



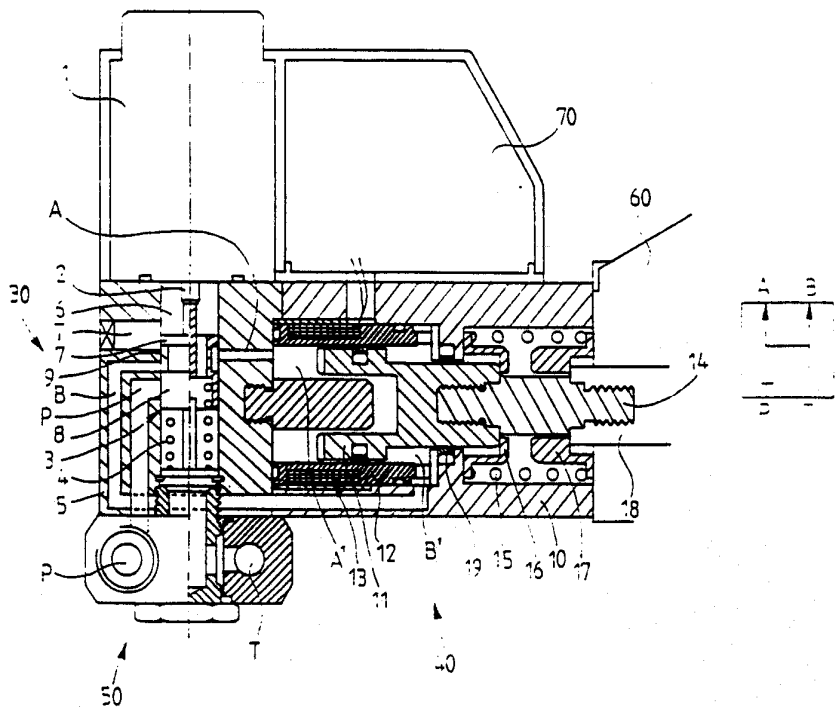
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<p>(21) International Application Number: PCT/FI92/00067 (22) International Filing Date: 11 March 1992 (11.03.92) (30) Priority data: 911256 13 March 1991 (13.03.91) FI (71) Applicant (for all designated States except US): OY NESTE-PAINE AB [FI/FI]; Harkkorautantie 8, SF-00700 Helsinki (FI). (72) Inventors; and (75) Inventors/Applicants (for US only) : AHONOJA, Ilkka [FI/FI]; Malminkartanonaukio 4 A 3, SF-00410 Helsinki (FI). LUOMARANTA, Markku [FI/FI]; Annalankatu 4 C 21, SF-33710 Tampere (FI). (74) Agent: OY KOLSTER AB; Stora Robertsgatan 23, P.O. Box 148, SF-00121 Helsinki (FI).</p>		<p>(81) Designated States: AT, AT (European patent), AU, BB, BE (European patent), BF (OAPI patent), BG, BJ (OAPI patent), BR, CA, CF (OAPI patent), CG (OAPI patent), CH, CH (European patent), CI (OAPI patent), CM (OAPI patent), CS, DE, DE (European patent), DK, DK (European patent), ES, ES (European patent), FI, FR (European patent), GA (OAPI patent), GB, GB (European patent), GN (OAPI patent), GR (European patent), HU, IT (European patent), JP, KP, KR, LK, LU, LU (European patent), MC (European patent), MG, ML (OAPI patent), MN, MR (OAPI patent), MW, NL, NL (European patent), NO, PL, RO, RU, SD, SE, SE (European patent), SN (OAPI patent), TD (OAPI patent), TG (OAPI patent), US. Published <i>With international search report. In English translation (filed in Finnish).</i></p>

(54) Title: PROPORTIONAL MECHANO-ELECTRONIC ACTUATOR MEANS

(57) Abstract

The invention relates to a proportional mechanical actuator for a device linearly controllable by a pressure fluid, the actuator being intended to be connected between a pressure source (P) and the device (60) to be controlled, comprising a proportional magnet (1); a pilot control spindle (3) arranged to be movable in a pilot control body (5) by the proportional magnet (1) for opening and closing different pressure fluid conduits (A, B, P, T); a positioner (11) for the device (60), the positioner (11) being linearly controllable in two directions by the pilot control spindle (3) so that the spindle (3) tends to keep the positioner (11) at each particular moment in a predetermined position corresponding to a control signal supplied by an electric control unit (70) of the actuator so as to linearly control the device (60) through a control spindle (14) or other similar external coupling device of the actuator. A position sensor (13) electrically sensing the position of the positioner (11) is provided in a substantially cylindrical means (12) defining a space where the positioner (11) moves, the position sensor comprising a winding fitted around the means (12).



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Proportional mechano-electronic actuator means

The invention relates to a proportional mechano-electronic actuator means for a device linearly controllable by a pressure fluid, the actuator means being intended to be connected between a pressure source and the device to be controlled, comprising a proportional magnet; a pilot control spindle arranged to be movable in a pilot control body by means of a proportional magnet for opening and closing different pressure fluid conduits; a positioner means for the device to be controlled, the positioner means being linearly controllable in two directions by means of the pilot control spindle so that the pilot control spindle tends to keep the positioner means at each particular moment in a pre-determined position corresponding to a control signal supplied by an electric control unit of the actuator means so as to linearly control the device to be controlled through a control spindle or other similar external coupling device of the actuator means.

A device of this type is known e.g. from EP Patent Specification 0 151 174, in which a pilot control spindle and a positioner are in mechanical contact with each other, the determination of the position of the positioner being inaccurate and its response relatively slow.

The object of the present invention is to eliminate the drawbacks of the prior art. This object is achieved by means of an actuator means according to the invention, which is characterized in that a position sensor electrically sensing the position of the positioner means is provided in a substantially cylindrical means defining a space where the positioner means moves, the position sensor comprising a

winding fitted around said means.

The valve according to the invention is connectable to any valve, and it is especially well suited for the control of a mobile directional valve, for instance.

In the following the invention will be described in greater detail with reference to the attached drawings, in which

Figures 1a, 2a, 3a and 4a show side views of the actuator means according to the invention in a partial section in different operating positions, the actuator means of Figure 4a deviating slightly from the actuator means of Figures 1a, 2a and 3a with respect to the arrangement of the position sensor; and

Figures 1b, 2b, 3b and 4b show pressure line coverage patterns associated with the operating positions shown in the above-mentioned figures.

Figures 1a, 2b and 3a show a proportional mechano-electronic actuator means comprising a proportional magnet 1, a pilot control unit 30, a positioner unit 40, a feed and return part 50 for pressure fluid, and an electronic unit 70, which are all connected fixedly together into a compact actuator means aggregate.

The pilot control unit 30 comprises a body 5 provided with a cylindrical boring 6 in which a vertically movable pilot control spindle 3 is positioned. The spindle 3 comprises an upper annular shoulder 7, a lower annular shoulder 8 and an annular conduit 9 positioned therebetween. A spring 4 is provided in the boring 6 below the pilot control spindle 3, a spindle 2 of the proportional magnet 1 moving the pilot control spindle 3 against the tension of the spring 4. The body 5 further comprises a pressure

fluid conduit P and a pressure fluid return conduit T communicating with the pressure fluid feed and return part 50. The feed and return part 50 is positioned immediately below the pilot control unit 30.

5 The positioner unit 40 comprises a housing 10 which is attached to the side of the pilot control unit 30. A rotation symmetrical cavity extends through the housing 10, and a cylinder pipe 12 of a non-magnetic material is secured in one end of the
10 cavity within the cavity close to the pilot control unit 30. A copper wire winding or coil 13 is embedded in the outer surface of the cylinder pipe 12 so as to extend around the pipe, and a positioner means 11 is arranged slideably against the inner surface of the
15 cylinder pipe 12 in a sealed manner. A control spindle 14 is attached to the end of the positioner means remote from the pilot control unit 30 for controlling a valve 60 attached to this end of the positioner unit 40. A spring assembly 15 to 18 is
20 installed within the corresponding end portion of the cavity of the housing 10; the spring assembly tends to center the positioner means 11 when the means is moved in either direction. The housing 10 is attached to the side of the pilot control body 5 so that the
25 axes of the pilot control spindle 3 and the positioner means 11 are perpendicular to each other. The cylinder pipe 12, in turn, defines another cavity within it, and this cavity is divided by the positioner means 11 into two pressure spaces A^1 and B^1 ,
30 of which one space A^1 acts on the front side (left side) of the positioner means 11, and the other space B^1 acts on the back side (right side) of the positioner means 11. The pressure space A^1 communicates with the boring 6 of the pilot control unit 30 by
35 means of a conduit A extending through the body 5,

and the pressure space B¹ by means of a conduit B extending through the housing 10 and the body 5. The pressure space B¹ is sealed by a seal 19 in the area of the housing 10 where the spring assembly 15 to 18 is positioned.

The above-described cylinder pipe 12, the coil 13 around it, the positioner means 11 acting as a coil core, and the requisite electronics in the electronic unit 70, to which the coil is connected electrically, together form an entity by means of which the position of the positioner means 11 operating in a piston-like manner is measured. The coil 13 and the means 11 are so positioned with respect to each other that the length of the portion of the means 11 remaining within the coil 13 varies with the position of the means 11. During operation within the measuring range, a certain length of the means 11 penetrated within the coil 13 corresponds to each position of the means 11. As the means 11 is made of a material in which eddy currents are liable to occur, the inductance of the coil 13 varies continuously as a function of the position. The intensity of the created eddy currents - and thus the sensitivity of the sensor arrangement - can be affected e.g. by controlling the force line pattern of the magnetic field of the coil 13 and increasing the intensity of the force lines in a desired manner.

In the present invention, the inductance of the coil 13 at each specific moment - and thus the position of the means 11 - is measured and converted into a pulse-length-modulated signal by means of a microprocessor.

In structure, the actuator means shown in Figure 4a corresponds to the actuator means shown in

Figures 1a, 2a and 3a with the exception of the arrangement of the position sensor. Here the position sensor 130 is wound on a spool 131 which is pushed over a cylinder pipe 120. This is another advantageous way of installing the position sensor around the cylinder pipe. The operating principle of the actuator means and the position sensor is not affected by this modification.

The actuator means aggregate operates as follows:

Figure 1a illustrates the rest state of the actuator means. When the proportional magnet 1 is currentless, the return spring 4 keeps the pilot control spindle 3 and the spindle 2 of the magnet 1 in the upper extreme position, a so-called safety position (Figure 1b). The shoulder 8 of the pilot control spindle 3 keeps the pressure fluid conduit P closed, whereas the conduit A and the conduit B communicate with the return fluid conduit T. The positioner means 11 is maintained in its center position by the action of the centering spring 15, and it may be moved mechanically by an external force.

In Figures 2a, 3a and 4b, the actuator means is shown in an operation state. In Figure 3a, current is supplied to the magnet 1 so that the magnet pushes the pilot control spindle 3 to a so-called center position (Figure 3b), in which the shoulder 7 prevents the flow between the conduit A and the return conduit T while allowing the flow between the pressure fluid conduit P and the conduit B. The position is sensed as described above by means of a signal processed by the means 11 and the microprocessor. The pilot control spindle 3 remains in this position to wait for the control signal, and it may move either downward (Figure 4b) or upward

(Figure 2b), depending on the difference between the external control signal and the control signal supplied by the positioner means 11.

As shown in Figure 2a, the pressure fluid conduit P is connected to the conduits A and B when the pilot control spindle 3 moves upward due to the difference between the external control signal and the position signal supplied by the positioner means 11. The shoulder 7 keeps the return fluid conduit T closed (Figure 2b). The positioner means 11 moves to the right due to the difference between the areas of the pressure spaces A^1 and B^1 until the signal supplied by the coil 13 corresponds to the control signal in magnitude, so that the pilot control spindle 3 returns to the center position (Figure 3b). The positioner means 11 remains in this new position as long as the control signal proportional to this position is maintained. The signal difference caused by the termination of the control signal displaces the pilot control spindle 3 from the center position (Figure 3b) to the position shown in Figure 4a, so that the pressure fluid conduit P is connected to the conduit B and the return conduit T to the conduit A. The positioner means 11 moves to the left, until the signal supplied by the coil 13 corresponds to the signal of the center position in magnitude, and so the pilot control spindle 3 returns to the center position (Figure 3b).

When the pilot control spindle 3 moves downward, as shown in Figure 4a, due to the difference between the external control signal and the position signal supplied by the positioner means 11, the pressure fluid conduit P is connected to the conduit B and the return conduit T is connected to the conduit A (Figure 4b). The positioner means 11 moves

to the left due to the pressure difference between the pressure spaces A^1 and B^1 until the signal supplied by the coil 13 correspond to the control signal in magnitude, and the pilot control spindle 3 returns to the center position (Figure 3b). The positioner means 11 remains in this new position as long as the control signal proportional to this position is maintained. The signal difference caused by the termination of the control signal displaces the pilot control spindle 3 from the center position (Figure 3b) to the position shown in Figure 2a, so that the pressure fluid conduit P is connected to the conduits A and B. The shoulder 7 keeps the return conduit T closed. The positioner means 11 moves to the right due to the difference between the areas of the pressure spaces A^1 and B^1 until the signal supplied by the coil 13 corresponds to the signal of the center position in magnitude, and the pilot control spindle 3 returns to the center position (Figure 3b).

It is typical of the actuator means according to the invention that it operates in a volume flow controlled manner, so that when it is connected to a pressure source, its pressure is constantly the same as that of the pressure source. In other words, the entire pressure of the pressure source can immediately be used to move the positioner means 11 when the control is started.

If the volume flow control is compared with the pressure control acting against the spring, a considerable functional advantage is obtained. It is typical of a pressure-controlled device that the control pressure required to obtain a certain initial control position may be e.g. one fourth of the required final pressure (initial pressure e.g. 6 bar,

final pressure 25 bar); as is well-known, this causes operational disturbances and even prevents the operation of the device due to viscosity problems when cold oil is employed.

Claims:

1. A proportional mechano-electronic actuator means for a device linearly controllable by a pressure fluid, the actuator means being intended to be connected between a pressure source (P) and the device (60) to be controlled, comprising:
- a proportional magnet (1);
 - a pilot control spindle (3) arranged to be movable in a pilot control body (5) by means of the proportional magnet (1) for opening and closing different pressure fluid conduits (A, B, P, T);
 - a positioner means (11) for the device (60) to be controlled, the positioner means (11) being linearly controllable in two directions by means of the pilot control spindle (3) so that the pilot control spindle (3) tends to keep the positioner means (11) at each particular moment in a pre-determined position corresponding to a control signal supplied by an electric control unit (70) of the actuator means so as to linearly control the device (60) to be controlled through a control spindle (14) or other similar external coupling device of the actuator means,
- characterized in that a position sensor (13; 130) electrically sensing the position of the positioner means (11) is provided in a substantially cylindrical means (12; 120) defining a space where the positioner means (11) moves, the position sensor comprising a winding fitted around said means (12; 120).
2. An actuator means according to claim 1, characterized in that the position sensor (13) is embedded in the outer surface of the cylinder pipe (12) positioned around the positioner

means (11).

3. An actuator means according to claim 2, characterized in that the position sensor (130) is wound on a spool (131) which is pushed over the cylinder pipe (120).

4. An actuator means according to claim 2 or 3, characterized in that the cylinder pipe (12; 120) is of a non-magnetic material.

5. An actuator means according to any of claims 2 to 4, characterized in that a housing (10) of the positioner means (11) is attached to the side to the pilot control body (5) so that the axes of the pilot control spindle (3) and the positioner means (11) are substantially perpendicular to each other, and that the cavity defined by the cylinder pipe (12; 120) comprises pressure spaces (A^1 , B^1) acting on the front and the back side of the positioner means (11), the pressure spaces communicating by means of one pressure fluid conduit (A, B) with a space in which the pilot control spindle (3) moves and which communicates with the pressure source (P).

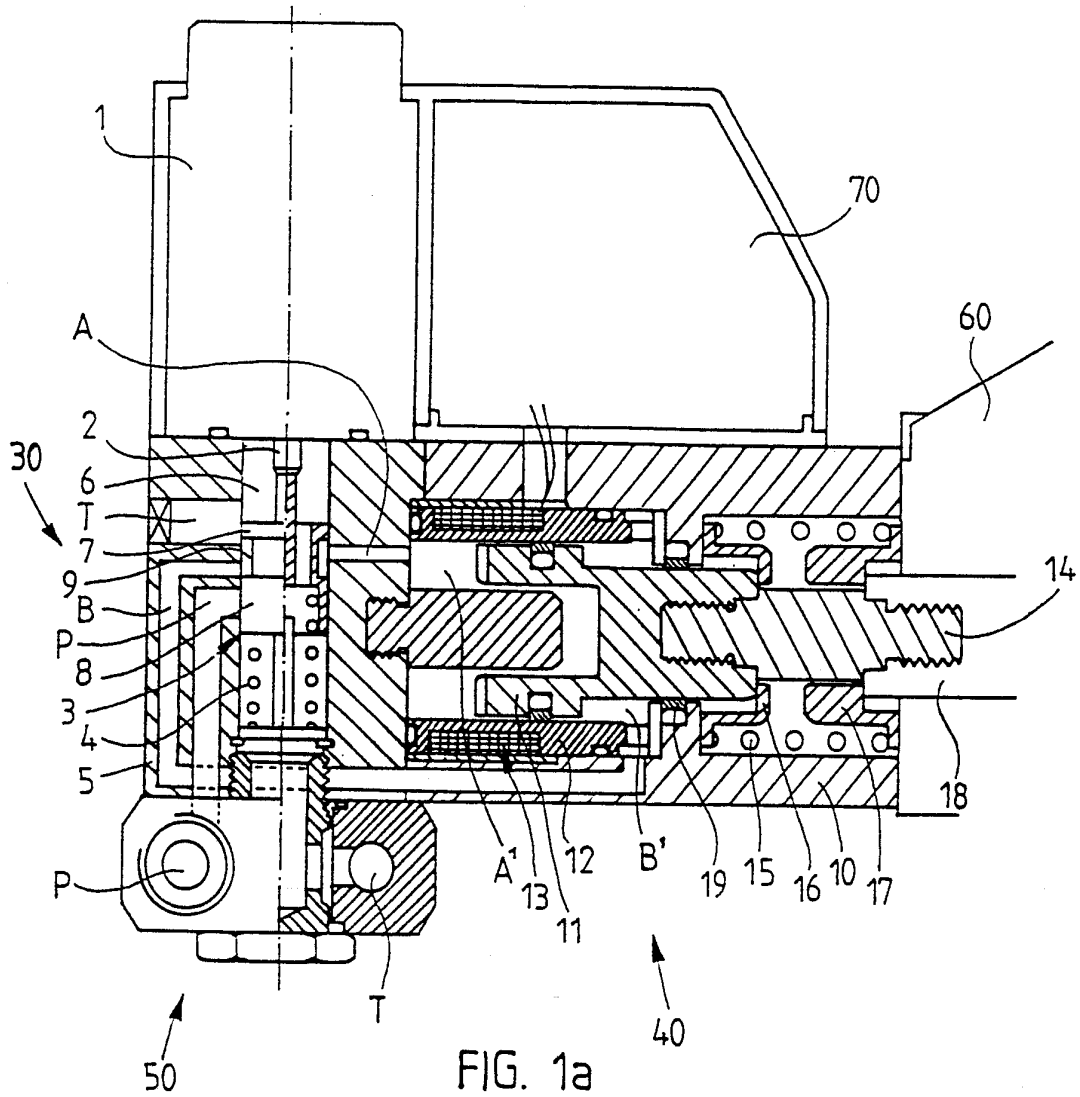


FIG. 1a

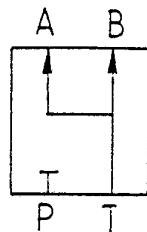


FIG. 1b

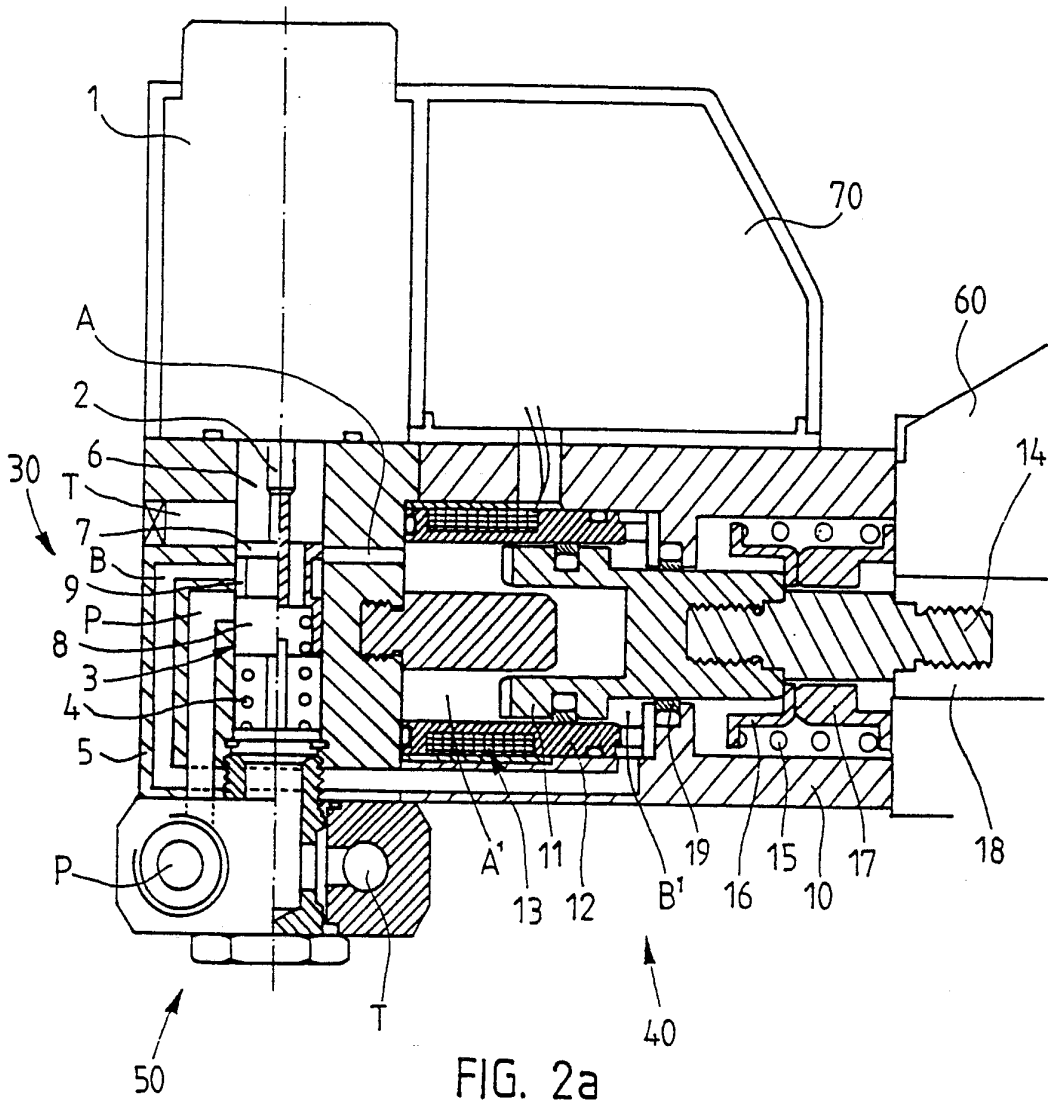


FIG. 2a

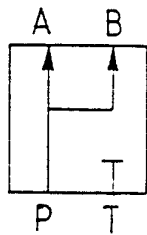


FIG. 2b

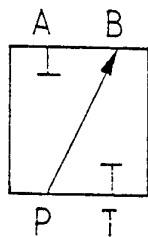
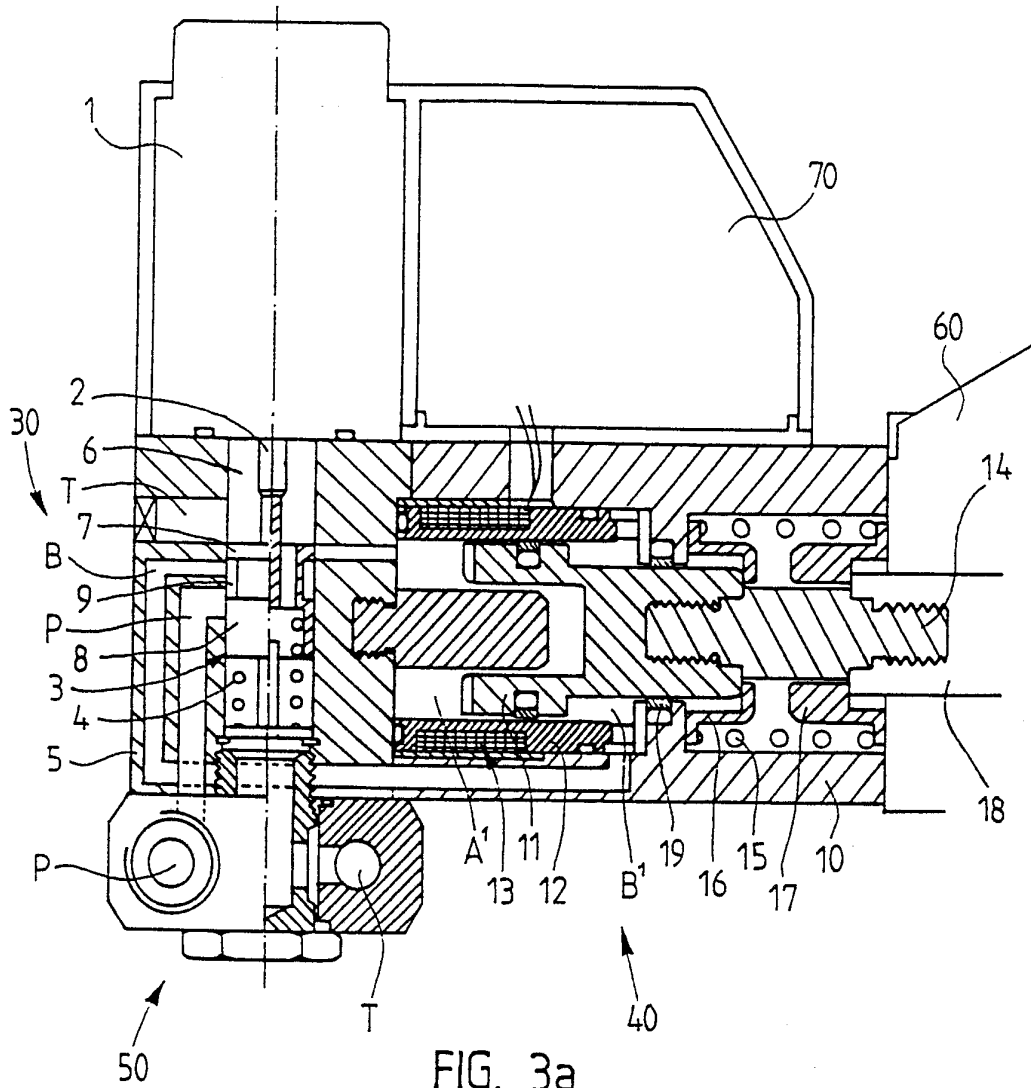


FIG. 3b

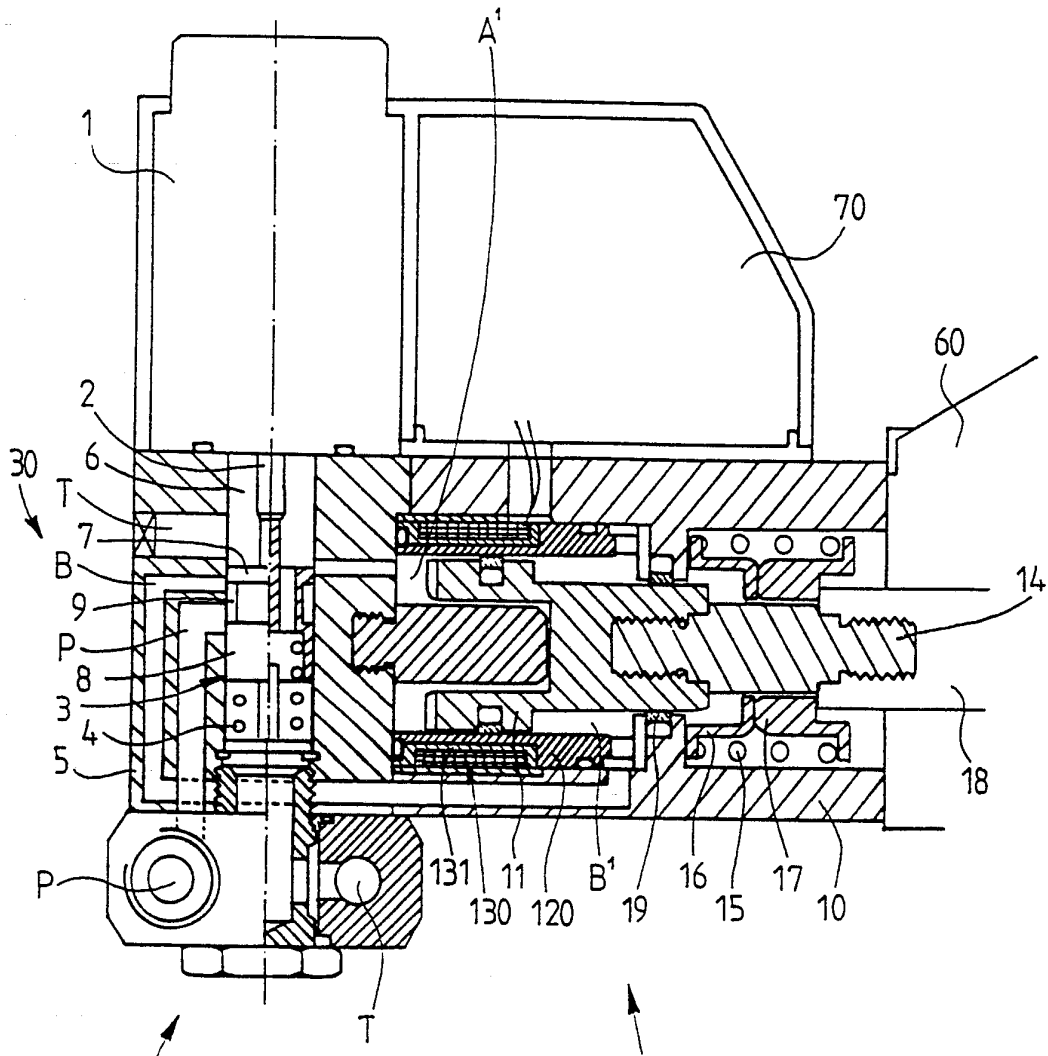


FIG. 4a

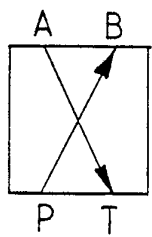



FIG. 4b

INTERNATIONAL SEARCH REPORT

International Application No PCT/FI 92/00067

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC5: F 15 B 13/043		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
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IPC5	F 15 B	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched ⁸		
SE,DK,FI,NO classes as above		
III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹		
Category *	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
Y	US, A, 4569273 (ANDERSON ET AL) 11 February 1986, see the whole document --	1-5
Y	DE, C2, 2904573 (MANNESMANN REXROTH GMBH) 27 January 1983, see the whole document --	1-5
Y	EP, A1, 0366605 (GEBRÜDER SULZER AKTIENGESELLSCHAFT) 2 May 1990, see the whole document --	1-5
Y	US, A, 2674232 (A. MASON) 6 April 1954, see the whole document --	1-5
<p>* Special categories of cited documents:¹⁰</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"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</p> <p>"X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"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.</p> <p>"&" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
11th June 1992	1992 -06- 23	
International Searching Authority	Signature of Authorized Officer	
SWEDISH PATENT OFFICE	 S-E Bergdahl	

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
Y	US, A, 3136224 (A.E. ESCOBOSA) 9 June 1964, see the whole document --	1-5
Y	US, A, 3279323 (C.W. ASCHE) 18 October 1966, see the whole document -- -----	1-5

**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.PCT/FI 92/00067**

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the Swedish Patent Office EDP file on **30/04/92**.
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4569273	86-02-11	CA-A- 1225568	87-08-18
		EP-A-B- 0151174	85-08-14
		JP-T- 60501869	85-10-31
		WO-A- 85/00642	85-02-14

DE-C2- 2904573	83-01-27	NONE	

EP-A1- 0366605	90-05-02	CH-A- 675752	90-10-31
		EP-A- 0427981	91-05-22
		JP-A- 2159401	90-06-19

US-A- 2674232	54-04-06	NONE	

US-A- 3136224	64-06-09	NONE	

US-A- 3279323	66-10-18	NONE	