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(54) **DOUBLE-ACTING HYDRAULIC CYLINDERS**

(57) A double-acting hydraulic cylinder which can be connected to means for supplying and discharging a working fluid, comprising a jacket **(10)** internally comprising a working chamber (**30**) having a longitudinal extension defining an axis (**X**) and a plunger (**20**) sealingly inserted into the jacket (**10**) to partition said working chamber (**30**) into at least one first and second variable volume half-chamber (**100**, **200**). The plunger (**20**) and the jacket (**10**) are mutually slidable along the axis (**X**) between at least one first operative position and a second operative position. The cylinder includes a locking device (**500**) for blocking the mutual sliding of the plunger (**20**) and of the jacket (**10**) which can be removably inserted into the jacket (**10**).

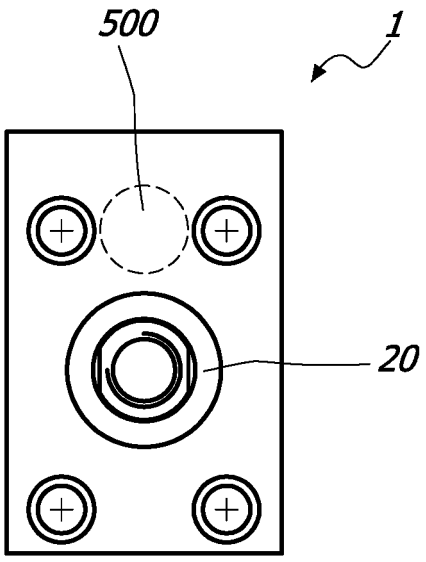

FIG. 1

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Description

Field of the invention

[0001] The present invention generally relates to the technical field of hydraulic cylinders, and it particularly relates to a lockable double-acting hydraulic cylinder.

State of the Art

[0002] Double-acting hydraulic cylinders, that is cylinders in which the sliding is controlled in both the sliding directions of the plunger, and in particular compact cylinders, are known.

[0003] As known, in order to regulate the inflow/outflow of oil from the cylinder, oil circuits comprising pumps and a plurality of ducts and fittings for fluidically connecting the pumps with the cylinder, are provided for.

[0004] It is clear that such systems have large overall dimensions which hinder operators in proximity of the machine in which the cylinder is installed.

[0005] Therefore, to this end, circuits in which the ducts are relatively very long so as to position the pumps and the motors away from the cylinder, are generally used.

[0006] In order to overcome the response delay between the control of the pump of the hydraulic circuit, for example shutting off the flow, and the ensuing action of the plunger, for example blocking the sliding, there is known the use of one or more "blocking valves" arranged externally along the ducts in proximity of the cylinder.

[0007] The drawback of such systems lies in the fact that it is particularly cumbersome, given that the circuits and the fittings in proximity of the blocking valve require a minimum radius of curvature due to the high oil pressures inside the ducts

[0008] Furthermore, the use of such blocking valves entails the use of a plurality of fittings, each of which must be mounted and closed correctly as well as constantly monitored to avoid leakage. A leak could mean, for example, that a pressing machine closes unintentionally, with all the ensuing risks.

[0009] Lastly, such blocking valves must necessarily be positioned at a certain distance from the cylinder both for safety reasons (it is necessary to prevent an operator or a machine from impacting against such blocking valves) and for practicability and encumbrance purposes, therefore resulting in a response delay between the blocking action and the actual blocking of the plunger.

Summary of the invention

[0010] An object of the present invention is to at least partly overcome the aforementioned drawbacks, by providing a hydraulic cylinder that is highly functional, easy to manufacture and cost-effective.

[0011] Another object of the present invention is to provide a lockable hydraulic cylinder.

[0012] Another object of the present invention is to provide a lockable hydraulic cylinder that is particularly safe.

[0013] Another object of the present invention is to provide a lockable hydraulic cylinder with small overall dimensions.

[0014] Another object of the present invention is to provide a lockable hydraulic cylinder with low response delay.

[0015] A further object of the present invention is to provide a locking device that is highly functional, easy to manufacture and cost-effective.

[0016] Another object of the present invention is to provide a locking device with particularly small overall dimensions.

[0017] Another object of the present invention is to provide a locking device that is easy to assemble.

[0018] These and other objects that will be more apparent hereinafter, are attained by a hydraulic cylinder as described, illustrated and/or claimed herein.

Brief description of the drawings

[0019] Further characteristics and advantages of the invention will be more apparent in light of the detailed description of some preferred but non-exclusive embodiments of the invention, illustrated by way of non-limiting example with reference to the attached drawings, wherein:

FIGS. 1, 2A and **2B** are respectively a front, top and lateral view of a hydraulic cylinder 1;

FIGS. 3, **5** and **7** are a lateral cross-sectional view of the hydraulic cylinder **1** in different operating steps;

FIGS. 4, 6 and **8** are an enlarged view of some details of a locking device **500** in the configurations corresponding to the configurations of the cylinder of respectively FIGS. 3, 5 and 7;

FIGS. 9, 10 and **11** are respectively a front, top and lateral view of a different embodiment of a hydraulic cylinder **1**;

FIGS. 12, 13 and **14** are respectively a front, top and lateral view of a different embodiment of a hydraulic cylinder **1**;

FIGS. 15, 16 and **17** are respectively a front, top and lateral view of a different embodiment of a hydraulic cylinder **1**;

FIG. 18 is a lateral cross-sectional view of a different embodiment of a hydraulic cylinder **1**;

FIG. 19 is a cross-sectional view of an embodiment of the locking device **500** which can be used in a hydraulic cylinder **1**;

FIG. 20 is an exploded view of the locking device **500**;

FIG. 21 is a partially cross-sectional view of a different embodiment of the locking device **500**.

Detailed description of some preferred embodiments

[0020] With reference to the attached figures, herein

described is a hydraulic cylinder **1.** This hydraulic cylinder **1** can be used in actuation systems.

[0021] Essentially, the cylinder **1** may therefore comprise a jacket **10** and a plunger **20** inserted in the jacket **10.** The jacket **10** and the plunger **20** may therefore slide mutually.

[0022] For the sake of simplicity, hereinafter reference will be made only to the sliding of the plunger **20** with respect to the jacket **10.**

[0023] The sliding of the plunger **20** may be promoted by a working fluid, for example oil, in a per se known manner. In particular, the cylinder **1** may preferably be a so-called "double-acting" cylinder, that is it may be effective in both the sliding directions of the plunger **20.**

[0024] The cylinder **1** may therefore internally comprise a working chamber **30** inside which the piston **20** may slide. The working chamber **30** can be a fluidically-closed chamber, and the oil may flow thereinto or therefrom only by means of suitable openings and circuits, as better explained hereinafter.

[0025] In particular, the jacket **10** may comprise a substantially cylindrical blind hole **11** which may define an axis **X.** On the other hand, the plunger **20** may sealingly slide into the blind hole **11** along the same axis **X.** The blind hole **11** may therefore define the working chamber **30.**

[0026] The working chamber **30** may comprise a lateral surface **33** and a pair of bottom walls **31** and **32.** In a per se known manner, the plunger **20** may comprise a stem **21** which may pass through one of the bottom walls **31.** In this case, a closing element **40** which is sealingly coupled to the jacket **10** may be provided for, and it may cooperate with the hole **11** in order to internally define the working chamber **30.**

[0027] The plunger **20** may be sealingly inserted into the working chamber **30** so as to partition it into at least one first half-chamber **100** and one second half-chamber **200.** The half-chambers **100** and **200** may have a variable volume.

[0028] For example, the plunger **20** may slide between at least one end-of-stroke position in which the half-chamber **100** has a maximum volume and the half-chamber **200** has a minimum volume and at least one start-of-stroke position in which the half-chamber **100** has a minimum volume and the half-chamber **200** has a maximum volume.

[0029] FIGS. 3, 5 and 7 show different positions of the plunger **20** in the chamber **30.** In particular, FIG. 3 shows a position close to the end-of-stroke position, FIG. 7 shows a position close to the start-of-stroke position, while FIG. 5 shows an intermediate position between the previous ones.

[0030] The cylinder **1** may comprise an opening **111** which can be fluidically connected with external hydraulic circuits, an opening **112** fluidically connected with the working chamber **100** and a hydraulic circuit **110** extending between the openings **111** and **112.** The cylinder **1** may further comprise an opening **211** which can be fluidically connected with external hydraulic circuits, an opening **212** fluidically connected with the working chamber **200** and a hydraulic circuit **210** extending between the openings **211** and **212.**

[0031] Preferably, the jacket **10** may comprise the openings **111**, **211** and **112**, **212.** In particular, the operating chamber **30** may include the openings **112**, **212**, so that they allow the oil to flow into or out from the half-chambers **100**, **200.**

[0032] The openings **111**, **211** may be accessible from the outside so that they can be fluidically connected with an external hydraulic circuit. Coupling means of the known type may be possibly provided for arranged at the openings **111**, **211** so as to allow the connection of the latter with such external hydraulic circuits. Preferably, the openings **111**, **211** may be arranged on the same face of the jacket **10.**

[0033] According to a particular aspect of the invention, the cylinder **1** may be substantially parallelepiped-shaped so that the overall dimensions are particularly small. It is clear that the cylinder **1** may be substantially cylindrical-shaped without departing from the scope of protection of the present invention.

[0034] Preferably, the jacket **10** may have a pair of base surfaces **12**, **13** and a lateral surface **14** interposed between the base surfaces **12**, **13.** The latter may be substantially perpendicular to the axis **X**, while the lateral surfaces **14** may all be parallel to the axis **X.**

[0035] Preferably, the jacket **10** may be parallelepiped-shaped and the lateral surfaces **14** may be four lateral faces.

[0036] The base surface **12** may comprise the hole **11.** The openings **111**, **211** may be arranged at the lateral surface **14** of the jacket **10**, both for example on one of the faces of the surface **14.**

[0037] The openings **112**, **212** may be arranged in proximity of the bottom wall **31**, **32** of the operating chamber **30.** For example, should the half-chamber **100** comprise the stem **21** of the plunger **20**, the lateral surface **33** of the chamber **30** may comprise the opening **112** which may be in proximity of the bottom wall **31.** On the other hand, the opposite bottom wall **32** of the chamber **30** may comprise the opening **212.**

[0038] In other words, the circuits **110**, **210** may be inside the jacket **10.**

[0039] The cylinder **1** may comprise at least one device **500** for blocking the sliding of the plunger **20.** Thanks to such device **500**, advantageously, the plunger **20** may be blocked in any position. For example, in the start-of-stroke position, the end-of-stroke position or in one or more intermediate positions.

[0040] In general, the locking device **500** may interact with the circuits **110**, **210** so as to selectively allow/prevent the through-flow of the oil therethrough and thus allow/prevent the inflow or the outflow of the oil into/from the half-chambers **100**, **200** and therefore allow or prevent (that is block) the sliding of the piston **20.**

[0041] Preferably, the jacket **10** may comprise a seat

15 for such locking device **500.** The latter may be removably insertable/removable into/from the seat **15** as better explained hereinafter.

[0042] In particular, once inserted into the seat **15**, the locking device **500** may be inside the jacket **10** and therefore in proximity of the half-chambers **100**, **200.** Thanks to this characteristic, the response delay can be particularly low, almost zero.

[0043] One or both of the circuits **110**, **210** may comprise the seat **15.** In this manner, the oil flowing between the openings **111**, **211** and **112**, **212** may pass through the seat **15** so as to shut off the locking device **500.**

[0044] Suitably, the seat **15** may comprise a pair of openings **113 114** fluidically connected respectively with the openings **111** and **112** and a pair of openings **213**, **214** fluidically connected respectively with the openings **211** and **212.**

[0045] Advantageously, therefore, the hydraulic circuits **110**, **210**, and preferably also the locking device **500**, may remain inside the jacket **10.** Thanks to this characteristic, the cylinder **1** may be extremely compact, have small overall dimensions, and it may be particularly safe. Furthermore, this may allow to prevent accidental damage caused by an operator or by a machine from affecting the ducts of the locking means, causing the release of the plunger with the possible serious consequences resulting therefrom.

[0046] The jacket **10** may comprise a hole **16** defining the seat **15**. In other words, the locking device **500** may be inserted in the hole **16** in a removable manner.

[0047] The locking device **500** and the hole **16** may be mutually configured so that once the locking device **500** has been inserted into the hole **16**, the former shuts off the oil flowing through the circuits **110**, **210**.

[0048] Preferably, the hole **16** may be substantially cylindrical-shaped.

[0049] The hole **16** may define an axis **X'** which may - preferably but not exclusively - be parallel to the axis **X** of the chamber **30**, for example as shown in FIG. 5. Possibly, the hole **16** may be configured so that the axis **X'** is substantially perpendicular to the axis **X**, for example as shown in FIG. 18.

[0050] Preferably, the locking device **500** may be substantially cylindrical-shaped defining an axis **Y.** Preferably, once the locking device **500** has been inserted in the hole **16**, the axes **Y** and **X'** may substantially coincide.

[0051] In particular, for example as schematically shown in FIGS. 1, 9, 12 and 15, the axis **Y** of the hole **16** may be substantially parallel to the sliding axis **X** and spaced therefrom. On the other hand, as schematically shown in FIG. 18, the axis **Y** of the hole **16** may be substantially perpendicular to the axis **X.**

[0052] The seat **15** and the locking device **500** may be mutually configured so that the latter remains entirely contained in the seat **15** so as not to protrude from the jacket **10.**

[0053] Advantageously, the blind hole **16** may be cylindrical and it may have - on one side - the circular bottom wall **162** and - on the opposite side - a circular opening **163** so to allow the insertion of the locking device **500.**

[0054] The surface **13** or **14** may comprise such opening **163.** Preferably, the surface **13** opposite the surface **12** may comprise such opening **163.**

[0055] The locking device **500** may be removably inserted into the hole **16** through the opening **163.**

[0056] This characteristic may allow an easy maintenance of the cylinder and/or replacement of the locking device **500**, which is the most sensitive and less durable part. Furthermore, the opening **163** may always remain accessible from outside, allowing the disengagement of the locking device **500** without having to disassemble the cylinder or the plunger **20** or open the jacket **10.**

[0057] The locking device **500** and the hole **16** may be mutually sized so that the locking device **500** may remain inside the hole **16** so as not to protrude from the surface **13.** For example, the locking device **500** may have a length substantially equal to or slightly smaller than the length of the hole **16.**

[0058] Suitably, a closing element **570** may be provided for to keep the locking device **500** in the hole **16.** For example, the closing element **570** may be a threaded plug screwed into the hole **16** which may comprise a corresponding counter-threading.

[0059] The plug **570** may possibly protrude from the hole **16** so as to have a vacant end **575** accessible by the operator. In this case, advantageously, such end **575** may facilitate the operations for removing the locking device **500** from the hole **16.**

[0060] The plug **570** may be sealingly screwed at the end **163** so that the hole **16** - once closed - may define a working chamber.

[0061] Suitably, the hole **16** may comprise the openings **113**, **114** and **213**, **214.** Preferably, the hole **16** may be cylindrical and the openings **113**, **114** and **213**, **214** may be arranged at the lateral surface **161** or at the bottom wall **162** thereof.

[0062] Suitably, ducts **115**, **215** may be provided for to fluidically connect the openings **111**, **211** with the openings **113**, **213.** Preferably, such ducts may be inside the jacket **10**, for example obtained in the body of the jacket by drilling.

[0063] Similarly, ducts **116**, **216** may be provided for to fluidically connect the openings **112**, **212** with the openings **114**, **214.** Preferably, such ducts may be inside the jacket **10**, for example obtained in the body of the jacket by drilling.

[0064] In particular, the jacket **10** may comprise a hole **19** defining an axis **Z** substantially perpendicular to the axis **X'** of the hole **16** having one end defining the opening **112** and comprising the opening **114.** In other words, the duct **116** may comprise or consist of the hole **19.** The circuit **110** may include the hole **19.**

[0065] On the other hand, the jacket **10** may comprise a hole **18** defining an axis **Z'** substantially perpendicular to the axis **X'** of the hole **16** and passing through the same which may comprise the opening **214.** In other

words, the duct **216** may comprise or consist of the hole **18.** The circuit **210** may include the hole **18.**

[0066] Such openings are observable in Fig. 3, which shows the cylinder **1** in which the locking device **500** is removed from the seat **15.**

[0067] On the other hand, the locking device **500** may comprise a pair of circuits **510**, **520** which may preferably be fluidically independent with respect to each other.

[0068] Suitably, once the locking device **500** has been inserted in the seat **16**, the circuit **510** may be fluidically connected with the circuit **110**, while the circuit **520** may be fluidically connected with the circuit **210.**

[0069] Advantageously, the locking device **500** may therefore be configured so that once inserted in the hole **16**, the openings **113**, **114** and **213**, **214** are in fluidic communication with the circuits **510** and **520.**

[0070] In particular, the locking device **500** may therefore comprise at least one pair of openings **511**, **512** and one pair of openings **521**, **522.** Preferably, such openings may be at the lateral surface or at the bottom wall of the locking device **500.** The circuit **510** may include the openings **511**, **512**, while the circuit **520** may include the openings **521, 522.**

[0071] Suitably, once the locking device **500** has been inserted into the hole **16** , the openings **113**, **114**, **213**, **214** may remain in fluidic communication with the openings **511**, **512**, **521**, **522** respectively. In other words, once the locking device **500** has been inserted, the circuit **110** may comprise the openings **111**, **112**, **113**, **114**, **511**, **521**, while the circuit **210** may comprise the openings **211**, **212**, **213**, **214**, **521**, **522.**

[0072] Suitably, the locking device **500** may be configured so that the operation thereof is independent from the rotation thereof with respect to the axis **X'**, that is with respect to the rotation around itself along the axis **Y.** In other words, the openings **511**, **512**, **521**, **522** may be configured so that they are fluidically connected with the openings **113**, **114**, **213**, **214** irrespective of the rotation of the locking device **500** with respect to the axis **X'.**

[0073] Thanks to this characteristic, the locking device **500** may be easy to position in the hole **16.** Furthermore, centring means and/or means for hindering the rotation of the locking device **500** inside the hole **16** are not required.

[0074] More particularly, as shown in FIG. 19, the openings **511** and **521** may be fluidically connected with the openings **113** and **213** by means of a peripheral conduit **513**, **523** defined by an annular recess of the locking device. The openings **512** and **522** may remain at the opposite bottom walls of the locking device **500.** Preferably, the openings **512** and **522** may be substantially coaxial to the axis **Y.** A respective peripheral conduit **514**, **524** may therefore be provided to place the openings **512** and **522** in fluidic communication with the openings **114** and **214.**

[0075] The locking device **500** may be sealingly inserted into the hole **16.** Therefore, once the locking device **500** has been inserted into the hole **16**, the openings **113**, **114**, **213**, **214** and the openings **511**, **512**, **521**, **522** may be mutually corresponding, for example the former facing the latter.

[0076] Suitably, sealing means, for example O-rings, may be provided for so as to allow such sealing insertion. For example, one or more O-rings may be provided for arranged between the outer surface of the locking device **500** and the inner surface of the hole **16.** Preferably, three O-rings may be provided so that each of the annular recesses **513**, **523** is interposed between a pair of O-rings.

[0077] Suitably, the locking device **500** may comprise corresponding seats **509** for the O-rings.

[0078] The locking device **500** may comprise valve means **515** and **525** acting respectively on the circuit **510** and **520** so as to selectively allow/hinder the through-flow of the fluid inside the circuits **510** and **520.** In particular, the valve means **515** and **525** may be selectively openable/closable so as to allow/hinder the through-flow of the fluid inside the circuits **510** and **520.**

[0079] In greater detail, the circuits **510** and **520** may comprise an opening for the through-flow of the fluid **516**, **526** interposed between openings **511** and **512**, **521** and **522.** The valve means **515** and **525** may act on the respective openings **516**, **526** to selectively allow/hinder the flow of the fluid therethrough.

[0080] The valve means **515**, **525** may preferably be of the normally closed type.

[0081] Suitably, the valve means **515**, **525** may comprise a shutter **515' 525'** and elastic means **515" 525"**acting on the shutter **515' 525'** to keep the latter closed, that is so that it closes the through-flow of the respective openings **516**, **526** as described above.

[0082] Suitably, the circuits **510**, **520** may include a respective working chamber **517**, **527** which may house the respective shutters **515' 525'.** Possibly, the working chamber **517**, **527** may also house the elastic means **515" 525".**

[0083] The working chamber **517**, **527** of one or both circuits **510**, **520** may have an extension substantially coaxial with the axis **Y.** The working chamber **517, 527** of one or both circuits **510**, **520** may be substantially cylindrical.

[0084] According to a particular preferred but non-exclusive embodiment of the invention, the shutters **515' 525'** and the elastic means **515" 525"** may be movable along the axis **Y.**

[0085] Possibly, the openings **516**, **526** may define the openings **511** and **521** or the openings **512** and **522.** In any case, the openings **516**, **526** may be fluidically connected to the openings **511**, **512** and **521**, **522.**

[0086] Preferably, the openings **512** and **522** may be in proximity of the ends **501**, **502** of the locking device **500**, while the openings may be spaced from the ends along the axis **Y.** In other words, the circuits **510** and **520** may have an extension along the axis **Y.**

[0087] Preferably, the valve means **515**, **525** may be configured to operate in a substantially opposite manner, that is elastic means **515"** - for example a spiral spring -

may force the shutter **515'** toward the opposite end **502** while the elastic means **525"** - for example a spiral spring - may force the shutter **525'** toward the opposite end **501.**

[0088] The circuits **510** and **520** may be fluidically independent.

[0089] Suitably, when the valve means **515**, **525** are closed, oil may be hindered from flowing through the respective openings **516**, **526** and therefore through the respective circuits **510**, **520**, while when the valve means **515**, **525** are open, the oil may be allowed to flow through the respective openings **516**, **526** and therefore through the respective circuits **510**, **520**.

[0090] According to a preferred but not exclusive embodiment, the valve means **515** may be configured to open when the oil flows into the opening **511** therefore so as to allow the oil to flow out from the opening **511** to the opening **512**, while they may be configured to remain closed when the oil flows into the opening **512** therefore so as to hinder the oil from flowing out from the opening **512** to the opening **511**. Similarly, the valve means **525** may be configured to open when the oil flows into the opening **521** so as not to shut the opening **526** and therefore allow the oil to flow through the opening **521** to the opening **522**, while they may be configured to remain closed when the oil flows into the opening **522** so as to shut the opening **526** and therefore prevent the oil from flowing from the opening **522** to the opening **521.**

[0091] In other words, the flow of oil may overcome the action of the spring **515"**, **525"** so as to promote the sliding of the shutter **515'**, **525'** inside the chamber **517**, **527** so as to move it away from the opening **516**, **526** and therefore allow the oil to flow through it.

[0092] Although hereinafter reference will be made to such configuration described above, it is however clear that the valve means **515**, **525** may be configured in an opposite manner, that is so that the flow of oil coming from the openings **512**, **522** allows the opening of the valve means **515**, **525** and therefore the flow of oil from the openings **512**, **522** to the openings **511**, **521** , while they may prevent the flow of oil from the openings **511**, **521** to the openings **512, 522** without departing from the scope of protection of the present invention.

[0093] In order to allow the oil to flow from the opening **512** and/or **522** to the opening **511** and/or **521** through the respective circuits **510** and **520**, one may selectively act on the respective valve means **515**, **525** so as to selectively open them and therefore allow the fluid to flow through the opening **516**, **526** from the respective opening **512**, **522** to the respective opening **511**, **521.**

[0094] The locking device **500** may therefore comprise a slider element **530** configured to act on one or both of the valve means **515**, **525** to selectively open the latter.

[0095] Suitably, the slider element **530** may be configured to alternately act on one or on the other of the valve means **515**, **525.**

[0096] For example, the slider **530** may be interposed between the valve means **515**, **525** and it may therefore be movable between at least one operative position in which it interacts with the valve means **515** and at least one operative position in which it interacts with the valve means **525.** Preferably, the slider **530** may be movable in a further inoperative position in which it does not interact with the valve means **515** and does not interact with the valve means **525.**

[0097] Suitably, the slider **530** may comprise a protuberance **531** designed to interact with the valve means **515** and in particular with the shutter **515'** to promote the sliding thereof in the working chamber **517** and therefore to space it apart from the opening **516** so as to allow the oil to flow through it. Similarly, the slider **530** may comprise a protuberance **532** designed to interact with the valve means **525** and in particular with the shutter **525'** to promote the sliding thereof in the working chamber **527** and therefore to space it apart from the opening **526** so as to allow the oil to flow through it.

[0098] The protuberance **531**, **532** may have a smaller cross-section with respect to the respective opening **516**, **526** so as to allow the insertion of the former into the latter without preventing the flow of oil through the respective opening **516**, **526.**

[0099] Advantageously, the slider **530** may have a length such that when it is in the inoperative position, both the protuberances **531** and **532** may remain spaced apart from the shutters **515'** and **525'.**

[0100] In particular, in the absence of inflowing oil, the action of the springs **515"** and **525"** may promote the sliding of the shutters **515'** and **525'** and therefore the sliding of the slider **530** in an intermediate position between the operative positions, that is in the inoperative position.

[0101] For example as shown in FIG. 19, the slider **530** may be slidable along the axis **Y** between the operative and inoperative positions described above. For example, the slider **530** may have a substantially cylindrical-shaped main body **533** with a pair of opposite walls **534**, **535**, while the protuberances **531**, **532** may extend on opposite sides of the cylindrical body **533**, preferably from the opposite walls **534, 535.**

[0102] Suitably, the locking device **500** may comprise a working chamber **536** fluidically connected with the opening **511** and the opening **516.** Preferably, the working chamber **536** may comprise the opening **511**, the shutter **515'** and the wall **534** of the slider **530.** Therefore, the inflow of the oil into the working chamber **536** from the opening **511** may promote the sliding of the shutter **515'** and the sliding of the wall **534**, and therefore the opening of the valve means **515** and the sliding of the slider **530** from an operative position toward the opposite operative position, for example toward the valve means **525.** In the absence of oil flowing in from the opening **511**, the valve means **515** will close due to the action of the spring **515".**

[0103] Similarly, the locking device **500** may comprise a working chamber **537** fluidically connected with the opening **521** and the opening **526.** Preferably, the working chamber **537** may comprise the opening **521**, the

shutter **525'** and the wall **535** of the slider **530.** Therefore, the inflow of the oil into the working chamber **537** from the opening **521** may promote the sliding of the shutter **525'** and the sliding of the wall **535**, and therefore the opening of the valve means **525** and the sliding of the slider **530** from an operative position toward the opposite operative position, for example toward the valve means **515.** In the absence of oil flowing in from the opening **521**, the valve means **525** will close due to the action of the spring **525".**

[0104] Preferably, a single working chamber **538** with the openings **511**, **521**, **516**, **526** may be provided for, while the slider **530** may be sealingly inserted into the chamber **538** to partition it into the chambers **536** and **537.** Therefore, the sliding of the slider **530** between the operative positions may correspond to the increase of the volume of one chamber and the decrease of the volume of the other and vice versa.

[0105] Suitably, the chamber **538** may comprise a pair of opposite abutment surfaces **539** to define the end-of-stroke of the slider **530** corresponding to an operative position and to the opposite operative position.

[0106] Advantageously, the inflow of oil into the opening **511** may therefore correspond both to the sliding of the actuator **515'** (and therefore the opening of the valve means **515** so as to allow the oil to flow from the opening **511** to the opening **512**) and the sliding of the slider **530** toward the valve means **525** and therefore the resulting sliding of the actuator **525'** due to the protuberance **532** (and therefore the forced opening of the valve means **525** so as to allow the oil to flow from the opening **522** to the opening **521**).

[0107] Similarly, the inflow of oil into the opening **521** may therefore correspond both to the sliding of the actuator **525'** (and therefore the opening of the valve means **525** so as to allow the oil to flow from the opening **521** to the opening **522**) and the sliding of the slider **530** toward the valve means **515** and therefore the resulting sliding of the actuator **515**' due to the protuberance **531** (and therefore the forced opening of the valve means **515** so as to allow the oil to flow from the opening **512** to the opening **511**).

[0108] Should there be no flow of oil flowing into both openings **511**, **521**, the slider **530** will be in the inoperative position and the valve means **515**, **525** will be closed. The possible inflow of oil from the openings **512** and **522** will not activate the valve means **515, 525** which may remain closed and therefore the oil will be hindered from flowing through the respective openings **516**, **526.**

[0109] Therefore, with regard to the description outlined above, the locking device **500** may therefore be a device for allowing the oil to flow from the opening **511** to the opening **512** and correspondingly from the opening **522** to the opening **521** when the opening **511** defines an inlet for the oil, or for allowing the oil to flow from the opening **521** to the opening **522** and correspondingly from the opening **512** to the opening **511** when the opening **521** defines an inlet for the oil, and so as to hinder the oil from flowing from the opening **512** and/or **522** to the respective openings **511**, **521** when the latter do not define the inflow of the oil.

[0110] Such locking device **500** may consist of several elements. In particular, the locking device **500** may comprise at least one element **540**, one element **550** and one element **560.**

[0111] The elements **540**, **550**, **560** may be mutually couplable along the axis **Y** so as to assemble the locking device **500.** Preferably, the elements **540**, **550**, **560** may all be substantially cylindrical-shaped.

[0112] The device **500** may be assembled in the cylinder **1**, for example in the hole **16** by sequentially inserting the elements **550**, **540**, **560** or **560**, **540** and **550.**

[0113] On the other hand, the device **500** may be preassembled. The elements **550**, **540**, **560** can be coupled to each other, and inserted in the hole **16** only subsequently. Such coupling may be of the removable type.

[0114] The elements **540**, **550** and **560** may be coupled removably, as schematically shown in FIG. 19. On the other hand, according to a particular embodiment, a cover **590** may be provided for. In particular, the locking device **500** may comprise the cover **590** suitable to internally retain the elements **540**, **550** and **560.**

[0115] Possibly, the locking devices **500** may have different configurations. Suitably, different locking devices **500** may be inserted alternately so that the cylinder **1** behaves differently depending on the needs.

[0116] In any case, once the elements **540**, **550** and **560** have been assembled, the latter may be fluidically connected so as to define the circuits **510**, **520** and the valve means **515**, **525** described above.

[0117] In greater detail, the element **550** which may include the hydraulic circuit **510** and the valve means **515**, the element **560** which may include the hydraulic circuit **520** and the valve means **525** and the element **540** which may comprise the slidable slider **530.**

[0118] The element **550** may comprise an internally hollow cylindrical body **551** so as to define the chamber **517** which may house the spring **515"** and the shutter **515'**. The body **551** may further comprise a bottom wall **552** and an opening **553** opposite to the bottom wall **552.** Similarly, the element **560** may comprise an internally hollow cylindrical body **561** so as to define the chamber **527** which may house the spring **525"** and the shutter **525'.** The body **561** may further comprise a bottom wall **562** and an opening **563** opposite to the bottom wall **562.**

[0119] Advantageously, the spring **515"** and the shutter **515'** and the spring **525"** and the shutter **525'** may be inserted into the respective chamber **517** and **527** through the opening **553** and **563.** Suitably, a plug element **555** and **565** may be provided for so as to close the respective chamber **517** and **527.** Possibly, the plug element **555 565** may include the respective opening **512** and **522.**

[0120] Suitably, the elastic means **515"** and **525"** may abut against the plug **555**, **565** to force the respective shutter **515' 525'** to close against the opening **516**, **526.**

[0121] The cylindrical bodies **551** and **561** may comprise a respective annular recess **551'** and **561'** defining the peripheral conduits **513** and **523.**

[0122] The element **540** may comprise an internally hollow cylindrical body **541** for housing the slider **530.** Preferably, the slider **530** may sealingly slide in the hollow cylindrical body **541.**

[0123] Possibly, as schematically shown in FIG. 19, the elements may be coupled axially along the axis **Y.** Should the cover **590** be present, the elements **540 550** and **560** may be inserted into the cover **590.** Preferably, the cover **590** may be substantially tubular so that the elements **540 550** and **560** may be inserted thereinto along the axis **Y.**

[0124] Once elements **540 550** and **560** have been inserted into the cover **590**, they may be coupled "in a pack-like manner" by means of a plug in a per se known manner so as to assemble the locking device **500.**

[0125] Once assembled, the locking device **500** may therefore define a single piece. For example, it may be marketed separately from the jacket **10** and plunger **20.**

[0126] The sliding of the plunger **20** may therefore correspond to the volume change in the half-chambers **100** and **200** and therefore to the through-flow of the oil through the circuits **110**, **210.** When the through-flow is allowed, the half-chambers **100** and **200** may change the volume thereof and therefore the plunger **20** may slide, while when the through-flow is hindered the plunger will not slide.

[0127] In particular, as better explained hereinafter, given that the openings **512** and **522** may be connected to the half-chambers **100** and **200**, the outflow of the oil from the latter without the introduction of oil into the openings **511** or **521** (and therefore **111** and **211**) can be hindered, thus blocking the sliding of the plunger **20** in both directions.

[0128] FIGS. 3 and 4 show a configuration of the cylinder **1** in which the plunger **20** is moving from the end-of-stroke position to the start-of-stroke position and correspondingly the locking device **500** is in an operative configuration (FIG.4). In this case, the oil flows in through the opening **211** and therefore through the opening **521**, promoting the sliding of the actuator **525'** toward the right and acting on the wall **535** to promote the sliding of the slider **530** toward the left. The protuberance **531** of the latter may act against the shutter **515.** Therefore, the oil will flow from the opening **521** to the opening **522** and then through the opening **212** into the half-chamber **200.** Simultaneously, the oil may flow out from the half-chamber **100** through the opening **112** and therefore flow through the opening **512** into the chamber **517**, flow through the opening **516** kept open by the slider and flow out from the opening **511** and therefore from the opening **111.**

[0129] FIGS. 7 and 8 show a configuration of the cylinder **1** in which the plunger **20** is moving from start-of-stroke position to the end-of-stroke position and correspondingly the locking device **500** is in a different operative configuration (FIG. 7). In this case, the oil flows in through the opening **111** and therefore through the opening **511**, promoting the sliding of the actuator **515'** toward the left and acting on the wall **534** to promote the sliding of the slider **530** toward the right. The protuberance **532** of the latter may act against the shutter **525.** Therefore, the oil will flow from the opening **511** to the opening **512** and then through the opening **112** into the half-chamber **100.** Simultaneously, the oil may flow out from the half-chamber **200** through the opening **212** and therefore flow through the opening **522** into the chamber **527**, flow through the opening **526** kept open by the slider **530** and flow out from the opening **521** and therefore from the opening **211.**

[0130] FIGS. 5 and 6 show a configuration of the cylinder **1** in which the plunger **20** is blocked. As a matter of fact, when there is no flow of oil into the openings **111** or **211**, the locking device is in the inoperative configuration in which it does not allow the oil to flow from the openings **512** and **522** to the openings **511** and **521** and therefore does not allow the oil to flow out from the half-chambers **100** and **200.** A similar configuration is shown in FIG. 18 in which the axis **X'** is perpendicular to the sliding axis **X** of the plunger **20.**

[0131] The configurations of the circuits **110**, **210** may possibly change, for example the conduits **115**, **215** and **116**, **216** may have different length and path and/or the openings **111**, **211** and **112**, **212** may have different positions, without departing from the scope of protection of the present invention.

[0132] In the light of the above, it is clear that the invention attains the pre-set objectives.

[0133] The invention is susceptible to numerous modifications and variants all falling within the inventive concept outlined in the attached claims. All details can be replaced by other technically equivalent elements, and the materials can be different depending on the technical needs, without departing from the scope of protection of the invention.

[0134] Even though the invention has been described with particular reference to the attached figures, the reference numerals used in the description and in the claims are meant for improving the intelligibility of the invention and thus do not limit the claimed scope of protection in any manner whatsoever.

Claims

1. A compact double-acting hydraulic cylinder which can be connected to means for supplying and discharging a working fluid, comprising:

   - a jacket (**10**) internally comprising a working chamber (**30**) having a longitudinal extension defining a first axis (**X**);
   - a plunger (**20**) sealingly inserted into said jacket (**10**) to partition said working chamber (**30**) into

at least one first and second variable volume half-chamber (**100**, **200**);

wherein said plunger (**20**) and said jacket (**10**) are mutually slidable along said first axis (**X**) between at least one first operative position in which said first half-chamber (**100**) has a maximum volume and said second half-chamber (**200**) has a minimum volume and at least one second operative position wherein said first half-chamber (**100**) has a minimum volume and said second half-chamber (**200**) has a maximum volume;

wherein said jacket (**10**) comprises a first and a second circuit (**110**, **210**) which are mutually fluidically independent extending between a respective first opening (**111**, **211**) which can be fluidically connected with the means for supplying/discharging the working fluid and a second opening (**112**, **212**) fluidically connected with respectively said at least one first (100) and said at least one second (**200**) half-chamber;

wherein, when said plunger (**20**) and said jacket (**10**) mutually slide from said first to said second operative position, the working fluid flows into said second half-chamber (**200**) through said second circuit (**210**) and the working fluid in said first half-chamber (**100**) flows out therefrom through said first circuit (**110**), and wherein when said plunger (**20**) and said jacket (**10**) mutually slide from said second to said first operative position, the working fluid flows into said first half-chamber (**100**) through said first circuit (**110**) and the working fluid in said second half-chamber (**200**) flows out therefrom through said second circuit (**210**);

wherein the cylinder further comprises a locking device (**500**), said jacket (**10**) including a seat (**15**) for said locking device (**500**), wherein said first and second circuit (**110**, **210**) are fluidically connected with said seat (**15**) so that once said locking device (**500**) has been inserted into said seat (**15**), the first is fluidically connected with said first and second circuit (**110**, **210**) to selectively block the mutual sliding of said plunger (**20**) and said jacket (**10**);

wherein said locking device (**500**) can be selectively removably inserted/removed from the outside into/from said seat (**15**).

2. Hydraulic cylinder according to claim 1, wherein said jacket (**10**) comprises a first cylindrical blind hole (**16**) defining said seat (**15**), said first blind hole (**16**) having a third opening (**163**) accessible from the outside, said locking device (**500**) being insertable/removable through said third opening (**163**).

3. Hydraulic cylinder according to the preceding claim, further comprising a plug (**570**) which can be sealingly coupled with said jacket (**10**) at said third opening (**163**) to close said seat (**15**), said plug (**570**) having an end (**575**) which can be operated by an operator.

4. Hydraulic cylinder according to claim 2 or 3, wherein said blind hole (**16**) has a length substantially equal to or slightly greater than said locking device (**500**).

5. Hydraulic cylinder according to one or more of claims 2, 3 or 4, wherein said jacket (**10**) has a first and second opposite outer base surface (**12**, **13**) and an outer lateral surface (**14**) interposed between said first and second base surfaces (**12**, **13**), the latter being substantially parallel to each other.

6. Hydraulic cylinder according to the preceding claim, wherein said first base surface (**12**) comprising a second blind hole (**11**) for said plunger (**20**) defining said chamber (**30**), said second base surface (**13**) or said outer lateral surface (**14**) comprising said first blind hole (**16**) for said locking device (**500**).

7. Hydraulic cylinder according to the preceding claim, wherein said second base surface (**13**) includes said third opening (**163**), said blind hole (**16**) defining a second axis (**X'**) substantially parallel to said first axis (**X**).

8. Hydraulic cylinder according to any one of the preceding claims, wherein said jacket (**10**) is a monobloc.

9. Hydraulic cylinder according to any one of claims 2 to the preceding claim, wherein said locking device (**500**) includes a third and fourth hydraulic circuit (**510**, **520**), said locking device (**500**) and said first hole (**16**) being mutually sized so that once the former (**500**) has been inserted into the latter (**16**), said first circuit (**110**) includes said third hydraulic circuit (**510**) and said second circuit (**210**) includes said fourth hydraulic circuit (**520**), said locking device (**500**) comprising first and second valve means (**515**, **525**) acting on said third and fourth hydraulic circuits (**510**, **520**) to selectively allow/prevent the throughflow of the working fluid therethrough.

10. Hydraulic cylinder according to the preceding claim, wherein said first hole (**16**) comprises fourth openings (**113**, **213**) and fifth openings (**114**, **214**) fluidically connected with respectively said first openings (**111**, **211**) and said second openings (**112**, **212**) of said first and second circuit (**110**, **210**), said locking

device (**500**) comprising respective sixth openings (**511**, **521**) and seventh openings (**512**, **522**) in order to allow the inflow/the outflow of the working fluid into/from said third and fourth hydraulic circuit (**510**, **520**), said sixth openings (**511**, **521**) and seventh openings (**512**, **522**) being designed to remain at said fourth openings (**113**, **213**) and fifth openings (**114**, **214**) once said locking device (**500**) has been inserted into said first hole (**16**).

11. Hydraulic cylinder according to the preceding claim, wherein said first blind hole (16) is substantially cylindrical-shaped, said locking device (**500**) being substantially cylindrical-shaped and being sealingly inserted into said blind hole (**16**), said locking device (**500**) having a first and a second annular recess (**513**, **523**) comprising said sixth openings (**511**, **521**).

12. Hydraulic cylinder according to the preceding claim, comprising a plurality of O-rings interposed between the outer surface of the locking device (**500**) and the inner surface of said hole (**16**), said O-rings being arranged so that each of said first and second annular recess (**511**, **521**) is interposed between a pair of O-rings.

13. Hydraulic cylinder according to claim 10, 11 or 12, wherein said locking device (**500**) comprises:

- a first element (**550**) including said third hydraulic circuit (**510**) and said first valve means (**515**) acting thereon, selectively openable/closable so as to allow/hinder the through-flow of the fluid through said third circuit (**510**);
- a second element (**560**) including said fourth hydraulic circuit (**520**) and said second valve means (**525**) acting thereon, selectively openable/closable so as to allow/hinder the through-flow of the fluid through said fourth circuit (**520**);
- a third element (**540**) comprising a slider (**530**) slidable between a first operative position in which it interacts with one of said first and second valve means (**515**, **525**) to open the latter, a second operative position in which it interacts with the other between said first and second valve means (**515**, **525**) to open the latter, and at least one inoperative position in which it does not interact with said first and second valve means (**515**, **525**), said first and second valve means (**515**, **525**) being normally closed;

wherein each of said first, second and third element (**550**, **560**, **540**) comprises a seat (**509**) for housing a respective O-ring;
wherein said first, second and third element (**550**, **560**, **540**) are separate pieces which can be mutually coupled along a third axis (**Y**) to define the locking device (**500**).

14. Hydraulic cylinder according to any one of claims 10 to the preceding claim, wherein said jacket (**10**) comprises a third hole (**19**) defining a fourth axis (**Z**) substantially perpendicular to said second axis (**X'**) having an end defining said second opening **(112**), said third hole (**19**) comprising one of said fifth openings (**114**), said first circuit (**110**) including said third hole (**19**), and wherein said jacket (**10**) comprises a fourth hole (**18**) defining a fifth axis (**Z'**) substantially perpendicular to said second axis (**X'**) passing through said blind hole (**16**), said fourth hole (**18**) comprising the other of said fifth openings (**224**), said second circuit (**210**) including said fourth hole (**18**).

15. Hydraulic cylinder according to any one of claims 9 to the preceding claim, wherein said plug (**570**) comprises an internal channel (**571**), said fourth circuit (**520**) of said locking device (**500**) including said internal channel (**571**).

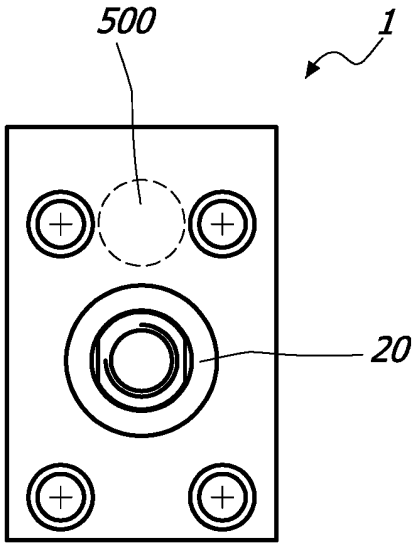

FIG. 1

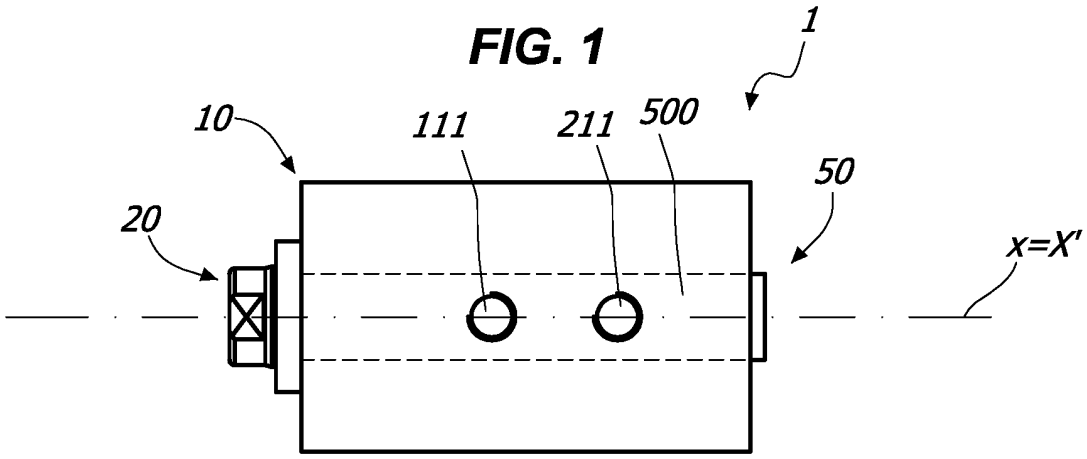

FIG. 2A

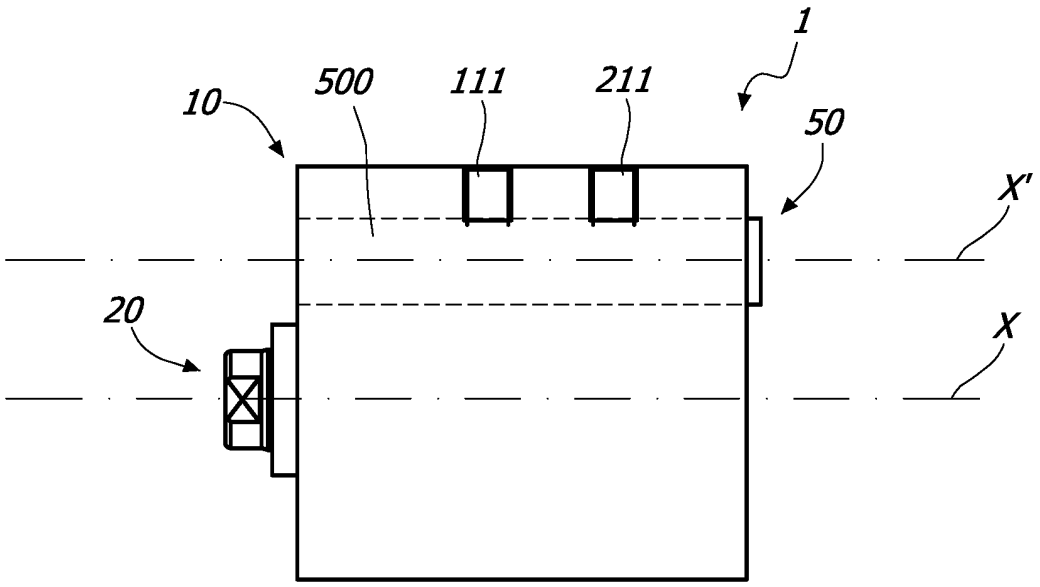

FIG. 2B

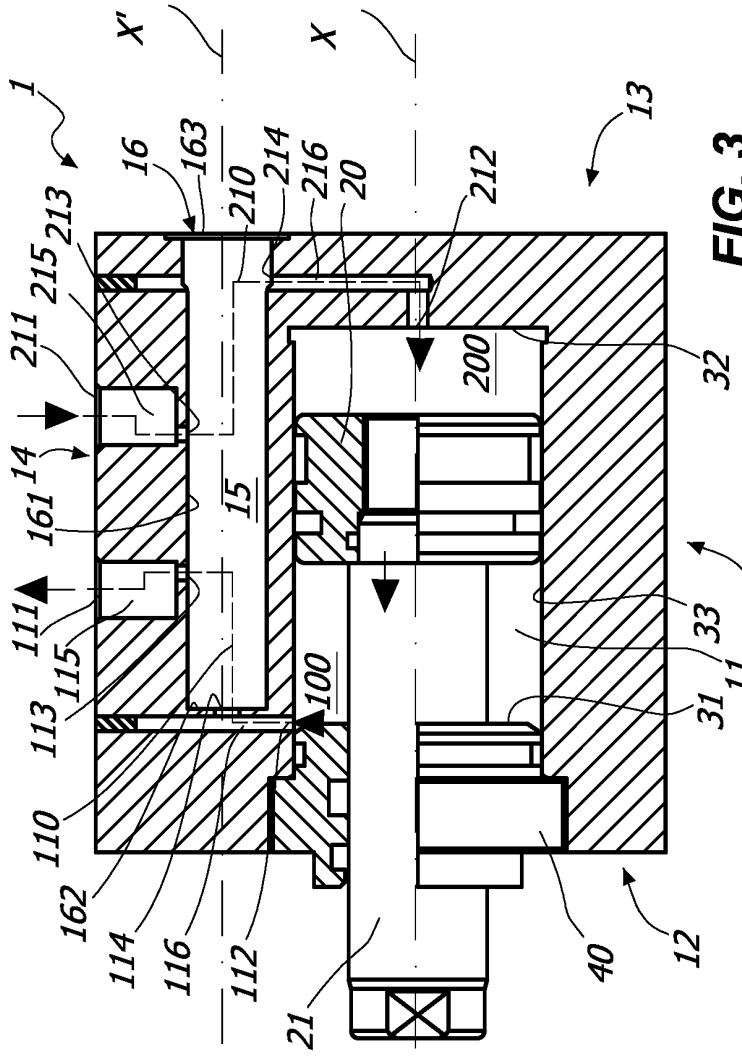
X'
X
1
13
16
163
210
214
216
20
212
213
215
211
200
32
14
161
15
111
115
113
100
33
11
31
110
162
114
116
112
21
40
12

FIG. 3

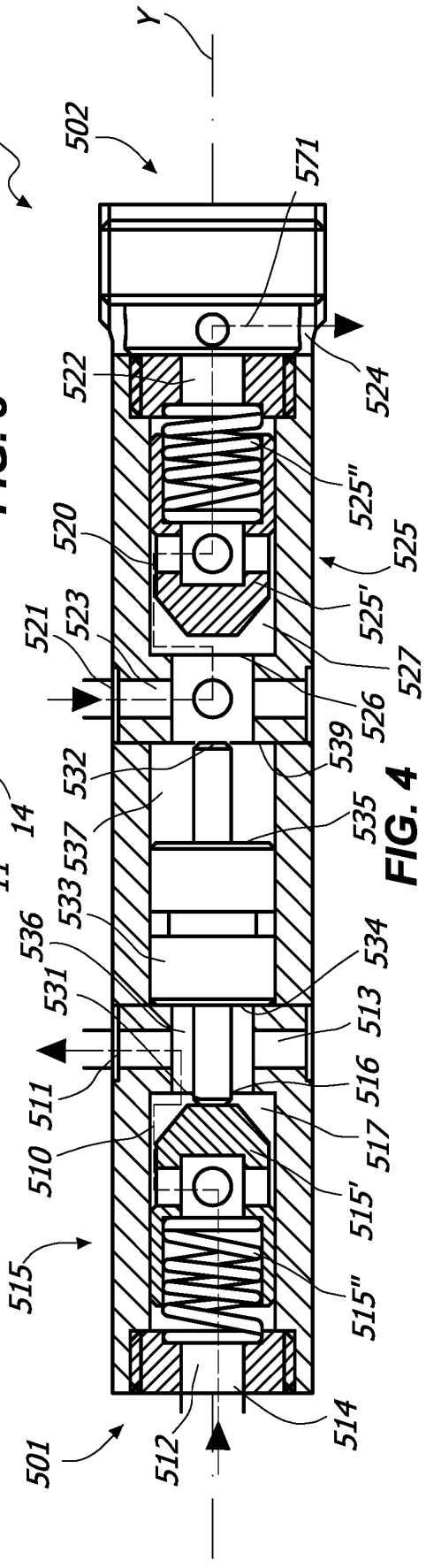
Y
500
502
571
522
524
525"
520
525
525'
521
523
527
526
539
532
535
537
533
536
534
531
513
511
516
510
517
515'
515
515"
501
512
514

FIG. 4

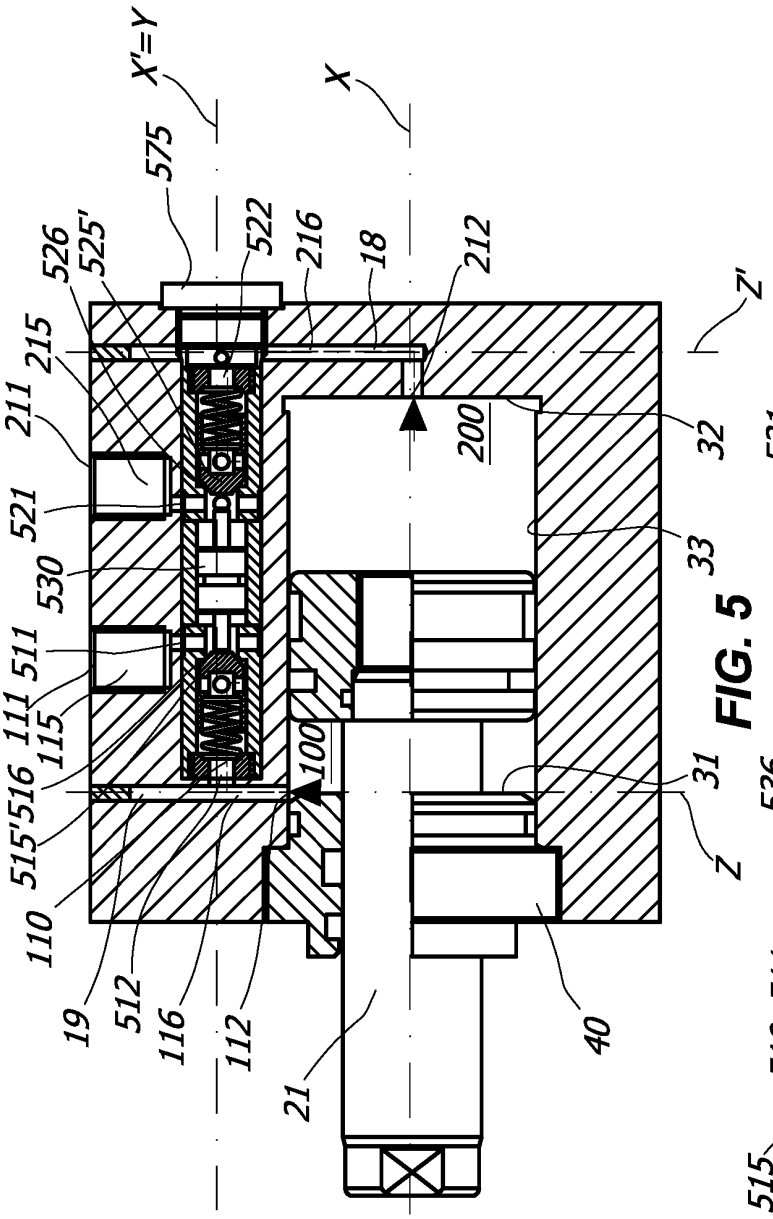
X'=Y
X
575
522
216
18
212
526
525'
215
211
521
530
511
111
115
516
515'
110
19
512
116
112
21
100
200
32
33
31
Z'
Z
40

FIG. 5

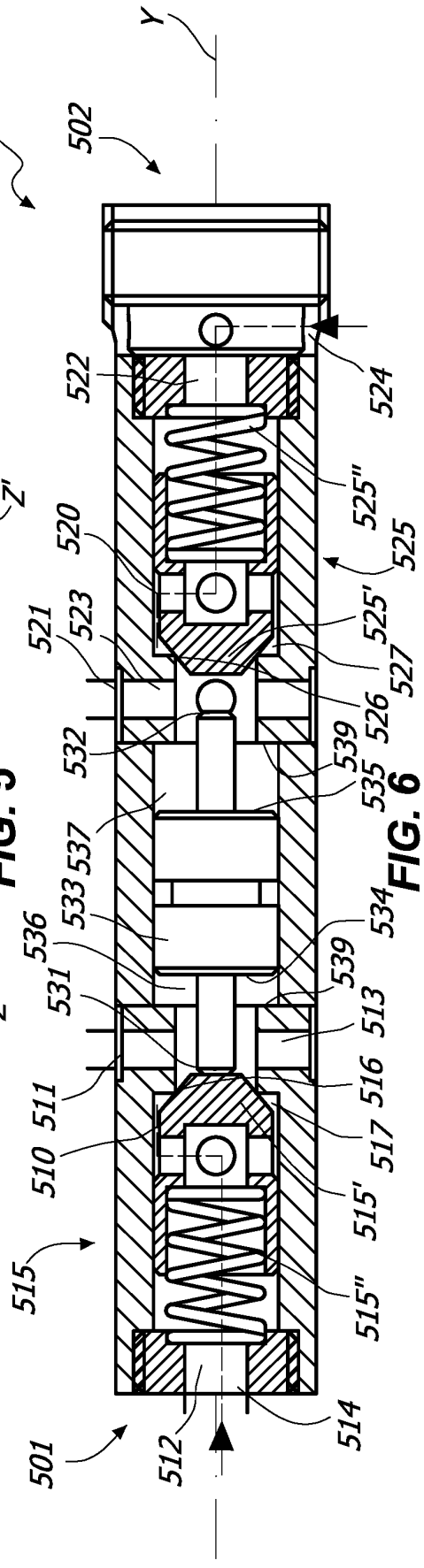
Y
500
502
522
524
525"
525
520
525'
521
523
527
526
532
539
535
537
533
534
536
531
513
511
516
517
510
515'
515
515"
514
501
512

FIG. 6

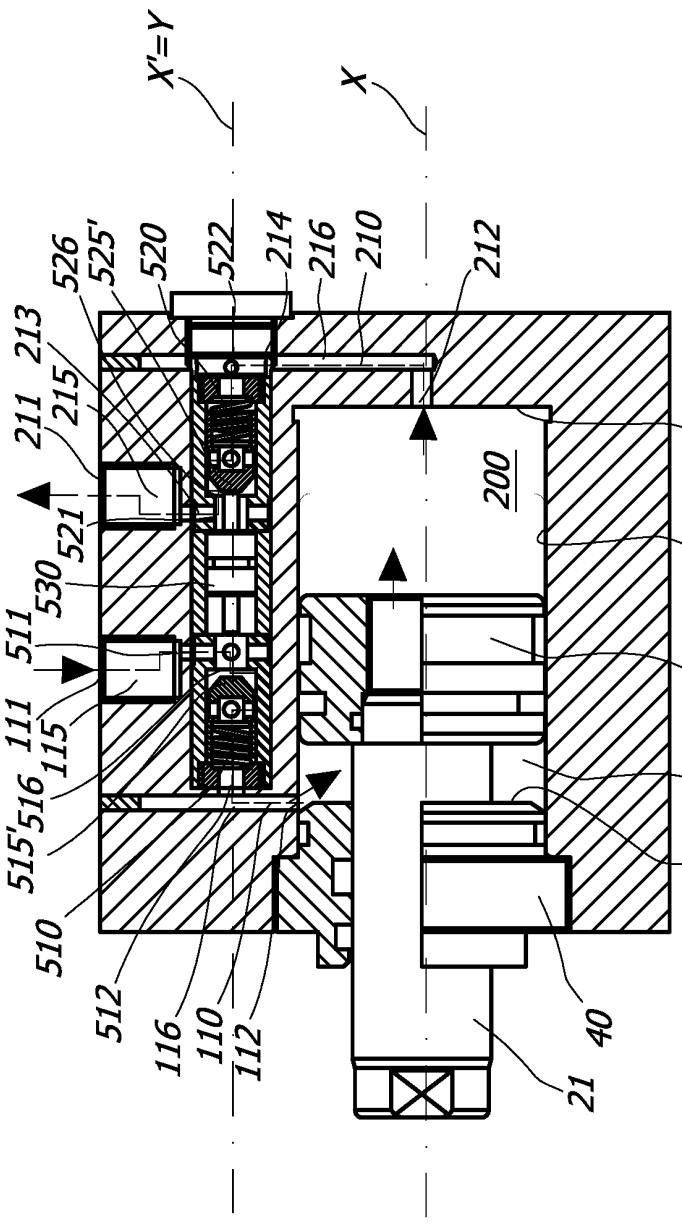
X'=Y
X
526
525'
520
522
214
216
210
212
213
211
215
521
530
511
111
115
516
515'
510
512
116
110
112
200
32
33
20
100
31
40
21

FIG. 7

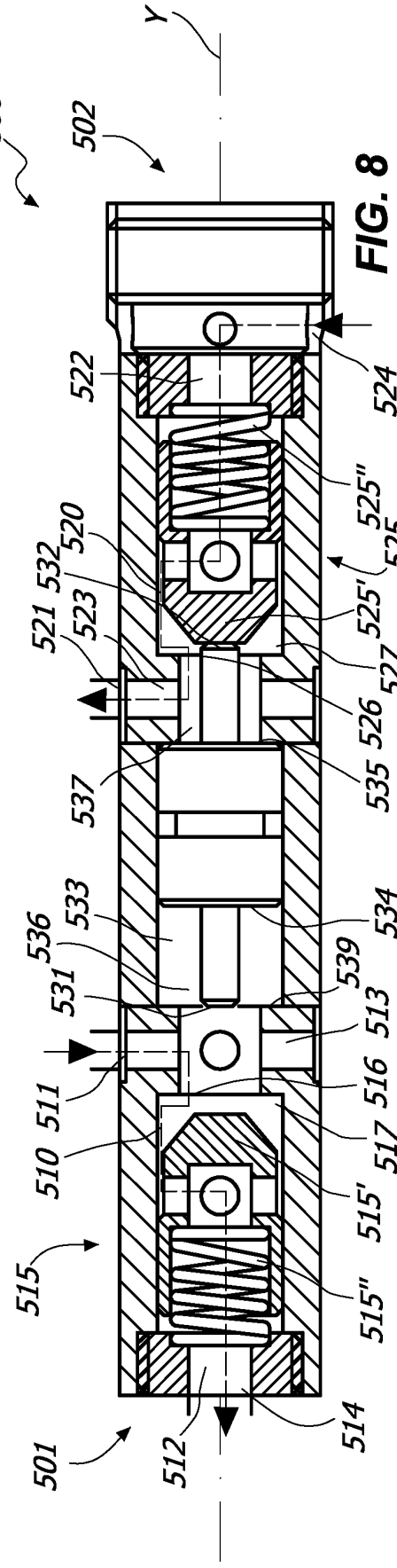
Y
500
502
522
524
525''
525
520
532
521
523
525'
527
526
535
537
533
534
536
539
531
513
511
516
510
517
515'
515
515''
514
501
512

FIG. 8

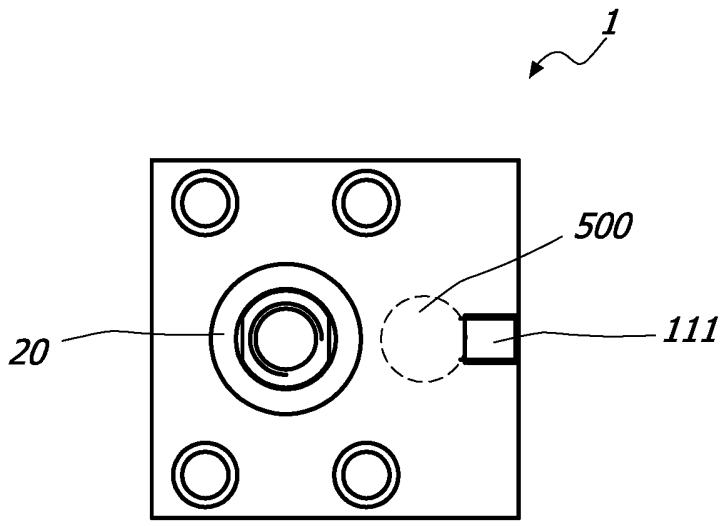

FIG. 9

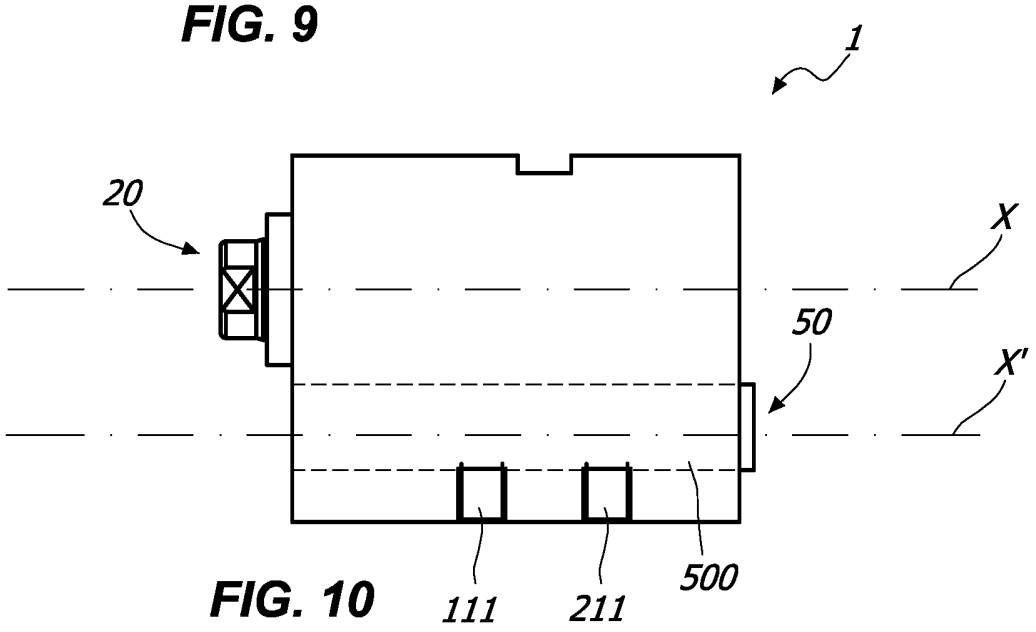

FIG. 10

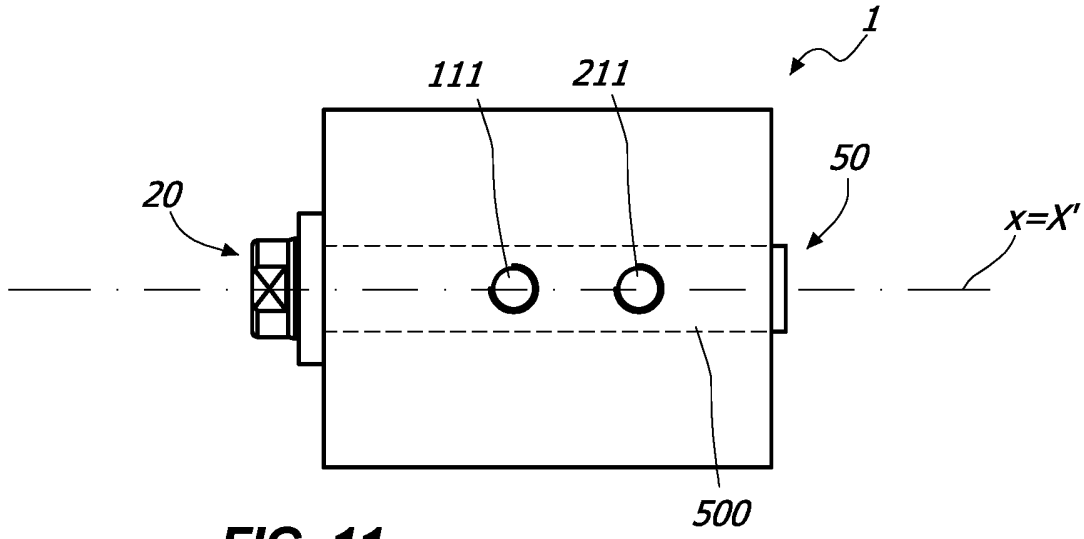

FIG. 11

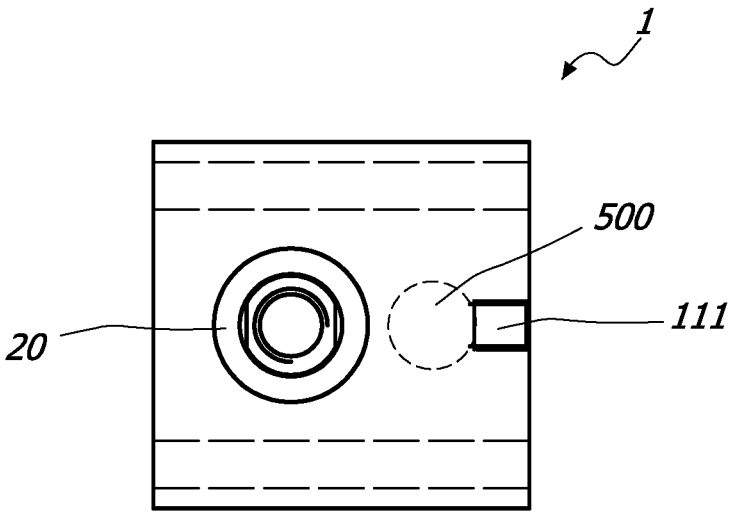

FIG. 12

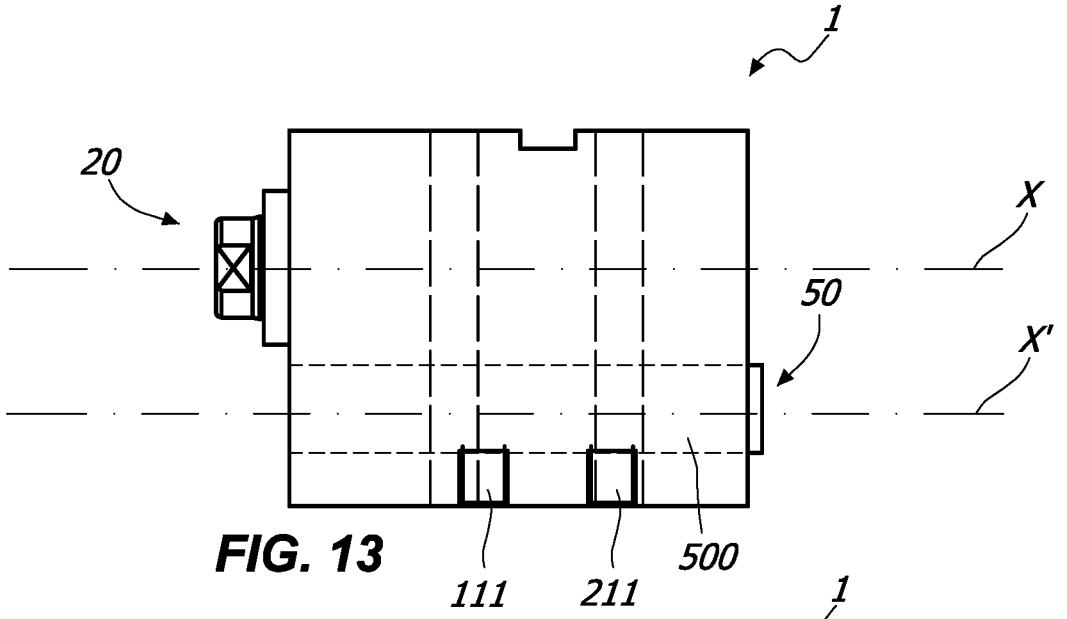

FIG. 13

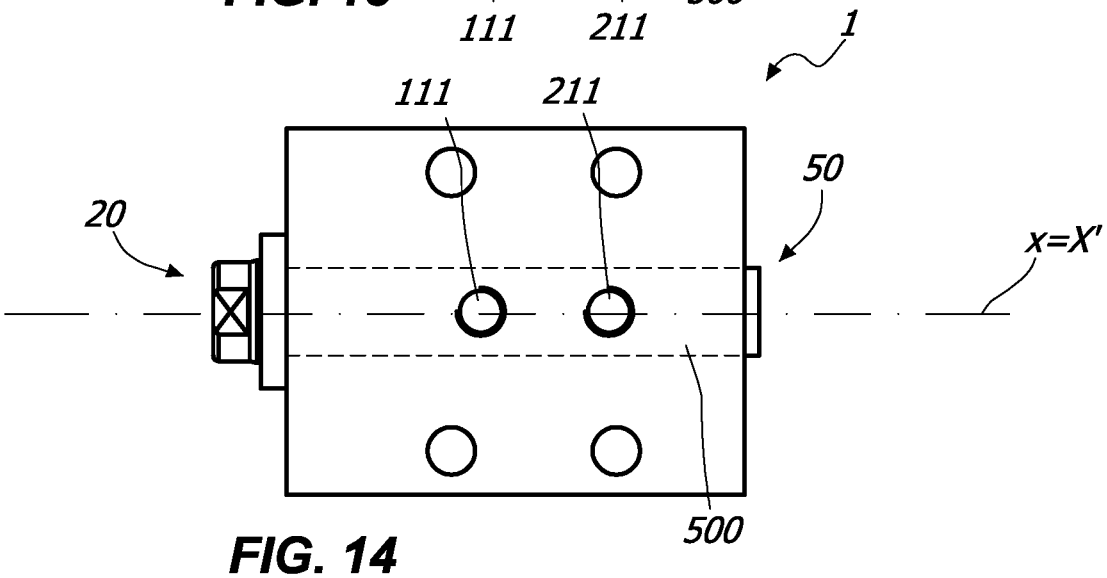

FIG. 14

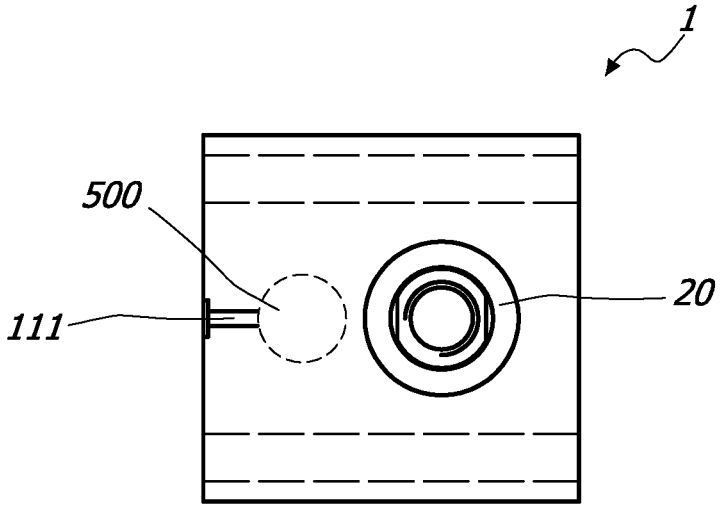

FIG. 15

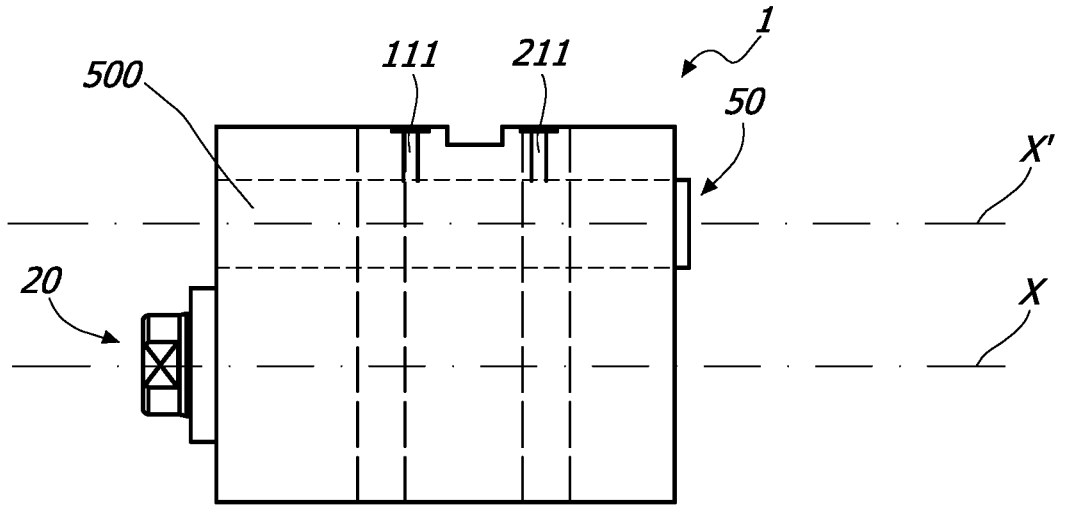

FIG. 16

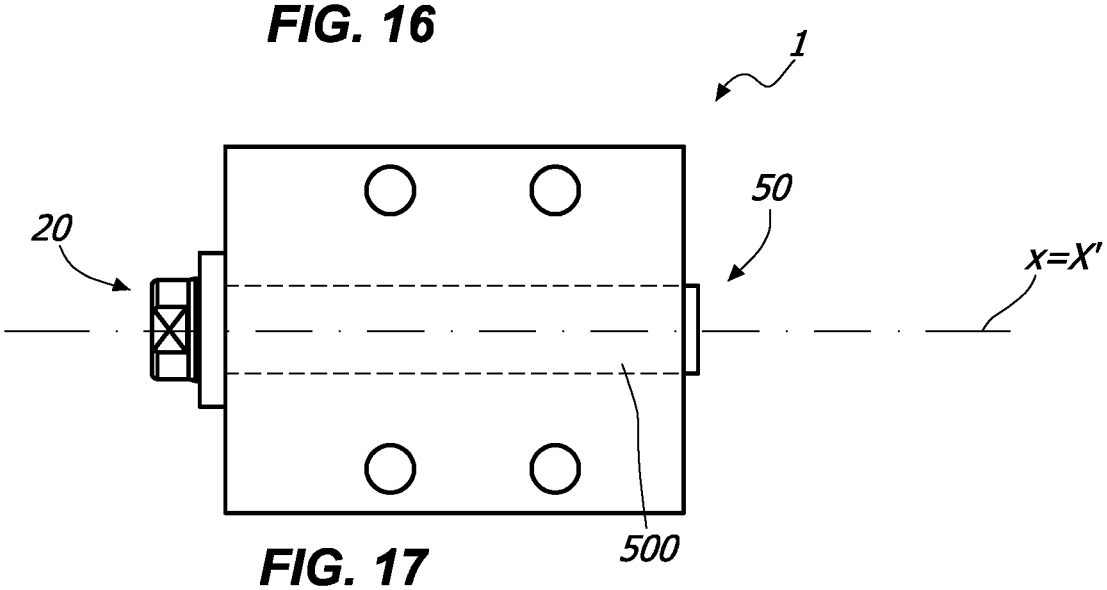

FIG. 17

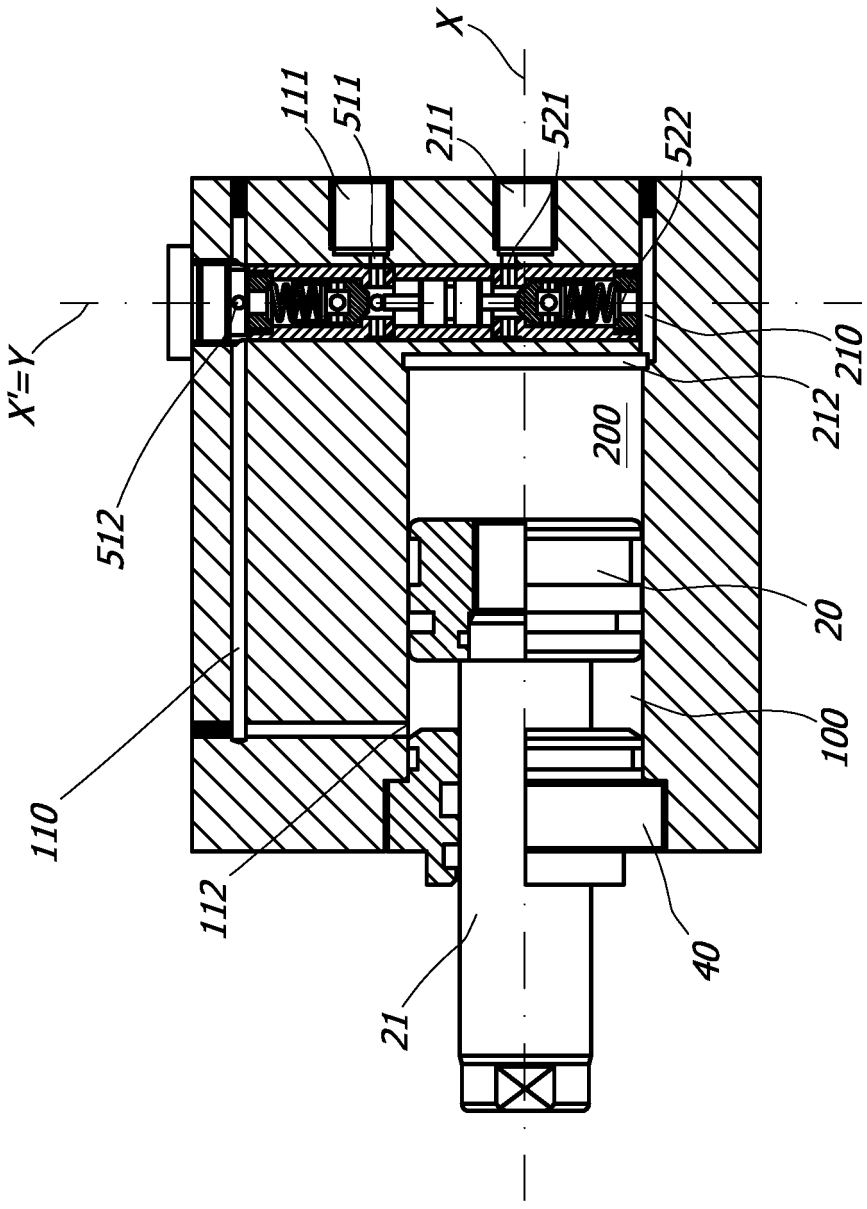

FIG. 18

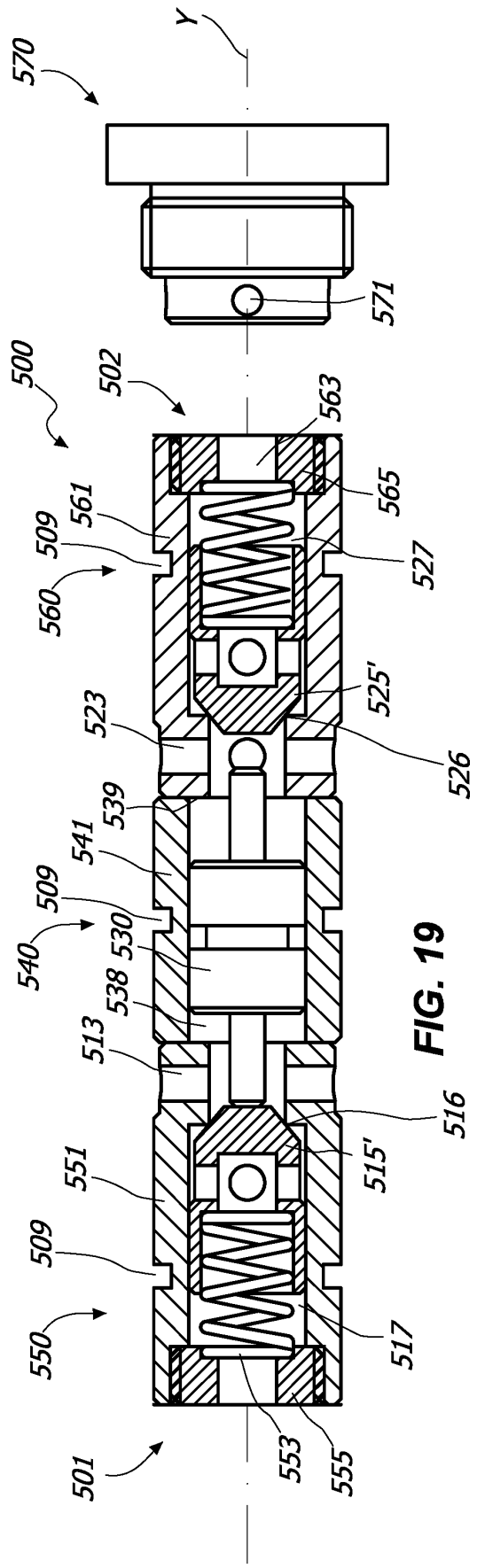
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FIG. 19

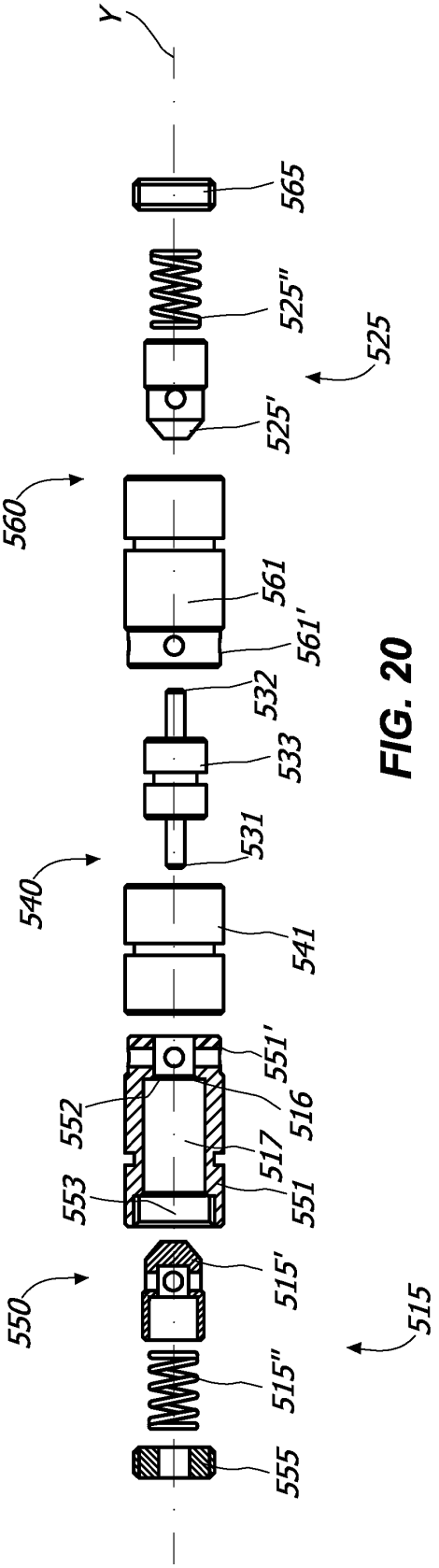
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FIG. 20

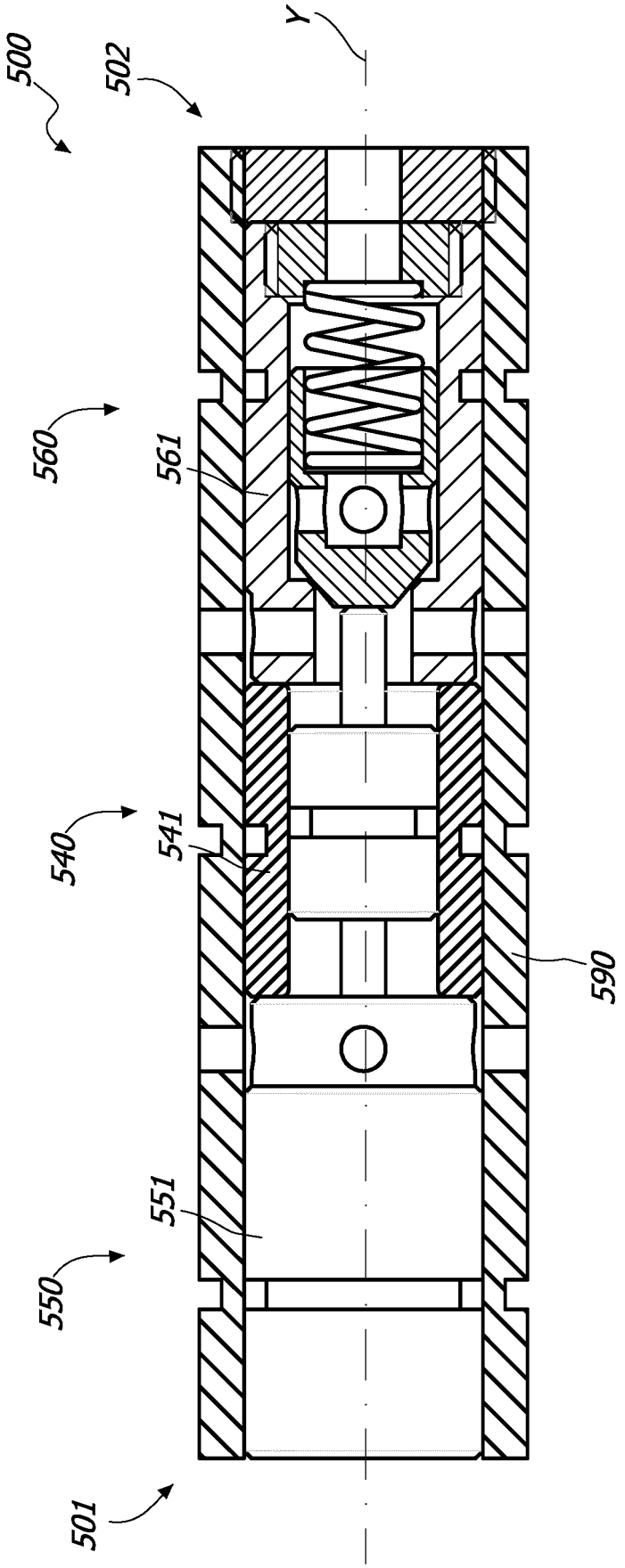

FIG. 21

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EUROPEAN SEARCH REPORT

Application Number
EP 22 16 7896

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 2 588 520 A (HALGREN HENRY A ET AL) 11 March 1952 (1952-03-11) * figures 1,2; examples E,E,D,A,15,16,13,27,28,25,26,19,20,35,36,37 *	1,8 2-7,9-15	INV. F15B13/01 F15B15/20
X A	DE 199 34 480 A1 (RAU SERTA HYDRAULIK GMBH [DE]) 1 February 2001 (2001-02-01) * figures 1,2; examples 1,2,17,18,19a,19b,19c,20,15,11,12 *	1-5,9, 10,13,15 6,7,11, 12,14	
X A	US 2016/153474 A1 (ANDERSON DAVID JOHN [US]) 2 June 2016 (2016-06-02) * see par. 0028 "cartridge valve"; figures 9,2,1,3; examples 12,34,56,58,40,42,44,60,62142,146 *	1,8 2-7,9-15	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	9 September 2022	Deligiannidis, N

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