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(54) Title: A DIRECTIONAL CONTROL VALVE FOR FLUID POWER SYSTEM

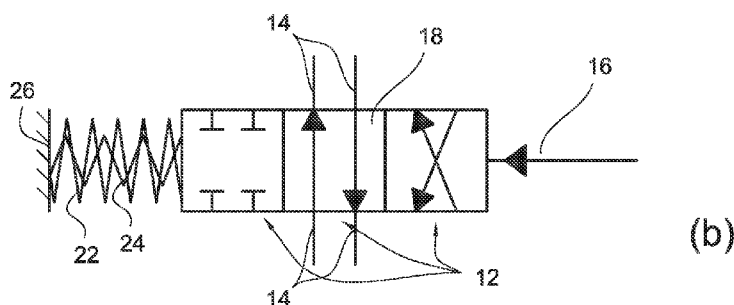


Fig. 1

(57) Abstract: Invention relates to a directional control valve (10) for fluid power system, comprising at least three operational positions (12) and in which a flow directing element arranged operable by control fluid so that applying of pressure of the control fluid (16) to the flow directing element causes the flow directing element to change its position, and spring unit (20) applying force to the flow directing element so that the force opposes the change of position. The spring unit (20) comprises a spring system (22, 24) which provides a discontinuously increasing change of the spring force exerted by the spring unit (20).

A directional control valve for fluid power system

5 Technical field

[001] The present invention relates to a directional control valve for fluid power system, comprising at least three operational positions and in which a flow directing element arranged operable by control fluid so that applying of pressure of the control fluid to the flow directing element causes the flow directing element to change its position, and spring unit applying force to the flow directing element so that the force opposes the change of position.

Background art

[002] Fluid power systems are commonly used for actuating various mechanical components in stationary and movable appliances, such as industrial machinery. In hydraulic system a force that is created at one location is transmitted to other location by a fluid. The fluid is advantageously substantially incompressible, however also air is used in some applications. As incompressible fluid oil is typically used but also other incompressible liquids may be utilized.

[003] Valves are generally used for control the flow of the fluid in a fluid power system. One of the most fundamental components of any fluid power system is the directional control valve. Such a valve may be referred to as discrete valve. This term refers to how the valves operate: they shift from one discrete position to another, such as extend, retract, and neutral. Discrete valves generally use a spool to achieve two, three, or more positions. Just for sake of clarity, proportional valves, which are also commonly used, on the other hand control direction and flow speed. In addition to shifting into discrete positions, proportional valves can shift into intermediate positions to control actuator direction, speed, acceleration, and deceleration.

[004] The two primary characteristics of a directional control valve are the number of fluid ports and the number of directional states, or operational positions, the valve can achieve. Valve ports provide a passageway for hydraulic fluid to flow to or from other components of the system through the directional control valve. The number of operational positions refers to the number of distinct flow paths a valve can provide.

[005] One of the valve ports typically may receive pressurized fluid from a pump, and one may route fluid back to the reservoir. The other ports are generally referred to as work ports and route fluid to or from an actuator. Naturally valves may be used for generally providing different flow paths for the fluid in a fluid power system.

[006] Spool-type valves are widely used because they use a flow directing element which can be shifted to two, three, or more positions for routing fluid between different combinations of flow paths. They are used extensively for directional control because a single valve can produce e.g. extension, retraction, and neutral of an actuator.

[007] Valve operators are the parts that apply force to shift the flow directing elements, such as spools, poppets, or plungers. Operators for directional-control valves may be either mechanical, hydraulic, electronic, or a combination of these. With a mechanical operator, a machine element or person applies force on the valve's flow-directing element to move or shift it to another position. However, mechanical operation is not always possible or desired to use.

[008] Springs are used in most directional valves to hold the flow directing element in a neutral position. In 2-position valves, for example, springs hold the non-actuated valve in one position until an actuating force great enough to compress the spring shifts the valve. When the actuating force is removed, the spring returns the valve to its original rest position. In 3-position valves, two opposite springs may hold the non-actuated valve in its center position until an actuating force shifts it. When the actuating force is removed, the springs re-center the valve spool.

[009] For example publications EP2378135 A1 and US 7946358 B2 disclose a sequence valve in which spring is used in positioning a flow direction element.

[0010] Hydraulically actuated valves are shifted by pressurized fluid that applies force to a piston that shifts the valve's flow-directing elements. An important advantage of hydraulic operation is that large shifting forces can be developed without the impact and wear that affects mechanically actuated valves. Hydraulic-operated valves can be mounted in any convenient or remote location to which actuating fluid can be conveyed e.g. through piping.

[0011] Hydraulically actuated valves with a spring has a shortcoming relating to controlling the position of the flow directing element. In order to set the flow directing element to correct position in the valve the hydraulic fluid pressure must be controlled very accurately, which requires sophisticated equipment to control the fluid pressure.

[0012] It is an object of the invention to provide a directional control valve hydraulic-actuated valve with a spring unit which provides simple and reliable construction and easily controllable operation.

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Disclosure of the Invention

[0013] The objects of the invention are met by a directional control valve for fluid power system, comprising a flow directing element and ports providing passageways for the fluid to the flow directing element, in which the flow directing element comprises at least three operational positions and a spring unit applying force to the flow directing element so that the force opposes the change of the position of the flow directing element. It is characteristic to the invention that the valve is provided with at least one control port and that the flow directing element is arranged operable by control fluid so that applying of pressure of the control fluid to the flow directing element causes the flow directing element to change its position, and the spring unit comprises a spring system which provides a discontinuously increasing change of the spring force exerted by the spring unit.

[0014] The directional control valve according to the invention comprises a number of fluid ports are intended to serve as connection to the fluid power system. The fluid ports are also in connection with the flow directing element. The direc-

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tional control valve is arranged to have a number of directional states, or operational positions, the valve can achieve. Valve ports provide passageways for hydraulic fluid to flow to or from other components of the system through the directional control valve depending on the operational positions of the valve. The number of operational positions refers to the number of distinct flow paths a valve can provide.

[0015] One of the valve ports typically may receive pressurized fluid e.g. from a pump, and one may route fluid back to the reservoir of the fluid. The other ports are arranged for routing fluid to or from an actuator or alike. Naturally valves may be used for generally providing different flow paths for the fluid in a fluid power system. These ports are here referred to as work ports. The flow directing element being arranged operable by control fluid it is provided with at least one control port via which the applying of pressure of the control fluid to the flow directing element may be accomplished.

[0016] According to an embodiment of the invention the change of spring force is arranged to commence after a first shifted position of the flow directing element in the control valve.

[0017] According to an embodiment of the invention the spring system comprises at least two parallel springs.

[0018] According to an embodiment of the invention the first spring is arranged to apply force to the flow directing element at its each position in the control valve, and the second spring is arranged to initiate to apply force to the flow directing element commencing after a first shifted position of the flow directing element.

[0019] According to an embodiment of the invention the first shifted position of the flow directing element is arranged to be at a position where the flow directing element is at its second operational position.

[0020] According to an embodiment of the invention the second spring is arranged to apply force at compressed state to the flow directing element at a position where the flow directing element is at its third operational position.

[0021] According to an embodiment of the invention the first position of the flow directing element is obtained by spring unit applying force to the flow directing element and without applying the control fluid to the flow directing element.

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[0022] According to an embodiment of the invention the second position of the flow directing element is obtained by spring unit applying force to the flow directing element and applying a first pressure of the control fluid to the flow directing element.

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[0023] According to an embodiment of the invention the third position of the flow directing element is obtained by spring unit applying force to the flow directing element and applying a second pressure of the control fluid to the flow directing element.

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[0024] According to an embodiment of the invention the control valve comprises N operational position and the spring system comprises N-1 parallel springs. N is an integer being greater or equal to 3.

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[0025] According to an embodiment of the invention each spring is arranged to initiate to apply force successively to the flow directing element commencing after a successive shifted positions of the flow directing element.

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[0026] Invention provides several benefits. Just to mention a few, by means of the invention it is possible to control a directional control valve by a single control fluid source making use of different pressure levels. Additionally the control of the pressure of the control fluid need not be very accurate for proper operation of the valve.

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Brief Description of Drawings

[0027] In the following, the invention will be described with reference to the accompanying exemplary, schematic drawings, in which

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Figure 1 illustrates a directional control valve for fluid power system according to an embodiment of the invention, and

Figure 2 illustrates a directional control valve for fluid power system according to another embodiment of the invention,

5 Figure 3 illustrates a directional control valve for fluid power system according to another embodiment of the invention, and

Figure 4 illustrates the operation of the spring unit according to an embodiment of the invention.

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Detailed Description of Drawings

[0028] Figure 1 discloses a symbolic presentation of a hydraulically actuated directional control valve 10 for a power system at different operational positions, views (a) and (b). The control valve comprises here three operational positions 12 and it has four valve ports 14. The control valve comprises a flow directing element 18 which is operable by control fluid which may be supplied to the valve via a control port 16. It is possible to apply pressure of control fluid to the flow directing element 18, which causes the flow directing element to change its position. The position of the flow directing element may change by linear translation or rotational movement, for example.

[0029] There is a spring unit 20 arranged to apply force to the flow directing element 18 so that the force opposes the change of the position caused by the pressure of the control fluid. In other words the control fluid exerts force to the flow directing element against the force of the spring unit 20.

[0030] The flow directing element is arranged to have at least three different operational positions 12 which provide different flow paths between the fluid ports 14. The spring unit comprises a spring system 22, 24 which provides a discontinuous change of the force exerted by the spring unit 20 against the flow directing element. This way the pressure required to shift the flow directing element 18 after it has reached a predetermined position increases considerably compared to the required force by which the flow directing element was shifted to the position. Due

to the considerable increase in the spring force setting the position accurately by means of the pressure of the control fluid is reliable.

5 [0031] In the embodiment of figure 1 the flow directing element 18 has three positions: first, second and third position. The second position may be also referred to as the first shifted position and the third position as second shifted position since the first position is the nominal position at which the flow directing element 18 is maintained by the spring unit without control fluid pressure applied. Advantageously
10 ly the change of spring force is arranged to commence just after the first shifted position of the flow directing element in relation to the direction to which the pressure fluid tends to move the flow directing element 18. This way due to the sudden increase of the spring force after the first shifted position the pressure of the control fluid need not be controlled too precisely but it may be set so that the movement
15 to the first shifted position surely takes place without a risk of shifting the flow directing element too far over the correct position. In the view (b) of figure 1 there is shown the first shifted position of the flow directing element 18.

[0032] Additionally, in case the flow directed element is desired to be moved to its
20 second shifted position pressure of the control fluid is increased to win the threshold force provided by the spring unit 20. If the pressure increases less than the threshold the flow directing element 18 will not move farther. When the threshold is overcome and even additional pressure to set the second spring 24 at compressed state the flow directing element is at a position where the flow directing
25 element is at its third operational position.

[0033] Preferably the spring system comprises at least two parallel springs 22, 24. In this case the change i.e. the increase of the spring force at the first shifted position is accomplished so that the second spring 24 is arranged to commence its effect
30 on the flow directing element 18 while the first spring is arranged to apply force to the flow directing element 18 at its each position in the control valve. This may be accomplished so that the second spring is arranged of such length that it is mechanically coupled between the flow directing element 18 and a body part or other stopping means 26 against which the spring may be compressed only at and

after the first shifted position. The springs are preferably helical springs and the second spring 24 is arranged inside or outside the first spring 22.

5 [0034] At the first shifted position the flow directing element 18 is arranged to be at a position where the flow directing element is at its second operational position 12, which is shown in view b.

10 [0035] It should also be understood that the spring may be of different type. figure 2 shows a directional control valve according to an embodiment of the invention where the second spring 24 of the spring unit 20 comprises a number of compression parts arranged between the coils of the first spring 22 having their dimension selected so that they will contact and effect on the compression of the first spring at the desired location of the flow directing element 18 as explained above. In figure 3 there is shown an embodiment in which the second spring 24 is a gas spring 15 which is arranged to effect on the flow directing element 18 at the desired location as well for example by arranging the flow directing element and the spring unit in a common gas tight cylinder and allowing venting of the gas from the cylinder until the flow directing element has reached a desired location.

20 [0036] In figure 4 is illustrated the operation of the spring unit 20 according to an embodiment of the invention. The horizontal axis represents the position X of the flow directing element and thus the compression of the spring unit which in the embodiment of the figure 4 comprises two springs. The position X1 represents the first position of the flow directing element 18 at which it is at its nominal position. At 25 this position the flow directing element 18 is maintained by the spring unit applying a force F1 against the flow directing element 18, without control fluid pressure applied. At the second position X2 the control fluid applies at least a force F2 to the fluid control element 18 compressing the first spring. Now, at the second location the second spring commences its effect providing a threshold F2-F2' to the need- 30 ed force for changing the position of the flow directing element from the second position X2. As can be seen in the figure the force applied by the control fluid may be anything between F2 – F2' and still the flow directing element remains in the second position X2. Thus the control of the pressure of the control fluid is allowed to have some considerable operating window which makes it easier and less

prone to disturbances. Only after the force F_2' has exceeded the flow directing element starts to move so that the position X3 requires at least the force F_3 .

5 [0037] It is clear that the control valve may comprise N pcs of operational positions and hence the spring system comprises N-1 parallel springs. Each spring is arranged to initiate to apply force successively to the flow directing element commencing after a successive shifted position of the flow directing element. It is also clear that the flow directing element may provide various types of flow paths, other than those shown here, between the ports 14.

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[0038] While the invention has been described herein by means of examples in connection with what are, at present, considered to be the most preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments, but is intended to cover various combinations or modifications of its features, and several other applications included within the scope of the invention, as defined in the appended claims. The details mentioned in connection with any embodiment above may be used in connection with another embodiment when such combination is technically feasible.

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Claims

1. A directional control valve (10) for fluid power system, comprising a flow directing element (18) and ports (14) providing passageways for the fluid to the flow directing element, in which the flow directing element comprises at least three operational positions (12), and a spring unit (20) applying force to the flow directing element (18) so that the force opposes the change of the position of the flow directing element, **characterized** in that the valve (10) is provided with at least one control port (16) and that the flow directing element (18) is arranged operable by control fluid so that applying of pressure of the control fluid via the control port (16) to the flow directing element causes the flow directing element (18) to change its position, and that the spring unit (20) comprises a spring system (22,24) which provides a discontinuously increasing change of the spring force exerted by the spring unit (20).
2. A directional control valve for fluid power system according to claim 1, **characterized** in that the change of spring force is arranged to commence after a first shifted position of the flow directing element (18) in the control valve.
3. A directional control valve for fluid power system according to claim 1, **characterized** in that the spring system comprises at least two parallel springs (22, 24).
4. A directional control valve for fluid power system according to claim 2, **characterized** in that the first spring (22) is arranged to apply force to the flow directing element at its each position in the control valve, and the second spring (24) is arranged to initiate to apply force to the flow directing element after a first shifted position of the flow directing element (18).
5. A directional control valve for fluid power system according to claim 1, **characterized** in that the first shifted position of the flow directing element (18) is arranged to be at a position where the flow directing element is at its second operational position.
6. A directional control valve for fluid power system according to claim 1, **characterized** in that the second spring (24) is arranged to apply force at com-

pressed state to the flow directing element at a position where the flow directing element (18) is at its third operational position.

7. A directional control valve for fluid power system according to claim 1, **characterized** in that the first position of the flow directing element (18) is obtained by spring unit (20) applying force to the flow directing element and without applying the control fluid to the flow directing element.

8. A directional control valve for fluid power system according to claim 1, **characterized** in that the second position of the flow directing element is obtained by spring unit (20) applying force to the flow directing element and applying a first pressure of the control fluid to the flow directing element.

9. A directional control valve for fluid power system according to claim 1, **characterized** in that the third position of the flow directing element is obtained by spring unit applying force to the flow directing element (18) and applying a second pressure of the control fluid to the flow directing element, being greater than the first pressure.

10. A directional control valve for fluid power system according to claim 2, **characterized** in that the control valve comprises N operational position and the spring system comprises N-1 parallel springs.

11. A directional control valve for fluid power system according to claim 10, **characterized** in that each spring is arranged to initiate to apply force successively to the flow directing element commencing after successive shifted positions of the flow directing element.

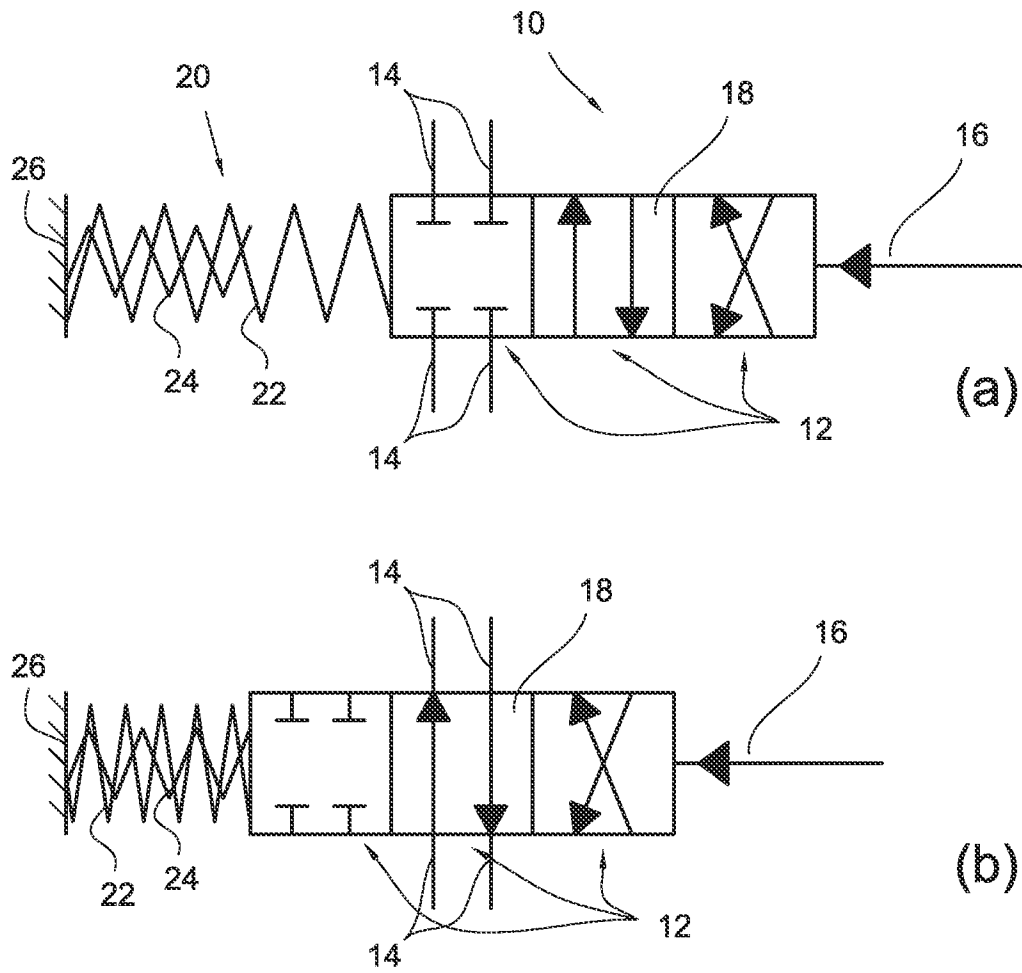


Fig. 1

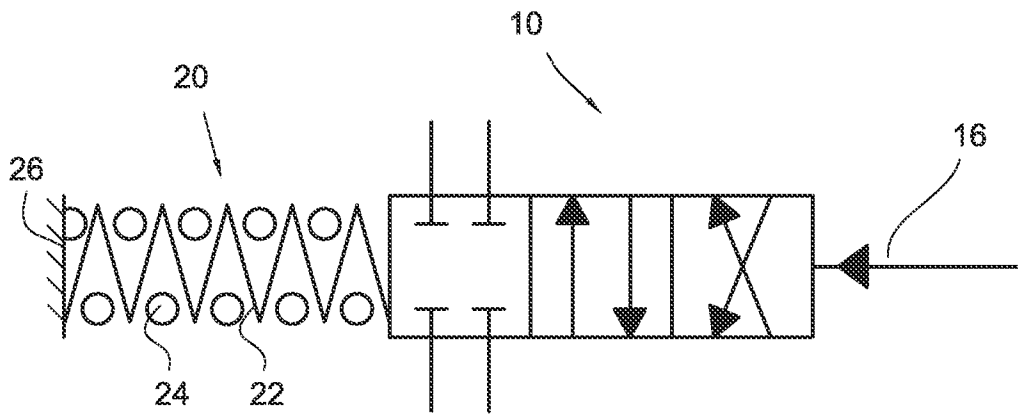


Fig. 2

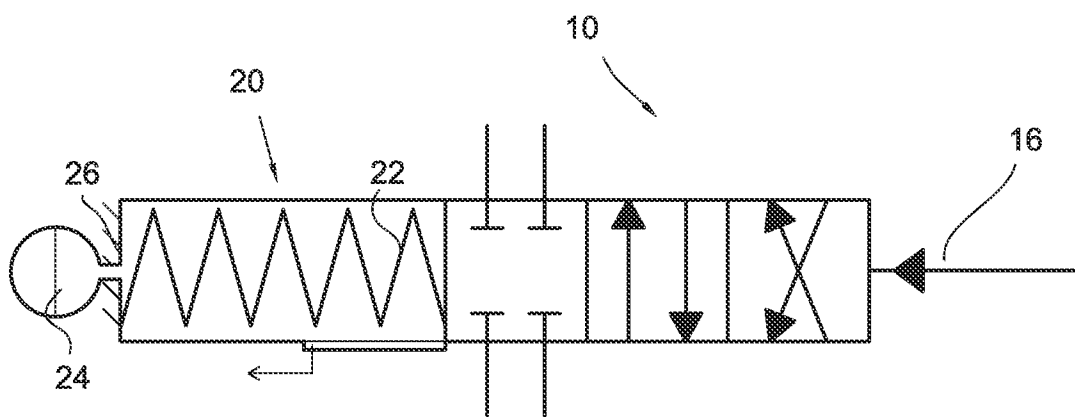


Fig. 3

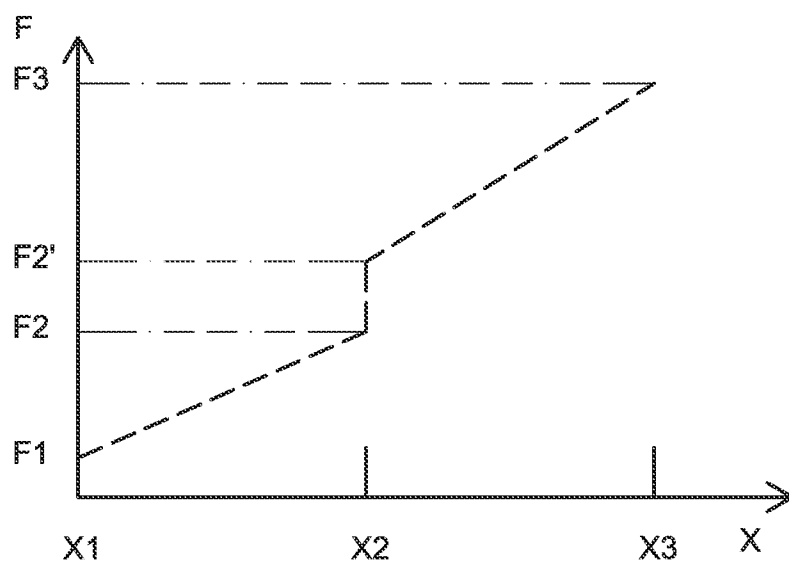


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2014/050169

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16K31/12 F16K11/00
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)
F16K

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 37 07 354 A1 (FESTO KG [DE]) 15 September 1988 (1988-09-15) abstract; figures 1-4 -----	1-11
A	DE 296 23 081 U1 (JCI REGELUNGSTECHNIK GMBH [DE]) 6 November 1997 (1997-11-06) figure 2 -----	1-11
A	DE 40 27 873 A1 (VOLKSWAGEN AG [DE]) 11 April 1991 (1991-04-11) figure 5 -----	1-11

☐

Further documents are listed in the continuation of Box C.

☒

See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

28 May 2014

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06/06/2014

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/FI2014/050169

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
DE 3707354	A1	15-09-1988	DE 3707354 A1	15-09-1988
			FR 2611850 A1	09-09-1988
DE 29623081	U1	06-11-1997	NONE	
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