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London EC1N 2JT(GB)(54) **Air damper apparatus.**

(57) A damper for controlling air flow through an air duct is provided. The damper includes a mounting frame secured to the interior of the duct which has a circular opening for air flow therethrough when the damper is open. A circular damper plate is provided which is dimensioned to block the circular opening in the closed position. The plate can be moved and rotated to a fully open position. The plate is rotated by an actuator and movement of the damper plate is controlled by a coupling mechanism. This mechanism can have a pair of spaced guide plates each of which is provided with two arcuate, diverging guide slots. Corresponding guide slots in the two plates are aligned. A support bracket for the damper plate has two guide pins which extend through the aligned slots and are movable therein.

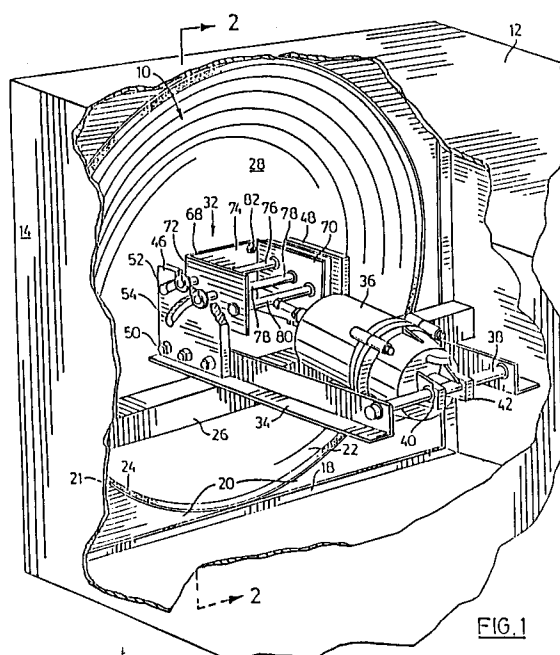


FIG. 1

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The present invention relates generally to fluid dampers, and particularly to air dampers used in building ventilation systems.

Building air distribution systems require stable and accurately controllable air valve or air dampers for control of building heating and air circulation functions. For maximum efficiency, large numbers of such air dampers are usually computer controlled simultaneously in order to provide the proper heat and air distribution within the building. Air dampers have been disclosed having longitudinal blades provided with sealing gaskets with the blades arranged in a venetian blind arrangement. Such systems are prone to leakage due to alignment problems which can arise over time. Other damper systems employ linkage assemblies having relatively slow response times.

Yet other systems employ piston driven damper plate utilizing a pair of guide pins which slide in an open ended slot and a guide pin slidably mounted in a closed longitudinal guideway wherein in the fully closed position pins are located at the closed ends of the guideway and slot. Systems of this type are disclosed in U.S. patent No. 4,605,198 issued August 12, 1986 to Seal-Air Control Systems Inc. A drawback to this kind of arrangement is that backlash problems developing in the damper plate opening and closing mechanism over time will cause the seal formed by the damper plate compressed against a gasket to degrade resulting in leakage. When this damper is opened, the guide pins move translationally along the slots thereby translationally displacing the damper plate until the pin in the open ended slot pivots around the pin located at the end portion of the closed guideway whereupon the damper plate rotates from a vertical to a substantially horizontal position. A drawback to this type of movement is that it is very difficult to reproducibly control the motion of the damper plate as it rotates open. Furthermore, it is very difficult to control the position of the damper plate in order to modulate the flow of air through the duct when the plate is not in the fully open or fully closed position. In other words, with this arrangement, there is not a desired linear relationship between the amount of piston movement and the amount of air flow through the system.

An earlier air damper apparatus is that taught in Canadian patent No. 1,143,992 issued April 5, 1983 to Mitco Corporation. In this damper apparatus there is also a disk shaped closure element that is operated by an actuator cylinder located in the air duct. First and second linkage mechanisms are employed to connect the closure element to the actuator and to the input port. Although this linkage mechanism works satisfactorily, a problem with this known damper construction and that shown in the aforementioned recent U.S. patent 4,605,198 is that

the relatively large actuator is disposed in the air duct itself and therefore interferes with the smooth flow of air through the duct when the damper is open. This tends to reduce the operating efficiency of the air distribution system.

A further difficulty with the air dampers described in both of the aforementioned patent specifications is that the disk shaped closure element is not very strong and rigid and this can result in eventual failure of the closure element or a loss in its capability of sealing the input port.

According to one aspect of the invention, there is provided a fluid damper for controlling fluid flow. The damper comprises a frame member having an opening for fluid flow therethrough when the damper is open. A closure member is movable between a closed position where the opening is blocked and an open position where the opening is unblocked. A mechanism for controlling the movement of the closure member includes a pair of spaced guide members which are rigidly fixed to the frame member. The guide members are each provided with first and second arcuate guide slots with the first guide slots in the two plates being in registration and the second guide slots being in registration. The actuator mechanism includes a support member having a first registration means fixed thereto and this first registration means is movably captive within the first guide slots. A second registration means is fixed in the support member and is movably captive within the second guide slots. The closure member is secured to the support member and a mechanism is provided to move the support member between a first position corresponding to the closure member in the closed position and a second position corresponding to the closure member being in the open position. Movement of the first and second registration means through the diverging guide slots causes the support member to rotate with respect to the guide members thereby rotationally moving the closure member with respect to the frame member.

According to another aspect of the invention, a damper for controlling air or gas flow through an opening in a duct comprises a closure member movable between a first position where the opening is blocked and a second position in which the opening is unblocked; actuating means and associated shaft connected thereto, said actuating means being capable of rotating said shaft about its centre axis between first and second limit positions and being mountable outside said duct with said shaft extending through one side of said duct and a substantial distance across said duct near said opening; a torque arm rigidly connected to said shaft and extending transversely thereto; a mounting bracket fixedly connected to said closure member; a connecting link member pivotally join-

ing an outer end portion of said torque arm to said mounting bracket; and means for coupling said mounting bracket to a fixed support structure mounted in said duct whereby said closure member can be moved between said first and second positions as said shaft rotates between said first and second limit positions, said closure member being initially linearly displaced from said opening and then being rotationally displaced as it moves to said second position, wherein said coupling means acts to guide the movement of said closure member between said first and second positions.

The invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a perspective view partly broken away of one embodiment of a fluid damper of the invention mounted in an air duct and in the fully closed position;

Figure 2 is a sectional side view of a fluid damper in the fully closed position;

Figure 3 is a sectional side view partly broken away showing the fluid damper in partially open positions;

Figure 4 is a schematic side view of a part of the driver mechanism of a fluid damper of the present invention showing the relative positioning of various parts of the driver mechanism during the opening and closing motions of the damper;

Figure 5 is a cross-sectional view taken through the centre line of an air duct fitted with another embodiment of the air damper of the present invention;

Figure 6 is an elevational view showing the end of an air duct fitted with an air damper of the invention, this view showing how the external actuator is mounted;

Figure 7 is a right side schematic view of the air damper of Figure 6 showing how the actuator is connected to the shaft that is used to move the closure member;

Figure 8 is a detailed cross-sectional view showing the shaft casing for mounting the shaft that is turned by the actuator and seals that extend around the shaft; and

Figure 9 is a cross-sectional view of an air duct similar to that of Figure 5 but showing a linkage type control mechanism for the air damper, which mechanism is operated by an actuator located outside the duct.

Referring to Figures 1 and 2, an air damper 10 is shown mounted within an air duct 12 bounded by walls 14 for controlling air flow therethrough. Fitted in the duct is a rectangular panel 20 with a central circular opening 21. The panel 20 is provided with edge flanges 18 for attachment of the panel to the walls 14 by welding or the use of bolts

(not shown). Mounted on or secured to the circular edge of panel 20 is a gasket 24. A support frame 26 extends horizontally across the opening 21 and between the opposite vertical flanges 18 of panel 20 at a point lower than the vertical midpoint thereof. The frame 26 can be connected to the panel 20 by means of bolts (not shown).

Damper 10 includes a circular closure member or damper plate 28 which is in the shape of a shallow bowl or dish and which has substantially central flat planar portion 30. Preferably it has a rolled circumferential edge 31 for increased strength and rigidity. In the closed position damper plate 28 is vertically disposed within duct 12 with the peripheral edge of plate 28 in contact with gasket 24 thereby forming an annular seal, as represented by the solid lines in Figure 2. Damper 10 also includes a damper plate control mechanism shown generally at 32 for controlling the movement of damper plate 28. Damper 10 includes a pair of spaced mounting frame members 34 secured to support frame 26 on which control mechanism 32 is mounted for mounting damper plate 28 in air duct 12.

Control mechanism 32 is operated by an actuating means which can be a pneumatic cylinder 36 pivotally mounted on a pivot rod 38 extending between and secured to frame members 34. The pivotal connection of cylinder 36 to pivot rod 38 is accomplished using a bushing 40 mounted within a bracket 42 which in turn is rigidly attached to the back end of cylinder 36. Pneumatic cylinder 36 is provided with a rod 44 attached to the front end thereof which is held firmly in a colinear relation with cylinder 36 while being reciprocally movable within cylinder 36. In the embodiment of Figures 1 to 3, the cylinder 36 is mounted inside the air duct 12.

Referring now to Figures 2-4, control mechanism 32 includes a pair of opposed and spaced outer vertical guide plates or guide members 46 and 48 each rigidly secured to one of mounting frame members 34 by bolts 50 at a position forward of cylinder 36. Guide plates 46 and 48 are each provided with a pair of downwardly arcuate or curvilinear guide slots 52 and 54 which are preferably closed at each end. The first slots 52 are located above second slots 54 in members 46 and 48. In addition first and second slots 52 and 54 are of different lengths with slot 52 being shorter than slot 54. Slots 52 in guide plates 46 and 48 are in registration, being horizontally matched. Similarly, the second slots 54 in plates 46 and 48 are in registration. Slots 52 have a back end 56 and a front end 58 while slots 54 have a back end 60 and a front end 62. Preferably, the slots 52 and 54 are of uniform width along substantially their entire length. Slots 52 and 54 are each provided with

horizontally parallel portions located adjacent the back end portions 56 and 60 respectively (substantially in the range between positions A-B in Figure 4) while slots 52 and 54 diverge relative to one another in the forward direction towards the closure member beyond these parallel portions.

Control mechanism 32 also includes a rectangular U-shaped mounting bracket 68 having side walls 70 and 72 and an end plate 74. This bracket 68 constitutes means for supporting the closure member 28. A pair of spaced and parallel guide pins 76 and 78 are mounted horizontally through walls 70 and 72 and project laterally through slots 52 and 54 respectively and being of the diameter as the slots so that they slide within the slots. These guide pins constitute first and second follower means mounted in or on the bracket 68. In this embodiment of the damper, the guide plates 46 and 48 and the guide pins 76 and 78 together constitute one form of means for coupling the mounting bracket 68 to the support structure provided in the air duct.

A connector bar 80 extends between walls 70 and 72 and is rotatably mounted therein. The end of cylinder rod 44 is rigidly attached to connector bar 80. End plate 74 is fixedly connected to the planar portion 30 of damper plate 28 by a plurality of bolts 82. Alternatively, end plate 74 and damper plate 28 may be coupled using other means such as welding or gluing, depending on the material of construction.

The operation of damper 10 will now be described with reference to Figures 2-4. The relative positions of pins or followers 76 and 78 in guide slots 52 and 54 respectively as cylinder 36 urges bracket 68 forwards and backwards is illustrated in Figure 4 wherein the corresponding positions of damper plate 28 are illustrated. In the closed position, represented by the solid lines in Figure 2, cylinder 36 and rod 44 are angled upwardly from the horizontal while plate 28 is sealingly engaged with gasket 24. In the closed position guide pins 76 and 78 are at the rearmost limit of travel in slots 52 and 54 and are spaced from the back end of the respective slots. As cylinder 36 urges the bracket or support means 68 forward, the motion of pins 76 and 78 through the horizontally parallel portions of the slots in the range from A to B results in plate 28 being initially displaced away from plate 20 as indicated by the ghost markings in Figure 2. Since slots 52 and 54 begin diverging in the latter portion of the region between A and B, guide pin 78 begins dropping relative to pin 76. Since pins 76 and 78 are rigidly mounted through walls 70 and 72, the centre-to-centre (cc) distance between pins 76 and 78 remains constant. Once pin 78 starts dropping with respect to pin 76, bracket 68 and hence damper plate 28 begin rotating upwards.

Therefore, as cylinder 36 urges bracket 68 forward the end of bracket 68 closest to cylinder 36 begins dropping and plate 28 undergoes both translational displacement forward and rotational motion counterclockwise as shown. The various positions of plate 28 are shown in Figure 4 marked A', B' ... to the fully open position marked G', with these positions corresponding to the positions of the pins marked with the same letters. As back end of bracket 68 drops relative to the front end thereof, piston shaft 44 is pulled down causing cylinder 36 to pivot downwards about pivot rod 38. Both pins 76 and 78 undergo forward motion in the respective slots until point E is reached. Beyond points E, the distance between the centre lines of slots 52 and 54 is greater than the centre-to-centre separation between pins 64 and 66 with the result that both pins can no longer undergo forward motion simultaneously. Consequently, pin 76 in slot 52 is forced to reverse direction with further forward urging of bracket 68 and undergoes retrograde or reverse motion in slot 52. As this occurs, the pin 78 continues to move forward and downwards in slot 54 to point F at which time pin 76 has reached point F in slot 52. Once pin 78 reaches point F it reverses direction and undergoes retrograde motion backwards in slot 54. When pins 76 and 78 reach positions G in their respective slots they stop moving since rod 44 has reached the end of its forward stroke and damper 10 is in the fully open position, see Figure 3. When damper plate 28 is in the fully open position, cylinder 36 is approximately horizontal.

The closing of damper 10 will retrace the opening procedure, with pins 76 and 78 moving in the forward direction from points G in the slots until pin 78 reaches point F whereupon it reverses direction in slot 54. Pin 76 continues moving forward until it reaches point F whereupon it reverses direction in slot 52. Both pins are then pulled backwards towards points A in the respective slots. Cylinder 36 pivots upwards about rod 38 until the pins reach the horizontally parallel portions of the respective slots. At this point plate 28 is translationally displaced backwards whereupon the peripheral edge of plate 28 is compressed against gasket 24 thereby sealing damper in the closed position. Due to the fact that in the closed position of the damper pins 76 and 78 are spaced from the back ends of slots 52 and 54, plate 28 will always be compressed against gasket 24 under a sufficient applied force thereby forming a positive seal. This circumvents the problem of a seal developing leakage over time due to backlash which may arise when the guide pins are designed to be positioned adjacent the slot ends in the closed position.

It will be appreciated that the rate of divergence of slots 52 and 54 determines the length of

the piston stroke required to move damper plate 28 from the open to the closed position. Specifically, the greater the divergence of the slots in the forward direction, the shorter the piston stroke required to move the closure member between the two extremes. Since the slots diverge, the pin located in the slot with the steepest slope will move more rapidly than the other pin thereby producing a more rapid opening and closing time than would be obtained for linear slots with the same piston speed.

It will also be understood that while guide slots 52 and 54 are arcuate downwards as disclosed above, they may be arcuate upwards as well. In this case damper plate 28 would be rotated clockwise downwards as viewed in Figure 2. In addition, the direction of divergence of guide slots 52 and 54 could be reversed and the piston stroke reversed where again the guide slots may be arcuate upwards or downwards as desired.

While the invention as disclosed employs guide slots which diverge at such a rate that both guide pins reverse direction between the damper open and closed position, it will be understood by those skilled in the art that the slots could be designed to diverge at such a rate that only one of the pins undergoes retrograde motion between the open and closed position.

Since the rotational motion of plate 28 occurs for most of the motion of pins 76 and 78 in the arcuate slots, it will be apparent that reproducible and stable control of damper plate 28 in intermediate positions between the fully open and fully closed position is achieved. In other words, this first damper embodiment is very linear in its control, that is, for a certain percentage of piston rod 44 movement, there is a corresponding percentage of total air flow allowed through the circular input opening 21. For example, a movement by the rod 44 of one third of its total stroke from the fully retracted position can be made to produce an air flow of about one third the total available air flow.

It will be appreciated that variations of this first embodiment may be made and will be apparent to one skilled in this art. For example, a reversing relay can be introduced between the cylinder 36 and the mounting bracket 68. The closure member 28 is then in the open position when the piston shaft 44 of the cylinder is fully retracted. The closure member 28 then starts to close as the shaft 44 is extended.

Turning now to the second embodiment of the invention illustrated in Figures 5 to 8, an air damper is shown mounted within an air duct 112 in which is mounted a panel 114, only the edges of which are shown. Mounted on a circular edge of this panel is the gasket 24 which, in the closed position of the damper, is engaged by damper plate 28, only a

central portion of which is shown. Extending across the duct is a supporting frame 126. Extending in the longitudinal direction and supported by the frame 126 are two spaced frame members 34. Mounted on these frame members 34 is a control mechanism for the damper that is essentially the same as that illustrated in Figures 1 and 2 of the drawings. However, in this embodiment of the damper, a pneumatic cylinder 136 which operates the control mechanism is positioned outside of the duct (see Figures 6 and 7). The pneumatic cylinder is connected to a shaft 137, sometimes called a jack shaft, which extends through the wall of the duct and is rotatably mounted on the two frame members 34. Rigidly connected to the shaft is a torque arm 139 which extends transversely to the shaft and is located midway between the frame members 34. A connecting link member 141 is pivotally joined to an outer end portion of the torque arm by bolt 143. This link member is connected to connector bar 180 which corresponds to the bar 80 in the embodiment of Figure 1. This link member is free to pivot around the bar 180. It will be appreciated that because the torque arm 139 and the link member 141 extend at an angle to one another, a partial rotation of the shaft 137 will drive the guide pins 76 and 78 along their respective slots in the manner described above.

Turning now to the mounting of the cylinder on the outside of the duct as illustrated in Figures 6 and 7, as in the embodiment of Figure 1 the rear end of the cylinder is fitted with a mounting bracket 142. Mounted in the side of the duct or on another rigid supporting surface is a support rod 138 which extends into the bracket 142. Thus, the cylinder 136 is free to pivot about the rod 138. A rod 144 which extends from the cylinder is pivotally connected to a torque arm 145 which in turn is rigidly connected to the aforementioned shaft 137. Thus, reciprocal movement of the rod 144 will rotate the shaft 137 a sufficient amount to open or close the damper.

Figure 8 illustrates how the shaft is rotatably mounted in the wall 14 of the duct. The shaft mounting includes an externally threaded sleeve member or casing 150 which can be made of stainless steel. Preferably this casing is formed with an external shoulder at 151 which locates the casing in the opening in wall 14. In order to prevent any air leakage around the casing, it is connected by a continuous weld to the wall on both sides thereof. A removable hex nut 152 is threaded onto the threaded end of the sleeve member. The sleeve member has an annular internal recess 154 at one end thereof in which are preferably arranged tandem seals 155 and 156 that extend around the shaft. These seals act to effectively seal any air gap between the shaft and the casing 150. In the

illustrated version, the two seals are arranged immediately adjacent one another. These seals can be PolyPak type "B" seals sold by Parker of Salt Lake City, Utah, U.S.A. These preferred seals are made from nitroxile. Two lips formed at one end of the seal are forced against the surfaces to be sealed by means of an O-ring type synthetic rubber O-spring. By using a tandem sealing arrangement, a good seal is assured because any air escaping past the first seal will be closed off by the second seal. If desired, a sintered bronze brushing (not shown) can be arranged between the hex nut 152 and the shaft to reduce friction and reduce wear on these two parts.

Figure 9 illustrates how an externally mounted pneumatic cylinder can also be used to operate a damper control mechanism such as that taught in the aforementioned Canadian patent No. 1,143,992. In this embodiment, the shaft 137 is again connected to a pneumatic cylinder located outside the duct and mounted as described above. Again, the shaft 137 is used to pivot a torque arm 139 which is pivotally connected to connecting link member 141. The linkage system used to control the movement of the damper plate 28 will be described only briefly herein as the linkage system per se is known. A U-bracket 200 is affixed to the concave portion of the damper plate. Cross bars 202, 204 and 206 are all pivotally mounted in the two parallel arms of the bracket 200. The link member 141 is rigidly connected to the cross-bar 202. A first pair of link elements 208 and 210 are pivotally connected to respective frame members 34. A second pair of linking elements 212 and 214 are pivotally connected as well to the frame members 34. It will thus be seen that the two pairs of linking elements together with the cross bars 202, 204 and 206 form means for coupling the U-bracket 200 to the fixed support structure mounted in the duct whereby the damper plate 28 can be moved between open and close positions as the shaft 137 rotates between two limit positions.

It will thus be seen that a very effective and efficient actuating mechanism for the means for controlling the movement of the damper plate has been provided, which mechanism permits a relatively large pneumatic cylinder to be located outside of the air duct. Moreover, this improved actuating mechanism can be used regardless of whether the control mechanism comprises the known linkage system or the new control system disclosed herein which employs two guide plates with diverging guide slots and first and second guide pins that move along these slots.

Claims

1. A damper for controlling fluid flow in a fluid

duct, comprising a frame member having an opening (21) for fluid flow therethrough when the damper is open; a closure member (28) movable between a closed position where the opening is blocked and a second position in which the opening is unblocked; a mechanism for controlling movement of said closure member, the mechanism including a pair of spaced guide members (46, 48) fixed to the frame member, each of which is provided with first and second guide slots (52, 54), the first guide slots in the two guide members being in registration with one another along their lengths, the second guide slots (54) also being in registration with one another along their lengths, and further including support means having first and second registration means in the form of guide pins fixed thereto and having said closure member secured thereto, the first registration means (76) being movably captive within the first guide slots (52) and the second registration means (78) being movable within the second guide slots; and means (36) for moving said support means between first and second positions corresponding respectively to the closed and open positions of the closure member (28), said damper characterized in that both of said first and second guide slots (52 and 54) are arcuate slots and the first guide slots (52) are diverging from the second guide slots (54) along a substantial portion of their length, wherein movement of the first and second registration means (76 and 78) through the guide slots causes said closure member (28) to undergo an initial translational movement away from said frame member (20) and then a rotational movement with respect to the guide members (46,48) and the frame member.

2. The damper according to Claim 1 characterized in that the divergence of the diverging portions of the slots (52, 54) is such that at a first intermediate position between the first and second positions one registration means (76) reverses direction.

3. The damper according to Claim 2 characterized in that the divergence of the diverging portions of the slots (52, 54) is such that at a second intermediate position between the open and closed position the other registration means (78) reverses direction.

4. The damper according to Claim 1 characterized in that the first and second slots (52, 54) each have portions adjacent the back ends of the slots that are substantially parallel to one

another such that when the first and second registration means (76, 78) move through said portions the support means (68) moves substantially translationally with respect to the frame member (20).

5. The damper according to claim 4 characterized in that the slots (52, 54) diverge from the back end of the guide members (46, 48) to the front of the guide members.

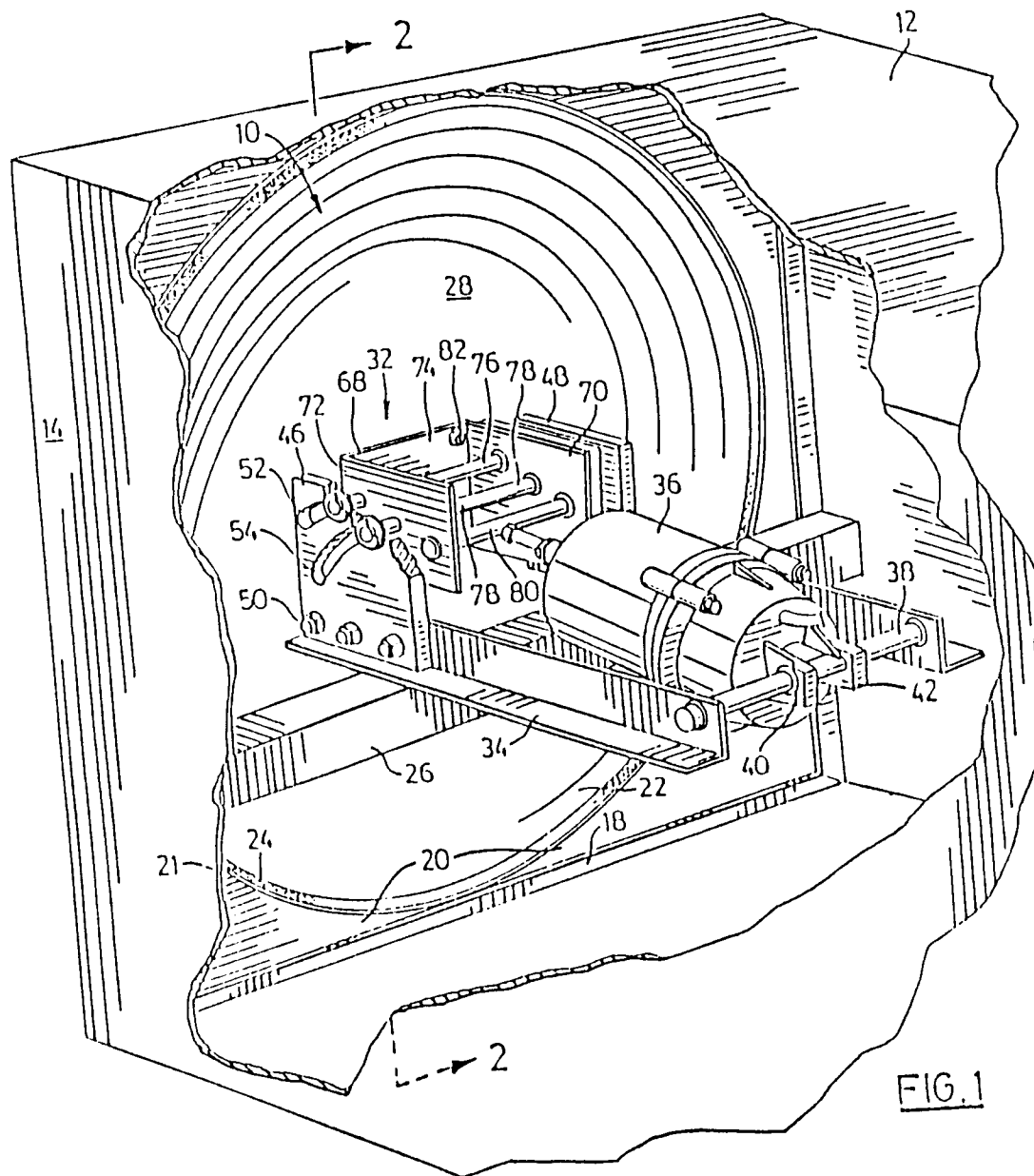
6. A damper for controlling air or gas flow through an opening in a duct, comprising a closure member (28) movable between a first position where the opening is blocked and a second position in which the opening is unblocked; a mounting bracket (68) fixedly connected to said closure member; and means for coupling said mounting bracket to a fixed support structure (26) mounted in said duct whereby said closure member can be moved between said first and second positions by being initially linearly displaced from said opening and then being rotationally displaced as it moves to said second position, said coupling means acting to guide the movement of the closure member between said first and second positions; and actuating means (36) for moving said mounting bracket and closure member, said damper characterized by a shaft (137) connected to said actuating means, said actuating means (136) being capable of rotating said shaft about its centre axis between first and second limit positions and being mountable outside said duct (112) with said shaft extending through one side of said duct and a substantial distance across said duct near said opening, a torque arm (139) rigidly connected to said shaft and extending transversely thereto, and a connecting link member (141) pivotally joining an outer end portion of said torque arm to said mounting bracket.

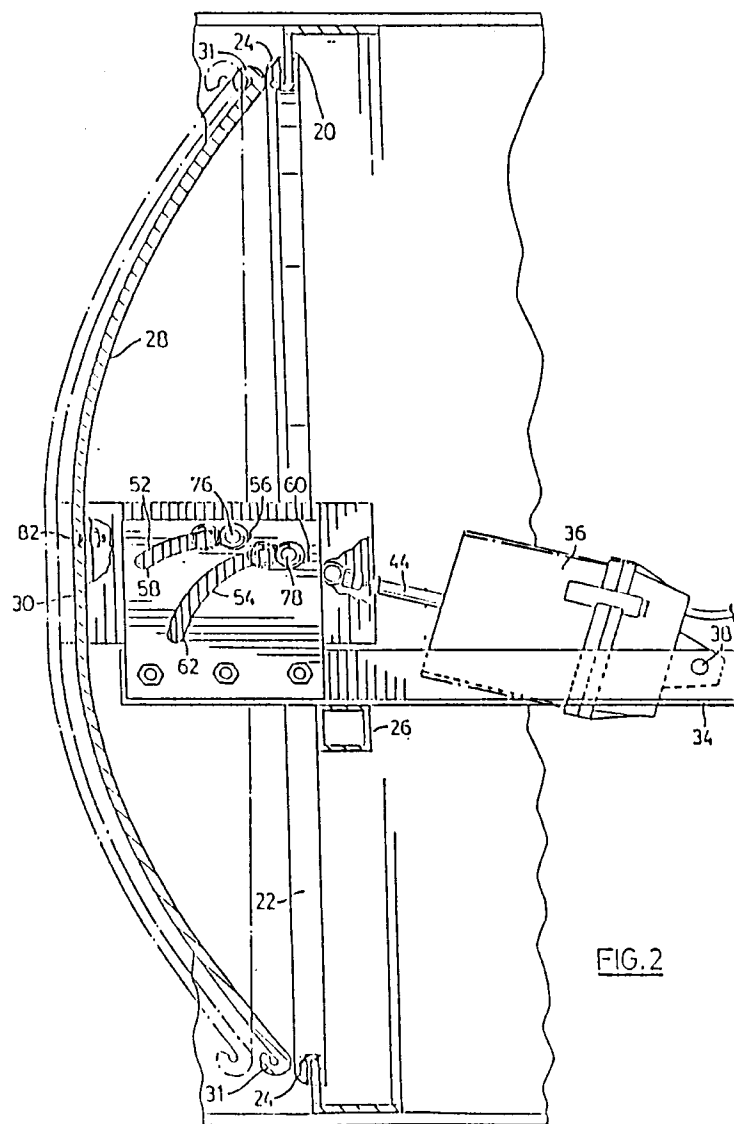
7. A damper according to claim 6 characterized in that said coupling means includes a pair of guide members (46, 48) adapted to be fixedly mounted to said support structure so as to be spaced apart from each other, said guide members each provided with diverging first and second arcuate guide slots (52, 54), each pair of said first and second guide slots being in registration along a substantial portion of their length, said coupling means further including first and second guide pin means (76, 78) fixedly mounted in said mounting bracket (68) and respectively movably captive within said first and second guide slots (52, 54).

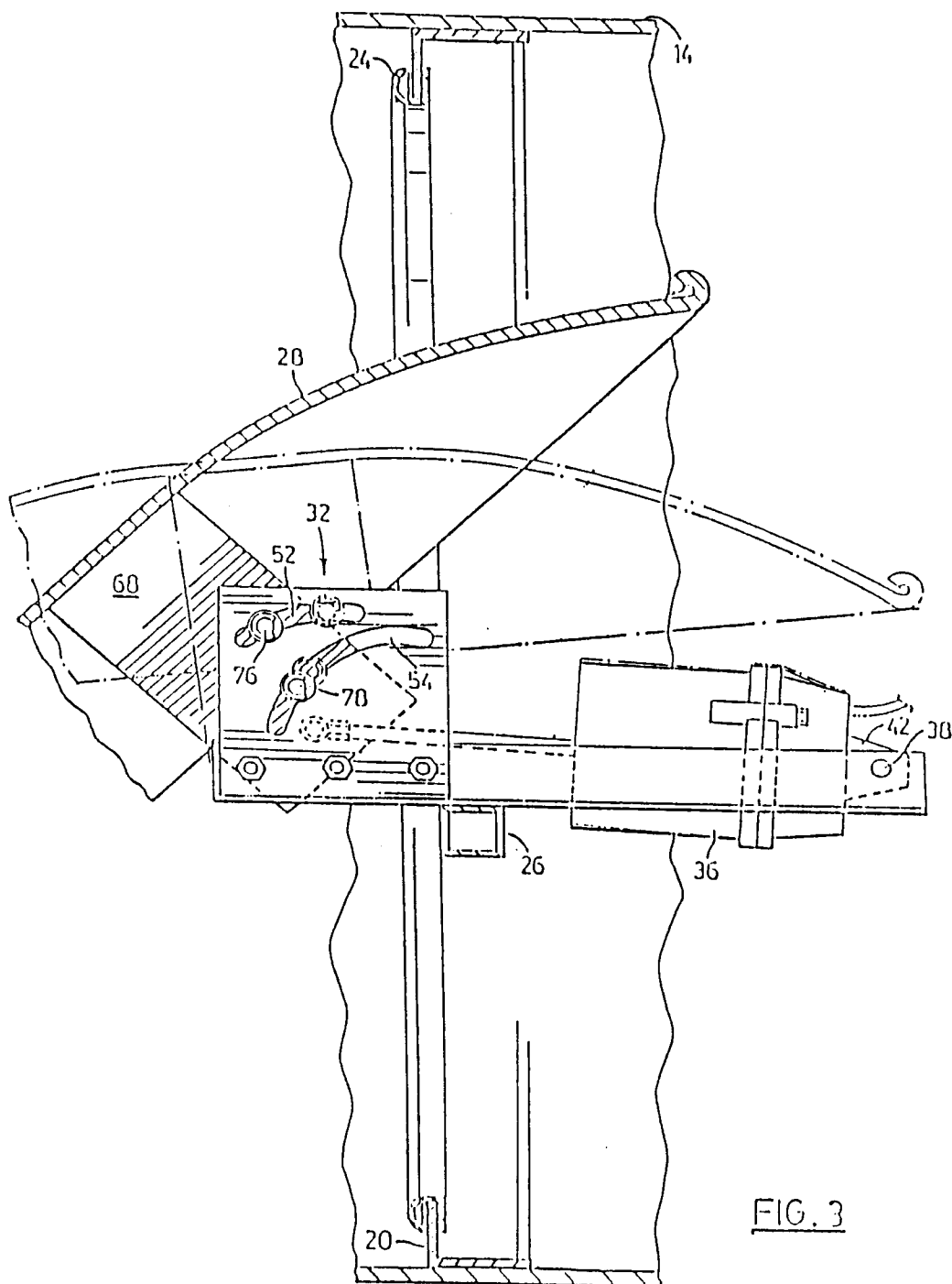
8. A damper according to claim 6 or 7 characterized by means (150, 152) for rotatably mounting a portion of said shaft in said one side of said duct, said mounting means including tandem seals (155, 156) that extend around said shaft (137) and act to effectively seal any air gap between said shaft and said mounting means.

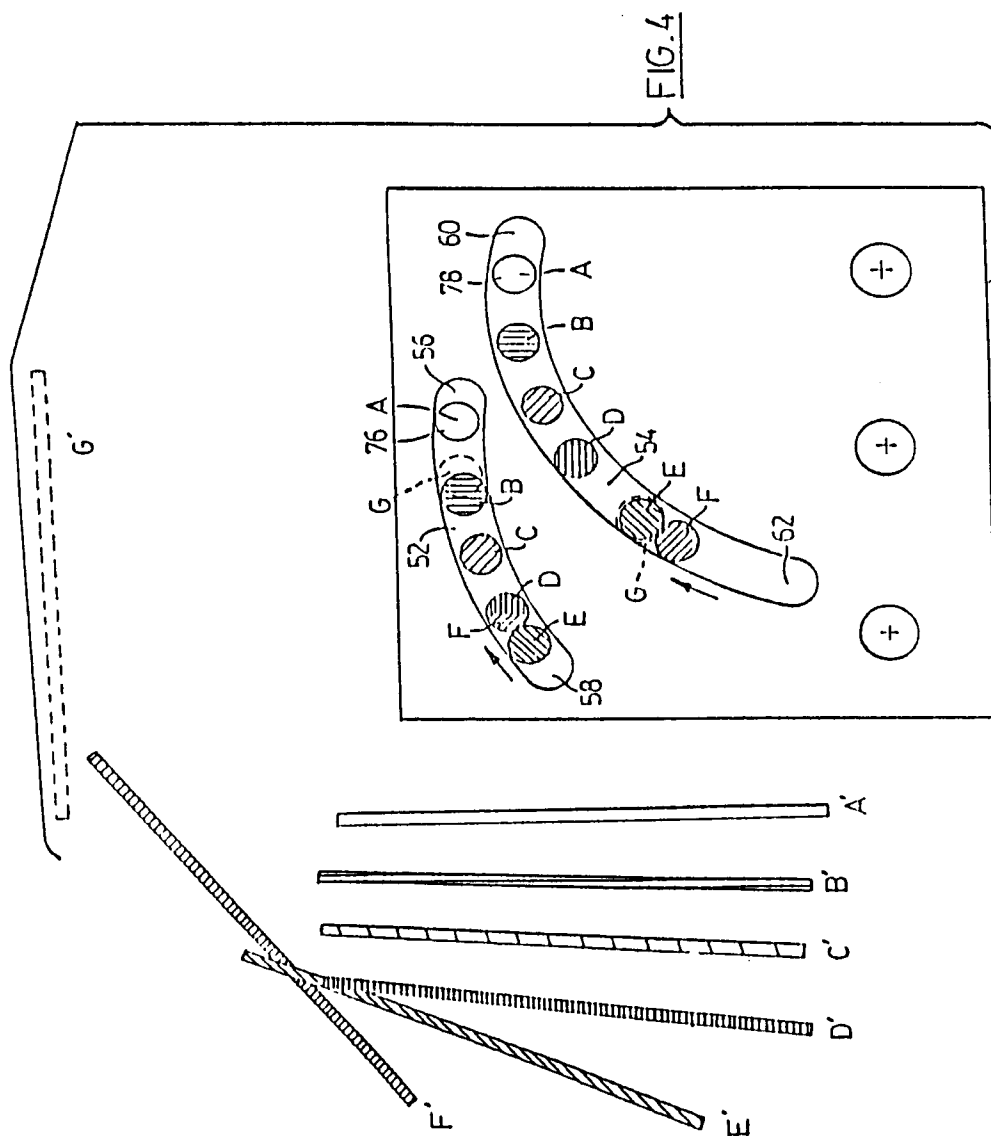
9. A damper according to claim 8 characterized in that said mounting means comprises an externally threaded sleeve member (150) welded to said one side of said duct and a removable nut member (152) threaded onto one end of said sleeve member and wherein said sleeve member has an annular internal recess (154) at said one end thereof in which said tandem seals are arranged immediately adjacent one another.

10. A damper according to any one of claims 1 to 9 characterized in that said closure member (28) is circular and disk shaped so as to close a circular opening, the circumferential edge of said closure member (28) being rolled outwardly in a direction away from said opening to increase the strength and rigidity of the closure member.









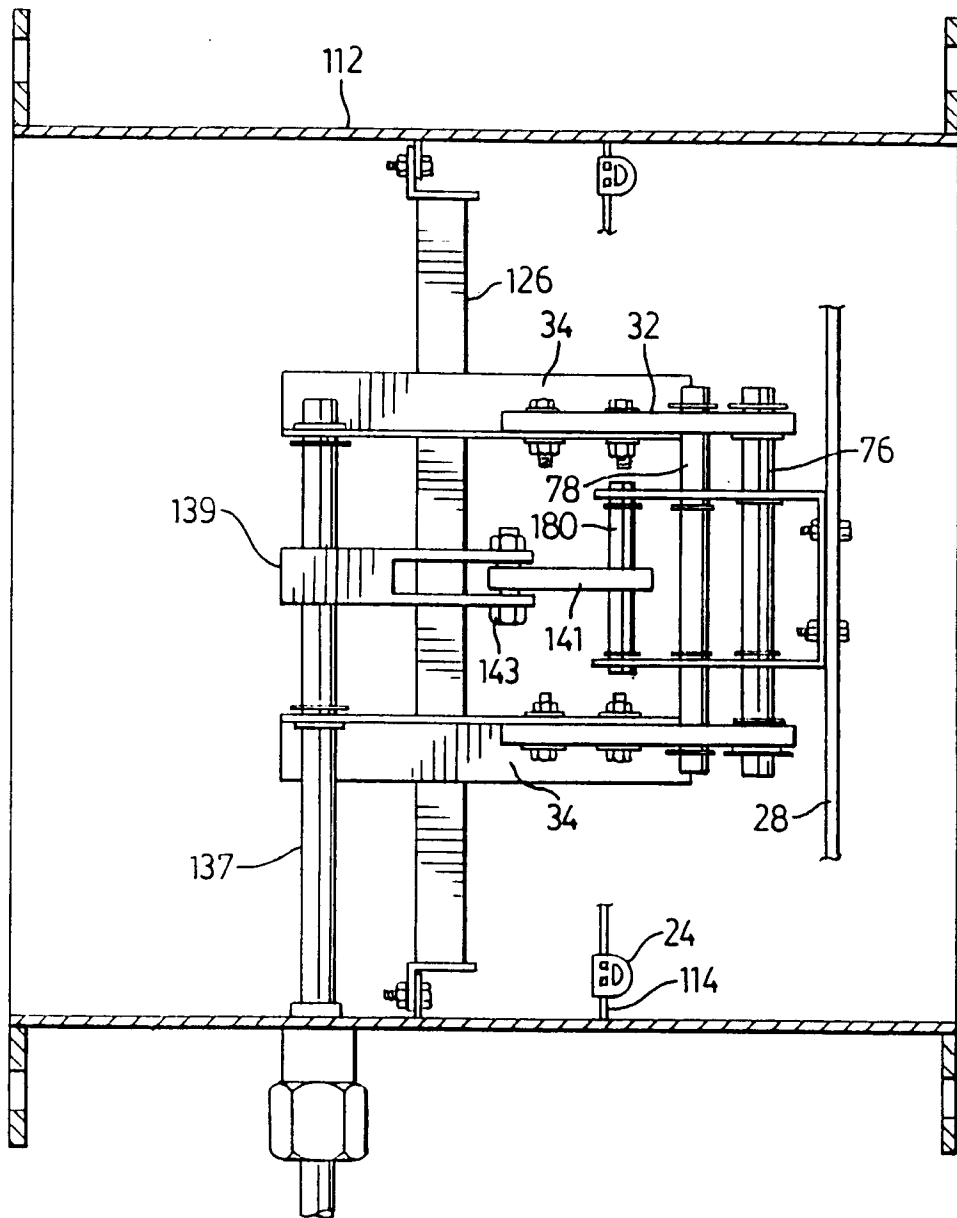


FIG. 5

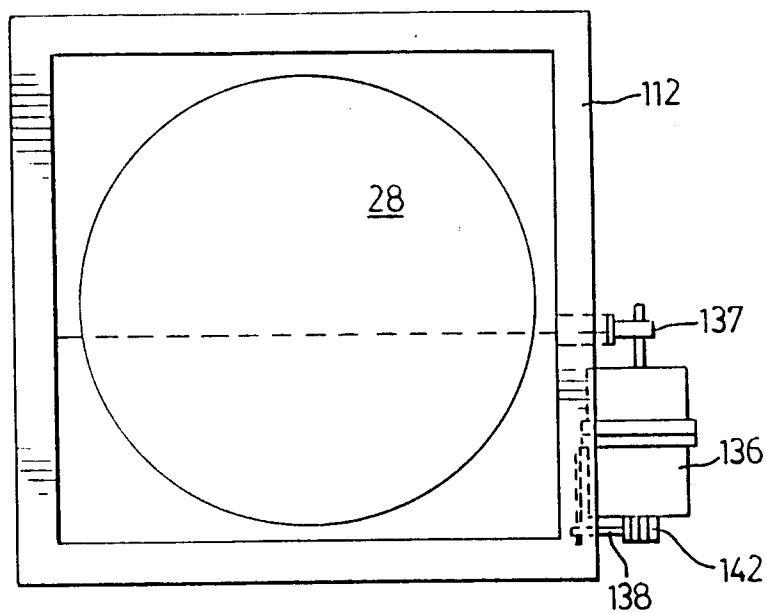


FIG. 6

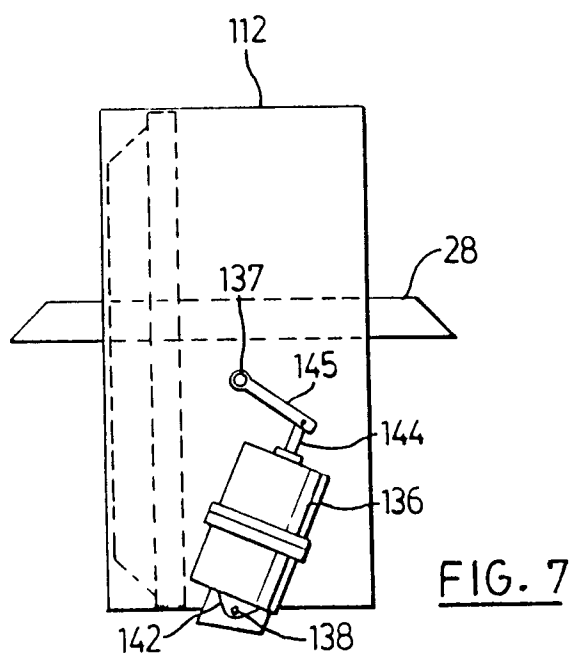


FIG. 7

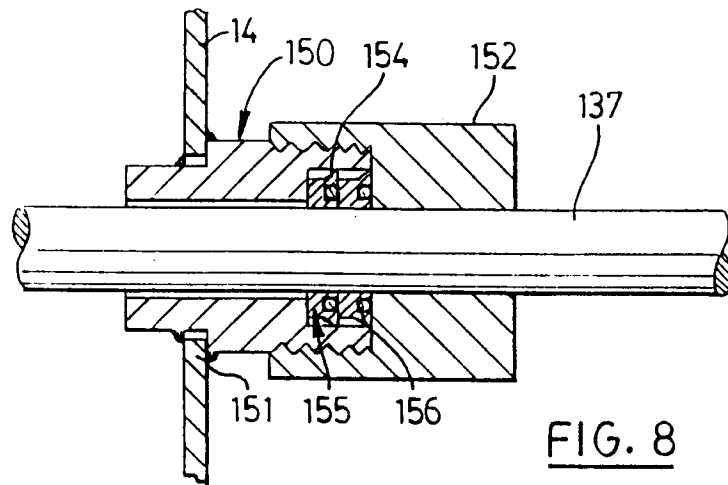


FIG. 8

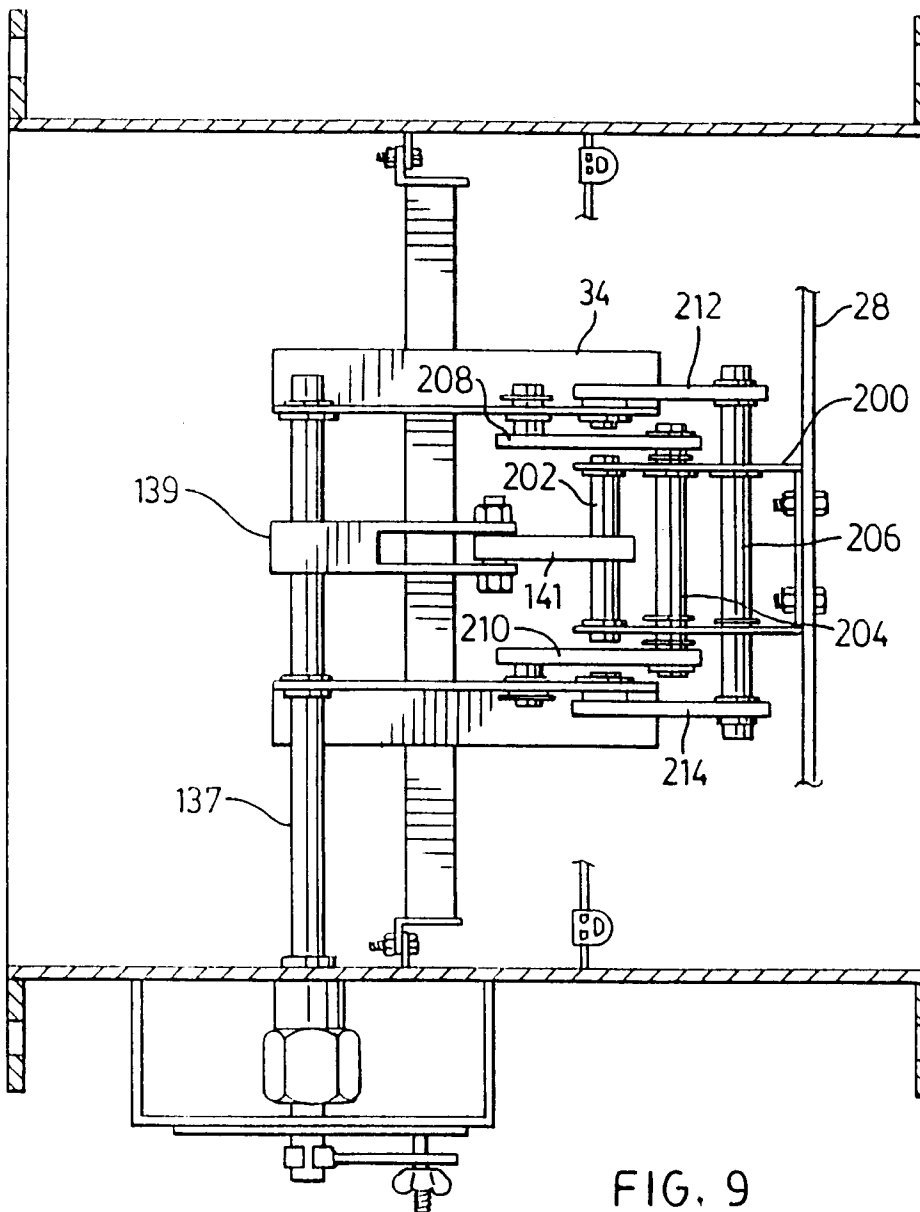


FIG. 9