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(54) **Fully integrated electro-hydraulic linear actuator**

Vollintegrierter elektrohydraulischer Linearaktuator

Actionneur linéaire électro-hydraulique entièrement intégré

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Description

TECHNICAL FIELD

[0001] The present disclosure relates in general to hydraulic control systems using hydraulic cylinders as linear actuators and in particular to a compact, fully integrated electro-hydraulic linear actuator device of universal usage, being practically maintenance-free and deployable in innumerable applications, needing solely an electrical cable connection to a control unit.

DISCUSSION OF RELATED ART

[0002] Commonly, for operating or configuring automated machinery, production lines, fluid processing plants, movable fixtures, etc. are often alternatively used electromechanical, pneumatic or hydraulic actuators, each type having typical characteristics that may orient, when not dictating it, the choice of the designer.

[0003] An electromechanical system typically comprises transmissions, gears and endless screw devices in order to transform the rotation motion of an electrical motor in a linear motion and suffers from relatively large "start off" frictional forces. In case of relatively low supply voltage applications (e.g. in vehicles) imply large start-up currents and large cross sections of the cable conductors. The mechanical components employed require a good wear resistance and high precision machining; aspects that make the device relatively expensive.

[0004] Pneumatic actuators, typically pneumatic cylinders, driven by a source of compressed air through electrically controlled valves, function at relatively low pressure and thus have relatively large sizes hardly compatible with a requirement of reducing encumbrances.

[0005] Hydraulic actuators consists of one or even several double effect cylinders in parallel (for heavy duty applications) the piston or pistons of which are driven with a work fluid, for example a mineral oil, that is pressurized by a pump, commonly a volumetric pump associated to a reservoir of hydraulic fluid. Control of the double effect piston or pistons is implemented through electrically controlled valves, normally installed in a hydraulic port array of hydraulic connections, associated to a centralized control unit, from which depart pipes or hoses of connection to the respective chambers of the double effect cylinders.

[0006] These devices, though offering robustness, compactness of the cylinders and reasonable costs, generally imply a complex hydraulic circuit layout that require qualified personal for assembling it, characteristic that leads to a marked criticalness of the accuracy of the installation which ends up to practically increasing overall cost.

[0007] Another attendant drawback is represented by the need of filling up with the working fluid the hydraulic circuits once completed and carefully de-aerating it for a proper functioning of the control system. Regular checks and maintenance that may contemplate a substitution of the working fluid with fresh fluid (eventually substituting any rotary seal packing, most subject to degradation) are generally a norm. These peculiarities further burden a prospective cost analysis comparison.

[0008] Moreover, real hydraulic fluids are not ideally uncompressible and achievement of an enhanced "rigidity" of the actuator may be sought only by minimizing the charge volume of working fluid.

[0009] There is a general need in industry of a fully integrated electro-hydraulic linear actuator device, substantially maintenance-free and of universal usage, of enhanced compactness and deployable in innumerable applications, needing solely an electrical cable connection to a system control unit.

[0010] CA 2313943 discloses a hydraulic system according to the preamble of claim 1.

SUMMARY OF THE DISCLOSURE

[0011] A solution to these demanding requisites of an electro-hydraulic linear actuator device, the stem of the double effect piston of which projects out of only one end of the fixed cylinder, has been found by the applicant and is the object of the claimed invention.

[0012] According to a basic embodiment, the volume of hydraulic working fluid is markedly reduced by eliminating any reservoir and providing fluid chambers of identical areas over opposite sides of the double effect piston. This allows an enhanced compactness, the possibility of embedding practically the whole hydraulic circuit within a base block of the cylinder, including paired hydraulically piloted valves and safety relief valves, and to associate to the base block, a reversible drive motor and pump assembly. A magnetic coupling between the motor and the pump avoids the presence of rotary seal packing for long lasting seal proofness. No piping is required, the hydraulic circuit may be factory-charged with de-aerated hydraulic fluid and remains permanently sealed. Installation of the fully integrated electro-hydraulic linear actuator simply requires electrical connection of the reversible drive motor to a control unit.

[0013] According to an embodiment, the projecting stem is the double effect piston itself, in form of an end capped tube that moves inward and outward of a fixed cylinder, solidly connected to a fluid distribution base block, associated to a motor-pump assembly block. The movable tubular stem-piston is closed at the outer end by a cap and adapter assembly and sealingly slides inside the fixed cylinder and over a fixed tubular inner stem, axially extending from the fluid distribution base block for hydraulically connecting an upper chamber inside the end-capped movable stem to the hydraulic circuit of the double effect piston, the circular sectional area of which is identical to the circular sectional crown area of a lower chamber, defined between the fixed tubular inner stem and the fixed cylinder.

[0014] Exemplary geometries, features and the manner in which the electro-hydraulic linear actuator device of the present disclosure operates, will be more easily described in detail by referring to exemplary embodiments illustrated in the attached drawings purely for illustrative purposes. The invention is defined in the annexed claims, the content of which is to be considered part of this description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Figure 1 depicts the basic hydraulic circuit diagram of an electro-hydraulic linear actuator device of the present disclosure.

Figure 2 shows the hydraulic circuit configuration during a stem extraction phase.

Figure 3 shows the hydraulic circuit configuration during a hold phase of the stem position.

Figure 4 shows the hydraulic circuit configuration during a stem retraction phase.

Figures 5a and **5b** shows how the relief valve pair intervene in the event of excessive pressure for the two situations of excessive compressive load and of excessive traction load, respectively.

Figure 6 shows orthogonal views of an exemplary embodiment of electro-hydraulic linear actuator device of the present disclosure, in fully retracted position, with indications of significant sectional planes.

Figure 7 is a cross sectional view on the sectional plane *a-a* of Figure 6.

Figure 8 is a cross sectional view on the sectional plane *a-a*, of the exemplary embodiment of electro-hydraulic linear actuator device of the present disclosure of Figure 6, in fully extended position.

Figure 9 is a cross sectional view on the sectional plane *c-c* of Figure 6.

Figure 10 is a cross sectional view on the sectional plane *d-d* of Figure 6.

Figure 11 is a cross sectional view on the sectional plane *e-e* of Figure 6.

Figures 12, 13, 14 and **15** are other cross sectional views of integration details.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0016] The basic hydraulic circuit diagram of an electro-hydraulic linear actuator device of this disclosure is depicted in **Figure 1**. The components, namely: the electric motor A of reversible direction of rotation, the volumetric pump B driven by the motor and the hydraulic cylinder 3 are symbolically represented, alike the other circuital components.

[0017] A double effect piston H integral to a mobile stem 2 separates a first or upper chamber 7 from a second or lower chamber 8, functionally defined on opposite sides of the piston.

[0018] The work fluid driven by the reversibly driven pump is injected and drawn to and from the two chambers 7 and 8 when extracting or retracting the mobile stem 2, or blocked in the chamber when holding in position the stem-piston. The correct circuital configuration is implemented by the hydraulically controlled pair of blocking valves F.

[0019] Two spring-biased safety pressure relief valves G or any other equivalent device, in respective by-pass paths between pump inlet and pump outlet branches of the circuit, ensure a relieving of pressure in case of excessive load on the actuator.

[0020] The hydraulic circuit further comprises at least a compressible air chamber D adapted to compensate internal thermal expansions/contractions, which is functionally connected to the pump inlet side branch of the hydraulic circuit, according to the commanded circuital configuration of the actuator. Hydraulic fluid flow path selecting means E may, for example, be in form of a pair of hydraulically piloted valves or shuttle valves of any other functionally equivalent device.

[0021] According to a most preferred embodiment, the mechanical coupling of the motor spindle to the pump rotor is implemented with a magnetic coupling. Elimination of a seal packing over a rotating spindle, far more subject to wear than linearly acting seal rings, is amenable to the production of the factory filled fully integrated device of this disclosure that is substantially sealed for its whole operative lifetime.

[0022] **Figures 2 to 5b** replicate the circuit diagram of Figure 1 for illustrating the configuration that the circuit assumes in distinct phases of operation, essentially implemented by the two pairs of hydraulically piloted devices F and E and by the volumetric pump B, reversibly driven by the reversible electrical motor A.

[0023] The tonality with which the circuit lines of fluid flow are traced differently from the lines inhibited to fluid flow and the directional arrows of fluid flow along the enabled lines, combined with the arrows indicating the direction of mechanical forces acting on the hydraulic actuator and the eventual stem displacement, make immediate the reading of the functional diagrams relative to the distinct phases of operation of the device, by any expert person.

[0024] **Figure 6** shows orthogonal views of an exemplary embodiment of electro-hydraulic linear actuator device of the present disclosure, in fully retracted position, with indications of significant sectional planes.

[0025] Contrarily to common art of double effect pistons, the device maintains the stem extending from a single side end of the cylinder 3 and at the same time the two fluid chambers, 7 and 8, respectively, are made with identical cross sectional area. This is achieved by employing a tubular mobile stem-piston 2, closed at the outer end, and delimiting at its interior a first or upper chamber 7, into which the working fluid, injected by a pump B, eventually pushes the tubular stem-piston 2 to project out of the cylinder 3, terminating with a common oil scraper, slydring and seal ring assembly 6, while its engrossed inner end 2p, provided with oil scraper, slydring and seal ring, sealingly slides inside the cylinder 3, expelling working fluid out of a second or lower chamber 8, defined over the wetted outer cylindrical surface of the mobile tubular stem-piston 2.

[0026] The circular cross sectional area of the upper chamber 7 and the circular-crown, cross sectional area of the lower chamber 8 are made identical. Delimitation of the upper chamber 7 is achieved by a coaxial, inner fixed piston-stem 9, provided with oil scraper, slydring and seal ring at its end, over which the movable stem-piston 2 sealingly slides, and through which a hydraulic connection bore 9d connects the upper chamber 7 to the hydraulic circuit.

[0027] Such a configuration has been found to be fully amenable to allow elimination of the customary reservoir of working fluid normally associated to a double effect piston actuator. Therefore, only a fully integrated minuscule compressible air chamber of volumetric compensation D of thermal expansions/contractions is implemented.

[0028] Moreover, the double effect stem-piston extending from a single side end of the cylinder, permits to form the whole functional hydraulic circuit in a composite fluid distribution block 4 at the closed end of the cylinder 3 and to embed a volumetric pump B and, preferably, even a magnetic coupling C with the shaft of a reversible electric motor A, fastened onto the block.

[0029] The electro-hydraulic linear actuator device of this disclosure is powered through a reversible direction electrical motor A that drives a volumetric pump B, preferably through a magnetic coupling C, and control is implemented through a pair of hydraulically piloted blocking valves F of the conduits to the two chambers 7 and 8 and a pair of hydraulically piloted valves E for switching the connection of the compensation chamber D to the fluid return branch of the hydraulic circuit when inverting the direction of pumping. A pair of safety relief valves G of excessive pressure between the paths of fluid circulation to and from the chambers of the linear hydraulic actuator complete the hydraulic system.

[0030] The hydraulic circuit may thus be wholly pre-filled with properly de-gassed working fluid and permanently sealed at the factory, for a long operative life, substantially maintenance-free.

[0031] The three orthogonal views of an exemplary embodiment of electro-hydraulic linear actuator device of the present disclosure, in fully retracted position, with indications of significant sectional planes, shown in **Figure 6** give an immediate perception of the extraordinary compactness of an exemplary embodiment of the linear actuator of the present disclosure that is functionally connectable to a control unit with only an electrical cable, connected to a common multi conductor terminal block of power distribution to the motor of the device, preferably of a water proof type or even permanently sealed that (not shown in the drawings).

[0032] The whole hydraulic circuit and the functional components of power supply and drive control are integrated in a practically monolithic article of manufacture, according to a fundamental feature of the multipurpose electro-hydraulic linear actuator device of this disclosure.

[0033] The two longitudinal cross sectional views of **Figures 7** and **8** of the exemplary embodiment of electro-hydraulic linear actuator device in the sectional plane *a-a* of Figure 6, in a fully retracted and extended position, show the mechanical construction of the hydraulic actuator and how the whole electro-hydraulic system is integrated according to this disclosure.

[0034] According to this exemplary embodiment, to a cylinder base block 4 is associated a motor-pump assembly split block composed of two parts 4ex1 and 4ex2 solidly connected together to form a composite solid block. The magnetic coupling C, the volumetric pump B, compressible air chambers of volumetric compensation D and related hydraulically piloted valves E (re: Figure 1) and appropriate hydraulic fluid flow connection ports are realized in such a side connected split assembly block, associated to the cylinder base block 4, thus fully integrating the hydraulic circuit and relative drive and +hydraulically piloted elements.

[0035] Preferably, association of the motor-pump assembly split block, 4ex1 and 4ex2, to the cylinder base block 4 is made in a way that allows to orient it in a most favourable angled position relative to the cylinder axis and to fix it in that coupled position, by providing a pin 11 that preserves circuital coherent fluid path continuity when rotating the motor-pump assembly split block with respect to the cylinder base block (i.e. the actuator axis) to a position that will not interfere with structural members or organs of the host machinery.

[0036] **Figure 9** is an enlarged detail cross sectional view on the sectional plane *c-c* of Figure 6, showing the way the pair of hydraulically piloted blocking valves F (re: Figure 1) of the conduits leading to the inlet/outlet ports of the reversible volumetric pump B, for selectively connecting them to the two chambers (7 and 8) of the double effect hydraulic actuator during stem extraction and retraction phases, and for closing both of them for retaining a position, are realized inside respective borings in the lower part 4ex2 of the motor-pump assembly split block, that are normally closed by plugs.

[0037] The pin 11 partially extends in coaxial borings, respectively into the cylinder base block 4 and into the lower part 4ex2 of the motor-pump assembly split block and has circular grooves adapted to co-ordinately intercept hydraulic circuit conduits in the semi block 4ex2 and in the base block 4, internal fluid distribution conduits and O-ring seals in order to preserve circuital coherent fluid paths continuity whenever should become necessary to rotate the motor-pump assembly split block with respect to the cylinder base block (i.e. the actuator axis) because of existing encumbrances in the host machinery.

[0038] **Figure 10** is an enlarged detail cross sectional view on the sectional plane *d-d* of Figure 6, showing the way a pair of spring-loaded safety relief valves G (re: Figure 1) may be realized inside respective borings in the cylinder base block 4, with spring load trim plugs, provided with an O-ring seal.

[0039] **Figure 11** is an enlarged detail cross sectional view on the sectional plane *e-e* of Figure 6, showing the way compensation compressible air chambers D delimited by a spring loaded piston are realized in the upper part 4ex1 of the motor-pump assembly split block. **Figures 12, 13, 14** and **15** are other cross sectional views useful for a more easily recognition of certain details of the integrated pump and related hydraulic circuital features.

[0040] The pump B is a volumetric, rotary pistons pump, the rotor 12 of which has radial borings into which move pistons 101 held in abutment against the surface of the inner ring of the eccentric ball bearing 13 by the centrifugal force generated by the rotation of the rotor 12.

[0041] Over the pump shaft 14, sustained in the bearing 15, fits a first part 16 of the magnetic coupling C, the other part 17 fitting over the shaft 18 of the electric motor A, mounted onto the upper part 4ex1 of the motor-pump assembly split block. The bell-shaped fluid containment shroud 20 of the magnetic coupling C is fixed to the upper part 4ex1, and an O-ring gasket ensures the necessary seal.

[0042] The rotor 12 turns over the hydraulic fluid distributor pin 19, held in a blind hole of the lower part 4ex2 of the motor-pump assembly split block. Therefore, the pistons 101 have an alternated inward and outward radial motion (toward and away from the center pin 19), obligated by their abutment onto the the surface of the inner ring of the eccentric ball bearing 13, which make them deliver hydraulic fluid to the hydraulic circuit when traveling inward and draw-in fluid from the hydraulic circuit when traveling outward, through delivery and return ports 19a and 19b and conduits 19c, 19d, present in the fluid distribution pin 19. Of course the pump system is reversible: changing the direction of rotation delivery and return paths automatically invert themselves.

[0043] The hydraulically driven valves E are also integrated within the lower part 4-ex2 of the motor-pump assembly split block, one for each branch of the hydraulic circuit, leading to the work fluid side cavity of a compressible air chamber of negligible volumetric requirement, in consideration of the fact that compensation need to account only for thermal expansions/expansions of the work fluid.

[0044] The two sectional views of **Figures 14** and **15**, show in detail the two identical valves E of the hydraulic circuit of the electro-hydraulic linear actuator.

[0045] **Fill-function**: if for any reason (thermal contraction of the circulating fluid), the suction branch (inlet of the pump) 105 should be starving of hydraulic fluid, the pressure in the delivery branch 103 will push the valve piston 104 as far as opening the shutter of the valve E allowing hydraulic fluid from the associated integrated volumetric compensator D, hydraulically connected to the valve E, to flow from the conduit 106 into the suction branch 105.

[0046] **Drain function**: if for any reason (thermal expansion of the circulating fluid), the pressure of the work fluid in the hydraulic circuit should rise, the hydraulically controlled valve E will similarly open releasing an exceeding volume of fluid out of the circuit through the conduit 106, toward the associated integrated volumetric compensator D.

[0047] The electrical motor A, magnetically coupled to the embedded pump B (re: Figures 6, 7 and 8), is fixed atop the upper part 4ex1 of the motor-pump assembly split block.

[0048] In the following table are indicated some of the materials that may be used for making the device, though special requirements may lead the designer to different choices.

REF.	DESCRIPTION	MATERIALS
A	**Motor**	
	stator stator windings	Fe-Si laminae enameled Cu wire
	rotor	malleable iron
	permanent magnets	Ferrite, Neodymium, Samarium, Cobalt
B	**Volumetric pump**	
	rotor carrying small pistons	bronze
	small pistons	chromium steel

(continued)

<table>
<tr><td>REF.</td><td>DESCRIPTION</td><td>MATERIALS</td></tr>
<tr><td>F and E</td><td>Check valves</td><td></td></tr>
<tr><td></td><td>body of check valve</td><td>malleable iron</td></tr>
<tr><td></td><td>seal</td><td>reinforced polyamide</td></tr>
<tr><td>G</td><td>Safety valves</td><td>alloy steel</td></tr>
<tr><td></td><td>Structural components</td><td></td></tr>
<tr><td>4, 4ex1, 4ex2</td><td>cylinder base block and motor-pump assembly split block</td><td rowspan="3">Al-Cu alloy (series 2000) or Al-Zn alloy (series 7000)</td></tr>
<tr><td>2 and 9</td><td>tubular stem-piston and inner fixed piston-stem</td></tr>
<tr><td>5 and 10</td><td>cap and adapter</td></tr>
<tr><td>3</td><td>cylinder</td><td>chromium coated carbon steel</td></tr>
<tr><td></td><td>Sealing elements</td><td></td></tr>
<tr><td>6</td><td>O-ring static gaskets</td><td rowspan="3">acryl nitril butadiene (nitrilic-NBR rubber) or fluorocarbide rubber (Viton-FKM)</td></tr>
<tr><td>7</td><td>dynamic seal rings</td></tr>
<tr><td></td><td>scraper rings of pistons</td></tr>
</table>

[0049] The features of the embodiments described above can be combined to provide further embodiments. These and other changes can be made to the embodiments in light of the above description. In general, in the following claims, the terms used should not be construed to limit the claims to the specific embodiments disclosed in the specification and claims, but should be construed to include all possible embodiments along with the full scope of equivalents to which such claims are entitled. Accordingly, the claims are not limited by the description.

Claims

1. An integrated electro-hydraulic linear actuator (1) without any work fluid reservoir, comprising:

- an electric motor (A) of reversible direction of rotation,
- a reversible volumetric pump (B) driven by said motor,
- a hydraulic cylinder (3),
- a double effect piston (H) and mobile stem in said cylinder separating a first chamber (7) from a second chamber (8) functionally defined on opposite sides of the piston,
- a hydraulic circuit driven by said pump for introducing and drawing out hydraulic work fluid to and from said chambers (7, 8) comprising hydraulically piloted valves,
- a compressible air chamber of volumetric compensation (D) of thermal expansions/contractions,
- hydraulically piloted fluid path selecting means (E) connecting a work fluid side of said compressible air chamber of volumetric compensation (D) to the reversible pump suction branch of the hydraulic circuit,
- a pair of hydraulically piloted blocking valves (F) of respective conduits connecting said chambers (7, 8) to inlet/outlet ports of said pump (B),

spring biased safety pressure relief valves (G) in respective by-pass paths between pump suction and pump delivery branches of the hydraulic circuit,
wherein

a) said stem (2) projects out of only one end of said cylinder (3) and said fluid chambers (7, 8) have identical cross sectional areas;
b) said cylinder (3) is solidly connected to a fluid distribution base block (4) associated to a motor-pump assembly split block (4ex1, 4ex2), said mobile stem (2) is tubular, closed at the outer end by a cap (5) and adapter (10) assembly, and sealingly slides in and out of said fixed cylinder (3) and over a fixed inner stem (9) axially extending

from said fluid distribution base block (4) and having a longitudinal bore for hydraulically connecting an upper chamber (7) inside the end-capped tubular mobile stem (2) to the hydraulic circuit of the double effect piston, the circular cross sectional area of which is identical to the circular crown area of a lower chamber (8) defined between said tubular mobile stem (2) and said cylinder (3); **characterized in that**

c) said reversible pump (B) is embedded between a first part (4ex1) and a second part (4ex2) of said split block (4ex1, 4ex2), a shaft (14) of which is driven by said motor (A) through a magnetic coupling (C) installed inside the first part (4ex1) of the motor-pump assembly block;

d) at least a compressible air chamber of volumetric compensation (D) of thermal expansions/contractions is defined within one or more internal bores of said first part (4ex1) of said motor-pump assembly block;

e) said hydraulically piloted fluid path selecting means (E) are in form of two hydraulically piloted valves adapted to intercept work fluid pathways between the pump delivery branch and the pump suction branch of the hydraulic circuit, respectively, and at least the hydraulic fluid side of a compressible air chamber of volumetric compensation (D).

2. The electro-hydraulic linear actuator of claim 1, wherein said motor-pump assembly split block (4ex1, 4ex2) may be fastened to said cylinder base block (4) at different selectable inclinations, having a pin (11) partially extending in coaxial borings, respectively into the cylinder base block (4) and into the lower part (4ex2) of the motor-pump assembly split block, and circular grooves adapted to co-ordinately intercept hydraulic circuit conduits in the block (4ex2) and in the base block (4), internal fluid distribution conduits and O-ring seals, adapted to preserve circuital coherent fluid path continuity.

Patentansprüche

1. Ein integrierter, elektrohydraulischer Linearaktuator (1) ohne jegliches Reservoir für ein Arbeitsfluid, umfassend:

- einen Elektromotor (A) mit reversibler Drehrichtung,
- eine von dem besagten Motor angetriebene, reversible Volumenpumpe (B),
- einen Hydraulikzylinder (3),
- in dem besagten Zylinder einen doppelt wirkenden Kolben (H) samt beweglicher Kolbenstange, welcher eine erste Kammer (7) von einer zweiten Kammer (8) trennt, die von den gegenüber liegenden Seiten des Kolbens funktionell abgegrenzt sind,
- einen von der besagten Pumpe angetriebenen Hydraulikkreis zum Hineinleiten und Herausziehen eines hydraulischen Arbeitsfluids in und aus den besagten Kammern (7, 8), umfassend hydraulisch gesteuerte Ventile,
- eine Kammer (D) für komprimierbare Luft zur Volumenkompensation von thermischen Ausdehnungen/Kontraktionen,
- einem hydraulisch gesteuerten Mittel (E) zur Auswahl eines Fluid-Pfades, der eine einem Arbeitsfluid zugeordnete Seite der besagten Kammer (D) für komprimierbare Luft zur Volumenkompensation mit dem Saugzweig der reversiblen Pumpe des Hydraulikkreises verbindet,
- ein Paar von hydraulisch gesteuerten Absperrventilen (F) an den jeweiligen Leitungen, welche die besagten Kammern (7, 8) mit dein Einlass-/Auslassanschlüssen der besagten Pumpe (B) verbinden,
- federvorgespannte Sicherheits-Überdruckablassventile (G) in jeweiligen Umleitungs-Pfaden zwischen den Pumpensaug- und Pumpenförderzweigen in dem Hydraulikkreis,

wobei

a) die besagte Kolbenstange (2) nur aus einem Ende des besagten Zylinders (3) herausragt, und wobei die besagten Fluidkammern (7, 8) identische Querschnittsbereiche aufweisen;

b) wobei der besagte Zylinder (3) an einem Sockelblock (4) fest angeschlossen ist, welcher einem geteilten Block (4ex1, 4ex2) einer Motor-Pumpen-Baugruppe zugeordnet ist, wobei die besagte Kolbenstange (2) rohrförmig und an ihrem äußeren Ende durch eine Baugruppe mit einer Kappe (5) und einem Adapter (10) verschlossen ist, und dichtend in den besagten Zylinder (3) hinein und aus diesem heraus gleitet, sowie über einer festgelegten, inneren Stange (9), welche sich in axialer Richtung von dem besagten Sockelblock (4) zur Verteilung des besagten Fluids weg erstreckt und eine Längsbohrung aufweist zur hydraulischen Verbindung mit einer oberen Kammer (7) innerhalb der endseitig durch eine Kappe verschlossenen, rohrförmigen beweglichen Stange (2) des Hydraulikkreises des doppelt wirkenden Kolbens, dessen kreisförmiger Querschnittsbereich identisch zu dem kreisförmigen Kranzbereich der unteren Kammer (8) ist, die zwischen der besagten, beweglichen Kolbenstange (2) und dem besagten Zylinder (3) definiert ist; **dadurch gekennzeichnet, dass**

c) die reversible Pumpe (B) zwischen einem ersten Teil (4ex1) und einem zweiten Teil (4ex2) des besagten, geteilten Blockes (4ex1, 4ex2) eingebettet ist, wobei eine Welle (14) desselben von dem besagten Motor (A) über eine innerhalb eines ersten Teils (4ex1) der Motor-Pumpen-Blockbaugruppe angeordnete Magnetkupplung (C) angetrieben wird;
d) wenigstens eine Kammer (D) für komprimierbare Luft zur Volumenkompensation von thermischen Ausdehnungen/Kontraktionen innerhalb einer oder mehrerer innerer Bohrungen des besagten ersten Teils (4ex1) der besagten Motor-Pumpen-Blockbaugruppe abgegrenzt ist;
e) das besagte, hydraulisch gesteuerte Mittel (E) zur Auswahl eines Fluid-Pfades die Form von zwei hydraulisch gesteuerten Ventilen hat, welche geeignet sind, Pfade für das Arbeitsfluid zwischen dem Pumpenförderzweig bzw. dem Pumpensaugzweig des Hydraulikkreises und wenigstens einer dem Hydraulikfluid zugeordneten Seite der Kammer (D) für komprimierbare Luft zur Volumenkompensation zu unterbrechen.

2. Der elektrohydraulische Linearaktuator nach Anspruch 1, wobei die besagte, geteilte Motor-Pumpen-Blockbaugruppe (4ex1, 4ex2) an dem besagten Zylinder-Sockelblock (4) unter verschiedenen, auswählbaren Neigungen befestigbar ist, mit einem Stift (11), der sich teilweise in koaxialen Bohrungen in dem Zylindersockelblock (4) und in dem unteren Teil (4ex2) der geteilten Motor-Pumpen-Blockbaugruppe erstreckt, mit kreisförmigen Nuten, welche in der Lage sind, koordiniert die Leitungen des Hydraulikkreises in dem Block (4ex2) und in dem Sockel block (4) zu unterbrechen, mit internen Fluidverteilungsleitungen und O-Ring-Dichtungen, welche in der Lage sind, in dem Kreis eine kohärente Kontinuität des Fluidpfades zu erhalten.

Revendications

1. Actionneur linéaire électrohydraulique intégré (1) sans aucun réservoir de fluide de travail, comprenant :

- un moteur électrique (A) de direction de rotation réversible,
- une pompe volumétrique réversible (B) entraînée par ledit moteur,
- un cylindre hydraulique (3),
- un piston à double effet (H) et une tige mobile dans ledit cylindre séparant une première chambre (7) d'une seconde chambre (8) fonctionnellement définies sur les côtés opposés du piston,
- un circuit hydraulique entraîné par ladite pompe pour introduire et retirer le fluide de travail hydraulique dans et hors desdites chambres (7, 8) comprenant des valves pilotées hydrauliquement,
- une chambre à air compressible de compensation volumétrique (D) d'expansions/contractions thermiques,
- des moyens de sélection de trajectoire de fluide pilotés hydrauliquement (E) raccordant un côté de fluide de travail de ladite chambre à air compressible de compensation volumétrique (D) à la branche d'aspiration de la pompe réversible du circuit hydraulique,
- une paire de valves de blocage pilotées hydrauliquement (F) de conduits respectifs raccordant lesdites chambres (7, 8) aux orifices d'entrée/sortie de ladite pompe (B),

des valves de décharge de pression de sécurité sollicitées par ressort (G) dans des trajectoires de dérivation respectives entre les branches d'aspiration de pompe et de distribution de pompe du circuit hydraulique, dans lequel

a) ladite tige (2) fait saillie hors d'une seule extrémité dudit cylindre (3) et lesdites chambres de fluide (7, 8) ont des surfaces de section transversale identiques ;
b) ledit cylindre (3) est solidement raccordé à un bloc de base de distribution de fluide (4) associé à un bloc fendu d'ensemble de moteur-pompe (4ex1, 4ex2), ladite tige mobile (2) est tubulaire, fermée au niveau de l'extrémité externe par un ensemble de capuchon (5) et d'adaptateur (10), et coulisse de manière étanche à l'intérieur et l'extérieur dudit cylindre fixe (3) et sur une tige interne fixe (9) s'étendant de manière axiale à partir dudit bloc de base de distribution de fluide (4) et ayant un alésage longitudinal pour raccorder hydrauliquement une chambre supérieure (7) à l'intérieur d'une tige mobile tubulaire à extrémité recouverte (2) au circuit hydraulique du piston à double effet, dont la surface de section transversale circulaire est identique à la surface de couronne circulaire d'une chambre inférieure (8) définie entre ladite tige mobile tubulaire (2) et ledit cylindre (3) ; **caractérisé en ce que**
c) ladite pompe réversible (B) est encastrée entre une première partie (4ex1) et une seconde partie (4ex2) dudit bloc fendu (4ex1, 4ex2), dont un arbre (14) est entraîné par ledit moteur (A) par un couplage magnétique (C) installé à l'intérieur de la première partie (4ex1) dudit bloc d'ensemble de moteur-pompe ;
d) au moins une chambre à air compressible de compensation volumétrique (D) d'expansions/contractions

thermiques est définie à l'intérieur d'un ou de plusieurs alésages internes de ladite première partie (4ex1) dudit bloc d'ensemble de moteur-pompe ;

e) lesdits moyens de sélection de trajectoire de fluide pilotés hydrauliquement (E) se présentent sous la forme de deux valves pilotées hydrauliquement, adaptées pour intercepter des voies de passage de fluide de travail entre la branche de distribution de pompe et la branche d'aspiration de pompe du circuit hydraulique, respectivement, et au moins le côté de fluide hydraulique d'une chambre à air compressible de compensation volumétrique (D).

2. Actionneur linéaire électrohydraulique selon la revendication 1, dans lequel ledit bloc fendu d'ensemble de moteur-pompe (4ex1, 4ex2) peut être fixé audit bloc de base de cylindre (4) à différentes inclinaisons pouvant être sélectionnées, ayant une broche (11) s'étendant partiellement dans des alésages coaxiaux, respectivement dans le bloc de base de cylindre (4) et dans la partie inférieure (4ex2) du bloc fendu d'ensemble de moteur-pompe et des rainures circulaires adaptées pour intercepter de manière coordonnée des conduits de circuit hydraulique dans le bloc (4ex2) et dans le bloc de base (4), des conduits de distribution de fluide internes et des joints toriques, adaptés pour préserver la continuité de la trajectoire de fluide cohérente de circuit.

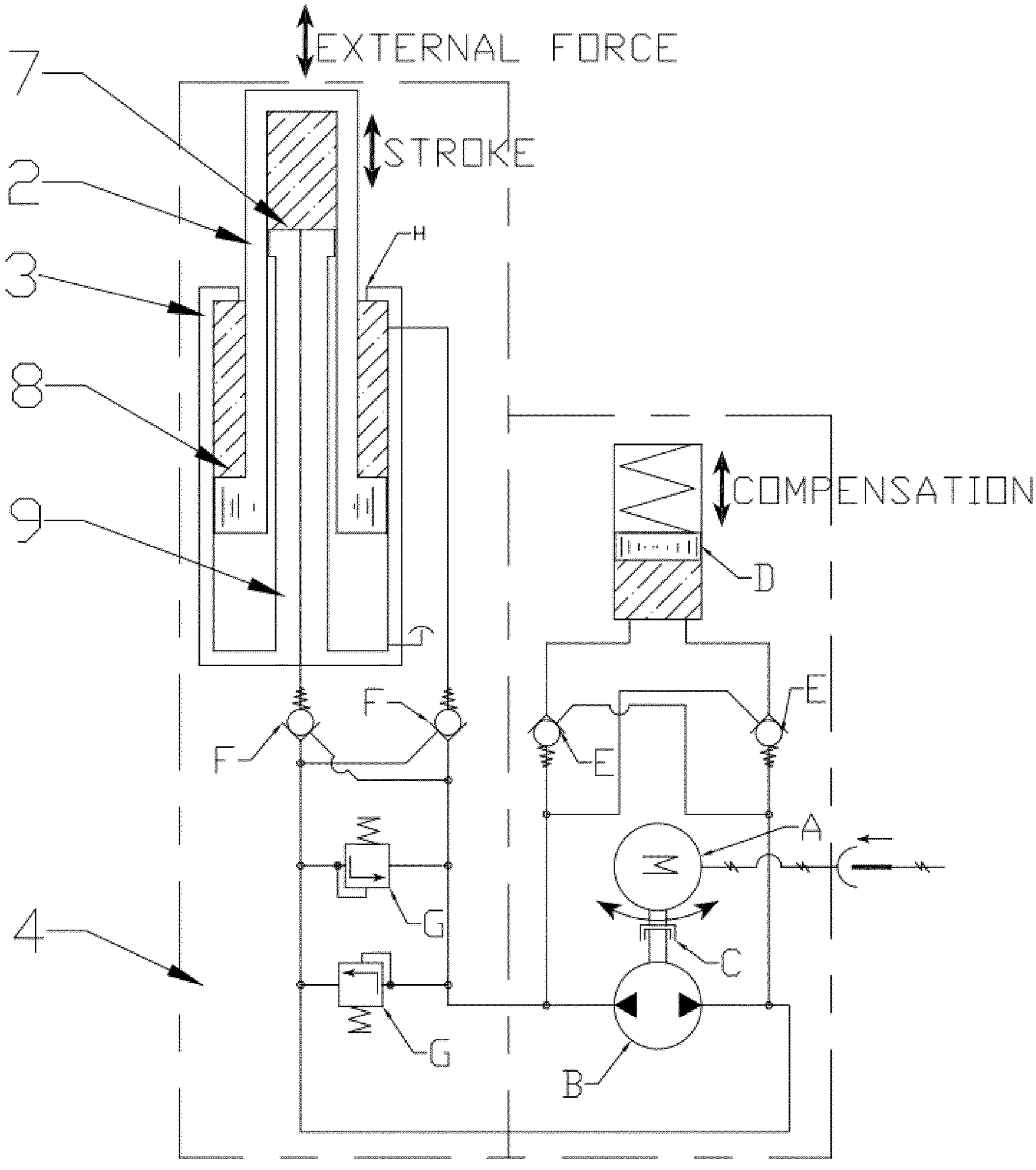


FIG. 1

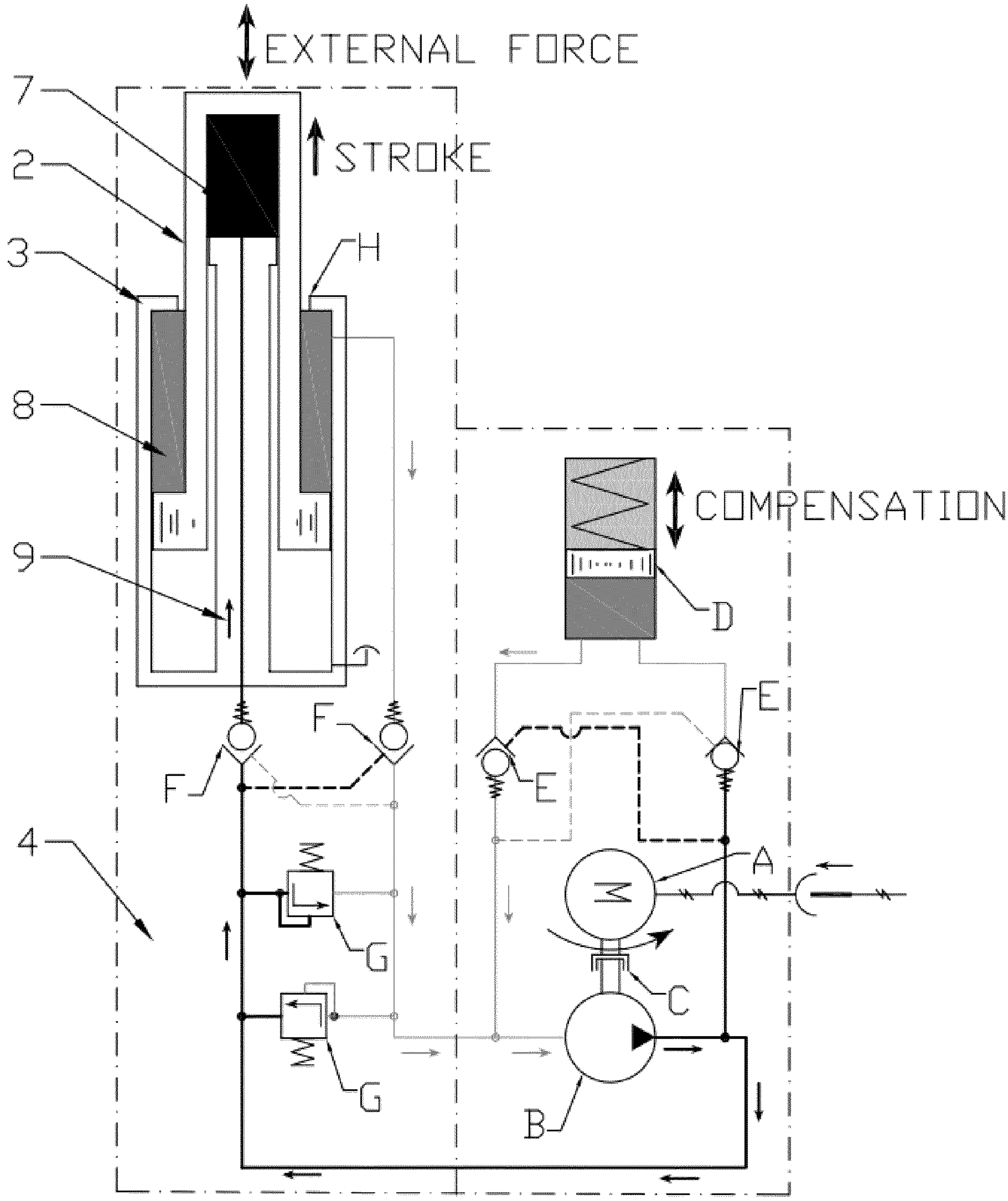


FIG. 2

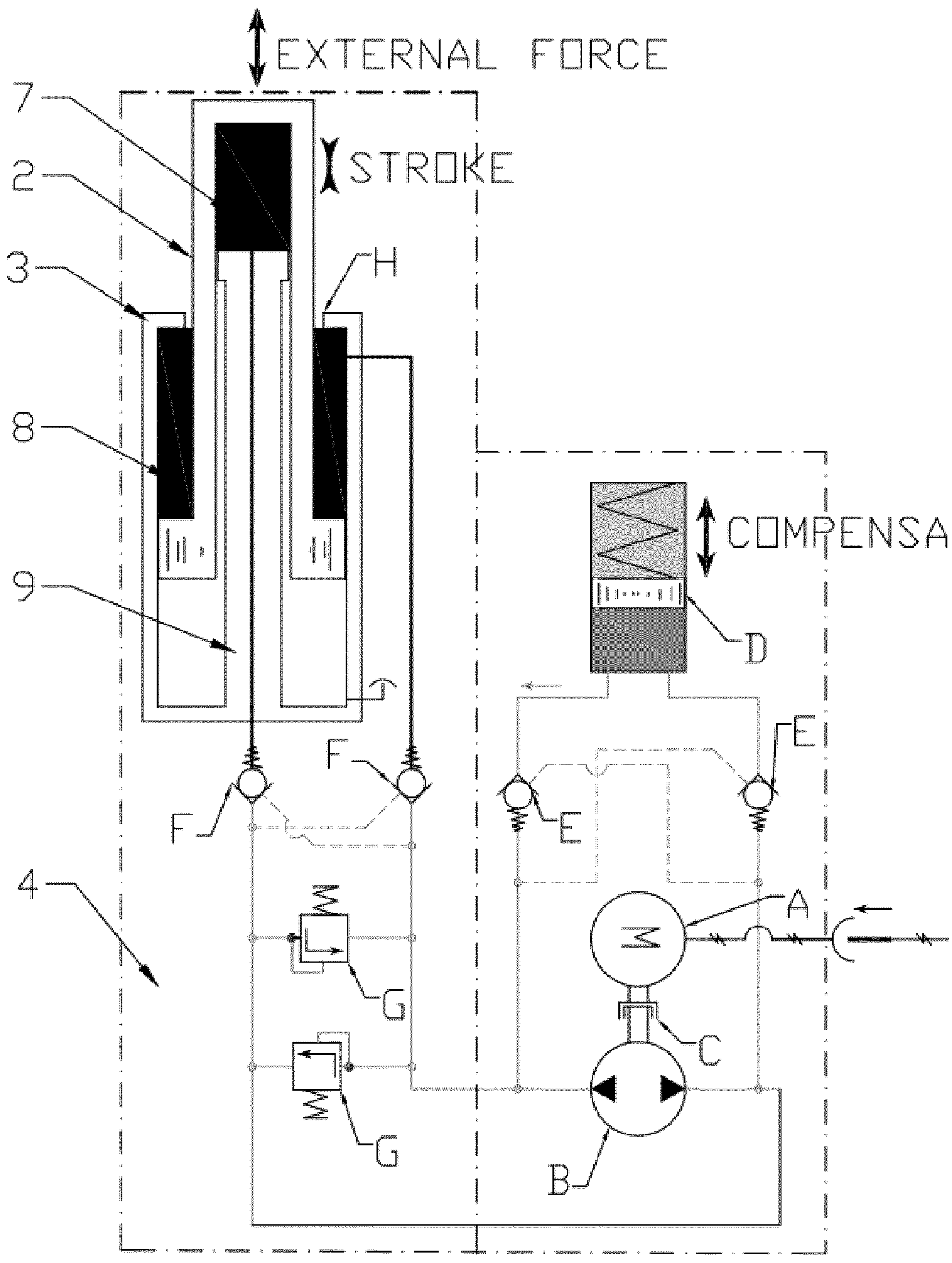
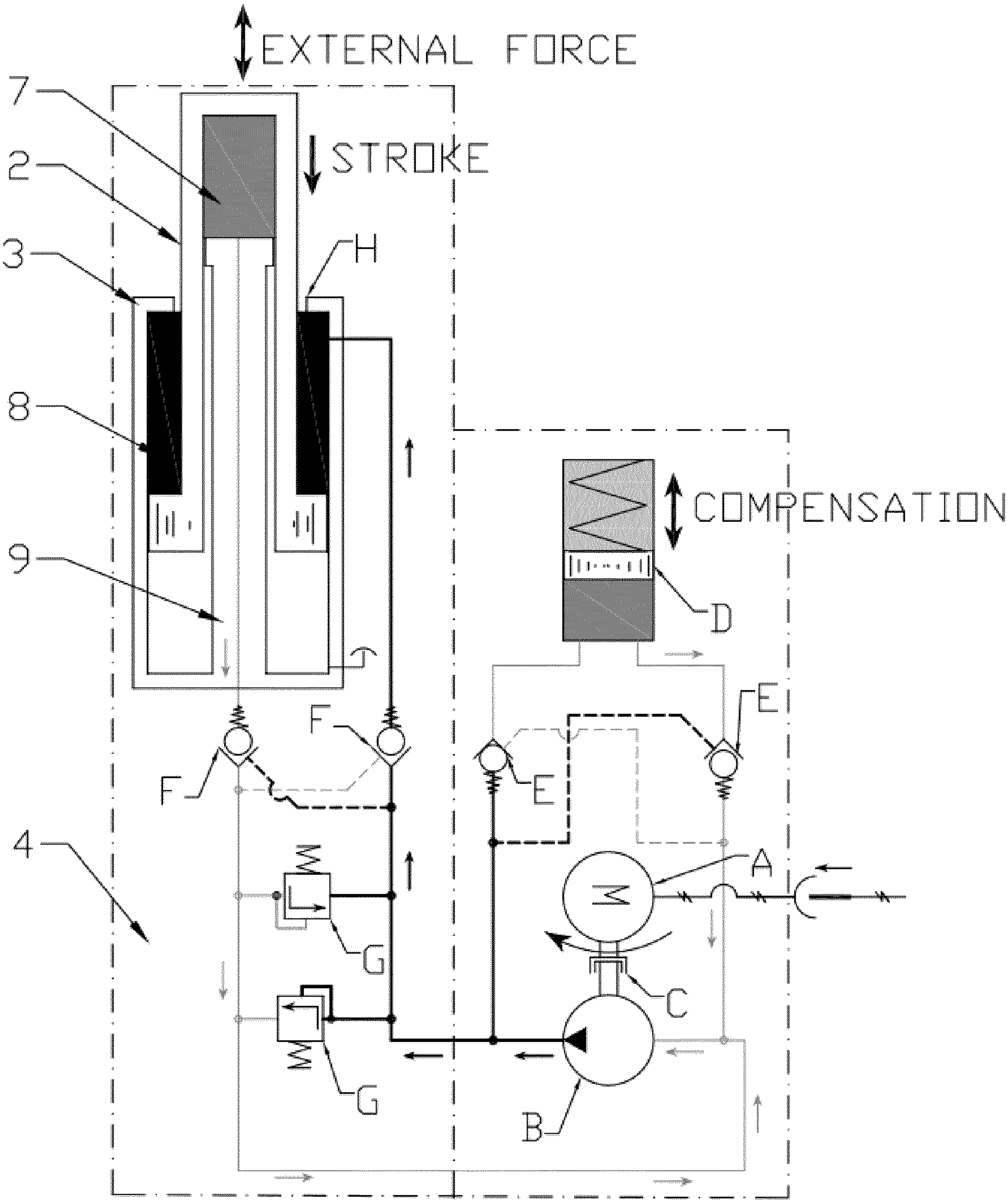


FIG. 3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STROKE
COMPENSATION
7
2
3
H
8
9
J
D
F
F
E
E
4
A
M
G
C
G
B

FIG. 4

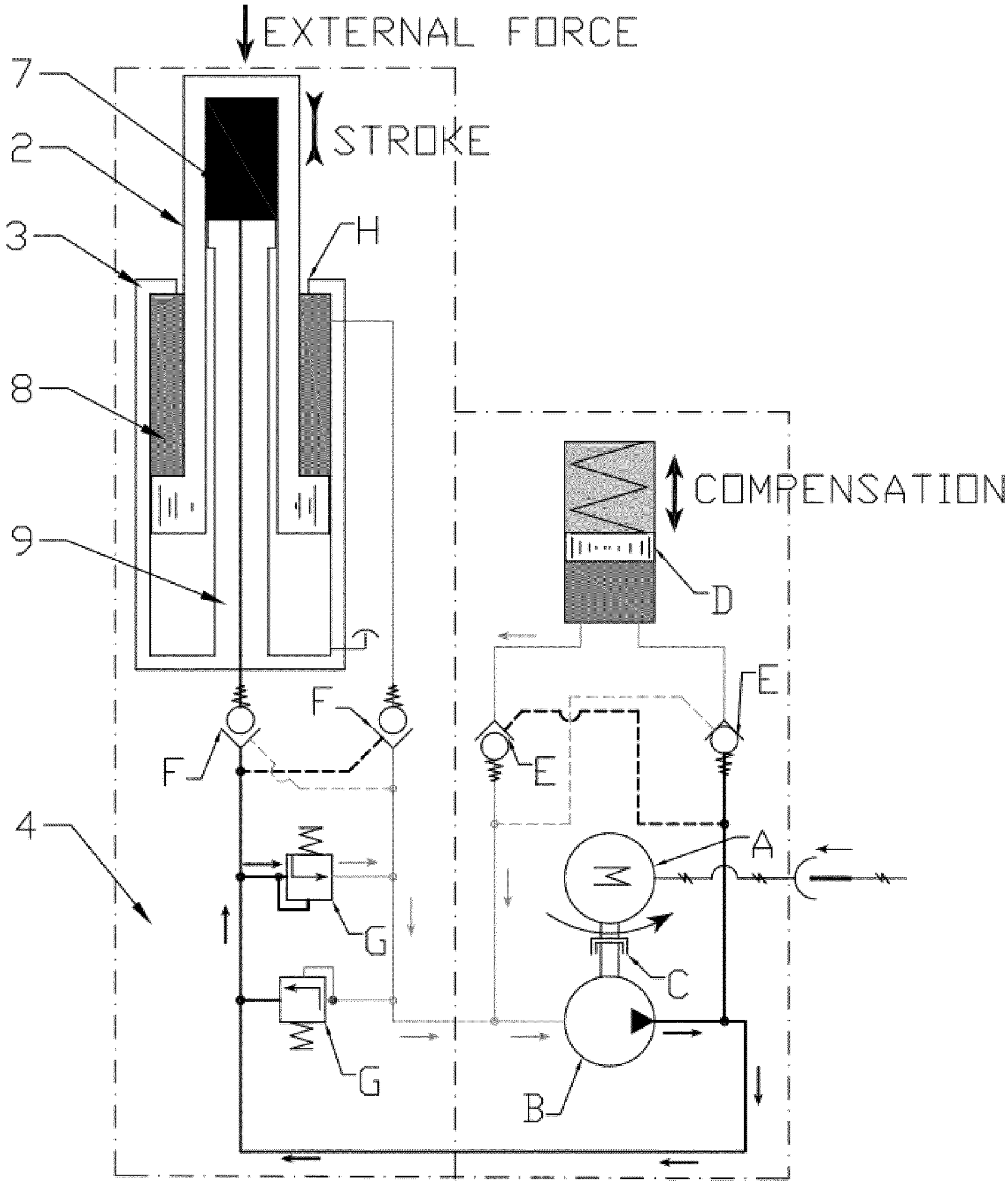

FIG. 5a

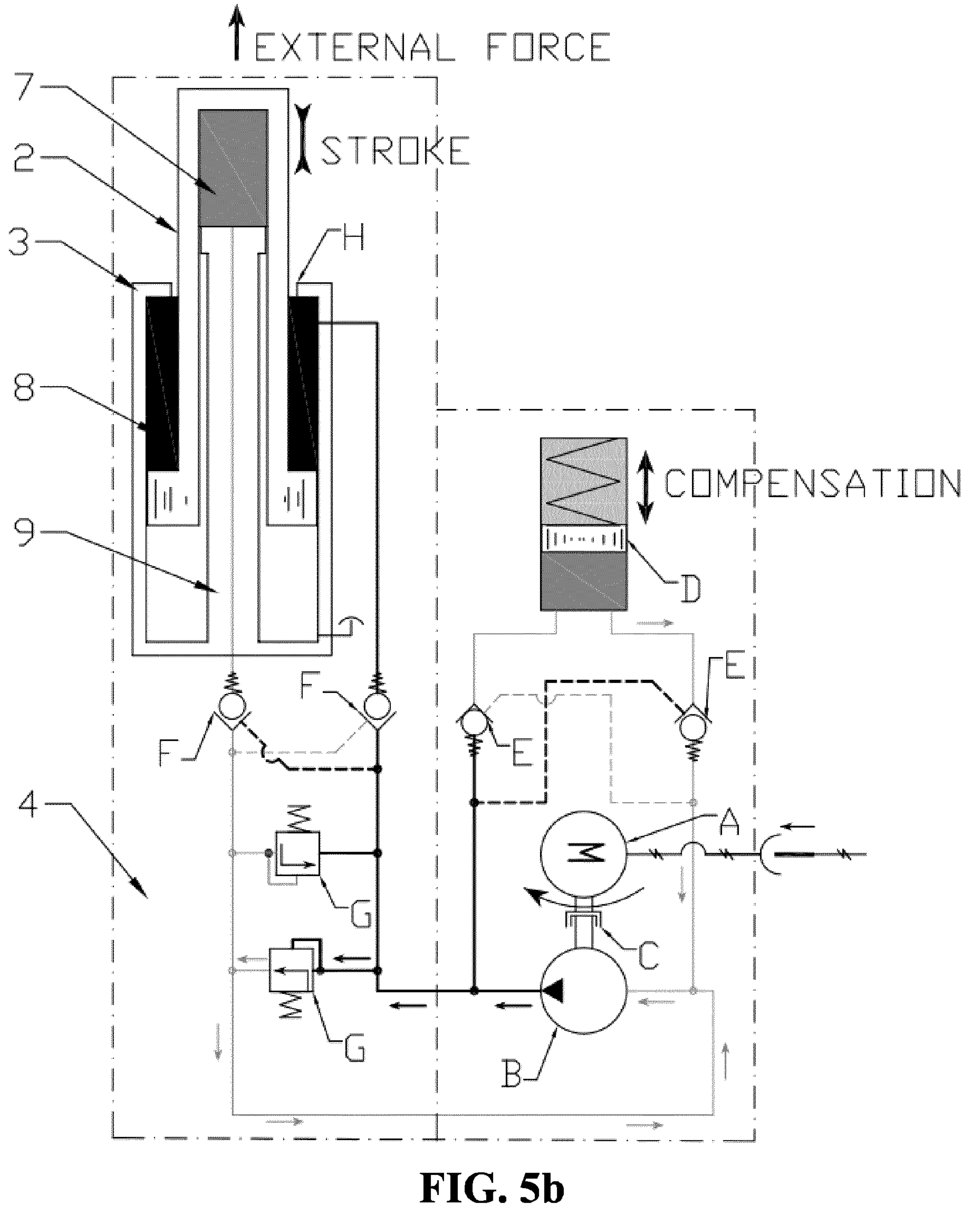
EXTERNAL FORCE
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FIG. 5b

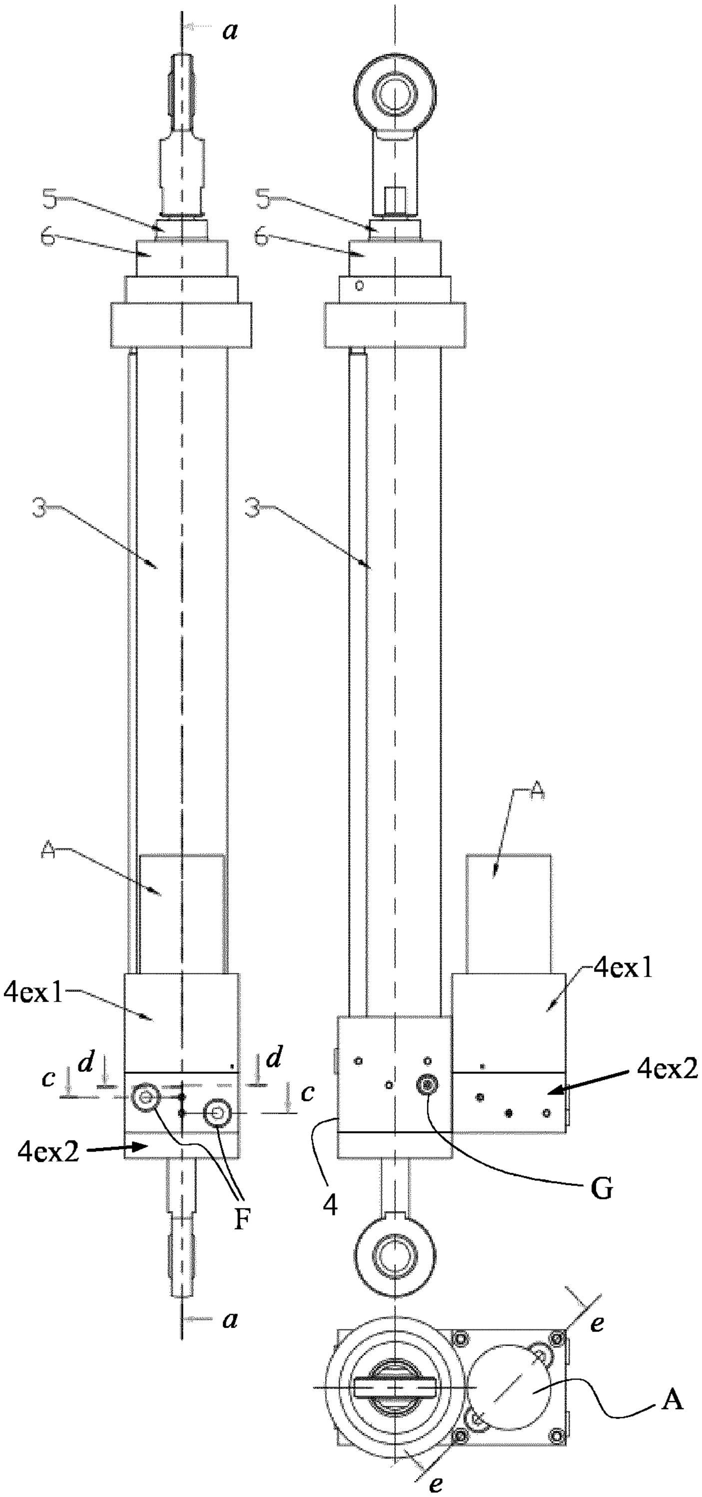

FIG. 6

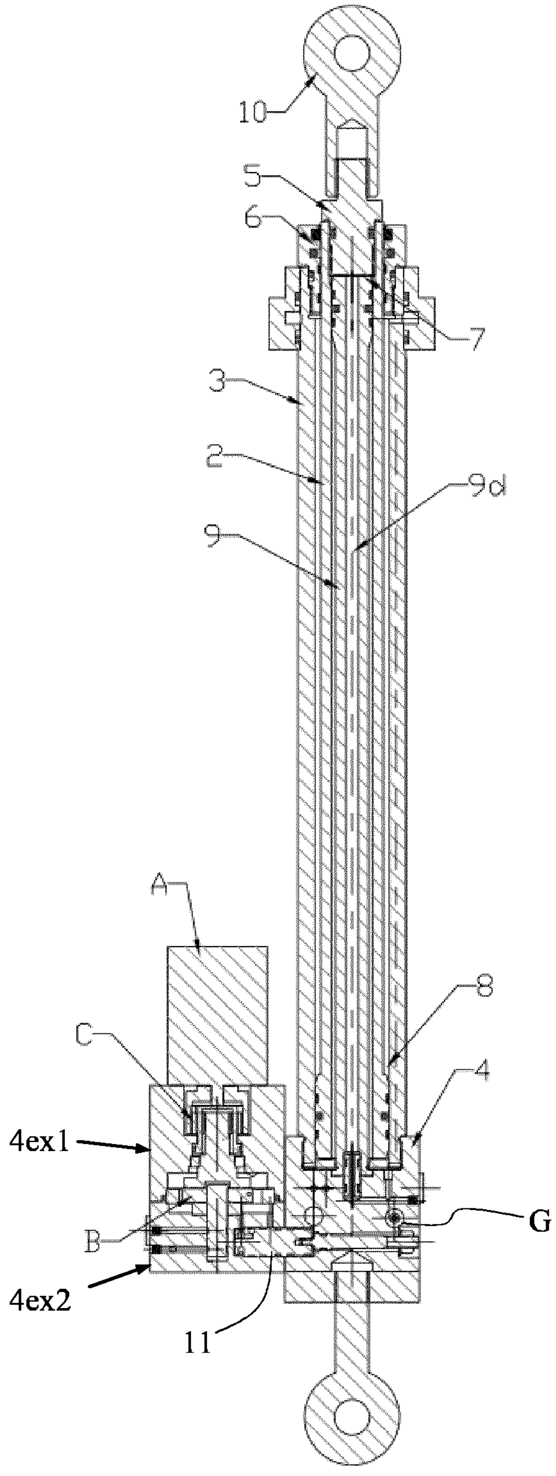

FIG. 7

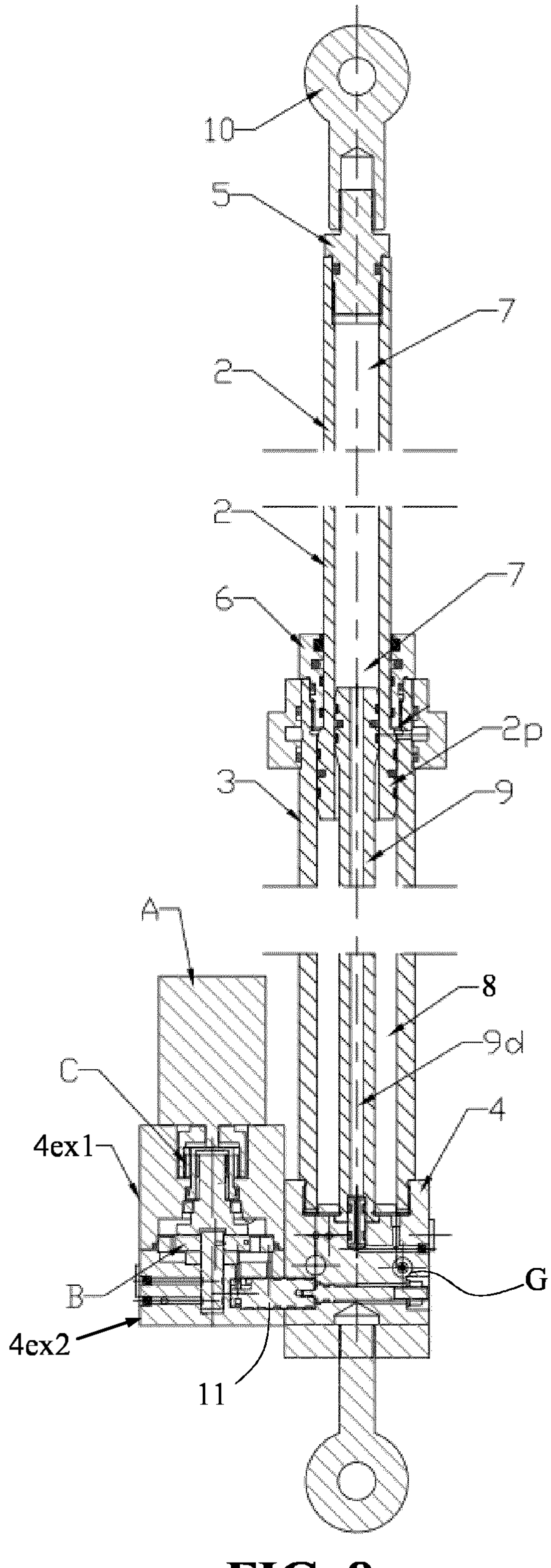

FIG. 8

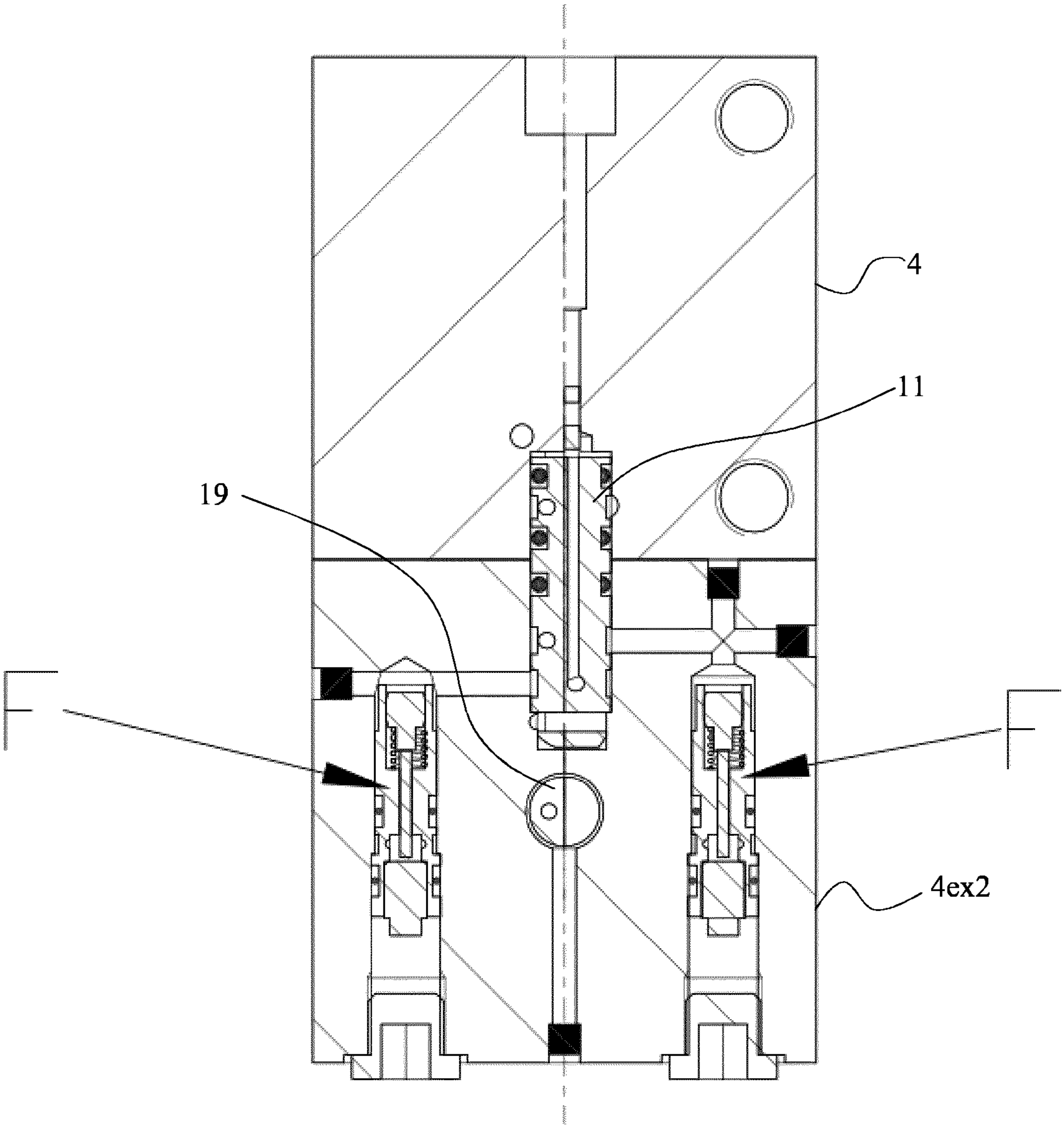

FIG. 9

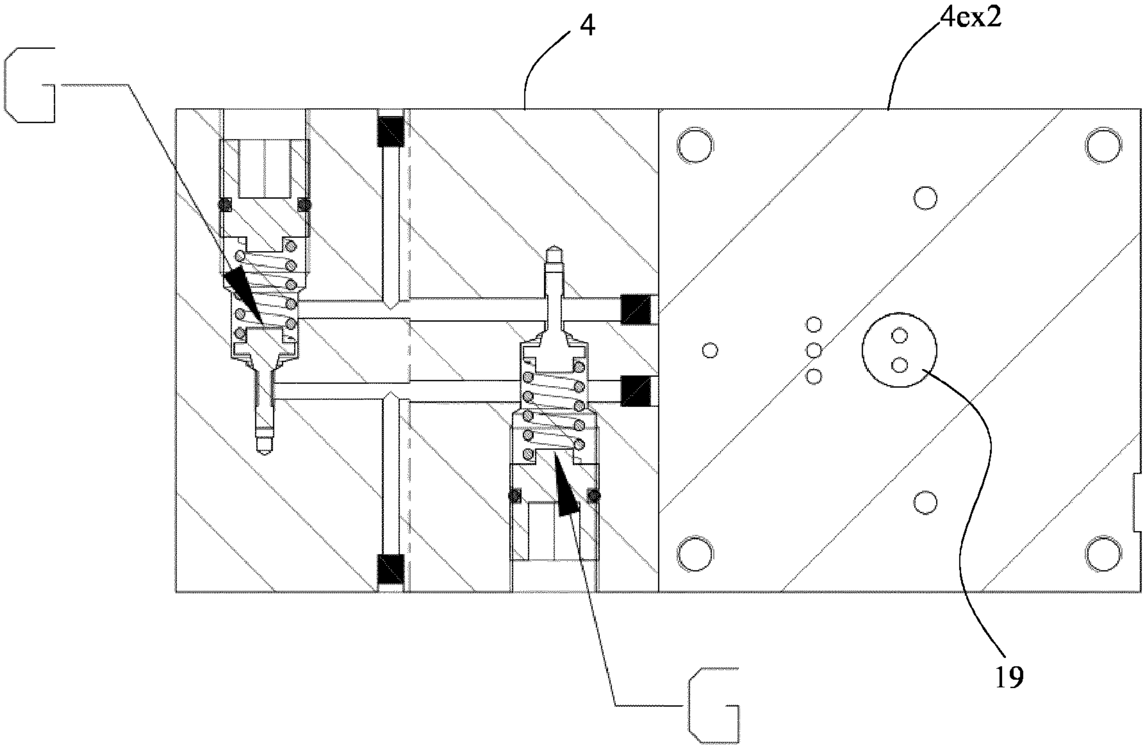

FIG. 10

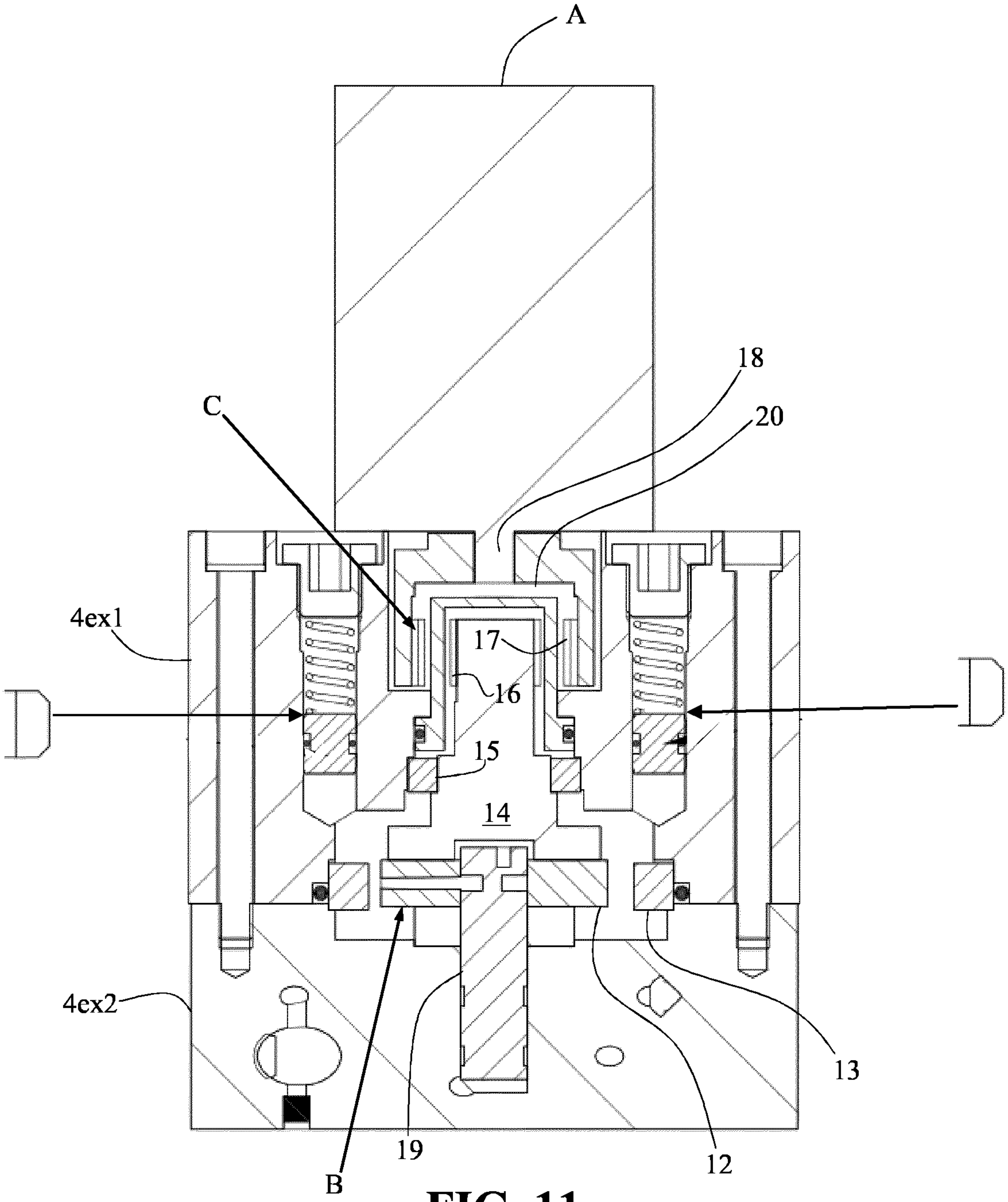

FIG. 11

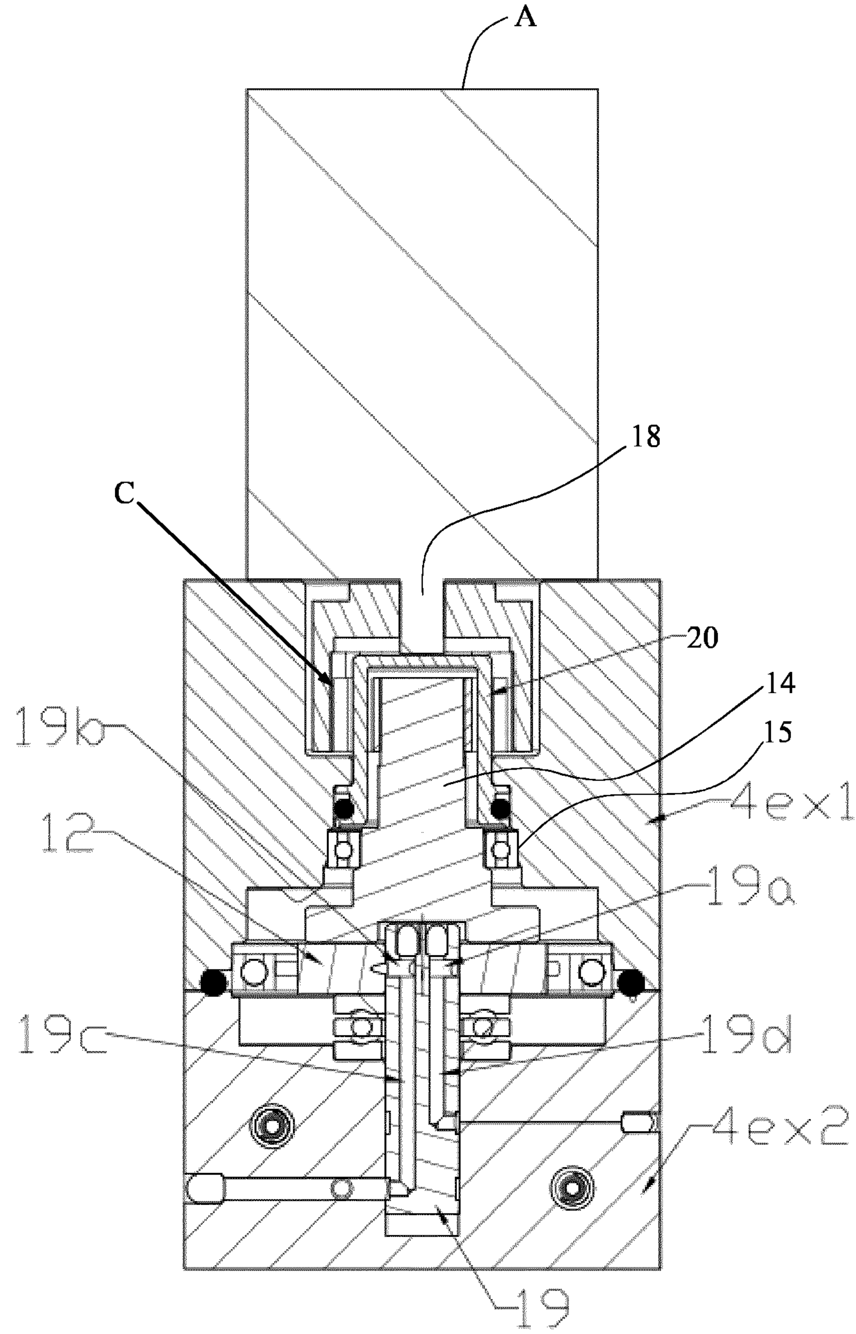

FIG. 12

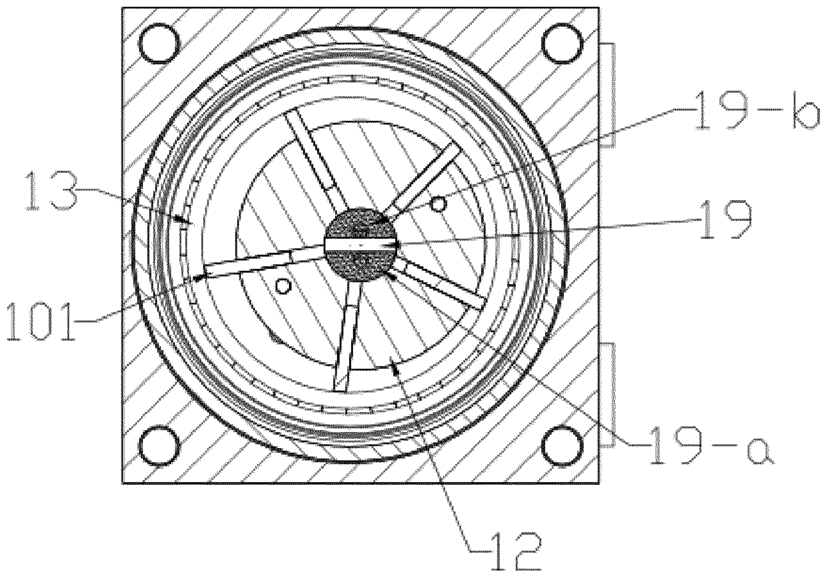

FIG. 13

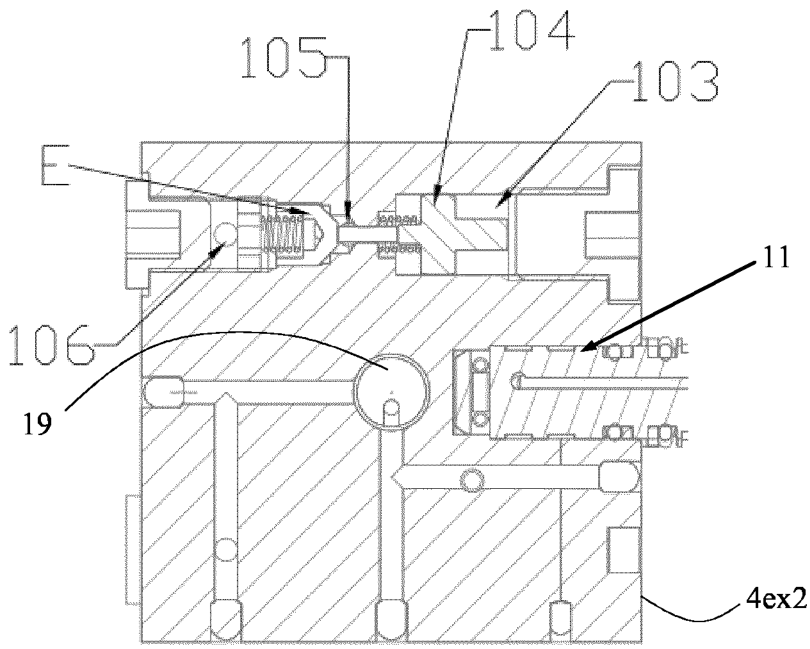

FIG. 14

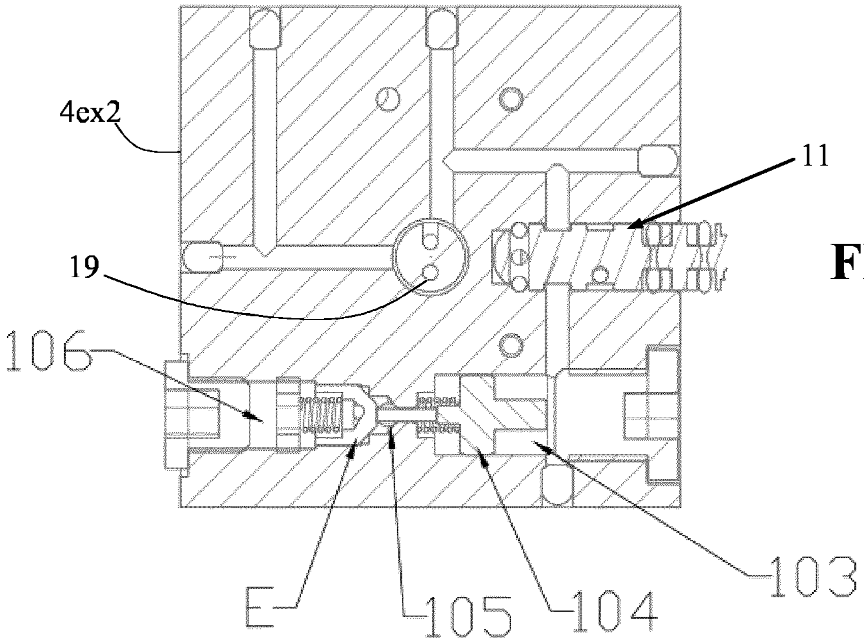

FIG. 15

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- CA 2313943 **[0010]**