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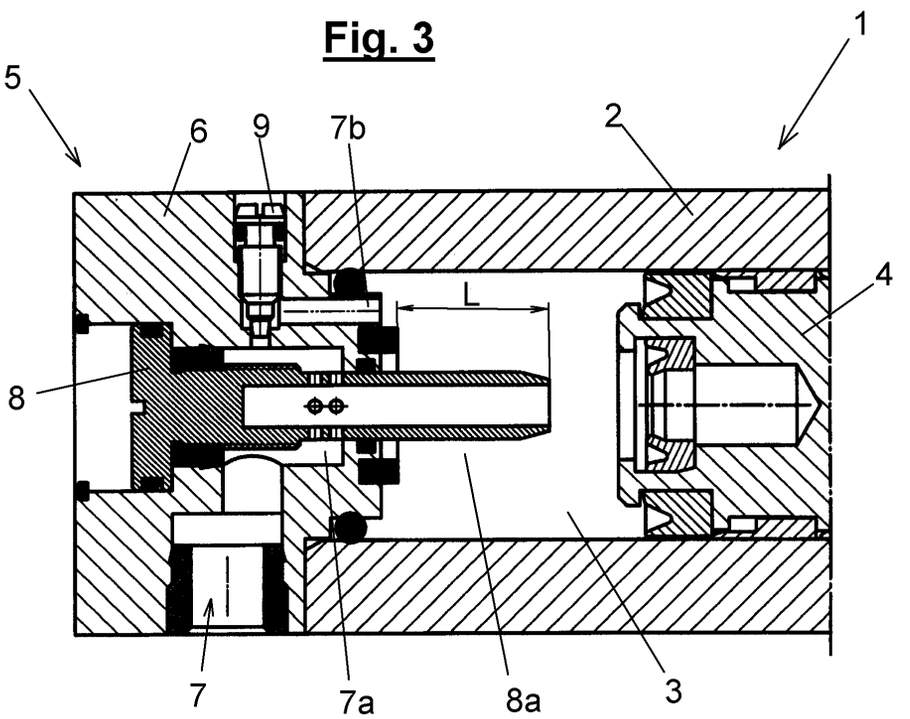
(54) Cushioning device

(57) The object of the present invention relates to a fluid cylinder (1) with end cushioning means comprising: a cylinder tube (2) having an internal space (3) in which a fluid and an axially moveable piston (4) are arranged in, and at least one end cap arrangement (5), whereby the end cap arrangement (5) comprises an end cap body (6) having an internal channel system (7), at least one fluid flow regulating member (9), and at least one cushioning member (8) cooperating with said piston (4) and fluidically connecting said internal space (3) and said internal channel system (7), having an cushioning area (8a) defining a cushioning length (L) for end cushioning said piston (4) in or near its stop position, whereby the cushioning member (8) of the end cap arrangement (5) is axially moveably arranged with regard to said piston (4), whereby said cushioning member (8) comprises at least one fixing means for fixing said cushioning member (8) in at least two different positions for realizing an adjustable cushioning length (L).

Fig. 3



EP 1 574 722 A2

Description

[0001] The present invention relates to a fluid cylinder with at least one end cushioning means comprising: a cylinder tube having an internal space in which a fluid and an axially moveable piston are arranged in, and at least one end cap arrangement for closing said internal space, whereby the end cap arrangement comprises an end cap body having an internal channel system through which said fluid can pass the fluid cylinder and the end cap arrangement respectively to the atmosphere, at least one fluid flow regulating member for regulating said fluid flowing through said internal channel system, at least one sealing member for sealing purposes between said end cap arrangement and adjacent cylinder components with regard to the fluid, and at least one cushioning member arranged in said end cap body facing and cooperating with at least an end area of said piston and fluidically connecting said internal space and said internal channel system, having at least a cushioning area defining a cushioning length (L) for end cushioning said piston in or near its stop position.

[0002] Fluid cylinders with end cushioning means are usually used in a wide area of automation applications, where the movement of a piston when arriving at its end position has to be cushioned before colliding with a surrounding cylinder or cylinder wall. Cushioning could be achieved inter alia by a fluid, often in combination with a cushioning or bossing element or by elastic bodies made of an elastic material. In the present invention cushioning will be achieved mainly by a fluid, especially by a compressible fluid.

[0003] In fluid or fluid pressure cylinders and particularly cylinders for compressible fluid like air it is often necessary to have the possibility of controlling the piston speed especially when the piston arrives at its end position, where in case of an end cushioning of the piston, the speed of the piston has to be zero. Likewise it is desired to slow down and cushion the movement of a piston and associated parts in the piston stroke ends to avoid stress on the equipment that it would be exposed to otherwise without cushioning. A completely uncushioned piston is capable of striking onto the cylinder end wall or the cylinder end cap arrangement with great mass energy forces as a result, while all the kinetic energy is cushioned by the throttling in an ideal cushioning process, so that the velocity of the piston falls down to zero when the piston reaches the cylinder end wall or end cap arrangement.

[0004] For the understanding of the complexity of the cushioning process it is pointed out that it depends on several parameters such as kinetic energy, impelling force, friction, dead volume, cushioning length, throttle area etc. To achieve an acceptable cushioning these parameters must be balanced to each other.

[0005] In US 5,307,729 a device for stroke end cushioning and speed regulating the movement of a piston in a fluid pressure cylinder is shown. This well known device for stroke end cushioning and speed regulating the movement of a piston in a fluid pressure cylinder has a common adjusting or fluid flow regulating member that is arranged for simultaneous setting of the throttle means for regulating the stroke end cushioning as well as the piston speed, for the purpose of avoiding very time consuming adjustment. In connection with the setting of the adjusting means the ratio between the flow areas of the respective throttle means is held within the range of 10%-60%. In most uncomplicated embodiment the common adjusting means may be comprised by a screw being fixed to the valve bodies of the respective throttle means.

[0006] This well known device for stroke end cushioning and speed regulating the movement of a piston in a fluid pressure cylinder has the drawback, that an ideal cushioning with a piston velocity zero at the end of the stroke and no rebound can only be achieved for one certain and small area of kinetic energy. No other adjustment is possible, for example of other parameters, so that potential areas for an optimised cushioning cannot be used.

[0007] Therefore it is an object of the present invention to provide a fluid cylinder with end cushioning means, which has an improved cushioning function with at least two means for adjusting different velocities and different levels of kinetic energy, so that at least two of the above mentioned relevant parameters, namely throttle area and cushioning length, are adjustable for achieving more or larger areas of ideal cushioning.

[0008] This issue is addressed by a fluid cylinder according to the preamble of claim 1 in conjunction with the features of the characterizing portion.

[0009] To achieve the forgoing and other objectives of the present invention the technical teachings include, that the cushioning member of the end cap arrangement is axially moveably arranged with regard to said piston, whereby said cushioning member comprises fixing means for fixing said cushioning member in at least two different positions for realizing an adjustable cushioning length.

[0010] The fluid cylinder with end cushioning means comprises: a cylinder tube having an internal space in which a fluid and an axially moveable piston are arranged in, and at least one end cap arrangement for closing said internal space, whereby the end cap arrangement comprises an end cap body having an internal channel system through which said fluid can pass the cylinder to the atmosphere, at least one fluid flow regulating member for regulating said fluid flowing through said internal channel system, at least one sealing member for sealing purposes between said end cap arrangement and adjacent cylinder components with regard to the fluid, and at least one cushioning member arranged in said end cap body facing and cooperating with at least an end area of said piston and fluidically connecting said internal space and said internal channel system, having at least an cushioning area defining a

cushioning length for end cushioning said piston in or near its stop position.

[0011] The fluid cylinder can be any fluid cylinder that operates with a compressible fluid preferably such as pneumatic cylinders. Such pneumatic cylinders include especially so-called shuttle cylinders. During compression, the fluid or the compressed fluid has to be guided to the atmosphere after or while compression. This happens by an internal channel system, which fluidically connects the internal space and the atmosphere. To regulate and/or control the flow of the fluid in or through the internal channel system, at least one fluid flow regulating member is arranged, for example by reducing the cross-sectional area of the channel(s) of said internal channel system, so that the fluid flow regulating member functions as a throttle.

[0012] Therefore the internal channel system is also known as throttled channel system. Other fluid flow regulating members could be any kind of valve, controlling the flow of said fluid.

[0013] To ensure that the fluid only passes through said internal channel system, at least one sealing member, preferably several sealing members are used. Such sealing members could be arranged at any position between at least two components of the fluid cylinder, where an unwanted fluid flow can happen, for example at the radial outer area of the piston between piston and cylinder tube or at the radial outer area of the cushioning member between cushioning member and end cap body.

The functioning of said fluid cylinder is described in the following:

[0014] As the piston moves to one end cap arrangement the working fluid is compressed and forced through all channels of the internal channel system facing and fluidically connected to the internal space. When approaching or approximating to the cushioning member the piston closes more and more the channel guiding through said cushioning member such, that when the end area of said piston cooperating with said cushioning member engages with said cushioning member this channel is fluidically closed. The fluid now is forced through said bypass channel which is throttled or regulated by said fluid flow regulating member and thus regulates the cushioning of said piston until the piston speed is zero and the piston has reached its end position. By adjusting said cushioning member and thus the cushioning length the cushioning of that piston can further be adjusted.

[0015] For limiting the movement of the piston, the fluid cylinder includes a bossing or cushioning element or member, which cooperates with the piston or more precisely with an end area of said piston. The cushioning member has an end cushioning area that defines a cushioning length. By the cushioning length the cushioning of the piston is controlled or adjusted. For achieving a smooth cushioning of the piston inter alia the cushioning length has to be adjusted according to the present situation especially shape, velocity, and/or mass of the piston.

[0016] Therefore it is an advantage, that the cushioning member is axially moveable, so that different cushioning lengths can be adjusted with regard to the piston. For example if a long cushioning length is required, the cushioning member can be adjusted such, that a longer cushioning length results. As well a shorter cushioning length can be realized. The cushioning length could be adjusted such, that between a minimum position having a short cushioning length and a maximum position having a long cushioning length, all positions in between can be realized. For adjusting and fixing any position between minimum position and maximum position including minimum and maximum position, fixing means are provided. Fixing means could be any means that is suitable to fix the cushioning member in any position in the adjusting range.

[0017] The cushioning length in the sense of the invention is defined as follows. As the cushioning member is axially moveably relatively to said end cap body, which represents a barrier and/or a bossing element for the piston the cushioning area has to be viewed in conjunction with said end cap body. The cushioning member has a cushioning area having certain geometry or shape with at least one dimension directed in axially direction to said piston, whereby along said dimension the cushioning length is defined. Depending on said geometry there are three basic positions the cushioning member can have in relation to said end cap body in the axial direction.

[0018] First the cushioning member, more precisely the surface of the cushioning member facing the internal space and cooperating with said end area of said piston can be flushed with said end cap body or more precisely the surface of said end cap body facing the internal space. The piston has its end position at the flushing surfaces of cushioning member and end cap body. In this case the cushioning length is zero.

[0019] Second the cushioning member can protrude from said end cap body. Thus the piston or the end area of said piston cooperating with said cushioning member stops depending on said protruding part. The difference in length, that is in axial direction, between the surfaces of the protruding part cooperating with said piston and the end cap body is the cushioning length. Third the cushioning member can stand back from said end cap body surface. In this case the cushioning length again is defined by the difference in length between the surface of the cushioning member cooperating with the piston and facing the internal space and the surface of the end cap body facing the internal space.

[0020] The cushioning member itself can have different shapes with different formed cushioning areas defming the cushioning length presumed the cushioning area corresponds to the accordant piston end area for

cooperating purposes.

[0021] Therefore preferably said cushioning area has a portion formed as a recess and the end area of the piston has a protruding portion, whereby the protruding portion and the recess are corresponding to each other. For example the recess can be formed like a sleeve into which the piston or the end area of said piston, which in this case preferably is arranged with a protruding part, can engage. Analogue the end area of the piston can be formed as a sleeve and the cushioning area of the cushioning member can be formed with a protruding portion. Essentially is, that said end area of said piston and said cushioning area of said cushioning member cooperates, whereby both areas engage. This engaging has to be such that no or nearly no fluid can exhaust from this cooperating combination. To ensure this, the cushioning member comprises at least one sealing member preferably more sealing members located between the piston or at least a part of the piston and the cushioning member or at least a part of the cushioning member. The cushioning length is defined by the recess, more precisely by the depth or the length of the recess in relation to the end cap body as mentioned before. The cross-sectional area of the recess could have any shape including a circular, an oval, or a rectangular shape. The cross-sectional area of the protruding portion has to have a correspondent cross-section area to that of the recess, being slightly smaller than that cross-sectional area of the recess, so that the protruding portion can engage in said recess.

[0022] It is also preferred, that said cushioning area has a protruding portion and the end area of the piston has a portion formed as a recess, whereby the protruding portion and the recess are cooperating to each other. In this case, the protruding portion of the cushioning element or member engages in the recess of the piston or the piston end area, as analogously described before.

[0023] Of course any other form of a cushioning element - piston combination is possible. So there could be more than one protruding portion or recess respectively. Even a combination of one recess or more recesses and protruding portion(s) on either the piston and/or the cushioning member respectively can be provided.

[0024] For realizing the above-mentioned cushioning function it is an advantage, that the cushioning member is located in an internal channel system section adjacent to the internal space of said cylinder. So the cushioning member serves on the one hand as bossing element and on the other hand as element for regulating the fluid flow from the internal space to the internal channel system. Preferably the section of the internal channel system in which the cushioning member is arranged in, is centrically with regard to the fluid cylinder.

[0025] Preferably the internal channel system section adjacent to the internal space is at least partly formed as a threaded hole and the cushioning member is at least partly formed with a thread for cooperating with said threaded hole for realizing a screw-like connection between cushioning member and end cap body. By this way an easy to handle connection between cushioning member and end cap body can be realized.

[0026] One further advantage of the invention is that the fixing means comprise a self-locking thread-threaded hole combination for fixing said cushioning member in at least two different positions relatively to said end cap body. By this arrangement the fixing means is integrated in said end cap body, so that no extra or separate fixing means is required. This embodiment saves volume and is easy to produce and/or handle, such that an easy adjustment of the cushioning member and thus the cushioning length can be achieved.

[0027] To regulate the flow of said fluid it is preferred, that said fluid flow regulating member is formed screw-like and axially moveable arranged to said end cap body for opening and closing said internal channel system by protruding inside at least a section of the internal channel system for functioning as a restrictor or throttle. By this separate fluid flow regulating member an additional adjustment for optimizing end cushioning of the piston is achieved.

[0028] It is further preferred, that said internal channel system has at least one first channel guiding from the internal space through said cushioning member passing a channel section regulated by said fluid flow regulating member ending at an outside of the end cap body disemboguing to the environment or atmosphere. By this first channel the compressed fluid can pass the cushioning member and the internal channel system for exhausting to the atmosphere, such that an optimized cushioning can be achieved.

[0029] For avoiding the danger of blocking and for adjustments it is further preferred, that said internal channel system has at least one second channel guiding from the internal space through said end cap body to the channel section regulated by said fluid flow regulating member for realizing a bypass channel with regard to the first channel. This second channel also serves for regulating the cushioning function, because a more precisely adjustment of the fluid flow through a larger channel volume formed by the first and the second channel in sum is possible, so that in a shorter time period the fluid can exhaust, ensuring a smooth cushioning.

[0030] Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention. The invention will now be described at the background of embodiments and with reference to the drawings, wherein

fig. 1 shows a longitudinal cross-sectional view through a shuttle cylinder having two end cap arrangements according to the present invention,

fig. 2 shows a longitudinal cross-sectional view in de-

tail of an end cap arrangement (for simpleness reasons, the port and throttle screw are shown in the same view)

fig. 3 shows a section of another embodiment of a piston and an end cap arrangement according to the present invention, and

fig. 4 shows a schematic diagram of the pistons velocity with regard to the internal fluid pressure showing the advantage of the present invention compared to the prior art.

[0031] Fig. 1 shows a longitudinal cross-section of a fluid cylinder 1 according to the present invention. The fluid cylinder 1 comprises a cylinder tube 2 surrounding an internal space 3 in which a fluid (not shown) and an axially moveable piston 4 are arranged. The fluid cylinder 1 is a double action fluid cylinder 1. The piston 4 therefore has to end areas, which in the present fig. 1 are symmetrically formed. The fluid cylinder 1 or more precisely the internal space 3 is closed on each side by two similar formed end cap arrangement 5. This end cap arrangement 5 is shown in detail in fig. 2.

[0032] When the piston 4 or one of the pistons 4 moves to its adjacent side of the fluid cylinder 1, the exhaust working fluid will pass through a part of the internal channel system being regulated by a fluid flow regulating member (shown in fig. 2) and thereafter leave the end cap arrangement 5 through an outlet. By the fluid flow regulating member the possibility of adjusting the piston speed when the piston is moving to its adjacent side is provided.

[0033] Fig. 2 shows a longitudinal cross-section of one end cap arrangement 5 of fig. 1. The end cap arrangement 5 comprises an end cap body 6. In this end cap body 6 several channels are drawn to form an internal channel system 7. In a centrically arranged first channel 7a, adjusted in line with the centerline or axis of the piston (chain line), a cushioning member 8 with a cushioning area 8a is arranged. The cushioning area 8a is formed as a recess, facing with its opening the internal space 3. This cushioning member 8 comprises a channel, which is fluidically connected to the recess and thus to internal space 3 and the internal channel system 7. So the channel of cushioning member 8 forms a section of a first channel 7a, which guides the fluid to the atmosphere via a throttled channel junction, in which the first channel 7a and a second channel 7b - a so called bypass channel - disembogues. The second channel 7b fluidically connects the internal space 3 and the first channel 7a in said channel junction. Via the throttled channel junction, which is regulated by a fluid flow regulating member 9, here screw-like attached to the end cap body 2, the fluid is guided to an outlet. The outlet guides the fluid to the atmosphere. The cushioning member 8 is formed as a screw with a thread. The part of the first channel 7a, which is in contact with the cushioning member 8 has at least partly a thread corresponding to the thread of the cushioning member 8, so that cushioning member 8 and first channel 7a form a thread - threaded hole combination. Thus by rotating the cushioning member 8, the cushioning member 8 and so the cushioning area 8a can be axially moved relatively to the end cap body 2 and/or the piston (not shown). The cushioning area 8a defines a cushioning length (shown in fig. 3), which is the length or depth of said recess in relation to the end cap body (6). By rotating the cushioning member 8, the cushioning length can be varied and thus adjusted with regard to the corresponding piston (not shown) and the end cap body 2. The end cap arrangement 5 further comprises sealing means 10 for realizing a sealing between the end cap arrangement 5 and the adjacent fluid cylinder components, so that the fluid is directed exclusively from the internal space 3 through the internal channel system 7. Another embodiment of a piston - end cap arrangement combination is shown in fig. 3.

[0034] In fig. 3 a cross-sectional view of another embodiment of an end cap arrangement 5 with a section of a fluid cylinder 1 including a cylinder tube 2 and a piston 4 is shown. The end cap arrangement 5 is similarly build up to the end cap arrangement in fig. 2. The end cap arrangement 5 according to fig. 3 comprises an end cap body 6 in which an internal channel system 7 is drawn. The internal channel system 7 comprises a first channel 7a, which is fluidically connected to the internal space 3 and a second channel 7b, connected to the internal space 3 via a channel junction, which is regulated by a srew-like fluid flow regulating member 9. The cushioning member 8 is screw-like connected to the end cap body 6. Cushioning member 8 comprises a cushioning area 8a. This cushioning area 8a has a protruding portion cooperating with the piston 4. The protruding portion in relation to the end cap body 6 defines a cushioning length L, namely the length of the protruding portion. The cushioning member 8 further comprises a channel reaching mainly in longitudinal direction through the protruding portion, being a section of said first channel 7a. Thus the first channel 7a is fluidically connected to the internal space 3 via the channel section guided through the protruding portion of the cushioning area 8a. The piston 4 or more precisely the end part of the piston 4 is formed to cooperate with the protruding portion of cushioning element 8 that is the end part of the piston 4 is shaped as a recess. The cross-sections of the protruding portion and the recess are corresponding to each other, such that the protruding portion can engage into said recess, here both formed with a circular cross-section. The advantages of such a construction are shown in the diagram of fig. 4.

[0035] Fig. 4 shows a schematic diagram of the velocity of the piston with regard to the pressure showing the advantage of the present invention compared to the prior art. In this diagram there are several areas marked. The first area A is an area, which could not be realized

due to the fact, that the cushioning length is always too short. Area B - the second area - shows an area for which ideal cushioning is possible according to the prior art. This area is shaped like a diagonal band. In this area or band the kinetic energy is substantially constant. Areas C - the third and fourth area - shows the areas, in which according to the prior art no ideal cushioning could be achieved. Either there is a rebound or an impact. Reason for that is that the cushioning length is too long. Again these areas are shaped as a diagonal band. The advantage of the present invention is that due to varying the cushioning length areas C could be realized.

List of reference numbers

[0036]

1	fluid cylinder
2	cylinder tube
3	internal space
4	piston
5	end cap arrangement
6	end cap body
7	internal channel system
7 a	first channel
7 b	second channel (bypass channel)
8	cushioning member
8 a	cushioning area
9	fluid flow regulating member
10	sealing means

A	first area
B	second area
C	third area
L	cushioning length

Claims

1. Fluid cylinder (1) with at least one end cushioning means comprising:

a cylinder tube (2) having an internal space (3) in which a fluid and an axially moveable piston (4) are arranged in, and
at least one end cap arrangement (5) for closing said internal space (3), whereby the end cap arrangement (5) comprises
an end cap body (6) having an internal channel system (7) through which said fluid can pass the fluid cylinder (1) to the atmosphere,
at least one fluid flow regulating member (9) for regulating said fluid flowing through said internal channel system (7),
at least one sealing member (10) for sealing purposes between said end cap arrangement (5) and adjacent cylinder components with regard to the fluid, and
at least one cushioning member (8) arranged in said end cap arrangement (5) facing and cooperating with at least an end area of said piston (4) and fluidically connecting said internal space (3) and said internal channel system (7), having at least an cushioning area (8a) defining a cushioning length (L) for end cushioning said piston (4) in or near its stop position, **characterized in,**

that the cushioning member (8) of the end cap arrangement (5) is axially moveably arranged with regard to said piston (4), whereby said cushioning member (8) comprises fixing means for fixing said cushioning member (8) in at least two different positions for realizing an adjustable cushioning length (L).

2. Fluid cylinder (1) according to claim 1, **characterized in,**
that said cushioning area (8a) has a portion formed as a recess and the end area of the piston (4) has a protruding portion, whereby the protruding portion and the recess are corresponding to each other (Fig. 1).

3. Fluid cylinder (1) according to claim 1, **characterized in,**
that said cushioning area (8a) has a protruding portion and the end area of the piston (4) has a portion formed as a recess, whereby the protruding portion and the recess are cooperating to each other (Fig. 3).

4. Fluid cylinder (1) according to one of the prior claims 1 to 3, **characterized in,**
that the cushioning member (8) is located in an internal channel system area adjacent to the internal space (3) of said fluid cylinder (1).

5. Fluid cylinder (1) according to claims 1 or 4, **characterized in,**
that the internal channel system area adjacent to the internal space (3) is at least partly formed as a threaded hole.

6. Fluid cylinder (1) according to claims 1 to 5, **characterized in,**
that the cushioning member (8) is at least partly formed with a thread for cooperating with said threaded hole for realizing a screw-like connection between cushioning member (8) and end cap body (6).

7. Fluid cylinder (1) according to claims 1, 4 or 5, **characterized in,**
that the at least one fixing means comprises a self-locking thread-threaded hole combination for fixing

said cushioning member (8) in at least two different positions relatively to said end cap body (6).

8. Fluid cylinder (1) according to claim 1, **characterized in,**
that said fluid flow regulating member (9) is formed screw-like and axially moveable arranged to said end cap body (6) for opening and closing said internal channel system (7) by protruding into the internal channel system (7) for functioning as a restrictor or throttle.

9. Fluid cylinder (1) according to claim 1 or 8, **characterized in,**
that said internal channel system (7) has at least one first channel (7a) guiding from the internal space (3) through said cushioning member (8) passing a channel section regulated by said fluid flow regulating member (9) ending at an outside of the end cap body (6) disemboguing to the atmosphere.

10. Fluid cylinder (1) according to claim 1, 8 or 9, **characterized in,**
that said internal channel system (7) has at least one second channel (7b) guiding from the internal space (3) through said end cap body (6) to the channel section regulated by said fluid flow regulating member (9) for realizing a bypass channel (7b) with regard to the first channel (7a).

Fig. 1

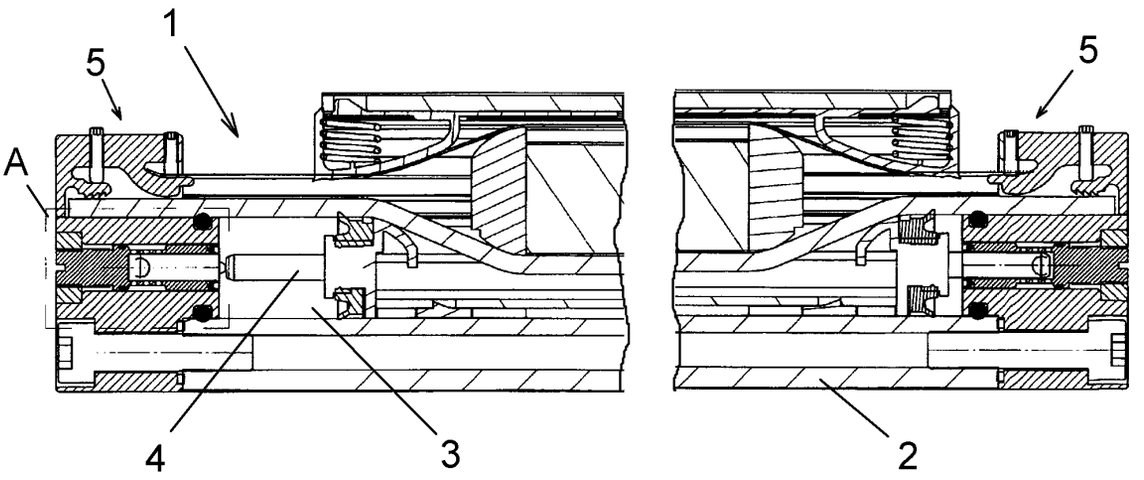


Fig. 2

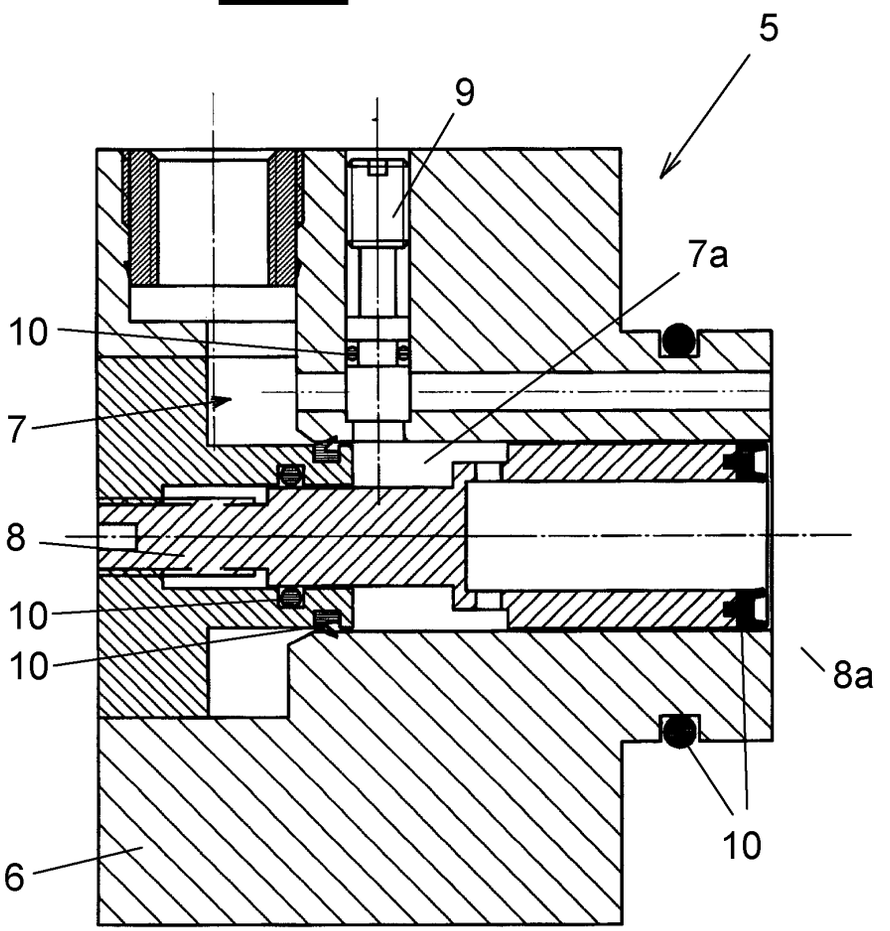
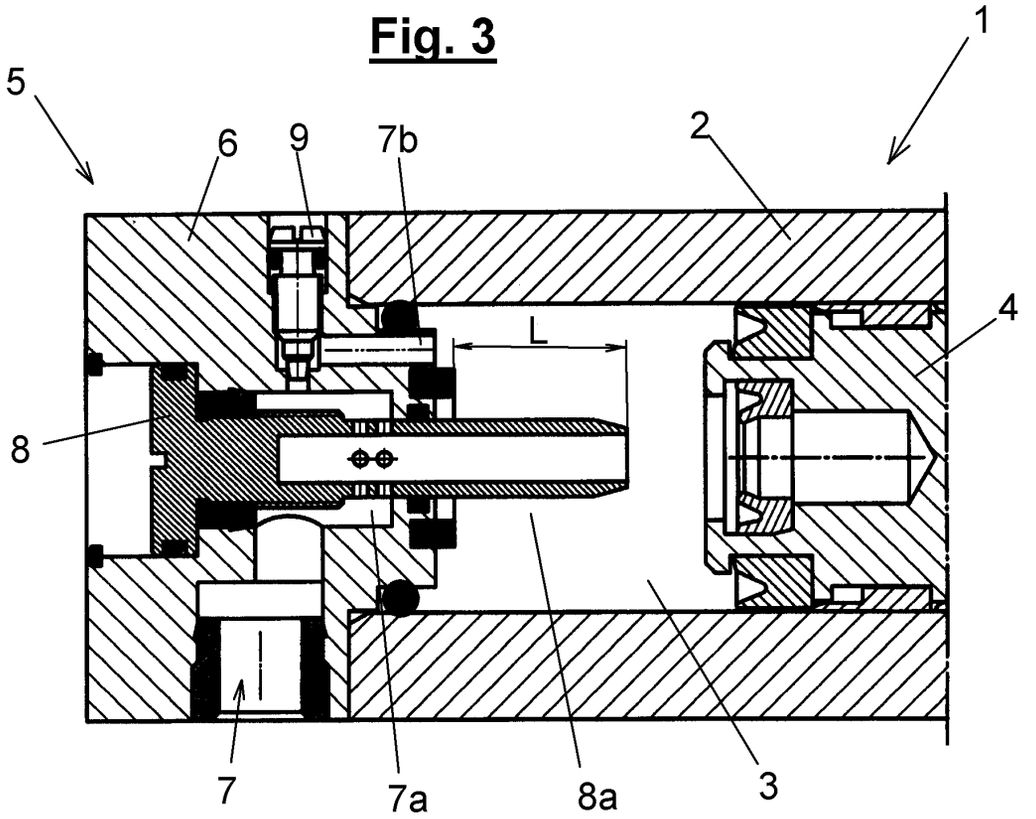


Fig. 3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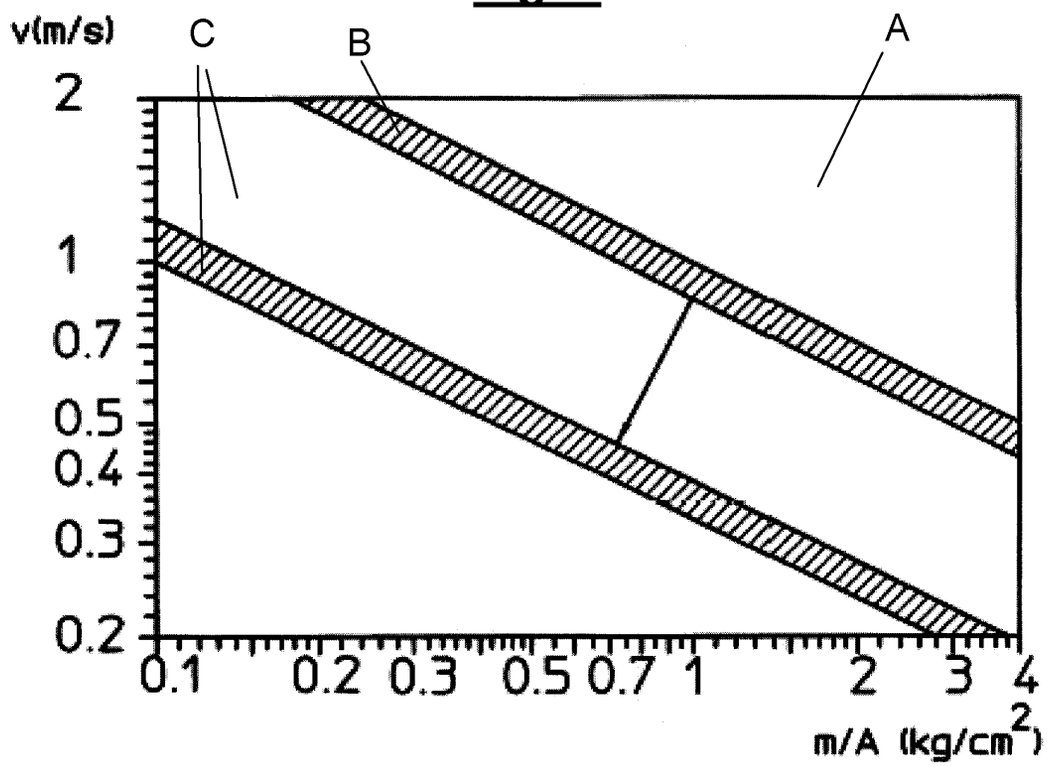
3

Fig. 4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