(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 417 887 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
21.08.2024 Bulletin 2024/34

(21) Application number: **24157618.0**

(22) Date of filing: **14.02.2024**

(51) International Patent Classification (IPC):
F24F 11/34 *(2018.01)* ***F24F 13/15*** *(2006.01)*
F24F 13/14 *(2006.01)* ***F24F 13/075*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F24F 13/15; F24F 11/34; F24F 13/075; F24F 13/1413; F24F 13/142; F24F 13/1426; F24F 2013/1446

(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 MA MD TN

(30) Priority: **14.02.2023 GB 202302106**

(71) Applicant: **Swegon Air Management Limited**
Shropshire WV15 5BB (GB)

(72) Inventors:
- **WARREN, Tyler**
  Shropshire, WV15 5BB (GB)
- **ILLIDGE, Andrew**
  Shropshire, WV15 5BB (GB)
- **KIMBERLEY, Malcolm**
  Shropshire, WV15 5BB (GB)

(74) Representative: **Marks & Clerk LLP**
15 Fetter Lane
London EC4A 1BW (GB)

(54) DAMPER

(57) A damper 10 has a damper housing 12 that forms a channel or passage 16 through which airflow can pass. Within the damper housing 12 are damper blades 14 consisting of a primary blade 24 and secondary blades 25. The damper blades 14 can be orientated between a fully closed position 10A where airflow through the passage 16 is prevented to a fully open position 10B where the airflow through the passage 16 is permitted to a maximum volume flow. The primary blade 24 can be controlled to be moved toward the open position 10B when the secondary blades 25 are in the closed position 10A. This means volume of air flow can be more accurately controlled at lower flow in comparison to when all the blades are moved from their closed position.

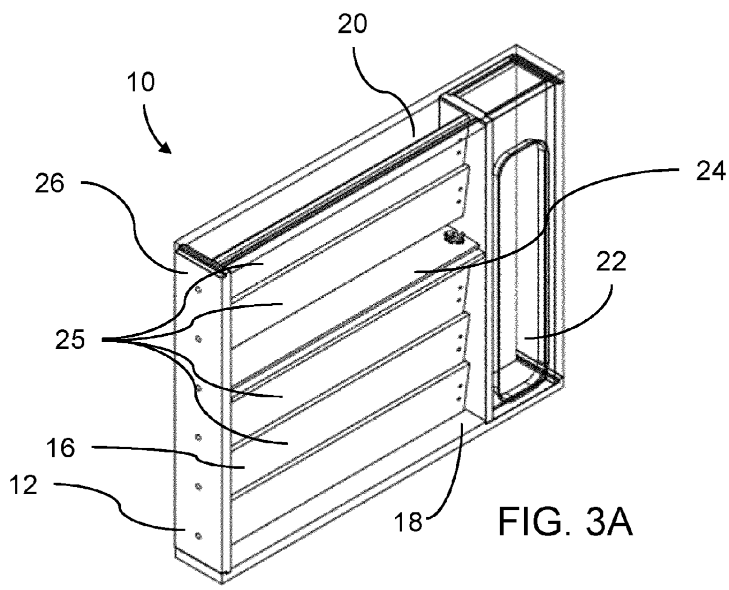

FIG. 3A

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Description

Field of the Invention

[0001] The present invention relates to dampers used for airflow, the dampers having blades to control the airflow.

Background

[0002] A damper can be used in a duct system to control the flow of air. Dampers can open and close accordingly to vary the volume of flow of air through the damper. The duct system can be connected to supply or extract an air flow.

[0003] One particular use of a damper is a smoke control damper. In the event of a fire, the damper can be opened to direct a flow of air to extract smoke carried by the air through the damper, therefore extracting an air flow. In a building or enclosure, this can direct smoke out of rooms or areas or away from other buildings. In such a use, the damper needs to have a large enough flow area to ensure the volume of flow is sufficient to remove and direct the smoke from the enclosure. In many countries, there are regulations concerning the use and functionality of smoke control dampers to ensure they meet the requirements.

[0004] A further use of a damper when installed in a room or area is for air ventilation. Air is supplied to a room through the damper to ensure adequate ventilation (in some cases the damper extracts air from a source at another position in the room to provide ventilation). However, too much ventilation can cause issues with temperature, energy use or dry air. Therefore, specific air ventilation dampers can be used to provide precise control for the varying requirements throughout the usage of the room and the environmental factors.

[0005] The volume of air that passes through a smoke control damper to provide adequate smoke extraction for a given room or area is much greater than the volume of air required for ventilation through an air ventilation damper. Therefore, whilst convenient, the use of the same damper for ventilation and smoke extraction causes difficulty due to the different levels of air flow control.

[0006] In some dampers, damper blades of smoke control dampers can be actuated to be positioned at different degrees of opening angles. Therefore, a smoke control damper could be used as an air ventilation damper by controlling the damper blades at the beginning of their opening range to allow a reduced volume of flow compared to the fully open volume of flow. However, at the start of the blade opening range, there is very little control for the low volume of air flow. This combined with manufacturing tolerances and hysteresis can further cause difficulties with the precise control of air flow that is required when using a damper with a large air flow capacity.

[0007] Therefore, there exists a need to provide precise volume of air flow control for low flow situations in dampers.

Summary of Invention

[0008] In accordance with an aspect of the invention, there is provided a damper comprising: a damper housing defining a passage; and a plurality of damper blades arranged within the housing, the plurality of damper blades being moveable between an open position for allowing airflow to pass through the passage and a closed position for preventing airflow to pass through the passage, wherein the plurality of damper blades comprise primary blades and secondary blades, the primary blades and the secondary blades each comprising at least one damper blade, and wherein, while the secondary blades are in the closed position, the primary blades are moveable towards the open position for allowing airflow to pass through the passage, or while the primary blades are in the open position, the secondary blades are moveable towards the closed position for preventing airflow to pass through the passage. In this way, the primary blades are movable while the secondary blades are in the closed position. By enabling only a limited number of (primary) blades to move separately from the movement of the remaining (secondary) blades which together form the plurality of blades, a volume of air flow can be more accurately controlled at lower flow as the actuation is not moving every blade in the housing. Therefore, to obtain the same volume of air flow compared to the partial opening of the plurality of blades, a lower number of primary blades can do so at a larger movement range. Therefore, the reduction in flow volume area allows for more precise control for constant air ventilation. Similarly, the secondary blades are movable while the primary blades are in the open position.

[0009] In one embodiment, the plurality of damper blades further comprises tertiary blades, the tertiary blades comprising at least one damper blade.

[0010] In one embodiment, while the secondary and tertiary blades are in the closed position, the primary blades are moveable towards the open position for allowing airflow to pass through the passage, and
wherein, while the tertiary blades are in the closed position, the secondary blades are moveable towards the open position for allowing airflow to pass through the passage. There may be further groups of blades which operate in a corresponding way. Each further group may have at least one or a plurality of blades.

[0011] In one embodiment, while the primary and secondary blades are in the open position, the tertiary blades are moveable towards the closed position for preventing airflow to pass through the passage, and
wherein, while the primary blades are in the open position, the secondary blades are moveable towards the closed position for preventing airflow to pass through the passage. There may be further groups of blades which operate in a corresponding way. Each further group may

have at least one or a plurality of blades.

[0012] The number of primary blades may be less than the number of secondary blades. The number of secondary blades may be less than the number of tertiary blades.

[0013] Preferably, the primary blade may be a control blade or blades. The control blade is moveable towards the open position for allowing airflow passing through the damper housing, wherein the at least one control blade is a partial amount of blades from the plurality blades.

[0014] Preferably, the primary blades are positionable to be held in a position between the open and closed position. The precise control for the air ventilation requires variation in the volume of flow. Therefore, a fully open primary blade would not always give the flow volume required. Instead, the primary blade is controllable between the fully closed and fully opened positions to be positioned to provide the volume of air flow required as dictated by the ventilation requirements. More preferably, the secondary blades are positionable to be held between the open and closed positions.

[0015] Preferably, each of the primary blades and/or each of the secondary blades are the same size. This allows for a simpler manufacturing process and avoids complications with installation.

[0016] More preferably, a sizing blade is provided which is a different size to the primary and secondary blade to allow for different size installations. The sizing blade can be configured to be moveable either with the primary or the secondary blades.

[0017] Preferably, the plurality of blades have a parallel arrangement in the damper housing. More preferably, the blades all have the same range of movement. This ensures a unitary design so flow through the damper such as when functioning as a smoke damper is not inhibited. This also simplifies manufacturing and maintenance, such as spare parts.

[0018] Preferably, the parallel arrangement of the blades extends between two opposing sides of the damper housing which are opposing in the direction in which the blades are adjacent, the opposing sides of the damper housing each being in direct contact with first and last blades of the plurality of blades when in the closed position. To ensure that the passage allows for the most amount of airflow when open, the blades are formed to the edge (i.e. sides) of the damper housing. In this manner, when closed, the blades are in contact with the opposite sides of the damper housing.

[0019] Preferably, at least one middle blade is arranged between the first and last blade, and wherein, in the closed position, each at least one middle blade is in direct contact with two blades of the plurality of blades. Where there are more than two blades, there are no further static objects in the passage that could prevent the flow. Therefore, each blade not at the opposing sides, i.e. middle blades, are directly next to two blades, and when in the closed position are in contact with the adjacent blades. This ensures that the maximum volume of the passage is provided to assist in the airflow.

[0020] In one embodiment, the primary blades and/or secondary blades each comprise two blades or a multiple of two blades. The blades are often provided in pairs, such as for gear movement and linkages. Therefore, there are benefits for the primary and/or secondary blades being two blades. However, in some cases, a single blade can be provided as the primary and/or secondary blade to reduce the individual flow volume, or more than two blades provided as the primary and/or secondary blades.

[0021] There may be at least two primary blades. There may be at least two secondary blades.

[0022] The primary blades may be positioned directly next to one another. Placing the primary blades next to one another has an advantage for the mechanism used to articulate them as this can be combined for multiple blades. However, it is also advantageous for the primary blades to be adjacent so that the flow volume can be more accurately controlled by having a commonly formed flow area.

[0023] Preferably, when the plurality of blades are positioned in the closed position, no gap is formed between each blade directly next to one another in the plurality of blades. The damper blades move between a closed position where they block air flow, to an open position where they do not block air flow. In this regard, the damper blades can rotate between a position where the face of the blade is facing the air flow, to a position where the face of the blade is inline with the flow of air. In the closed position each blade and its adjacent blade may form a wall of blades, each of which may be aligned with the face of the blade substantially perpendicular to the air flow. In this position, each blade may be aligned substantially vertically, for example when the air flows in a substantially horizontal direction. In the open position, each blade may be aligned substantially horizontally. As there is no gap between the blades, the airflow can be stopped or greatly reduced in this position.

[0024] Preferably, when the plurality of blades are positioned in the closed position, each blade directly adjacent to another in the plurality of blades is in contact. To further reduce the volume of air flow through a closed damper, the blades can be arranged to be in contact such that they overlap or occlude at their edges when the damper is in the closed position. The overlap can be formed by seals extending from the blade edges.

[0025] In one embodiment, the directly adjacent primary blades are configured to move in a mirror facing-fashion. As discussed, the damper blades may rotate from a substantially vertically aligned position to a substantially horizontally aligned position. There are two directions of rotation for this movement. If the adjacent blades rotate in a mirror fashion, such that they rotate in different or opposite directions, this can produce a less disrupted flow through the damper as the air flows over the blades, i.e. a nozzle or diffuser can be created with the blades' orientation. This can give an improved airflow.

[0026] Preferably, the damper housing is a single module enclosed at its sides with the plurality of blades all being positioned within the sides of the damper housing. This ensures that the damper is a standalone module for placing into a ducting system. Therefore, a single damper can be used for all operation modes. In one embodiment, two or more of these modules are formed into a multiple array. In this way, the size of the damper can be increased.

[0027] Preferably, the plurality of blades are controlled by a geared linkage. Whilst a number of options can be used to control the blades, such as separate or linked actuators / motors, pulley or chain mechanism, spring or tension systems, etc., a geared linkage can provide a reliable means for the blade movement.

[0028] Preferably, the damper comprises geared linkage which, when driven and while the secondary blades are in the closed position, is configured to move the primary blades towards the open position for allowing airflow to pass through the passage.

[0029] Preferably, the geared linkage comprises a linkage bar connected to at least two secondary blades so that the at least two secondary blades are configured to move together.

[0030] Preferably, the damper comprises an actuator which, while the secondary blades are in the closed position, is configured to move the primary blades towards the open position for allowing airflow to pass through the passage.

[0031] Preferably, movement of the plurality of blades is by a single actuator. More preferably, operation of the actuator is configured to move the primary blades from the closed position toward the open position and continued operation of the actuator is configured to move the secondary blades from the closed position toward the open position. In this way, the primary blades move first and the secondary blades move afterwards. This allows the movement of blades to be controlled by a single movement or actuation. The initial movement can cause movement of the primary blades to the fully open position and further movement can cause movement of the secondary blades to the open position. Therefore, the primary blades can be operated to control airflow before movement of the secondary blades. This provides greater control and allows for a simpler mechanism and fewer actuators, therefore improving manufacturing.

[0032] Preferably, movement of the primary blades from the closed position toward the open position causes the movement of only the primary blades for part of the movement and causes movement of both the primary blades and the secondary blades for the remainder of the movement. This allows the movement of blades to be controlled by a single movement or actuation. The initial movement can cause movement of the primary blades and further movement can cause movement of the secondary blades (optionally with the primary blades). This allows a simpler mechanism and fewer actuators, therefore improving manufacturing.

[0033] Preferably, the primary blades are connected to and moveable by a rotatable gear having a portion with discontinuous teeth; and the secondary blades are connected to a linkage, the linkage being engagable with the teeth of the gear, wherein the linkage is moveable by rotation of the gear when engaged with the teeth. Whilst a single movement can be used to actuate staggered movement of the blades, there are numerous means for incorporating a delay before the secondary blades move, such as cams, spooling, etc. A gearing mechanism which engages different blades via further gears or linkages at different points of actuated movement enables freedom in the movement of the blades, such as the delay before movement and he movement rate.

Brief Description of the Figures

[0034]

Figure 1	shows an isometric schematic of a damper according to the present invention;
Figure 2	shows an isometric schematic of the damper of Figure 1 in a further configuration;
Figure 3A	shows an isometric schematic of the damper of Figure 1 in a mode of operation;
Figure 3B	shows a front view schematic of the damper in the same mode as Figure 3A;
Figure 4	shows a trend of the operation of various dampers;
Figure 5A	shows a side view of a schematic of the actuator assembly of the damper of Figure 1; and
Figure 5B	shows the same side view as 5B in a different arrangement.

[0035] A fully and enabling disclosure of the present invention, including the best mode thereof, to one of ordinary skill in the art, is set forth more particularly in the remainder of the specification. Reference now will be made in detail to the embodiments of the invention, one or more examples of which are set forth below. Each example is provided by way of explanation of the invention, not limitation of the invention.

[0036] It will be apparent to those of ordinary skill in the art that various modifications and variations can be made in the present invention without departing from the scope of the invention. For instance, features described as part of one embodiment can be used on another embodiment to yield a still further embodiment. Thus, it is intended that the present invention cover such modifications and variations as come within the scope of the appended claims and their equivalents.

[0037] Other objects, features, and aspects of the present invention are disclosed in the remainder of the specification. It is to be understood by one of ordinary skill in the art that the present discussion is a description of exemplary embodiments only and is not intended as limiting the broader aspects of the present invention, which broader aspects are embodied in the exemplary constructions.

[0038] A listing of reference symbols used herein is given at the end of the description. Repeat use of reference symbols in the present specification and drawings is intended to represent the same or analogous features or elements.

[0039] Referring to Figure 1, there is provided a damper 10 according to the invention. As discussed below, the damper 10 is shown in the closed position 10A. The damper 10 is placeable in a duct or surface such as a wall and controls airflow through the damper 10. The damper 10 has a damper housing 12 that forms a channel or passage 16 through which airflow can pass through the damper housing 12 and thus damper 10. The damper housing 12 generally forms the sides or walls of the passage 16 such that there is an inlet and outlet from the passage 16.

[0040] As shown in Figure 1, a four sided damper housing 12 is formed therefore providing a square or rectangular shape when viewed from the front.

[0041] In the four sided damper 10 shown, the damper housing 12 has opposing sides formed between a top side 20 and a bottom side 18. Likewise, there are further opposing sides between a left side 26 and a right side 28 of the damper housing 12. Therefore, the periphery of the passage 16 is formed by the two sets of opposing sides. Airflow passes within these two sets of opposing sides through the passage 16 of the damper housing 12.

[0042] Whilst a four sided damper has been described, numerous shapes for the damper 10 can be used depending on the requirements. For instance, a circular damper housing 12 can be used in some situations.

[0043] Within the damper housing 12 are damper blades 14. The damper blades 14 are generally rectangular in shape when viewed from a plan view having a height and width and forming a damper blade surface. The damper blades 14 are arranged to extend across the width of the damper housing between the left side 26 and the right side 28 such that a single blade can extend between these opposing sides. Therefore, the longest side (e.g. width) of a rectangular blade 14 extends between the left side 26 and the right side 28. The damper blades 14 are also arranged within the damper housing 12 between the top side 20 and the bottom side 18. In this configuration, multiple blades are arranged in parallel between the top side 20 and bottom side 18.

[0044] Whilst the terms, top 20, bottom 18, left 26 and right 28 sides have been used for the walls of the damper housing 12, it is to be understood that the walls can be orientated in any manner not limited by the terms "top", "bottom", "left" and "right".

[0045] The damper blades 14 can be orientated between a fully closed position 10A where airflow through the passage 16 is prevented to a fully open position 10B (Figure 2) where the airflow through the passage 16 is permitted to a maximum volume flow.

[0046] Each damper blade 14 is pivotable on its own axis extending between the left 26 and right 28 sides of the damper housing 12. Therefore, each damper blade 14 can be moved to rotate about its axis, i.e. towards or away from the top 20 and bottom 18 sides of the damper housing 12. The passage 16 can be blocked to airflow when the damper blades 14 are rotated to an orientation that fills the passage 16 of the damper housing 12. Therefore, when the blade 14 is orientated substantially vertically, such that its surface is faced against the airflow through the passage 16, the damper 10 is closed, i.e. in the closed position 10A. Multiple blades 14 are positioned in the damper housing 12 and to close the damper 10 all of these are orientated substantially vertically such that airflow cannot pass through the passage 16. Therefore, when the blade is viewed from the front as a rectangle, the shortest side (e.g. height) of a rectangular blade 14 is positioned between the top side 20 and the bottom side 18.

[0047] It will be appreciated that the complete prevention of airflow through the passage 16 may not occur in the closed position 10A due to sealing with surfaces, such as adjacent blades 14 and the sides of the damper housing 12.

[0048] Referring to Figure 2, the damper 10 in the open configuration 10B is shown. The damper blades 14 can be moved between a closed 10A and an open position 10B. In the open position 10B the damper blades 14 are arranged to permit flow through the passage 16. The rotation of the blades 14 through their axis to a position wherein the blade 14 is orientated substantially horizontally, such that its surface is faced in-line with the airflow through the passage 16 to permit airflow over the blade 14 (and in-between multiple blades 14), will result in the damper 10 being open, i.e. in an open position 10B.

[0049] The open position 10B and closed position 10A describe a fully open and a fully closed configuration. Therefore, in the fully open position 10B, the blade 14 is orientated as flat and horizontal as is permissible to the flow of air through the passage 16. However, it will be appreciated that the blade 14 may not be completely horizontal in this configuration. There can be positions in which the damper blades 14 are held between fully open 10B and fully closed 10A where airflow is controlled between the two extremes.

[0050] Whilst six damper blades 14 have been shown in Figures 1 and 2, any number of blades 14 can be provided. For instance, it is possible to have a single blade 14 to control the opening and closing of the passage 16. However, multiple blades 14 can also be provided and are required for the operation described later.

[0051] The damper blades 14 can be all the same size or they can have different sizes. However, a set of damper blades 14 being all the same size except for one blade

14 allows for a mostly uniform arrangement where the one differently sized blade is used as a sizing blade which allows a damper 10 to be accurately sized for a particular duct or damper space without changing the sizes of all the blades 14.

[0052] The blades 14 in the closed position 10A do not need to be sized so that they fill the passage 16 such that the blade edges touch blade edges of adjacent blades 14. Instead, the blades 14 can overlap in the closed position 10A such that a front surface of a blade 14 overlaps with a back surface of an adjacent blade 14. This overlapping configuration provides a larger surface area for forming a seal with a blade 14. Therefore, in the closed position 10A, the blades 14 do not need to be fully vertical to be in a fully closed position 10A, instead the blades 14 are substantially vertical. In some cases, seals are provided at the edges of the blades 14.

[0053] Referring to Figures 1 and 2, there is shown an actuator body 22 arranged on the side of the damper housing 12. In this case the actuator body 22 is arranged on the right side 28 of the damper body 12. The actuator body 22 forms part of the damper 10 and provides the actuation and control for moving the damper blades 14, such as between open and closed positions 10B, 10A. A further description of a possible mechanism contained within the actuator body 22 is provided below.

[0054] Referring to Figures 3A and 3B, the damper blades 14 are shown to be provided in the closed position 10A except for one blade. This blade 14 is a primary blade 24 and can be controlled to be moved toward the open position 10B when the remainder of the damper blades 14, or secondary blades 25, are in the closed position 10A. The primary blade 24 in the open position 10B whilst the secondary blades 25 are in the closed position 10A provides a smaller front sectional area through which a flow can pass through the passage 16 than the damper blades 14 all being in the open position 10B.

[0055] Whilst one damper blade 14 is shown as being a primary blade 24, multiple blades can be used as primary blades 24. The use of a small number, for instance one or two primary blades 24, allow a fine level of control over the movement of the primary blades 24 to control a level of flow through the damper body 12. Therefore, the primary blade 24 can be moved a small amount from the closed position 10A toward the open position 10B to provide a small area throughout which an airflow can pass. Whereas the movement of all of the damper blades 14 even by a small amount from the closed position 10A will require more precise control to provide the same airflow area given that all the blades 14 have to move and the hysteresis and mechanical tolerance in the movement of the blades 14 of the function of the actuator.

[0056] The primary blade 24 can move to any position between the fully closed 10A and fully closed 10B positions. This allows the airflow through the passage 16 to be varied with fewer than the full set of damper blades 14.

[0057] Whilst shown in Figures 3A and 3B as a middle or central blade of the damper blades 14 being a primary blade 24 (i.e. a blade that is not directly adjacent to the top side 20 or bottom side 18) any blade or selection of damper blades 14 can be selected as the primary blade 24. However, a more central blade can have advantages for providing an airflow profile that avoids boundary conditions and flow effects caused by the duct walls at the top side 20 and bottom side 18 of the damper body 12. Likewise, where there are multiple primary blades 24, these can arranged to be adjacent to each other, or separate and at any damper blade location 14 within the damper housing 12.

[0058] Referring to Figure 4, there is provided a trend 30 to show the effectiveness of using primary blades 24 in a smoke control damper 10 when used for ventilation compared to using all of the damper blades 14 for this purpose.

[0059] The trend 30 shows the actuator angle on the x-axis and the percentage flow rate on the y-axis. The actuator angle dictates the amount of opening of the blade, which will generally move from a 0 degree angle when in the fully closed position 10A to a 90 degree angle when in the fully open position 10B. The percentage flow rate measures the amount of airflow through the passage 16 compared to the extremes of fully closed 10A where there is no airflow through the passage 16 and fully open where there is the maximum airflow through the passage 16. The percentage of flow between these are then shown on the y-axis.

[0060] Referring to line 34 of the trend 30, a parallel seal arrangement of blades 14 is shown. Therefore, all the damper blades 14 move in unison and all rotate in the same direction, i.e. all either clockwise or counter clockwise to reach the fully open position 10B.

[0061] Line 34 shows that within the first 10 degrees of actuator angle, the percentage flow rate only increases by a small margin , e.g. around 2%. However, within this angle, the flow rate is also seen to drop slightly. Therefore, accurate control of the airflow is difficult to predict and control. Line 34 further shows that at 30 degrees of actuator angle, 80 percent of the flow rate is achieved. Therefore, the parallel seal arrangement of blades needs to be controlled for almost 80% of its flow within 20 degrees of actuator angle.

[0062] The lack of linear control shown by line 34 evidences that airflow is difficult to control, particularly around the low percentage flow area. Furthermore, the mechanical tolerances and hysteresis will provide further difficulty as the system will not be consistent to the line every time and small variations in actuator angle will have large consequences in airflow.

[0063] Referring to line 32 of the trend 30, an opposed arrangement of blades 14 is shown. Therefore, the damper blades 14 are paired to move in a mirror facing-fashion to their adjacent blade in the pair, and to move together. Therefore, as one blade of the pair rotates clockwise, the other blade in the pair will rotate counter clockwise to reach the fully open position 10B.

[0064] Line 32 shows a marginally more favourable configuration to line 34. In the first 10 degrees of actuator movement there is negligible change in the percentage of flowrate. From the 10 to 20 degree range, the approximately 18% of the flowrate is controlled. However, similarly to line 34, the 20 degrees of actuator movement (from 20 degrees to 40 degrees) accounts for approximately 62% of the remaining flow. Therefore, the lack of linear control shown by line 32 evidences that airflow is difficult to control, particular around the low percentage flow area.

[0065] Referring to line 36 of the trend 30, a damper 10 having a primary blade 24 that is a single blade is shown. The first 18 to 19 degrees of actuator movement shows negligible percent flowrate of air. However, after this point, the 18 to 60 degree actuator angle accounts for around 38 percent of the flowrate. There is also shown a predominantly linear relationship between actuator angle and percentage flowrate. Therefore, the over 40 degrees of actuator angle account for around 38 percent of the flowrate. This provides a much more precise control for the flowrate through the passage 16 by the use of the single primary blade 24.

[0066] The damper 10 articulates the damper blades 14 with different timings by use of primary blades 24 and secondary blades 25, which gives a singular or multiple blade 24 movement in the first instance to allow balancing, followed by the rest of the blades 25 then moving after for use in the case of extracting smoke should the room need to be cleared.

[0067] Referring to Figures 5A and 5B, a side view of the damper 10 is shown. In particular, one possible arrangement for the gearing within the actuator body 22 is shown. This arrangement of gearing can be used to produce the line 36 of trend 30 of Figure 4.

[0068] Figure 5A shows a linkage assembly 40. The linkage assembly 40 has blade linkage holders 42 that are fixed positions connected to the damper blades 14. The blade linkage holders 42 allow the damper blades 14 to rotate within the body of the blade linkage holders 42. The blade linkage holders 42 are generally fixed to prevent rotation of the holder 42 when the damper blades 14 rotate within the holders 42.

[0069] A linkage bar 44 is provided which is moveably attached to each blade linkage holder 42. Therefore, the linkage bar 44 is able to move relative to each blade linkage holder 42. Referring to Figure 5B, a further linkage assembly 40 without the linkage bar 44 is shown. The removal of the linkage bar 44 in the further linkage assembly 40 is to provide a clearer view of the features.

[0070] The linkage bar 44 is connected to each blade linkage holder 42 by a blade linkage 52. Each blade linkage 52 connects to the damper blade 14 at the point where the blade 14 rotates within the blade linkage holder 42. Therefore, movement of the linkage bar 44 moves the blade linkages 52 which in turn move the damper blades 14 whilst the blade linkage holder 42 remains fixed other than any required portion to allow rotation of the blade 14 and blade linkage 52 connected therein.

[0071] The linkage bar44 can be an elongate member with the blade linkages 52 being elongate members rotatably fixed at one of their ends to the linkage bar 44 body and rotatably fixed at their other end to the blades 14. Therefore, substantially transverse (perpendicular) movement of the linkage bar 44 to the elongate body of the blade linkages 52 causes rotation of the ends of the blade linkages 52. Where these are fixed to the blades 14, the blades 14 are also caused to rotate. A 90 degree rotation movement can move the damper blades 14 from a fully closed position 10A to a fully open position 10B. In certain embodiments, when the elongate body of the linkage bar 44 is at a movement position that is directly perpendicular to the elongate body of the blade linkage 52, the damper blade 14 can be positioned equally between the fully closed 10A and fully open 10B positions, i.e. at an angle of 45 degrees from each position where there is a 90 degree movement.

[0072] To provide the timed movement of the primary blades 24, the damper blades 14 can all be linked by a common linkage assembly 40. This also reduces the requirements for the separate control and actuator systems which is an aim of the present invention.

[0073] Referring to the above, the blade linkages 52 can all be connected to the secondary blades 25. Therefore, the movement of the linkage bar 44 results in movement, i.e. opening or closing, of the secondary blades 25. A drive gear 48 is provided in linkage assembly 40 and is driven by an actuator (not shown) such as, for example, an electric motor. Therefore the drive gear 48 rotates in accordance with the actuator. The drive gear 48 can contact a movement gear 46. Wherein, the rotation of the drive gear 48 causes the movement gear 46 to rotate, i.e. by engagement and contact between the gears. The movement gear 46 is connected to the primary blade 24. Therefore, rotation of the drive gear 48 causes rotation of the movement gear 46 and thus movement of the primary blade 24. Movement of the primary blade 24 stops when it is in the fully open position 10B by the drive gear 48 having a first toothed portion 56 and a first discontinuous or un-toothed portion 58. Wherein, the first toothed portion 56 engages with gear teeth of the movement gear 46 in a first movement, e.g. the movement from fully closed 10A to fully open 10B positions and where the first discontinuous portion 58 has no gear teeth and thus disengages the movement gear 46 once the primary blade 24 is at the fully open position 10B. The movement gear 46 may also have toothed portions and discontinuous portions without gear teeth to ensure correct movement.

[0074] To provide movement to the linkage bar 44 and thus the secondary blades, a further linkage bar gear 54 is provided. The linkage bar gear 54 is positioned to be engaged by the drive gear 48. When engaged by the drive gear 48, rotation of the drive gear 48 results in consequential movement of the linkage bar gear 54. The linkage bar gear 54 is rotatably connected to the linkage bar 44. Therefore, movement of the linkage bar gear 54 causes the linkage bar 44 to move to result in the movement of the secondary blades 25. The linkage bar gear 54 itself is connected to a secondary blade 25 to also move the blade with its own rotation movement.

[0075] To provide the delay to allow the timing of the primary blade 24 operation, a second toothed portion 60 is provided on the drive gear 48. The second toothed portion 60 does not engage with the linkage bar gear 54 until the primary blade 24 has reached the open position 10B. The drive gear 48 has a second discontinuous portion 62. Where the first toothed portion 56 of the drive gear 48 is engaged with teeth of the movement gear 46, the second discontinuous portion 62 which has not gear teeth does not engage with the linkage bar gear 54. Once the drive gear 48 has disengaged with the movement gear 46 due to the first discontinuous portion 58, the second tooth portion 60 engages with the linkage bar gear 54. Therefore, continued movement of the drive gear 48 moves only the secondary blades 25.

[0076] This provides an initial movement of primary blades 24 prior to movement of secondary blades 25. Whilst specific gearing and blade connections have been described, the gears can be varied to have more primary blades 24 connected to the actuator and the drive gear 48. Furthermore, the timing can be altered so that the primary blade 24 movement also results in some secondary blade movement 25 at the end of the movement range. For instance, 60 degrees of actuator movement also engage the secondary blades 25 as the primary blades 24 never need to be fully open to provide the required ventilation. Therefore, smoke damper operation can be initiated more quickly when switching between modes.

[0077] In view of the above, precise damper blade control is provided.

<u>Reference Signs</u>

[0078]

10 -	Damper
10A -	Damper Fully Closed
10B -	Damper Fully Open
12 -	Damper Housing
14 -	Damper Blades
16 -	Passage
18 -	Bottom Side
20 -	Top Side
22 -	Actuator Body
24 -	Primary Blades
25 -	Secondary Blades
26 -	Left Side
28 -	Right Side
30 -	Trend of Actuator Angle vs %Flow rate
32 -	Trend Line of Opposed Blades
34 -	Trend Line of Parallel Seals
36 -	Trend Line of Single Blade with Seals
40 -	Linkage Assembly
42 -	Blade Linkage Holder
44 -	Linkage Bar
46 -	Movement Gear
48 -	Drive gear
52 -	Blade Linkage
54 -	Linkage Bar gear
56 -	First Toothed Portion
58 -	First Discontinuous Portion
60 -	Second Toothed Portion
62 -	Second Discontinuous Portion

[0079] The application discloses the subject matter set out in the following clauses:

1. A damper comprising:

   a damper housing defining a passage; and
   a plurality of damper blades arranged within the housing, the plurality of damper blades being moveable between an open position for allowing airflow to pass through the passage and a closed position for preventing airflow to pass through the passage,
   wherein the plurality of damper blades comprise primary blades and secondary blades, the primary blades and the secondary blades each comprising at least one damper blade, and wherein, while the secondary blades are in the closed position, the primary blades are moveable towards the open position for allowing airflow to pass through the passage, or
   while the primary blades are in the open position, the secondary blades are moveable towards the closed position for preventing airflow to pass through the passage.

2. The damper according to clause 1, wherein the primary blades are positionable to be held between the open position and the closed position.

3. The damper according to any preceding clause, wherein each of the primary blades and/or each of the secondary blades are the same size.

4. The damper according to any preceding clause, wherein the plurality of blades have a parallel arrangement in the damper housing.

5. The damper according to any preceding clause, wherein the primary and/or secondary blades each comprise at least two blades.

6. The damper according to clause 5, wherein the primary blades are positioned directly adjacent to one another.

7. The damper according to clause 6, wherein the directly adjacent primary blades are configured to

move in a mirror facing-fashion.

8. The damper according to any preceding clause, wherein, when the plurality of blades are positioned in the closed position no gap is formed between each blade directly next to one another in the plurality of blades.

9. The damper according to any preceding clause, wherein the damper housing is a single module with the passage enclosed by sides of the damper housing, wherein the plurality of blades are positioned within the sides of the damper housing.

10. The damper according to any preceding clause when dependent on clause 4, wherein the parallel arrangement of the blades extends between two opposing sides of damper housing which are opposing in the direction in which the blades are adjacent, the opposing sides of the damper housing each being in direct contact with first and last blades of the plurality of blades when in the closed position.

11. The damper according to clause 10, wherein at least one middle blade is arranged between the first and last blade, and wherein, in the closed position, each at least one middle blade is in direct contact with two blades of the plurality of blades.

12. The damper according to any preceding clause, wherein the plurality of blades are controlled by a geared linkage.

13. The damper according to any preceding clause, wherein movement of the plurality of blades is by a single actuator.

14. The damper according to clause 13, wherein operation of the actuator is configured to move the primary blades from the closed position toward the open position and continued operation of the actuator is configured to move the secondary blades from the closed position toward the open position.

15. The damper according to any preceding clause, wherein:

the primary blades are connected to and moveable by a rotatable gear having a portion with discontinuous teeth; and
the secondary blades are connected to a linkage, the linkage being engagable with the teeth of the gear, wherein the linkage is moveable by rotation of the gear when engaged with the teeth.

Claims

1. A damper comprising:

a damper housing defining a passage; and
a plurality of damper blades arranged within the housing, the plurality of damper blades being moveable between an open position for allowing airflow to pass through the passage and a closed position for preventing airflow to pass through the passage,
wherein the plurality of damper blades comprise at least one primary blade and at least one secondary blade,
wherein the damper comprises an actuator which, while the at least one secondary blade is in the closed position, is configured to move the at least one primary blade towards the open position for allowing airflow to pass through the passage, and
wherein the plurality of blades are controlled by a geared linkage.

2. The damper according to claim 1, wherein the at least one primary blade is positionable to be held between the open position and the closed position.

3. The damper according to any preceding claim, wherein each of the at least one primary blade and/or each of the at least one secondary blade is the same size.

4. The damper according to any preceding claim, wherein the plurality of blades have a parallel arrangement in the damper housing.

5. The damper according to any preceding claim, wherein the at least one primary and/or secondary blades each comprise at least two blades.

6. The damper according to claim 5, wherein the primary blades are positioned directly adjacent to one another.

7. The damper according to claim 6, wherein the directly adjacent primary blades are configured to move in a mirror facing-fashion.

8. The damper according to any preceding claim, wherein, when the plurality of blades are positioned in the closed position no gap is formed between each blade directly next to one another in the plurality of blades.

9. The damper according to any preceding claim, wherein the damper housing is a single module with the passage enclosed by sides of the damper housing, wherein the plurality of blades are positioned within the sides of the damper housing.

10. The damper according to any preceding claim when dependent on claim 4, wherein the parallel arrangement of the blades extends between two opposing sides of damper housing which are opposing in the direction in which the blades are adjacent, the opposing sides of the damper housing each being in direct contact with first and last blades of the plurality of blades when in the closed position.

11. The damper according to claim 10, wherein at least one middle blade is arranged between the first and last blade, and wherein, in the closed position, each at least one middle blade is in direct contact with two blades of the plurality of blades.

12. The damper according to any preceding claim, wherein movement of the plurality of blades is by a single actuator.

13. The damper according to any preceding claim, wherein operation of the actuator is configured to move the at least one primary blade from the closed position toward the open position and continued operation of the actuator is configured to move the at least one secondary blade from the closed position toward the open position.

14. The damper according to any preceding claim, wherein:

the at least one primary blade is connected to and moveable by a rotatable gear having a portion with discontinuous teeth; and
the at least one secondary blade is connected to a linkage, the linkage being engagable with the teeth of the gear, wherein the linkage is moveable by rotation of the gear when engaged with the teeth.

15. The damper according to any preceding claim, wherein the geared linkage comprises a linkage bar connected to at least two secondary blades so that the at least two secondary blades are configured to move together.

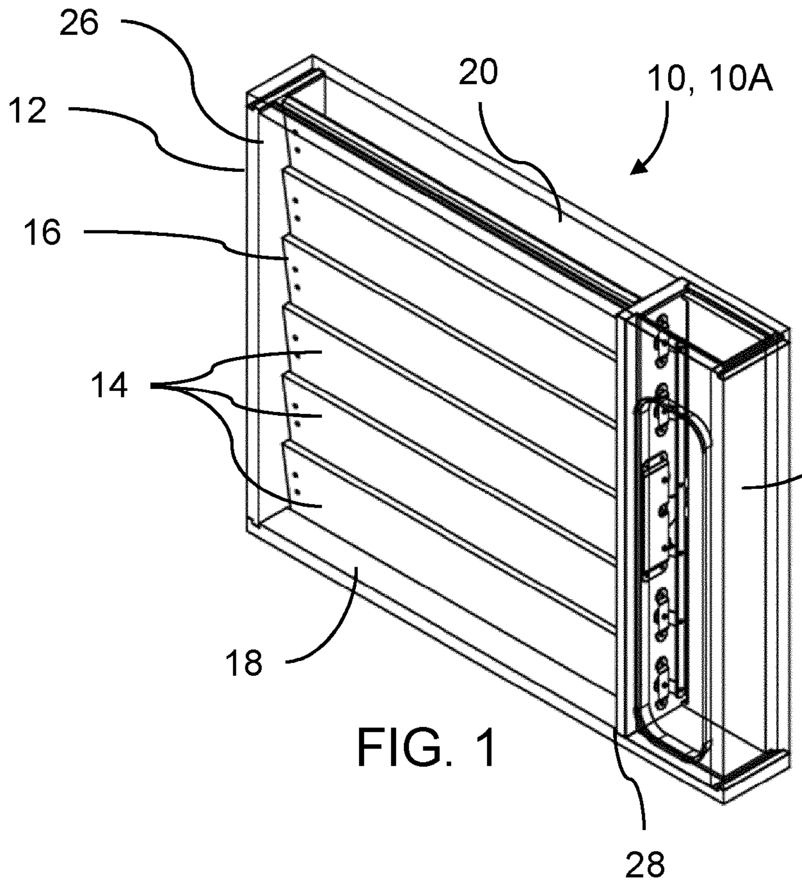


FIG. 1

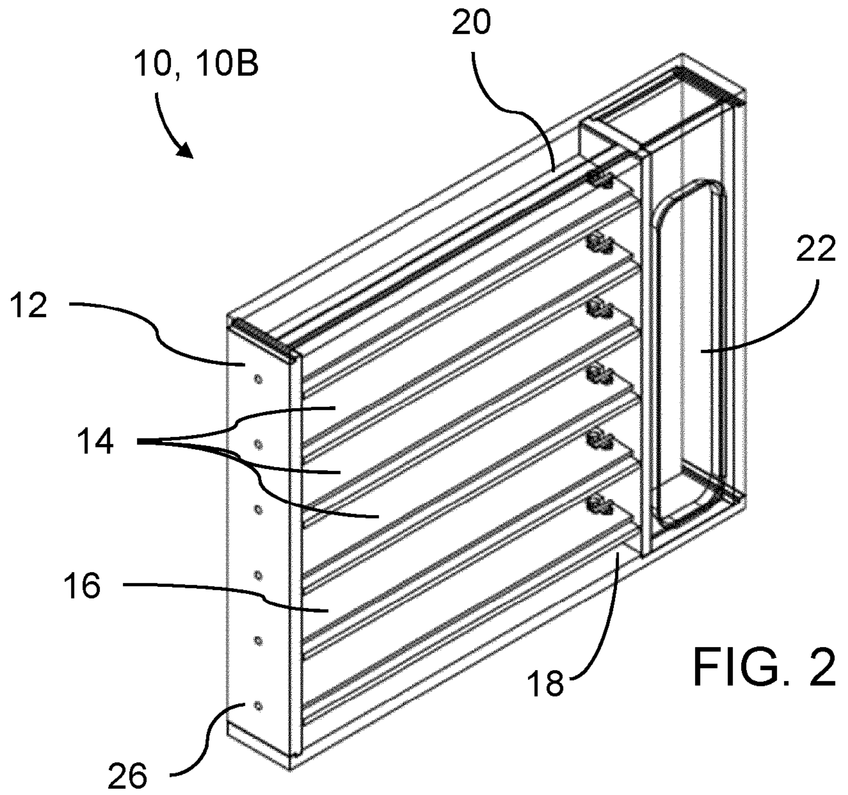


FIG. 2

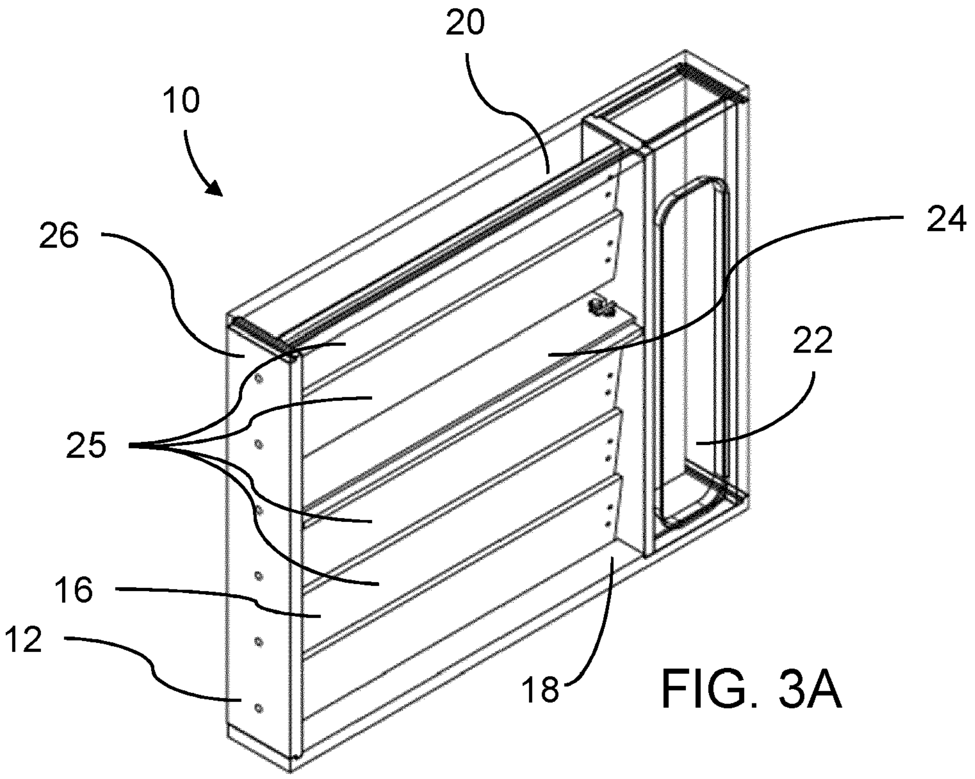


FIG. 3A

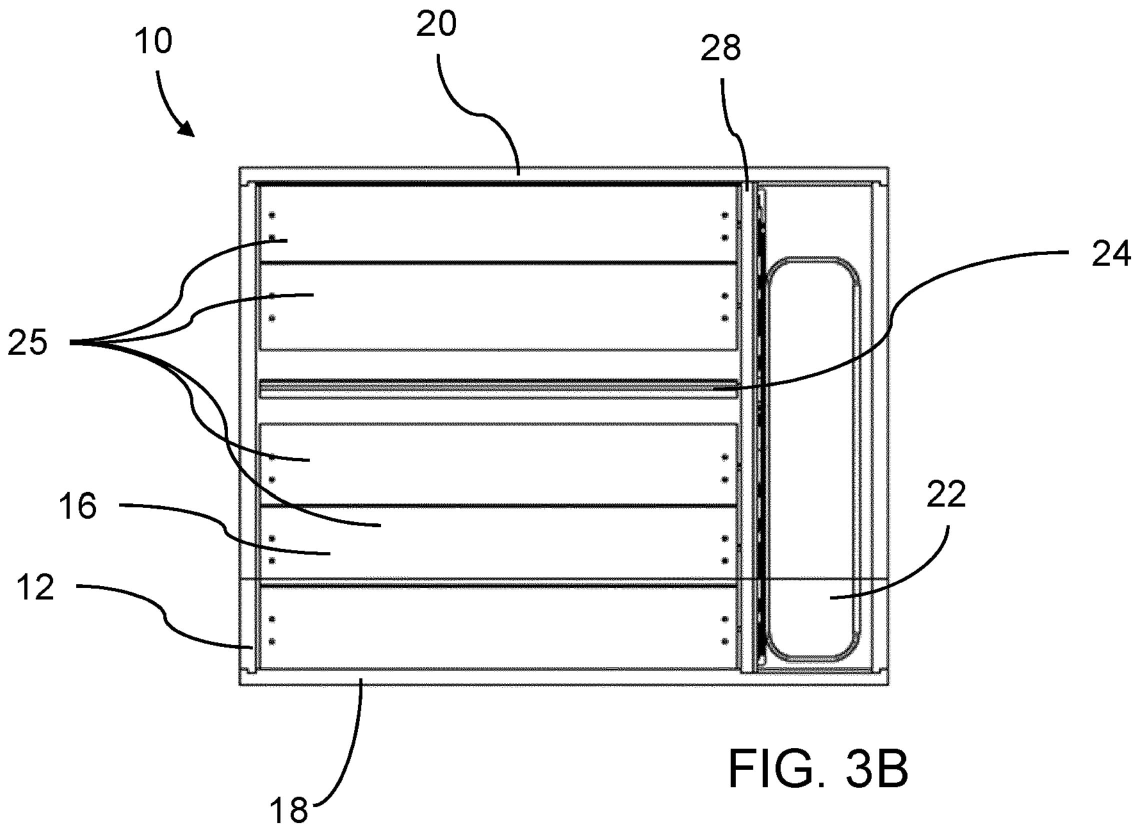
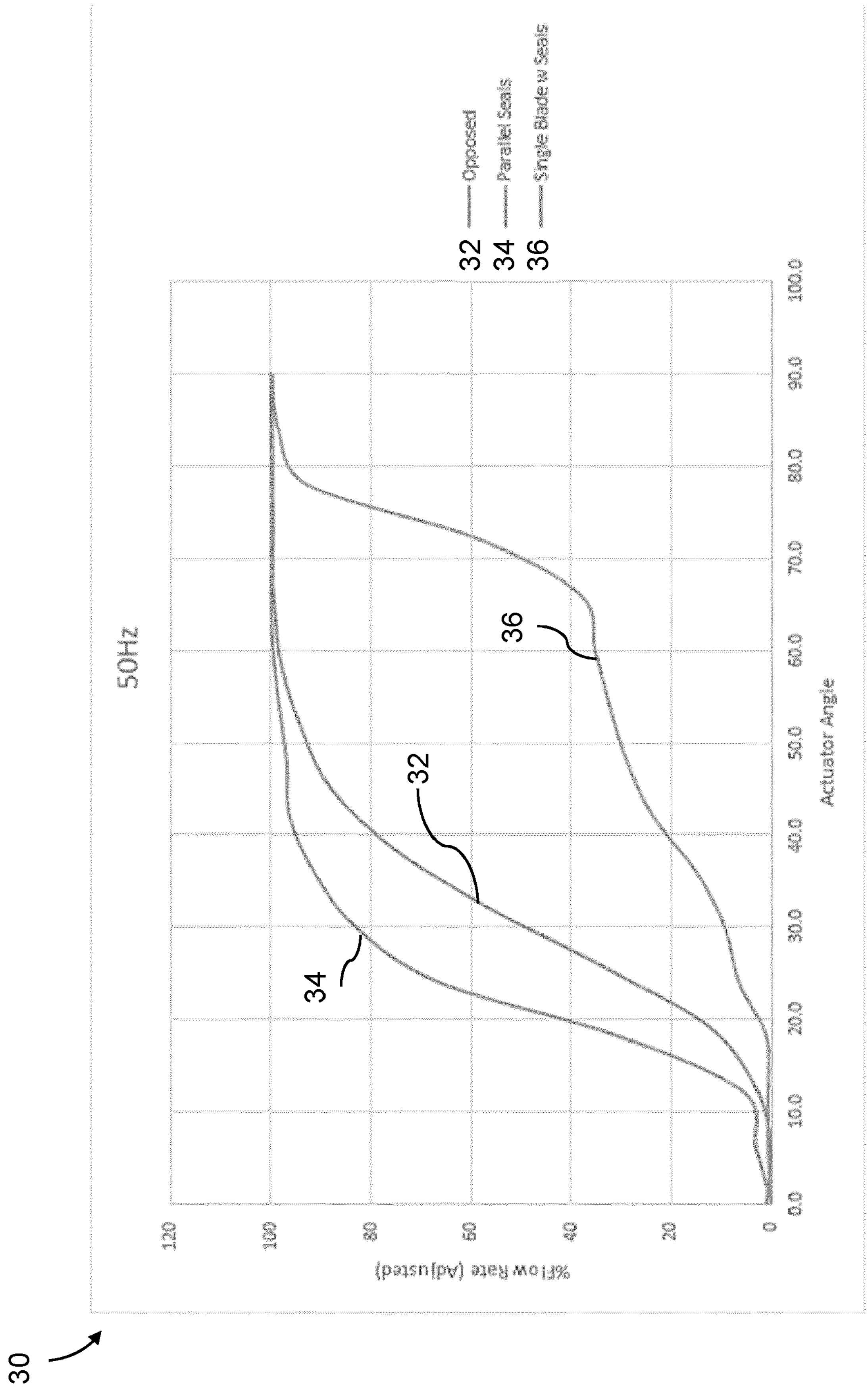


FIG. 3B



30
50Hz
%Flow Rate (Adjusted)
120
100
80
60
40
20
0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Actuator Angle
32 Opposed
34 Parallel Seals
36 Single Blade w Seals
32
34
36

FIG. 4

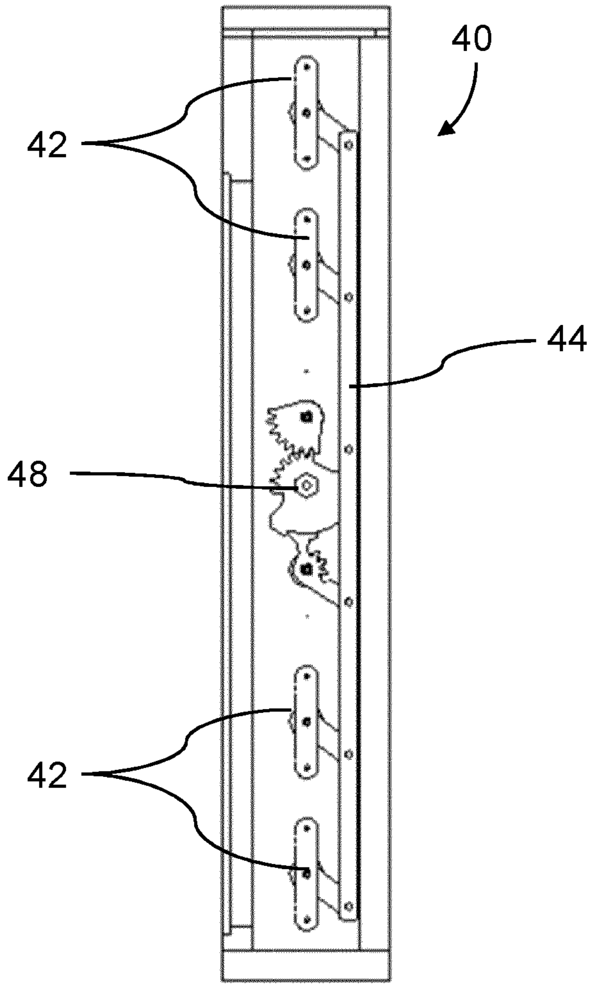


FIG. 5A

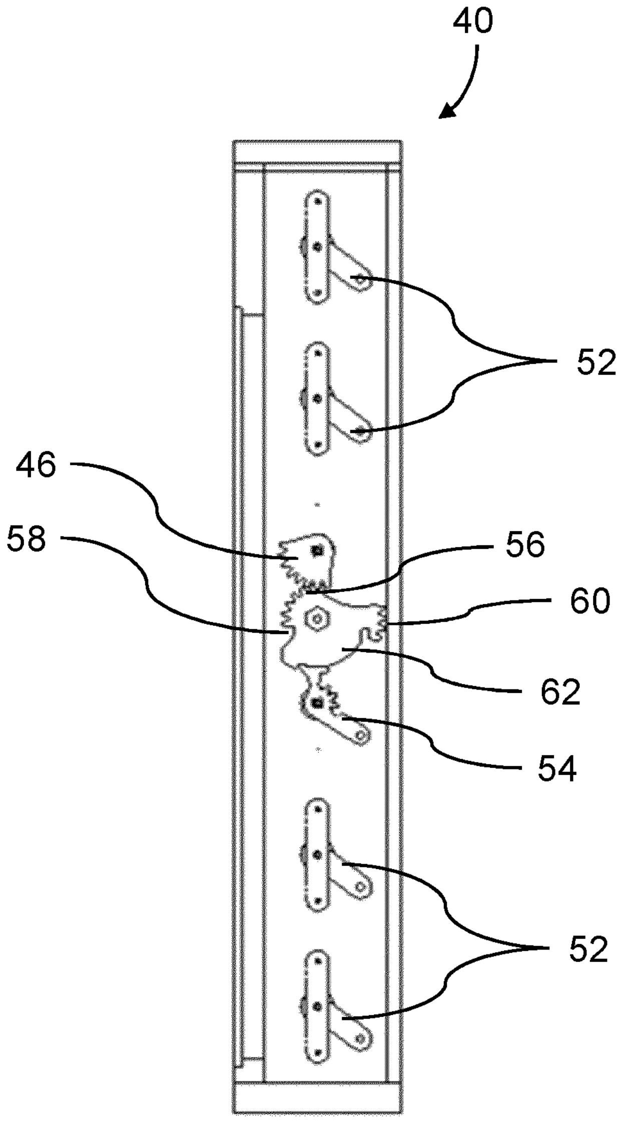


FIG. 5B

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EUROPEAN SEARCH REPORT

Application Number
EP 24 15 7618

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	KR 101 525 186 B1 (KO YOUNG SEOK [KR]) 4 June 2015 (2015-06-04) * paragraph [0015] - paragraph [0051]; claims 1-5; figures 1-10 *	1-15	INV. F24F11/34 F24F13/15 F24F13/14 F24F13/075
X	CN 107 449 127 A (NINGBO AUX ELECTRIC CO LTD) 8 December 2017 (2017-12-08) * paragraph [0043] - paragraph [0051]; claims 1-14; figures 4-6 *	1	
X	CA 2 641 478 A1 (ZHI LIN [CA]) 20 February 2010 (2010-02-20) * abstract; figure 1 *	1	
X	CN 108 758 802 A (GUANGDONG MIDEA REFRIGERATION EQUIPMENT CO LTD) 6 November 2018 (2018-11-06) * paragraph [0009] - paragraph [0087]; claims 1-15; figures 1, 4 *	1	

TECHNICAL FIELDS SEARCHED (IPC)

F24F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	12 June 2024	Silex, Anna

CATEGORY OF CITED DOCUMENTS

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12-06-2024

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