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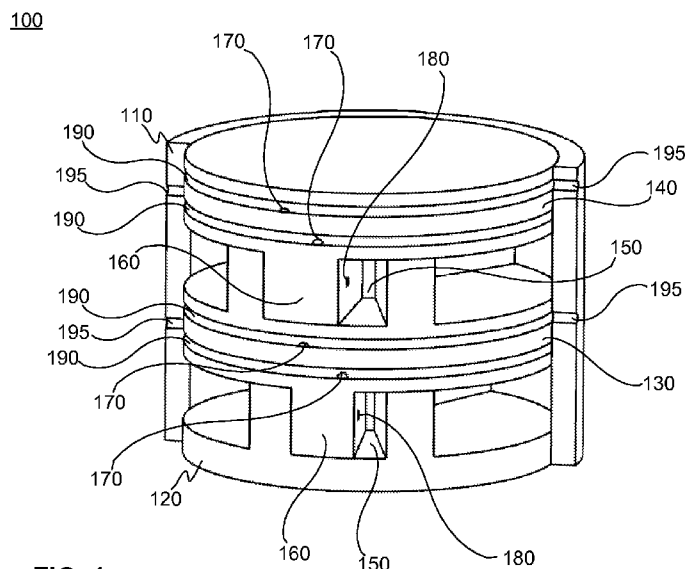


FIG. 1

(57) Abstract: The invention relates to an actuator comprising a body part and at least two coaxially mounted cylindrical rotor parts. A first interconnection formed between the first rotor part and the body part, and at least one second interconnection formed between two rotor parts. Each of the first and the second interconnection is provided with at least one cavity formed into one of the interconnected parts and the other interconnected part is provided with a protrusion movable within the cavity and the actuator is further provided with at least one fluid channel for the at least one cavity of each of the interconnection in order to control a rotational position of at least one of the rotor parts by controlling pressure in the at least one fluid channel of each interconnection. The invention relates also an actuator system.

Pressure controlled actuator

TECHNICAL FIELD

The invention concerns in general the technical field of controlling. Especially the invention concerns an actuator and a system for controlling purposes.

5 BACKGROUND OF THE INVENTION

Actuators are widely used in controlling of devices and systems. Actuators are operated by a source of energy, typically in the form of an electric current, hydraulic fluid pressure or pneumatic pressure. The energy fed to the actuator is by some means converted to a motion, such as linear, rotational or oscillating
10 movement, in the actuator. The movement achieved may then be utilized for controlling of a device or a system. For example, in diesel engine fuel rack or butterfly valve thermostat may be controlled by a rotary motion of a specific lever attached to the shaft and driven by a linear actuator.

Patent document GB1520119(A) discloses a rotary fluid-pressure actuator
15 comprising a hollow cylindrical body having internal radial ribs and containing vanes fixed to an oscillatable shaft, which vanes and shaft together with the said ribs divide the space within the body compartments, each of the compartments containing an inflatable flexible-walled chamber into which the working fluid can be introduced, and the chambers having folds directed approxi-
20 mately radially when the chambers are not inflated. To operate the actuator the chambers lying in the two diametrically opposite compartments are inflated simultaneously by allowing the fluid contained in the two chambers to escape. The inflated chambers bear against the ribs and then push the vanes towards the opposite rib until the stop abuts against one of the abutments. For the re-
25 verse movement, the deflated chambers are inflated and the others are connected to the outlet.

The drawback with the above-described prior art actuator is that the controlling is only possible between the two extreme positions by inflating and deflating the opposite chambers simultaneously. As a result, the possibilities for control
30 are very limited.

One possibility to enable continuous controlling is to utilize so called servo actuators. The advantage of the servo actuators is that controlling of them is

quite straightforward with electrical input signal and the motion can be achieved directly. The drawback of the servo actuators is that they are expensive at least partly due to the fact that a feedback loop is required to meet sufficient repeatability of the operation.

5 SUMMARY OF THE INVENTION

An objective of the invention is to present an actuator and a system for controlling. Another objective of the invention is that the actuator and system for controlling provide a sophisticated control mechanism for versatile purposes.

10 The objects of the invention are reached by an actuator and a system as defined by the respective independent claims.

According to a first aspect, an actuator is provided, wherein the actuator comprises a body part with a ground plane, the body part having a hollow cylindrical inner space; at least two coaxially mounted cylindrical rotor parts rotatable within the hollow cylindrical inner space of the body part, wherein the first rotor
15 part being interposed between the ground plane and the second rotor part; a first interconnection formed between the first rotor part and the body part, and at least one second interconnection formed between two rotor parts; wherein each of the first and the second interconnection is provided with at least one cavity formed into one of the interconnected parts and the other interconnected
20 part is provided with a protrusion for each of the at least one cavity movable within the cavity between angular positions defined by first and second edges of each cavity; the actuator is further provided with at least one fluid channel for the at least one cavity of each of the interconnection in order to control a rotational position of at least one of the rotor parts by controlling pressure in the
25 at least one fluid channel of each interconnection.

In the actuator a first fluid channel may be arranged to a first space between the protrusion and the first edge of the at least one cavity and a second fluid channel may be arranged to a second space between the protrusion and the second edge of the at least one cavity in each of the interconnection.

30 In the actuator the at least one fluid channel may be arranged through at least one of the following: the protrusion of at least one interconnected part, a wall of the cavity of at least one interconnected part, the ground plane of the body part.

The actuator may further comprise a groove channel for each of the at least one fluid channel for bringing the fluid to the at least one fluid channel, wherein the groove channel may be arranged to at least one of the following: the body part, at least one rotor part.

- 5 The body part of the actuator may comprise an opening for bringing the fluid into the groove channel.

The actuator may further comprise an actuating interface in order to output the force achieved in the actuator to an external entity, wherein the actuating interface is configured to be formed to at least one of the following: at least one rotor part in the actuator, the body part of the actuator. The actuating interface may be at least one of the following: a lever fixed in the outermost rotor part of the at least two rotor parts seen from the ground plane, a shaft mounted in the outermost rotor part forming the actuating interface to an external entity. The actuating interface may further be at least one of the following: a lever mounted on the outer surface of the body part, a protrusion arranged on the outer surface of the body part.

The body part of the actuator may also be configured to form the actuating interface in order to output the force achieved in the actuator to an external entity.

- 20 According to a second aspect, an actuator system is provided wherein the system comprises a shaft, at least two actuators as described above which are installed along the shaft.

The shaft in the actuator system may be configured to penetrate each of the at least two actuators.

- 25 At least one rotor part of at least one of the actuators in the actuator system may be fixed with the shaft.

At least a body part of each of the actuator in the system may be fixed with the shaft.

- 30 Each of the actuators in the system may comprise a lever in order to bring the output force to at least one external entity. The lever in the system may be arranged in at least one of the following: a rotor part of at least one of the actuators, a body part of at least one of the actuators.

The exemplary embodiments of the invention presented in this patent application are not to be interpreted to pose limitations to the applicability of the appended claims. The verb "to comprise" is used in this patent application as an open limitation that does not exclude the existence of also un-recited features.

- 5 The features recited in depending claims are mutually freely combinable unless otherwise explicitly stated.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional
10 objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

- Fig. 1 illustrates an exemplified structure of the actuator,
- 15 figs. 2a and 2b illustrate an embodiment of the rotor part according to the invention from two different viewing angles,
- fig. 3 illustrates a simplified cross-sectional view of an actuator according to an embodiment of the invention,
- fig. 4 illustrates operational modes of the actuator according to an
20 embodiment of the invention,
- fig. 5 illustrates an embodiment of the actuator according to the invention,
- fig. 6 illustrates a further embodiment of the actuator according to the invention,
- 25 fig 7a and 7b illustrate embodiments of the system according to the invention, and
- fig. 8 illustrates an example of a control system according to the invention.

DETAILED DESCRIPTION OF THE INVENTION AND ITS ADVANTAGEOUS EMBODIMENTS

The invention relates to an actuator which can be applied in versatile environments for controlling. More specifically, the actuator according to the invention may be utilized in e.g. diesel engines. The invention comprises a body part with a ground plane. The body part has a hollow cylindrical inner space. The actuator further comprises at least two coaxially mounted cylindrical rotor parts within the body, wherein the first rotor part is interposed between the ground plane and the second rotor part. A first interconnection is thus formed between the first rotor part and the body and at least one second interconnection is formed between two rotor parts. According to the invention the first and the second interconnection are provided with at least one cavity formed into one of the interconnected part, i.e. into the body or one or more of the rotor parts, and other interconnected part, i.e. the body or one or more of the rotor parts, is provided with a corresponding protrusion to each of the cavities. The protrusion is configured to be movable within the corresponding cavity between angular positions defined by first and second edges of each cavity. Furthermore, the actuator is further provided with at least one fluid channel for the at least one cavity of each of the interconnection in order to control a rotational position of at least one of the rotor parts by controlling pressure in at least one fluid channels of each interconnection. The invention further relates to a system utilizing the actuator as described. Within the system at least two actuators as described may be coupled to a shaft or to shaft parts for providing at least part of the rotational motion in order to provide force for an external entity.

The main parts of an actuator according to the invention are illustrated in Fig. 1. The actuator 100 comprises a body part 110 with a ground plane 120. The actuator 100 according to this implementation comprises a first rotor part 130 and a second rotor part 140, but as already mentioned there can be even more rotor parts 130, 140 superposed on each other. With the term 'superposed' it is meant that the rotor parts are taken into interconnection with each other in such a manner that the mutual angular motion can be achieved with respect to the rotor parts. The first interconnection between the ground plane 120 and the first rotor part 130 is achieved with a cavity 150 formed in the ground plane 120 and a protrusion 160 implemented in the first rotor part 130. The second interconnection between the first rotor part 130 and the second rotor part 140 is achieved with a cavity 150 formed in the first rotor part 130 and a protrusion

160 implemented in the second rotor part 140. As can be seen from Fig. 1 the rotation of the protrusions 160, i.e. the angular positions of the parts of the interconnection, in each of the interconnection, is limited by the width of the cavity, i.e. the first and the second edges of the cavity. The amount of angular movement can also be adjusted by selecting the size of the protrusion 160 according to desired rotational angle. In other words, the freedom of the parts forming the interconnection to rotate is dependent on the size, i.e. angular width, of the cavity 150 compared to the size of the protrusion 160.

In the exemplified structure as illustrated in Fig. 1 the second rotor part 140 operates also as a so called actuating part, which is, in this embodiment, equipped with an actuating interface, by means of which a total output force achieved with the rotational motion of at least some parts of the structure is to be taken to an external entity. This may be achieved with e.g. a shaft (not illustrated in Fig. 1) or a lever (not illustrated in Fig. 1) implemented on the second rotor part 140 and coupled to the external entity.

The actuator 100 as illustrated in Fig. 1 comprises also at least one fluid channel 170 for at least one cavity 150 of each of the interconnection by means of which pressurized fluid can be taken into and out from at least one space in the cavity 150 which space is achieved by dividing the cavity 150 with the protrusion 160. Thus, the fluid channel is arranged with a through hole from the outer surface of the respective part, i.e. ground plane 120 or a rotor part 130, 140, to at least one space in the cavity 150. The fluid channel may also be formed with a groove on the surface of the rotor parts 130, 140 so that the fluid can be delivered to the at least one cavity. In Fig. 1 the fluid channels 170 are arranged in rotor parts 130, 140 wherein the respective fluid channels are brought into the cavities 150 with openings 180 in the protrusions 160. Alternatively or in addition, the fluid channels 170 may be arranged into such a location in a cavity wall, which enables the provision of the fluid to a corresponding space or spaces in the interconnection. The term "cavity wall" shall be understood to cover any point in a cavity surface, such as a bottom plane of the cavity as well as wall plane of the cavity. Furthermore, it is possible to provide the fluid into the first interconnection, i.e. between the body part 110 and the first rotor 130, directly through the ground plane 120 by arranging a through hole with an opening in the corresponding space or spaces in the interconnection.

As can be seen from Fig. 1 the fluid is brought to the fluid channels 170 through groove channels 190, which are here arranged on the outer surface of the rotor parts 130, 140 in order to input and output the fluid to and from the cavities 150. It is also possible to arrange the groove channels 190 to the inner
5 surface of the body part 110 instead of the groove channels on the outer surface of the rotor parts 130, 140. Alternatively, one solution can be that the groove channels 190 are formed with a combination of matching grooves on both the outer surface of the rotor parts 130, 140 and inner surface of the body part 110. The groove channels 190 shall extend so that the fluid can be input
10 and output in all rotational positions of the rotor parts 130, 140. Furthermore, openings 195 are also arranged into the body part 110 so that the external source can provide the pressurized fluid into and from the actuator 100. The provision of the pressurized fluid in each of the fluid channel may be arranged either independently or dependently of the other fluid channels.

15 The fluid used in the actuator 100 according to the invention may be liquid or gas, such as air or oil. The selection of the fluid to be used may depend e.g. on the desired response time i.e. how fast one needs to control the rotation of a part in the structure. Alternatively or in addition, one may need to take into account the forces needed in the operation, which may lead to consider a compressibility of the fluid in use. In order to achieve rapid response in some im-
20 plementations it may be advantageous to choose such a fluid, which does not essentially compress under heavy forces.

The actuator 100, as depicted in Fig. 1, comprises a body part with a ground plane. Advantageously, the hollow inner space of the body part is a cylinder or
25 cylindrical in shape. According to one embodiment of the invention the body part may comprise a solid ground plane. This is advantageously achieved by manufacturing the body part with the ground plane from a continuous material with an applicable manufacturing method, such as milling. According to some other embodiment of the invention the ground plane may be a separate ele-
30 ment, which is mounted with the body part either in a fixed or detachably fixed manner. The ground plane may comprise a hole on it in order to bring a shaft element through it if a shaft is applied in the structure.

According to the invention at least two rotor parts are installed in the body part. From an operational point of view the body part and the at least two rotor parts
35 are configured to form interconnections with each other in order to achieve the

desired operation of the invention. A first interconnection is formed between the body part 110 and the first rotor part 130. Any further interconnection is formed between separate rotor parts the number of which is dependent on the application area of the actuator 100 according to the invention. In order to maintain the simplicity in explaining the inventive idea it is now described only with two rotor parts wherein the first rotor part 130 is configured to be interposed between the ground plane 120 and the second rotor part 140. Thus, in this context a second interconnection is formed between the first and the second rotor parts 130, 140. The first and the second rotor parts 130, 140 are arranged to be coaxial and cylindrical in shape. Further, the first and the second rotor parts 130, 140 are configured to be such in size and in shape that they may be arranged to rotate with respect to the body part and with respect to each other. The same applies when there are even more rotor parts than two. It is not necessarily so that the some of the at least two rotor parts are exactly similar in shape as long as the interconnections between them are implemented as explained later. Important is that the rotor parts are coaxial and they can rotate with respect to the body part and with respect to each other.

The interconnections are arranged in such a manner that the first and the second parts being involved in the interconnection form such structural arrangement, which allows a predetermined amount of angular rotation of the parts with respect to each other. This is achieved by arranging a cavity 150 to either of the parts being involved in the interconnection and a protrusion 160 to the other part being involved in the interconnection. The protrusion 160 is configured to be such in shape that it matches into the cavity 150 so that it divides the cavity 150 into two spaces. As the parts are configured to be rotated with respect to each other the angular limits of the rotation are defined by the first and the second edges of the cavity 150 in which the protrusion moves in a rotational manner. As regards the first interconnection the cavity 150 may be arranged either in the body part 110 or in the first rotor part 130. The same applies with the protrusion 160. As indicated, the requirement is that the cavity 150 and the corresponding protrusion 160 shall be arranged so that they match together in the described manner, when the parts are brought to the interconnection. In case of body part the cavity 150 or the protrusion 160 may be arranged to the wall of the body part 110 or to the ground plane 120. Similarly, the cavity 150 or the protrusion 160 may be arranged to the outer side surface

of the first rotor part 130 or the outer plane surface of the first rotor part 130 which is against the ground plane 120.

Figs 2a and 2b illustrate an embodiment of the rotor part 130 according to the invention from two different viewing angles. Fig. 2a illustrates one side of a rotor part 130, which comprises two protrusions 160, which are matched with the cavities 150 in the other part of the interconnection. The rotor part in Fig. 2a also discloses two fluid channels with openings 180. In such a case the limits for the angular motion are defined by the first and second edges 161, 162 of the cavity 150 of fig. 2b, which in this case are defined with the edges of the respective protrusions. In Fig. 2b the other, opposite, side of the rotor part 130 comprises multiple cavities 150 formed between four protrusions 160. It is clear that the number of protrusions in a rotor part, or in the body part, can vary a lot according to a need. The inventive idea can be achieved with even one protrusion 160 arranged in the rotor part, or a cavity 150 if that is the case. With multiple protrusion and cavity combinations in one interconnection it is possible to provide more area to pressurize the structure and thus, provide more force to achieve the rotation of the rotor part 130.

The rotor part 130, as illustrated in Figs. 2a and 2b, may comprise a hole in the centre of the part. The hole is arranged in the rotor part 130 in order to bring a centre shaft to the structure. By means of the center shaft the structure may be kept aligned as well as the assembly is easier than without it. The utilization of the shaft also provides some additional benefits in an operational sense. Namely, it is possible to arrange that the body part is fixed compared to the other parts and elements in the actuator structure. In such an arrangement the total force achieved with angular motion of the rotor parts in the structure may be output through the shaft which is mounted with at least one rotor part in the structure. Thus, the shaft is arranged to rotate in response to an angular motion control achieved with a provision of fluid in the structure as described. According to some embodiment of the invention it is possible to arrange that the shaft is fixed with a rotor part, such as with the outermost rotor part of the at least two rotor parts seen from the ground plane. As the shaft and the at least one rotor part are fixed with respect to each other, it is possible to achieve the rotation of the body part by bringing the fluid to a cavity within the structure. The body part may be equipped with a lever by means of which the rotational motion, i.e. the total output force of the structure, can be taken to an external entity. Thus, the body part operates as an actuating part forming the actuating

interface to an external entity, which actuating interface in this context may be a lever mounted on the outer surface of the body part. The lever may be replaced with any other structure arranged on the outer surface of the body part, such as a protrusion, by means of which the rotational motion, i.e. the output
5 force, can be conveyed to the external entity.

According to still further embodiment of the invention it is possible to arrange two separate shafts with the actuator, by means of which two output forces can be provided through the shafts. Namely, each of the shafts is fixed to some distinct rotor parts, e.g. the outermost rotor parts in both ends of the actuator,
10 in the actuator. Now, by providing control to rotor parts within the structure with a pressurized fluid it is possible to achieve output forces to both shafts simultaneously, and thus it is possible to provide the force to two external entities at the same time. As can be seen the body part shall be fixed with respect to the rotor parts in this implementation.

15 The shaft as disclosed is one implementation by means of which it is possible to improve the alignment of the parts in the structure. According to some other embodiment the improved alignment may be achieved by arranging alignment means between each of the part being involved in an interconnection. For example, in case of the interconnection between two rotor parts 130, 140 a pin
20 may be arranged in the first rotor part 130, 140 and an aperture for the pin is arranged to the second rotor part 130, 140. The same arrangement may be applied in every interconnection in the structure. As already described, the necessary alignment may also be achieved by matching the size of the rotor parts 130, 140 with the body part 110.

25 In the description of Fig. 3 the same reference numbers as disclosed with respect to previous figures are also used here. Fig. 3 discloses a simplified cross-sectional view of an actuator 100. More precisely, the operation of the actuator 100 in one of the interconnections is shown. Here, it is illustrated a first rotor part 130 with a cavity 150. Only the protrusion 160 of the second rotor part is illustrated in order to maintain the clarity. However, the rotor parts
30 130, 140 are superposed in order to achieve the result of the invention. The protrusion 160 is matched in the cavity 150 and the protrusion is arranged to rotate a maximum angle α , in response to an input of pressurized fluid in at least one space of the cavity. The spaces are marked with A, A', B and B' in
35 Fig. 3. If pressurized fluid is arranged to at least one of the spaces A or A', the

rotor part with the protrusion 160 rotates to a direction of D1 with respect to the rotor part 130 until the edge of the cavity 150 limits the rotation. Correspondingly, if pressurized fluid is arranged to at least one of the spaces B or B', the rotor part with the protrusion 160 rotates to a direction of D2 until the other

5 edge of the cavity 150 limits the rotation. The same applies even if pressurized fluid is, for one reason or another, provided simultaneously in spaces having an opposite effect to the rotation as long as there is a pressure difference between the spaces, wherein the difference is such that it overcomes any friction force or counter force between the parts so that the rotation can be achieved.

10 The counter force may be arranged with some additional components, such as by arranging a spring to maintain a position of the parts with respect to each other in a predetermined manner. Even though Fig. 3 depicts the first and the second rotor parts, the same applies in interconnections between the body part and a first rotor part or between any other rotor parts.

15 Figs. 4a-4d depicts operational modes of the actuator 100 which is implemented with two rotor parts and in which implementation a shaft 400 is used for outputting the force from the actuator 100. The shaft is fixed to the second rotor part 140. Each interconnection in the actuator 100 is provided with at least two fluid channels by means of which it is possible to achieve the rotational

20 motion in both directions. In practice, this means that the fluid channels are advantageously arranged to both sides of the protrusion, i.e. both spaces of the cavity, in each of the interconnection. The fluid channels can be controlled independently. In Fig. 4a the rotor parts 130, 140 are in a first position, i.e. in a first operational mode, wherein pressurized fluid may be provided in spaces

25 150A, 150C in the interconnections that the positions of the parts, as illustrated in Fig. 4a, can be maintained. Fig. 4b illustrates a second operational mode of the actuator 100. In Fig. 4b, compared to Fig. 4a, pressurized fluid is provided into other space 150B of the first interconnection between the ground plane 120 and the first rotor part 130 in such a manner, that the first rotor part 130

30 rotates. At the same time the fluid is removed from the space 150A shown in Fig. 4a. As a result the shaft 400 turns the angle defined by the size of the cavity in the ground plane 120 as the rotation of the first rotor part 130 forces also the second rotor part 140 to rotate. In a further, i.e. a third, operational mode the first position in the first interconnection is maintained, but the rotational mo-

35 tion is achieved by providing pressurized fluid into the second interconnection in such a manner that the second rotor part 140 rotates from the first position

to a second position. This is illustrated in Fig. 4c. Furthermore, in the fourth operational mode the rotational motion is achieved by providing the pressurized fluid into the spaces 150B, 150D in the first interconnection and the second interconnection so that both interconnections are rotated, thus producing the maximum rotation in the shaft 400. This is illustrated in Fig. 4d.

According to some embodiments of the invention it is arranged so that pressurized fluid is always provided in either of the spaces of a cavity 150, which are formed with the protrusion 160 in the interconnection. By means of such arrangement an undesired rotation of a rotor part can be prevented as the pressure in a predefined space maintains the status of the parts in the interconnection. This may be advantageous especially in implementations in which multiple rotor parts 130, 140 are interposed and only some of them are rotated.

In some embodiment of the invention the sizes of the cavities in different interconnections are the same. This means that the angular rotation between the parts being involved in the interconnection in each of the interconnection is the same. Naturally, the total effect of the rotations in each of the interconnection is summed in the actuating part through which the output force, i.e. motion, is taken to the external entity. In order to introduce a controlling system with the actuator 100 according to the invention the resolution of the controlling can be improved if the provided angular motion in various interconnections is different. In other words, the cavities in separate interconnections are arranged to be different in size so that the amount of rotational motion of the respective protrusion, and thus the respective part, varies. Alternatively or in addition it is possible to add limiters in the cavities in order to adjust the size of the cavity. Such limiter may be a specific shim plate, which can be mounted in the cavity. According to some embodiment of the invention in which there are, for example, four interconnections it is arranged so that the parts forming the first interconnection are arranged to rotate 5 degrees with respect to each other, the parts forming the second interconnection are arranged to rotate 10 degrees with respect to each other, the parts forming the third interconnection are arranged to rotate 20 degrees with respect to each other and the parts forming the fourth interconnection are arranged to rotate 40 degrees with respect to each other. The rotations are advantageously separately controllable. As a result, it is possible to achieve a total amount of angular motion of 75 degrees in 5 degrees intervals in the topmost rotor part with respect to the ground plane. Thus, such a binary coded angular motion provides very sophisticated way of controlling.

As can be seen, the angular motion in the interconnections can be defined on a case-by-case basis by selecting parts comprising an applicable cavity size for the needs. The order of the interconnections enabling different angular motions in the superposed structure is not relevant as such from the operational point of view. The mentioned first, second, third and fourth interconnection may all be arranged between two rotor parts or alternatively, at least one of them is arranged between the body part and a first rotor part. The interconnections in this context are named as first, second, third and fourth interconnection for clarity reasons.

It is also possible to control the speed of the rotation in a specific interconnection by providing pressurized fluid into both of the spaces in a cavity at least partly simultaneously. The amount of pressurized fluid input to respective space can be controlled, or according to an embodiment of the invention it is possible to adjust the pressure of the fluid so that different spaces are provided fluids with different pressures. This also enables the controlling of the speed of the rotation in different interconnections in individual manner if that is needed in the target entity for controlling.

The axial movement of the rotor parts superposed in the structure are arranged to be limited in order to keep the rotor parts closely stacked i.e. maintain the superposed state of the rotor parts. This can be achieved by arranging locking means in e.g. a protrusion in the body part or a locking ring arranged in the shaft if the shaft is implemented in the structure. Alternatively or in addition, the axial movement may be limited by arranging a cover 501 to the body part 110, as illustrated in Fig. 5. The cover 501 is fixed with the body part 110.

In the above the invention is described mainly by referring to an actuator 100 comprising two rotor parts 130, 140. As already mentioned the inventive idea also allows an implementation of the actuator 100 with more than two rotor parts. Fig. 6 illustrates an example of an actuator according to the invention, which comprises three rotor parts 130 mounted along a shaft 400 within a body part 110. The ground plane is not illustrated in Fig. 6. As discussed a first interconnection is arranged to be formed between the body part 110 and the first rotor part 130. In the structure as illustrated in Fig. 6 multiple second interconnections are arranged to be formed between rotor parts 130. The principle in each of the second interconnection is the same as already explained even if the interconnections are not necessarily exactly the same.

Figs. 7a and 7b illustrate two embodiments of the system according to the invention in which systems at least two actuators 100 as previously described are installed along a shaft. The number of the actuators can also be more than two.

5 Fig. 7a shows two actuators in parallel connection, wherein:

- A shaft 700 is continuous and is fixed to body 110a and to body 110b
- Rotational position of the shaft 700 is controlled by base angle 750
- Levers 702a and 702b are fixed to respective rotor 140a and 140b
- Lever 702a output is the sum of base angle 750 and actuator 110a

10 - Lever 702b output is the sum of base angle 750 and actuator 110b.

A hole is also arranged to the body parts 110a, 110b so that the shaft 700 can be taken through the actuators. In the system as illustrated in Fig. 7a the body part of each of the actuators are fixed with the shaft 700. The actuators 100a, 100b in the system comprise respective rotor parts 140a, 140b by means of which the rotational motion of the rotor parts can output to an external entity. More precisely, a lever 702a, 702b is mounted to the rightmost rotor part of respective actuator 100a, 100b so that the force from the rotational motion of the rotor parts can be output to an external entity.

The parallel system as described may be utilized in a fuel supply system of an internal combustion engine. Base angle 750, i.e. the rotation of the shaft may be controlled with a motor or with an actuator. The fuel supply to cylinders can be modified with the actuators 100a, 100b belonging to the system. Parallel system allows actuators to modify the rotational position of the base angle. Each actuator 100a, 100b can independently increase or decrease the movement of base angle 750.

Fig. 7b shows two actuators in serial connection, wherein:

- Rotational position of the shaft 700a is controlled by base angle 750
- Shaft part 700a fixed to body 110a
- Shaft part 700b fixed to body 110b & rotor 140a

- Shaft part 700c fixed to rotor 140b
- Lever 702a output is the sum of base angle 750 and actuator 100a
- Lever 702b output is the sum of base angle 750, actuator 100a and actuator 100b.

5 The actuators 100a, 100b are interconnected along the shaft parts 700a - 700c in such a manner that by rotating the first actuator 100a, the rotational motion is taken to the next actuator 100b via shaft part 700b which is fixed to body part 110b of the second actuator 100b.

10 Figs. 7a and 7b disclose only rotor parts 140a, 140b. Other rotor parts can be similar to the previously described. The actuator may comprise any number of rotor parts, but at least two. Also, the control mechanisms by means of which the rotational motion is achieved into the rotor parts within the actuators may be similar to the previously described.

15 In Figs. 7a and 7b, the shaft is fixed to body part (as illustrated with black dots). The actuators can be fixed with the shaft, by e.g. welding.

Alternatively, the shaft can be fixed to rotor part within each actuator in the system. The body parts of the actuators in the system are rotably mounted with respect to the shaft. Furthermore, the body parts may comprise a lever forming the actuating interface by means which the output force achieved by means of rotational motions of the rotor parts can be brought to at least one external entity.

20 Previous descriptions are some examples of the system according to the inventive idea. Naturally, in order to bring the rotational motion into the shaft a motor or an actuator is needed, which is configured to produce and bring the rotational force to the shaft. Necessary coupling is arranged between the motor/actuator and the shaft

30 Fig. 8 illustrates an example of a control system providing pressurized fluid into and from the actuator 100 according to the invention. The control system comprises a container 810 for the fluid in which the fluid is stored in either pressurized form or in the natural pressure for the fluid in question. It is also possible that the fluid is pressurized when it is taken out from the container. The container 810 is coupled to the actuator 100 via fluid conduits 830A, 830B and

- 830C. The number of fluid conduits may be dependent on the number of interconnections in the actuator 100, whose rotation is controlled by providing the pressurized fluid. The fluid conduits 830A, 830B and 830C may comprise both inlet and outlet conduits for the fluid to and from the actuator 100 (not illustrated for clarity reasons). According to the embodiment as illustrated in Fig. 8 the inlet and outlet of the pressurized fluid to and from the actuator 100 may be controlled with a computing unit 820. The computing unit 820 may be arranged to control the operation of at least one fluid conduit 830A, 830B and 830C with a control signal delivered to a valve in the at least one fluid conduit. The controlling means that the computing unit 820 controls the valve in question according to a need or predetermined operation. The controlling can be achieved by executing at least portions of computer code in at least one processor of the computing unit 820, which produces control signal to be delivered to at least one valve. Moreover, the control system may comprise a feedback loop 840 from the actuator 100 in order to deliver e.g. status information of the operation of the actuator 100 to the computing unit 820. The status information may be utilized in the controlling. The status information may be received from the actuator with appropriate sensors by means of which it is possible to retrieve information on the operation of the actuator 100.
- Some advantageous embodiments according to the invention were described above. The invention is not limited to the embodiments described. The inventive idea can be applied in numerous ways within the scope defined by the claims attached hereto.

CLAIMS

1. An actuator (100), comprising:

- a body part (110) with a ground plane (120), the body part (110) having a hollow cylindrical inner space,

5 - at least two coaxially mounted cylindrical rotor parts (130, 140) rotatable within the hollow cylindrical inner space of the body part (110), wherein the first rotor part (130) being interposed between the ground plane (120) and the second rotor part (140),

10 - a first interconnection formed between the first rotor part (130) and the body part (110), and

- at least one second interconnection formed between two rotor parts (130, 140),

15 wherein each of the first and the second interconnection is provided with at least one cavity (150) formed into one of the interconnected parts and the other interconnected part is provided with a protrusion (160) for each of the at least one cavity (150) movable within the cavity (150) between angular positions defined by first and second edges of each cavity (150),

20 the actuator (100) is further provided with at least one fluid channel (170) for the at least one cavity (150) of each of the interconnection in order to control a rotational position of at least one of the rotor parts (130, 140) by controlling pressure in the at least one fluid channel (170) of each interconnection.

25 2. An actuator (100) according to claim 1, wherein a first fluid channel (170) is arranged to a first space between the protrusion (160) and the first edge (161) of the at least one cavity (150) and a second fluid channel (170) is arranged to a second space between the protrusion (160) and the second edge (162) of the at least one cavity (150) in each of the interconnection.

30 3. An actuator (100) according to claim 1 or 2, wherein the at least one fluid channel (170) is arranged through at least one of the following: the protrusion (160) of at least one interconnected part, a wall of the cavity (150) of at least one interconnected part, the ground plane (120) of the body part (110).

4. An actuator (100) according to any of the preceding claims, the actuator (100) further comprising a groove channel (190) for each of the at least one fluid channel (170) for bringing the fluid to the at least one fluid channel, wherein the groove channel (190) is arranged to at least one of the following:
- 5 the body part (110), at least one rotor part (130, 140).
5. An actuator (100) according to claim 4, wherein the body part (110) comprises an opening (195) for bringing the fluid into the groove channel (190).
6. An actuator (100) according to claim 1, the actuator (100) further comprising an actuating interface in order to output the force achieved in the actuator
- 10 (100) to an external entity, wherein the actuating interface is configured to be formed to at least one of the following: at least one rotor part in the actuator, the body part (110) of the actuator.
7. An actuator (100) according to claim 6, wherein the actuating interface is at least one of the following: a lever fixed in the outermost rotor part of the at
- 15 least two rotor parts (130, 140) seen from the ground plane (120), a shaft mounted in the outermost rotor part forming the actuating interface to an external entity.
8. An actuator (100) according to claim 6, wherein the actuating interface is at least one of the following: a lever mounted on the outer surface of the body
- 20 part (110), a protrusion arranged on the outer surface of the body part (110).
9. An actuator (100) according to claim 6, wherein the body part (110) is configured to form the actuating interface in order to output the force achieved in the actuator (100) to an external entity.
10. An actuator system, comprising
- 25 - a shaft (700)
- at least two actuators (100) as claimed in the claims 1-9 installed along the shaft (700).
11. An actuator system according to claim 10, wherein the shaft (700) is configured to penetrate each of the at least two actuators (100).

12. An actuator system according to claim 10, wherein at least one rotor part (130; 140) of at least one of the actuators is fixed with the shaft (700).
13. An actuator system according to claim 10, wherein at least a body part (110) of each of the actuator is fixed with the shaft (700).
- 5 14. An actuator system according to any of the claims 10-13, wherein each of the actuators in the system comprises a lever (702) in order to bring the output force to at least one external entity.
15. An actuator system according to claim 14, wherein the lever (702) is arranged in at least one of the following: a rotor part (130, 140) of at least one of
10 the actuators, a body part (110) of at least one of the actuators (100).

100

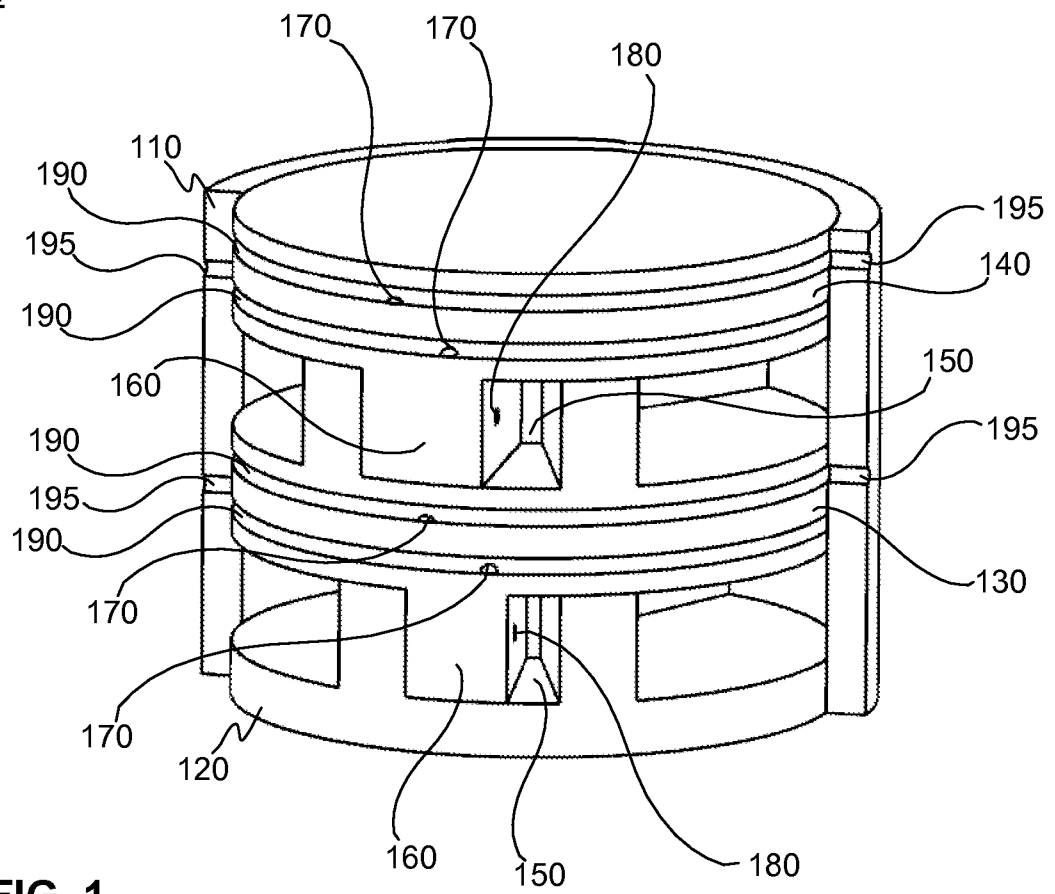


FIG. 1

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130

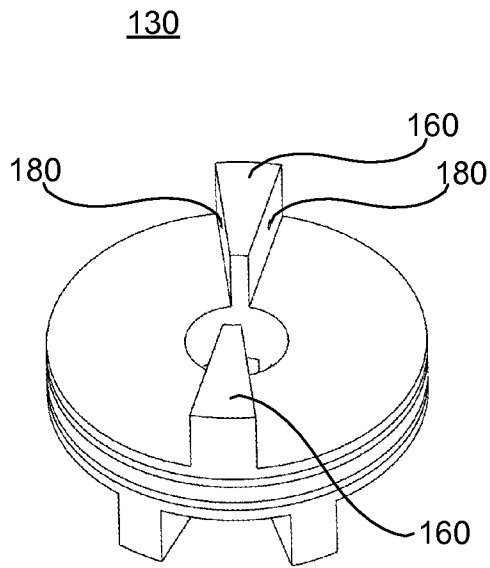


FIG. 2a

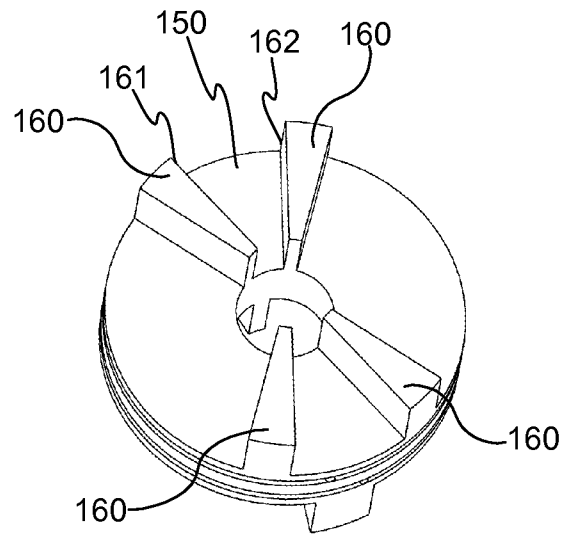


FIG. 2b

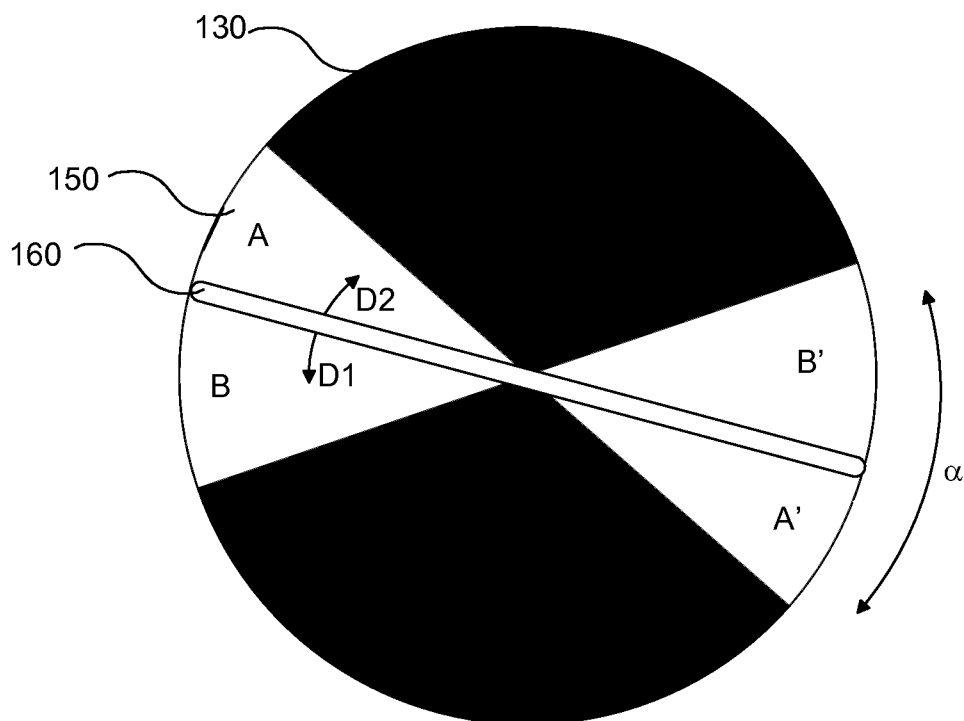


FIG. 3

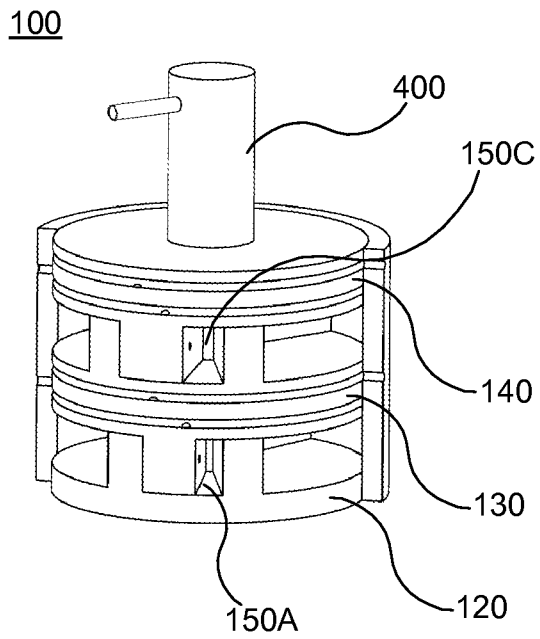


FIG. 4a

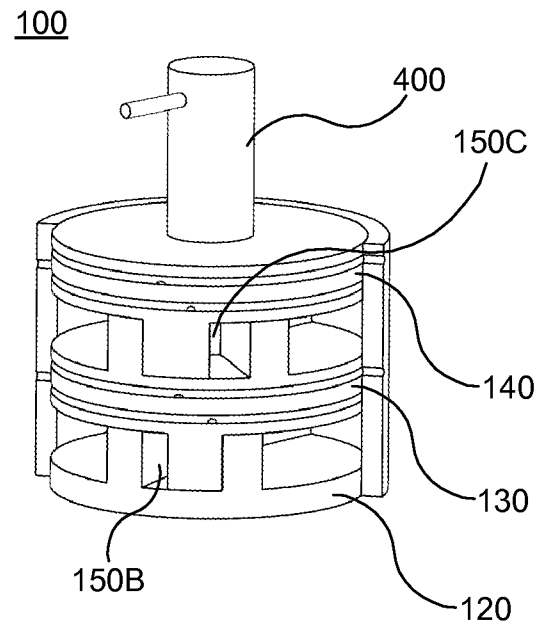


FIG. 4b

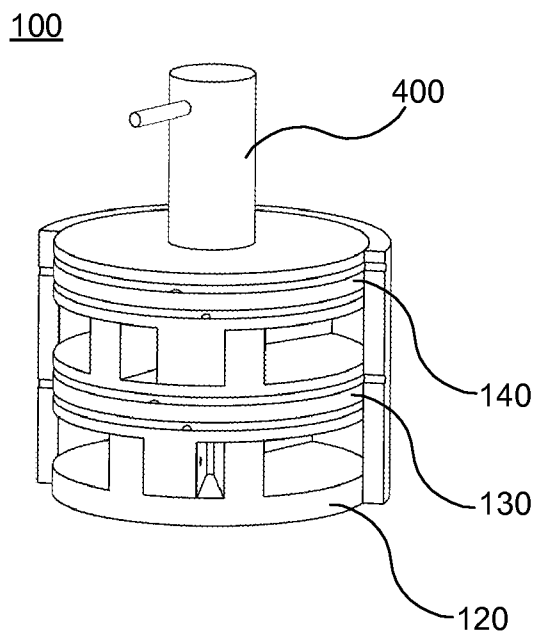


FIG. 4c

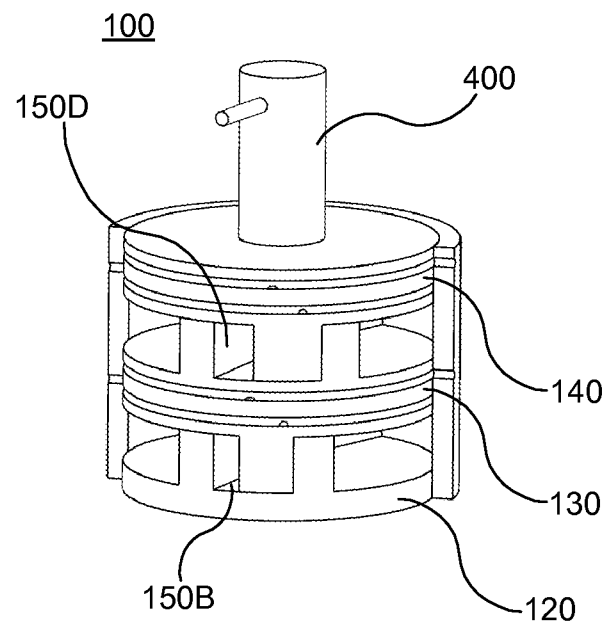


FIG. 4d

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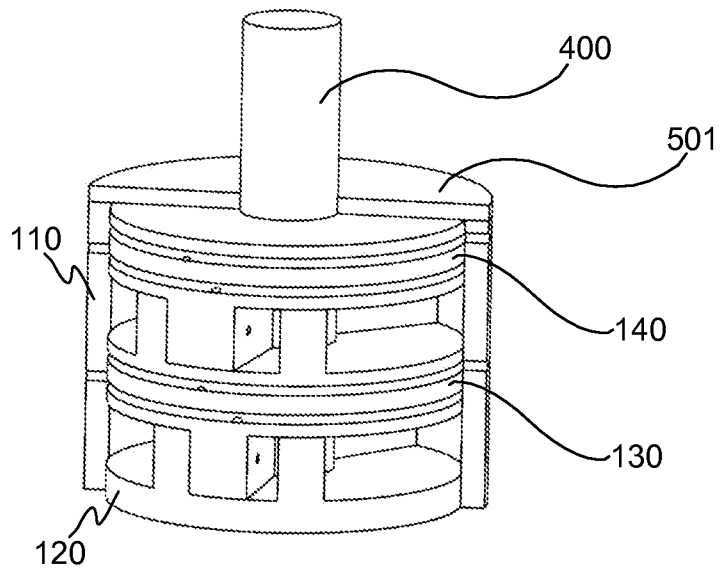


FIG. 5

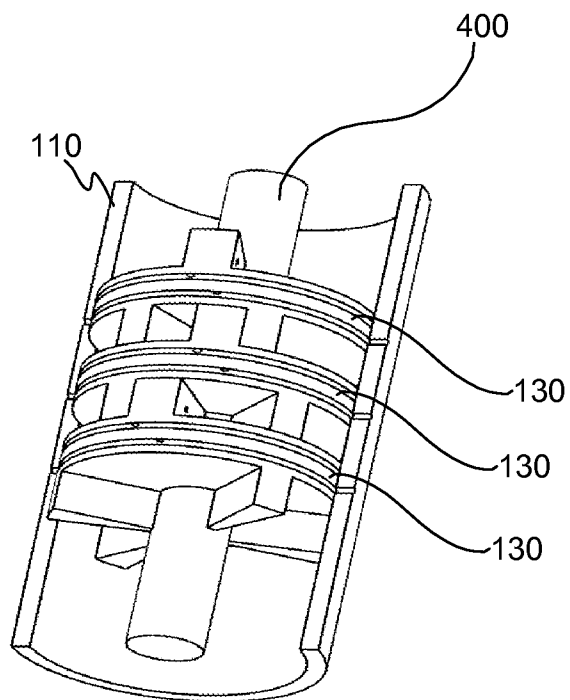


FIG. 6

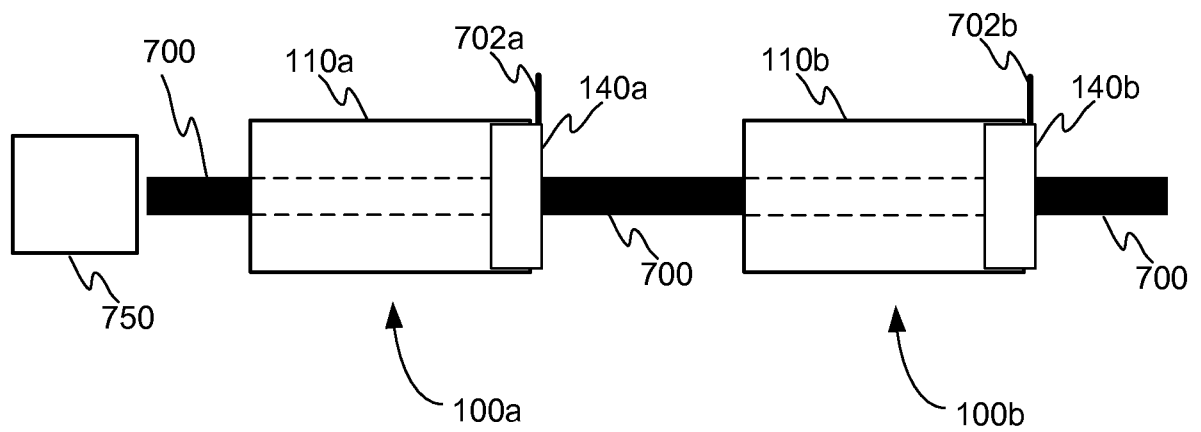


FIG. 7a

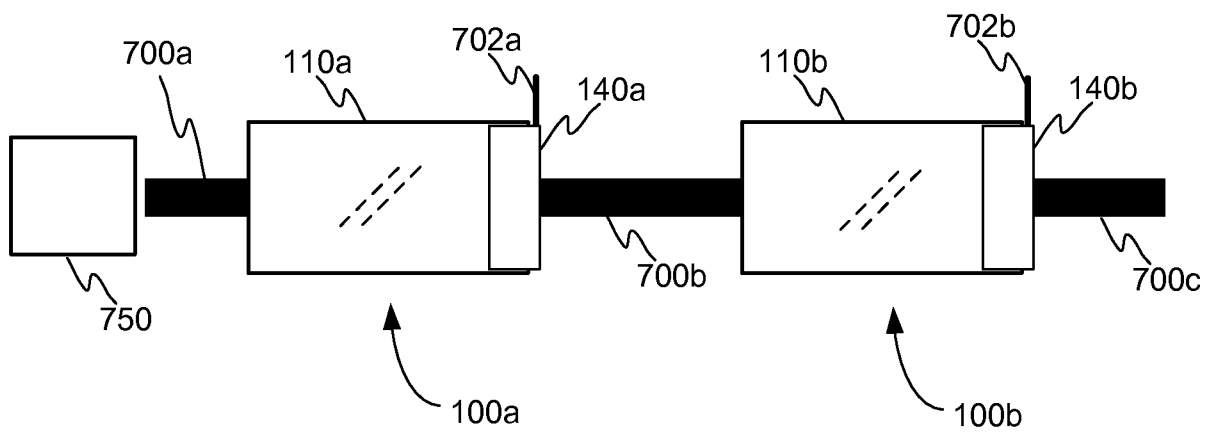


FIG. 7b

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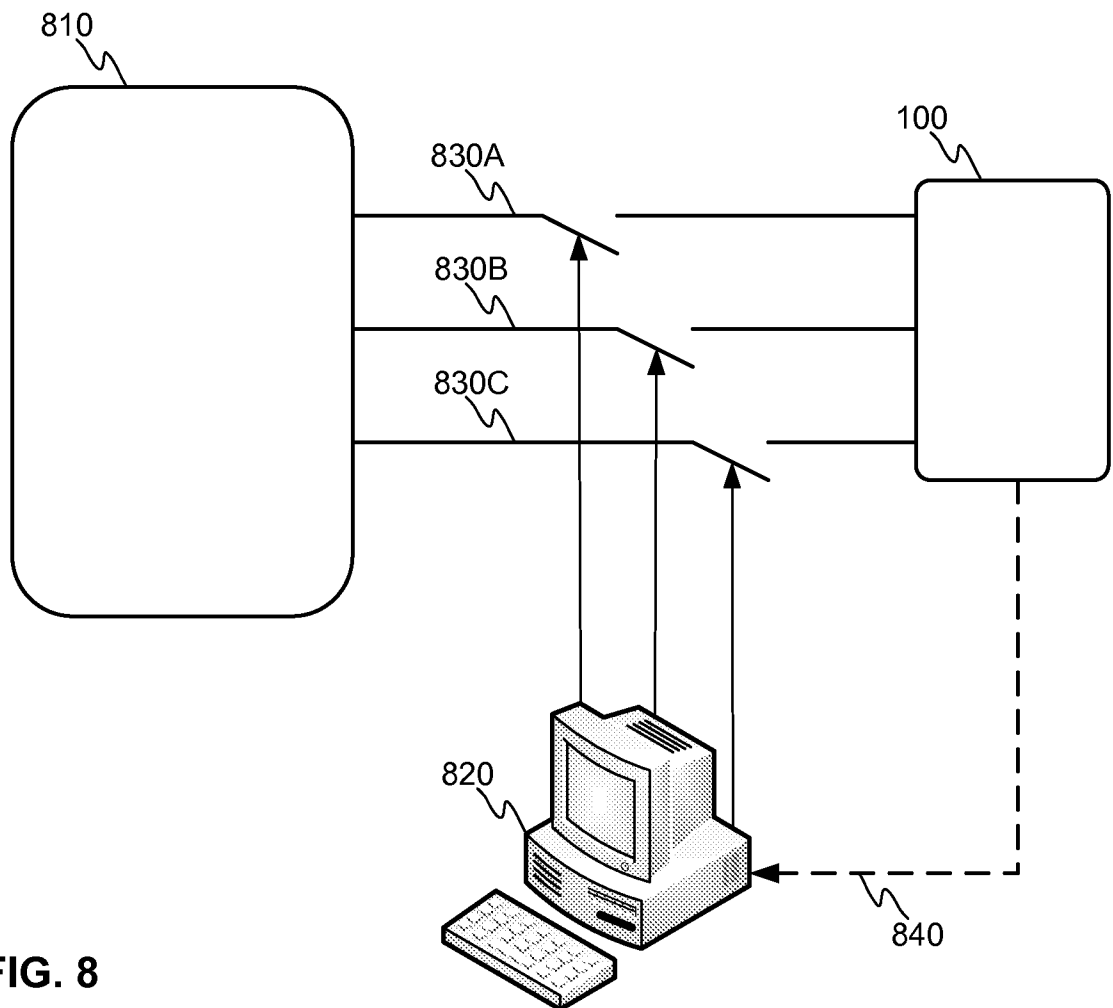


FIG. 8

INTERNATIONAL SEARCH REPORT

International application No

PCT/FI2013/051081

A. CLASSIFICATION OF SUBJECT MATTER

INV. F15B15/12

ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F15B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EP0-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 203 162 A1 (RAIKAMO ESKO [FI]) 8 May 2002 (2002-05-08) paragraphs [0023] - [0032] -----	1-15
X	US 2 911 956 A (SMITH JR JOSEPH EARL) 10 November 1959 (1959-11-10) column 3, lines 23-74 -----	1-3,6,7, 10-13,15
X	JP S48 66552 U (UNKNOWN) 23 August 1973 (1973-08-23) figures 1-2 -----	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search

6 February 2014

Date of mailing of the international search report

12/02/2014

Name and mailing address of the ISA/

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Authorized officer

Toffolo, Olivier

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/FI2013/051081

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