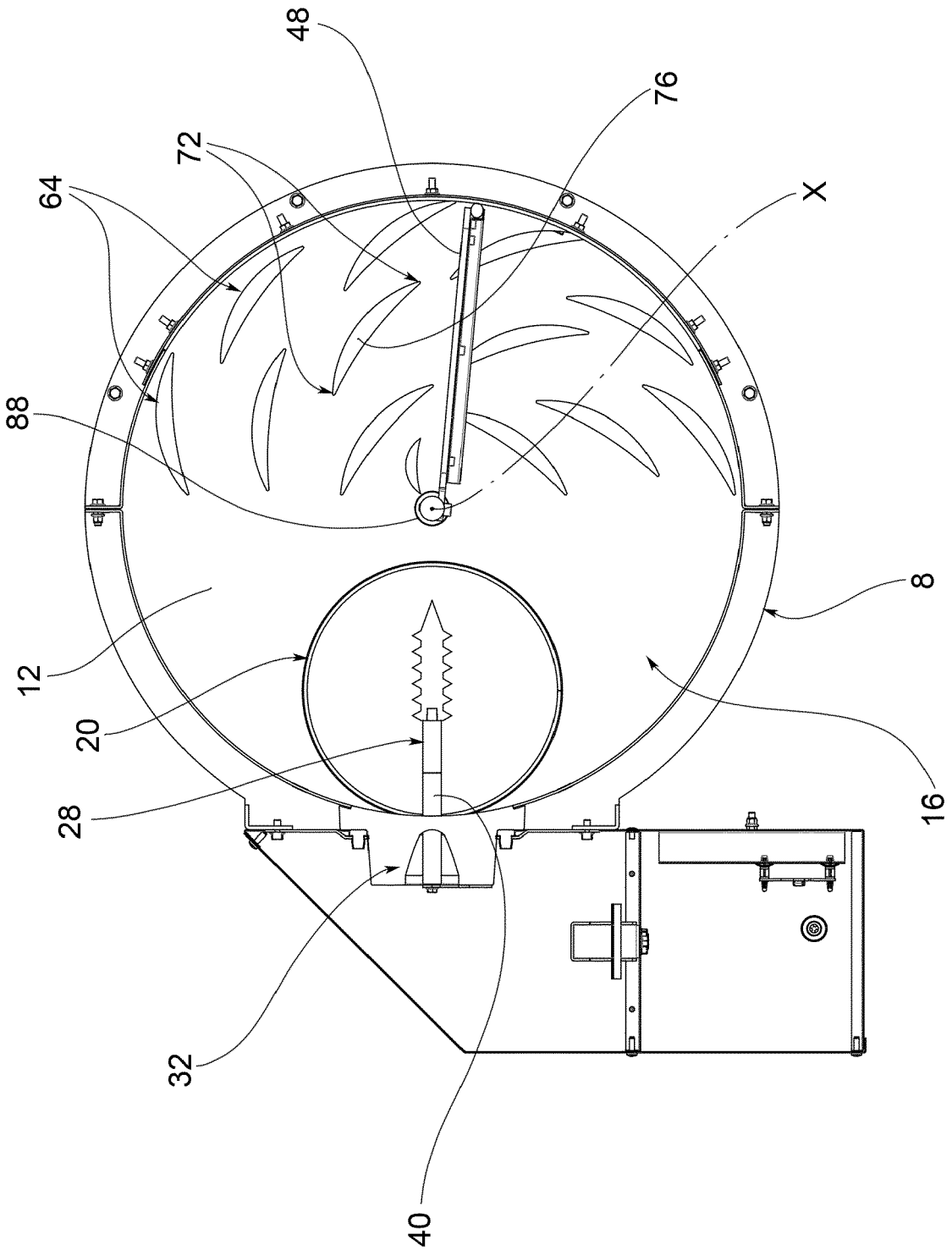

FIG.3

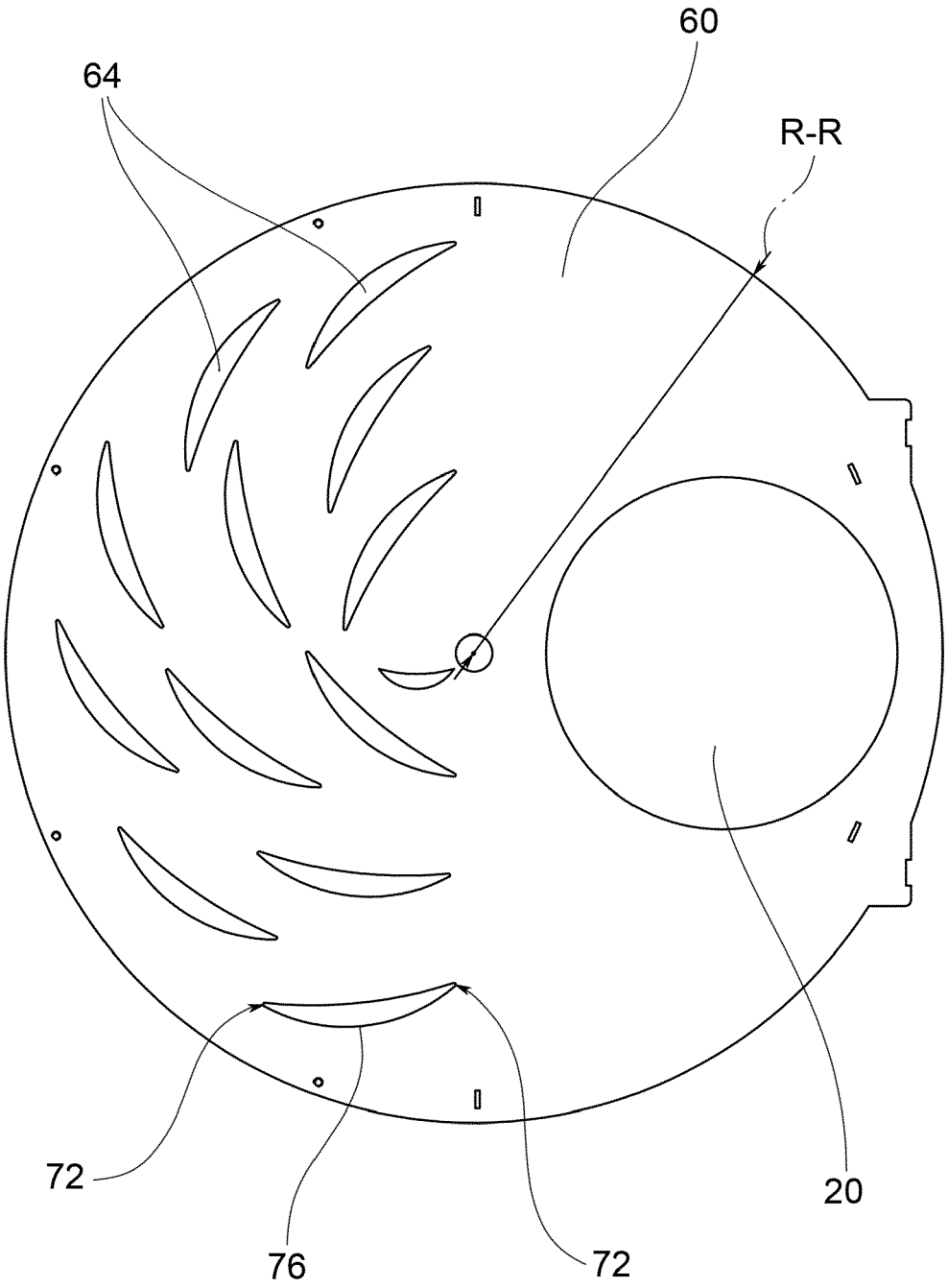

FIG.4

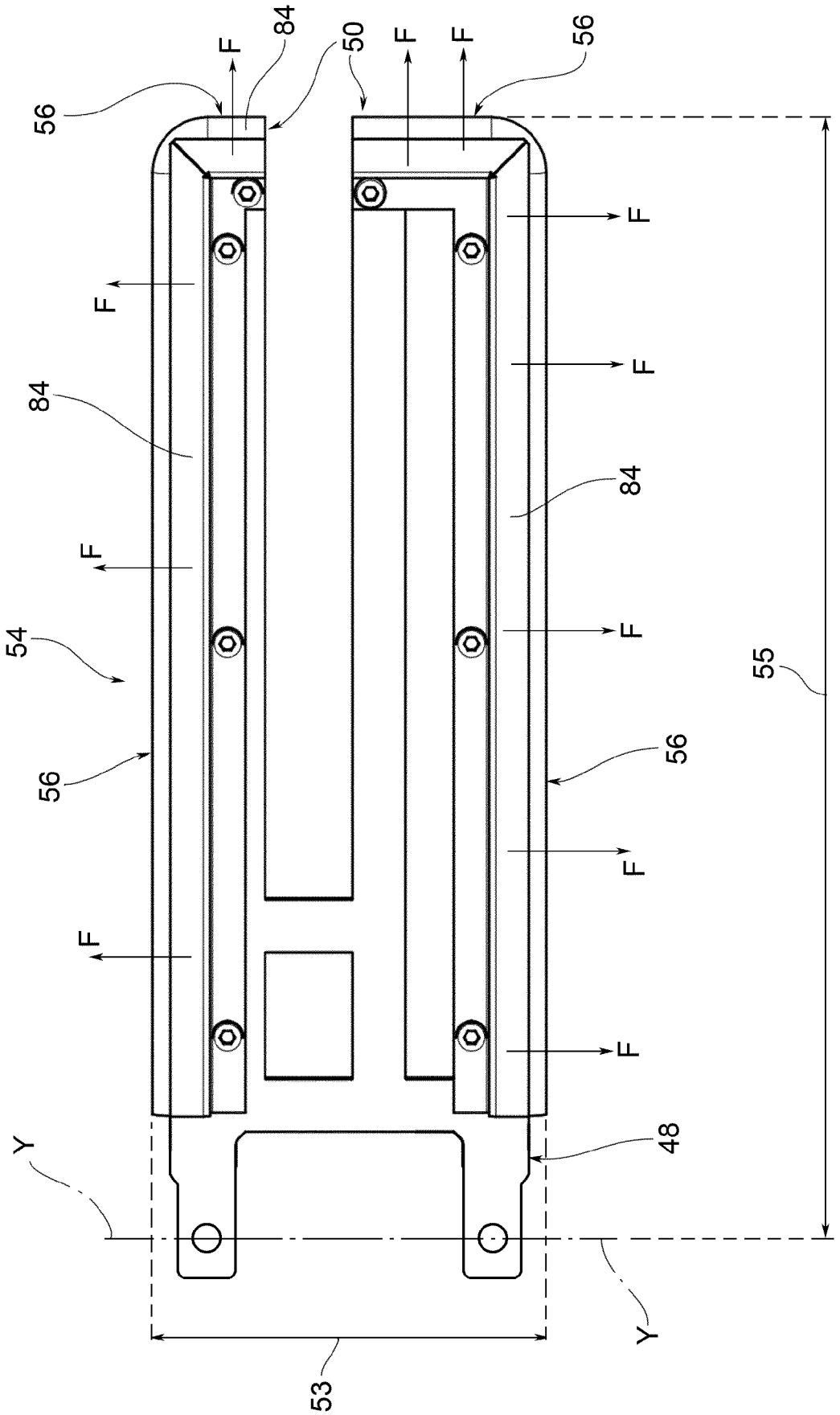

FIG.5

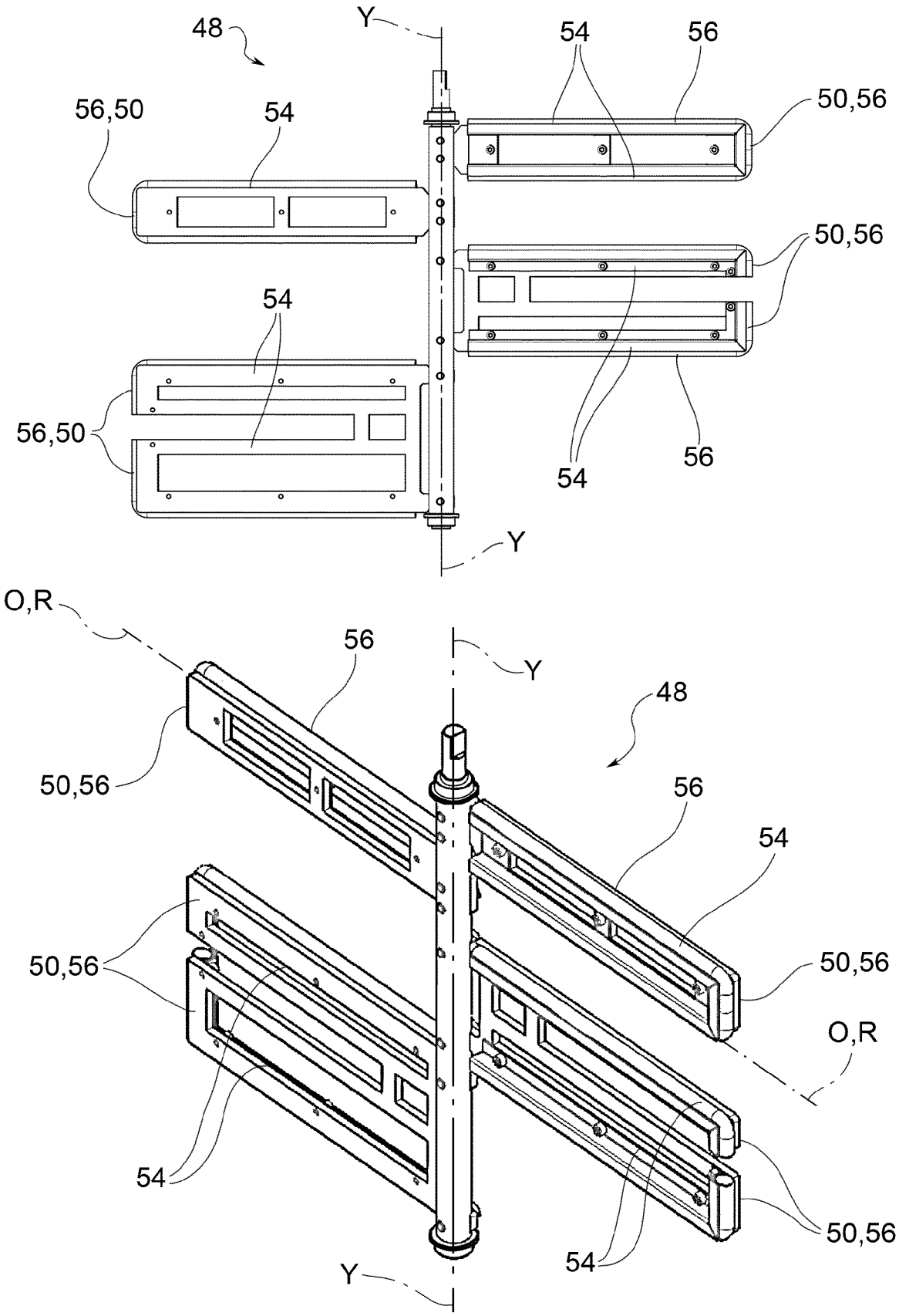
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FIG.6

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EUROPEAN SEARCH REPORT

Application Number
EP 22 21 3725

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 2 236 209 A1 (GEORG HIPP MASCHB GMBH [DE]) 6 October 2010 (2010-10-06) * column 11, paragraph 48 - column 12, paragraph 49 * * figures 19-22 *	1-15	INV. F23J15/02 B03C3/41 B03C3/74 F01N3/01
A	EP 2 583 755 A1 (KARLSRUHER INST TECHNOLOGIE [DE]) 24 April 2013 (2013-04-24) * column 10, paragraph 47 * * figure 2 *	1-15	
A	US 2020/009579 A1 (CHEN YAJUN [CN]) 9 January 2020 (2020-01-09) * page 2, paragraph 21 - page 3, paragraph 30 * * figures 1-3 *	1-15	

TECHNICAL FIELDS SEARCHED (IPC)
F23J F01N B03C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	16 May 2023	Gavriliu, Costin

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 22 21 3725

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