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(54) ROLLING MACHINE WITH HYDRAULIC ACTUATION AND ROLLING PROCESS FOR FORMING IMPRESSIONS ON CYLINDRICAL BODIES

(57) Rolling machine with hydraulic actuation, which comprises two or more forming rollers (6), mechanically associated with the support structure (2) and adapted to plastically deform a cylindrical body arranged along a central work axis (A) of the machine (1). Each forming roller (6) is provided with a shaped profile and is driven to rotate around its rotation axis (Z) by a brushless motor (16) and is driven to be moved along a respective first transverse axis (R) perpendicular to the work axis (A) by a corresponding hydraulic actuator (15). A pressurized oil hydraulic system (100) is provided that is associated with the machine, which comprises an oil storage tank (200), a circulation pump (101) connected to the storage tank (200), at least two accumulators (106, 107) connected to the hydraulic actuators (15), each which having at the outlet an interception valve (108, 109) for directing the pressurized oil flow towards the hydraulic actuators (15) in order to allow their movement along the transverse axis R and their rolling action. The invention also relates to a rolling process for forming impressions on cylindrical bodies by means of such a roller machine.

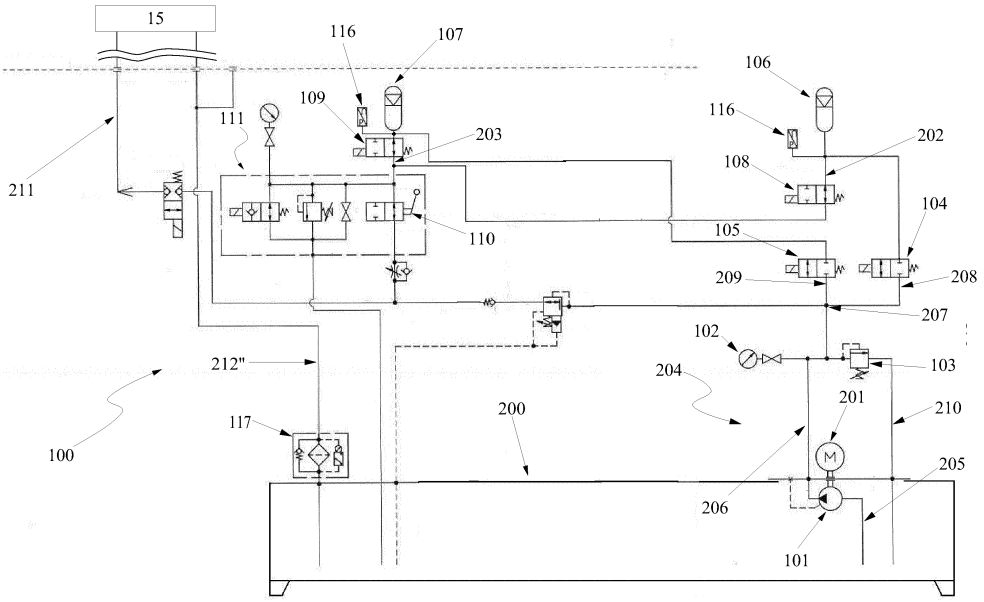

Fig. 3

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Description

Field of application

[0001] The present invention regards a rolling machine with hydraulic actuation and a rolling process for forming impressions on cylindrical bodies, according to the preamble of the respective independent claims.

[0002] The rolling machine and the present process are inserted in the industrial field of precision mechanical machining obtained by means of cold plastic deformation and capable of conferring high mechanical performances to the machined metal components, in particular tenacity and fatigue strength.

[0003] The machine and the process, object of the invention, are advantageously intended to be employed for plunge or through feed rolling, obtaining threads, teeth, rings or other machining, on metal cylindrical bodies such as shafts, bars, rods etc.

State of the art

[0004] The rolling machines of known type, and currently available on the market, usually comprise two or more forming rollers mounted on a support structure, each of which provided with a shaped profile, such as a thread for making an impression on a cylindrical body to be formed. The surface machining of the rollers cooperate with each other in succession in order to plastically deform the surface of the cylindrical body placed along a central work axis and for making the desired treatment thereon.

[0005] One example of the aforesaid rolling machines of known type, discussed in detail hereinbelow, is described in the patent GB 933132.

[0006] Hereinbelow, the expression "cylindrical body" indicates the mechanical piece or member, whether a shaft, a bar, a rod or another cylindrical metal body to be formed, on which it is desired to obtain the desired treatment in order to obtain an impression by means of cold plastic deformation.

[0007] As is known, the forming by means of cold plastic deformation allows obtaining mechanically machined cylindrical bodies that are particularly strong, since the metal fibers of the body subjected to machining are not cut as in a normal milling process.

[0008] During the rolling process, the desired machining receives forging properties that contribute to considerably increasing the fatigue strength of the material.

[0009] More in detail, each forming roller is mounted on a tool holder shaft or mandrel and is driven to rotate by a corresponding motor; in addition, each forming roller is also driven to be moved by a corresponding actuator along a transverse axis substantially perpendicular to the work axis in order to impart, by means of compression, an impression on the metal body to be formed.

[0010] The cylindrical body to be formed is supported at the center of the work axis by a suitable support and is cold deformed by the surface machining of the forming rollers which compress it by rotating thereon.

[0011] The single forming rollers are adapted to form in succession the desired treatment on the metal body to be machined and for such purpose the shaped profile of each roller must follow, in an extremely precise manner, the impression made on the metal body by the shaped profile of the preceding forming roller.

[0012] The formation operations are controlled by means of a logic control unit, preferably of numeric control type directed by an external computer (CNC).

[0013] The logic control units receives the instructions from the operator by means of a work program that uses, for example, a standardized ISO code language.

[0014] Since the radial compression stresses and the axial cutting stresses that affect both the cylindrical body and the shaped profile of the forming roller are very high, two or more forming rollers are generally used in a manner such to equally distribute the stresses and avoid risks of breakage.

[0015] As is known, the actuator means are driven through an oil hydraulic system to be moved close to and away from the cylindrical body to be formed.

[0016] More in detail, a first approaching or moving away travel is provided, in which the hydraulic actuators move the forming rollers with respect to the cylindrical body without however subjecting it to machining, and a second work travel is provided, in which the actuator means move the forming rollers on the cylindrical body to be formed, exerting the necessary pressure to obtain a cold deformation of the cylindrical body.

[0017] In particular, the first approaching/moving away travel has a greater length than the second work travel.

[0018] The hydraulic system must oversee, with its oil feeding, the operative functioning of the forming rollers for both travels.

[0019] For such purpose, the hydraulic system comprises a circulation pump, connected through a drive shaft to an electric motor, and usually provided with two impellers connected to two separate deliveries.

[0020] A first impeller is capable of ensuring a high flow at a lower operating pressure in order to drive the actuator means to carry out the first approaching/moving away travel. The second impeller is capable of instead ensuring a reduced flow at a higher operating pressure in order to drive the actuator means to carry out the second work travel during a step of forming the cylindrical body, in which the latter plastically deforms the surface of the body to be formed.

[0021] Such hydraulic system also comprises an oil storage tank, from which the pump draws the oil in order to send it to the actuator means; before returning into the storage tank, the oil is advantageously filtered.

[0022] In operation, both impellers send the oil towards the actuator means through the two deliveries, in order to obtain the aforesaid two movement and work travels of the forming rollers.

[0023] In particular, during the step of forming by the

forming rollers, the high-pressure second impeller ensures the pressure necessary for carrying out the action of plastic deformation on the cylindrical body by driving the small movements of the actuator means adapted to form the impression on the cylindrical body with the desired shape and depth. During such forming step, the delivery of the other impeller, i.e. of the first impeller, continues to remain in function, since it is connected to the same drive shaft.

[0024] The oil sent to such first impeller continuously recirculates, passing through the storage tank. Such considerable continuous recirculation of oil flow requires that the same be cooled by means of an air/oil heat exchanger provided with a fan for the heat exchange with the air.

[0025] The rolling machines with hydraulic actuation and the relative processes of rolling for forming impressions on cylindrical bodies of the above-described known type have demonstrated that they are not free of drawbacks.

[0026] A first drawback lies in the high use of oil, which the hydraulic system of the rolling machines of known type uses in order to move the actuator means.

[0027] A second drawback lies in the electricity costs, and hence more generally in the machine operating costs, necessary for maintaining the operation of the pump with the high oil flow required by the two impellers of the pump. Indeed, even if for most of the machine operation, i.e. during rolling, the only flow required is for high-pressure supplying the actuator means of the forming rollers, all the oil flow continues to recirculate.

[0028] A further third drawback regards the consumption of electrical energy in order to operate the cooling fan of the heat exchanger for cooling the oil.

Presentation of the invention

[0029] In this situation, the problem underlying the present invention is therefore that of overcoming the drawbacks manifested by the abovementioned solutions of known type by providing a rolling machine with hydraulic actuation and a rolling process for forming impressions on cylindrical bodies, which allows reducing the consumption of oil employed for moving the actuator means.

[0030] A further object of the present invention is to provide a rolling machine with hydraulic actuation which allows reducing the electric power of the circulation pump present in the system.

[0031] A further object of the present invention is to provide a rolling machine with hydraulic actuation which allows reducing the oil system operating costs, in particular connected to the costs of electrical energy of the circulation pump present in the hydraulic system. A further object of the present invention is to provide a rolling machine with hydraulic actuation which is simple and inexpensive to achieve.

[0032] These and still other objects are all attained by the machine and by the process according to the enclosed claims.

Brief description of the drawings

[0033] The technical characteristics of the present invention, according to the aforesaid objects, can be seen in the contents of the below-reported claims, and the advantages thereof will be more evident from the following detailed description, made with reference to the enclosed figures, which represent a merely exemplifying and non-limiting embodiment of the invention, in which:

- figure 1 shows a front perspective view of the rolling machine, object of the present invention;
- figure 2 shows a rear perspective view of the rolling machine according to the invention with the motor means underlined;
- figure 3 shows a detail of the machine, object of the present invention, relative to a first portion of the diagram of a provided oil hydraulic circuit;
- figure 4 shows a second portion of the diagram of the hydraulic circuit of the machine according to the present invention;
- figure 5 shows a detail of the diagram of figure 3 relative to an interception valve;
- figure 6 shows a detail of the diagram of figure 3 relative to a delivery valve;
- figure 7 shows a detail of the diagram of figure 4 relative to a control valve.

Detailed description of preferred embodiments

[0034] With reference to the drawing set, reference number 1 overall indicates a rolling machine with hydraulic actuation for attaining an impression on cylindrical bodies to be formed in accordance with the present invention.

[0035] This is generally intended to be employed for making treatments of threading, toothing, rings or other impressions on cylindrical bodies of mechanical members such as shafts, bars, rods etc. for many different applications.

[0036] The aforesaid treatments are obtained, in a *per se* known and conventional manner, by means of cold plastic deformation of the surface of the cylindrical body to be formed, compressing it between multiple forming rollers placed peripherally with respect to the cylindrical body itself.

[0037] More in detail, the rolling machine 1 is provided with a support structure 2 intended to be abutted against the ground, which is mechanically associated with two or more forming rollers 6 provided with a shaped profile. The forming rollers 6, as described in detail hereinbelow, operate with their shaped profile against the peripheral surface of the body to be formed, being driven to machine by rotating substantially parallel to each other in a common rotation direction, and compressed on the surface of the cylindrical body to be formed.

[0038] Preferably the support structure 2 is obtained by means of a metal framework, closed with paneling

that confer it a box-like appearance. In such support structure 2, one can identify a longitudinal extension parallel to a central work axis A at which the cylindrical body to be formed can be coaxially arranged.

[0039] In accordance with the embodiment of the enclosed figures, the support structure 2 is longitudinally extended between a front wall 3 and a rear wall 4, each provided with a central opening 5, for example of circular shape.

[0040] The central work axis A is arranged orthogonally to the walls 3, 4 and passes through the center of the aforesaid openings 5, which are then traversed by the cylindrical body to be machined.

[0041] Each forming roller 6 is constituted by a cylindrical body, preferably made of steel, provided with a central symmetry axis that corresponds with its rotation axis Z, and is provided with the abovementioned shaped profile on its external peripheral surface.

[0042] The shaped profile is therefore extended on the external peripheral surface of the roller 6 and around the rotation axis Z with shape and pitch characteristics that vary in accordance with the application requirements of the cylindrical body to be formed.

[0043] In accordance with the embodiment illustrated in the enclosed figures, the machine 1 provides for three forming rollers 6, placed at 120 degrees from each other, which are adapted to plastically deform under cold conditions the cylindrical body to be formed arranged along the central work axis A of the machine and supported in such position by a suitable support structure (not illustrated). The latter structure is constituted for example by a plate with V-shaped concavity directed upward and fixed to the support structure 2 of the machine 1.

[0044] The machine 1 also comprises two or more hydraulic actuators 15 mechanically associated with the support structure 2, each mechanically connected to a corresponding forming roller 6 in order to move it along a respective first transverse axis R substantially perpendicular to the work axis A.

[0045] The forming rollers 6 are positioned around the central work axis A with their extension axes Z preferably parallel to the central work axis A and at an adjustable radial distance due to the driving of the hydraulic actuators 15.

[0046] Due to the aforesaid hydraulic actuators 15, the forming rollers 6 are able to achieve at least one first approaching/moving away travel in which the forming roller 6 is moved from a position that is distal with respect to the work axis A to a position proximal to the central work axis. The forming rollers 6 are also able to achieve at least one second work travel, placed in succession after the first and in which the forming roller 6 operates in compression on the cylindrical body to be formed in order to plastically deform it according to its shaped profile.

[0047] In particular the distal position of the forming rollers 6 is defined on the corresponding transverse axis R at a distance with respect to the maximum or end stop work axis A or at least such to allow an operator to maneuver and substitute the cylindrical bodies to be machined without being obstructed in operation by the size of the forming rollers; in such distal position, the forming rollers 6 are therefore not in contact with the cylindrical body to be formed.

[0048] The proximal position of the forming rollers is still defined on the corresponding transverse axis R but in this case the shaped profile of the forming roller 6 is proximal to the cylindrical body to be machined, i.e. it is in contact therewith.

[0049] Motor means 16 are further provided, arranged on the support structure 2, mechanically connected to the forming rollers 6 in order to drive them in rotation at least while they are in abutment against the cylindrical body to be formed, so as to impart a cold plastic deformation on the external surface thereof due to their shaped profile.

[0050] For such purpose, the forming rollers 6 have a seat, e.g. a through hole made along their longitudinal extension axis Z, in which a tool holder shaft 14 is inserted in coupling relationship, connected by means of a transmission to the motor means 16.

[0051] The latter are for example obtained with electric motors 160 in particular of brushless type, each associated with a corresponding forming roller 6, and provided with drive shaft connected to the tool holder shaft by means of a cardan joint transmission.

[0052] The motor means 16, and in particular the brushless motors, are capable of precisely controlling the rotation speed of its shafts and their angular position (and hence the position of the forming roller that they drive in rotation) with respect to an angular reference position.

[0053] The cardan joints interposed between the drive shafts and the tool holder shafts 14 allow the transmission of the rotation without the necessary condition of alignment of the drive shafts with the axes of the forming rollers 6, which can therefore rotate at different distances from the central work axis A and they can also have a tilt with respect to the rotation axes of the drive shafts.

[0054] The rotation axes Z of the tool holder shafts 14 (or tool holder mandrels) are susceptible of being tilt-adjusted, in a known manner, with respect to the central work axis A, even if to a first approximation they can be considered substantially parallel to the work axis A itself of the cylindrical body to be machined.

[0055] The combination of the transverse compression action due to the hydraulic actuators 15 which compress the forming rollers 6 on the cylindrical body to be formed, and the rotation motion of the forming rollers 6 around their rotation axis Z due to the motor means 16 allows plastically deforming the cylindrical body placed along the central work axis A, obtaining progressive impressions on its peripheral external surface until the desired shape is attained.

[0056] Advantageously, in accordance with the embodiment of the machine 1 illustrated in the enclosed figures, three forming rollers 6 are provided, arranged at

120° from each other with respect to the work axis A in a manner such to equally distribute the stresses on the cylindrical body to be formed.

[0057] The hydraulic actuators 15 are connected to a hydraulic system 100 which drives the hydraulic actuator to be moved along its first and second travel.

[0058] The hydraulic system 100 is provided with at least one first accumulator 106 hydraulically connected to the hydraulic actuators 15 through at least one first supply duct 202, in order to supply them in parallel with a first flow. The latter is placed at a first operative pressure, and capable of moving the hydraulic actuators 15 along the first approaching/moving away travel.

[0059] At least one second accumulator 107 is also provided, it too hydraulically connected to the hydraulic actuators 15 through at least one second supply duct 203 in order to supply them in parallel with a second flow, less than the first flow.

[0060] The aforesaid second flow is placed at a second operative pressure greater than the first operative pressure, and is able to move the hydraulic actuators 15 along the second work travel.

[0061] The first and the second accumulator 106, 107 are in particular bladder accumulators, such bladder is filled with a gas at a pressure, termed precharge, less than the minimum operating pressure of the accumulator.

[0062] Advantageously the gas used is nitrogen which, being an inert gas, does not have the risk of triggering explosion phenomena.

[0063] When the bladder is precharged with gas, it occupies the entire volume of the accumulator and closes a poppet valve present to close the accumulator.

[0064] When the oil pressure exceeds the precharge of the gas in the system, the oil flows into the accumulator through the poppet valve and the nitrogen contained in the bladder is compressed; the gas volume is reduced by a quantity equal to that of the volume of oil introduced in the tank; when there is a drawing of oil, the bladder returns to expanded arrangement.

[0065] The first accumulator 106 provides for a difference between the maximum operating pressure and the minimum operating pressure greater than 100 bar, and in particular 175 bar; this high difference between the operating pressures allows the first accumulator to release a quantity of oil that is consequently high, thus ensuring the flow necessary for carrying out the first approaching/moving away travel which is much greater than the second work travel.

[0066] The second accumulator 107 has a difference between the maximum operating pressure and the minimum operating pressure less than 50 bar, and in particular 30 bar; this reduced difference between the pressures ensures a pressure that is basically constant during the second work travel, which is much shorter than the operating travel since it must only bring the forming rollers to cover the variations of the impression imparted on the cylindrical body to be formed.

[0067] Advantageously, a sensor means 116 is present, in particular a pressure transducer, for each accumulator 106, 107, which is connected to the supply ducts 202, 203; the sensor means 116 detects the oil pressure exiting from the accumulator.

[0068] In accordance with the preferred embodiment illustrated in the enclosed figures, the hydraulic system 100 comprises a first interception valve 108 mounted on the first supply duct 202, which is capable of controlling the hydraulic supply from the first accumulator 106 to the hydraulic actuators 15, and a second interception valve 109, mounted on the second supply duct 203, which is capable of controlling the hydraulic supply from the second accumulator 107 to the hydraulic actuators 15.

[0069] The first and the second interception valve 108, 109 are in particular slide valves, provided with a first operative position 108A, in which the oil passes through the valve, and a second operative position 108B in which the passage of the oil is blocked.

[0070] The oil supply to the two accumulators is advantageously attained as specified hereinbelow.

[0071] For such purpose, the hydraulic system 100 also comprises at least one storage tank 200 and a circulation pump 101, which is hydraulically connected to the storage tank 200 and to the first accumulator 106 and to the second accumulator 107 in order to supply them with the oil present in the storage tank 200.

[0072] More in detail the hydraulic system comprises a supply branch 204 which hydraulically connects the storage tank 200 to the two accumulators 106 and 107.

[0073] More in detail, the supply branch 204 comprises a suction duct 205 placed to connect the storage tank 200 with the inlet connection of the circulation pump 101, a common delivery duct 206, which is extended from the outlet connection of the circulation pump 101 up to a branch connection 207 from which two delivery ducts 208 and 209 are extended, of which a first delivery duct 208 is connected to the first accumulator 106 and a second delivery duct 209 is connected to the second accumulator 107.

[0074] At the exit of the circulation pump 101, the following are also advantageously present: a manometer 102, for measuring the pressure, and a safety valve 103 which is placed to intercept a discharge duct 210 that connects the common delivery duct 206, placed downstream of the circulation pump 101, to the storage tank 200.

[0075] Such safety valve 103 is automatically driven into open position in order to discharge the oil into the storage tank 200, if the oil pressure in the common delivery duct 206 exceeds the maximum safety value for which the safety valve 103 is calibrated.

[0076] The circulation pump 101 is operated by a motor 201, preferably electric, fit on the shaft of the circulation pump 101.

[0077] Advantageously, the first and the second delivery duct 208, 209 are respectively intercepted by a first and a second delivery valve 104, 105, which control the passage of the oil exiting from the circulation pump 101.

[0078] The first and the second delivery valve 104, 105 are in particular slide valves, provided with a charge position 104A, in which the oil flows through the valve, and with a blocking position 104B, in which the passage of the oil is blocked.

[0079] The first supply duct 202 and the second supply duct 203 have a common terminal section 211. The latter is divided in proximity to the hydraulic actuators 15 into three supply branches 211', each of which intercepted by at least one control valve 114, which is capable of changing the oil traversing direction in the corresponding hydraulic actuator 15, to which it is connected, in order to modify the movement direction thereof along the transverse axis R.

[0080] More in detail, the control valve 114 is a proportional regulating valve, which for example has four different operating positions: a maintenance position 114A, in which the passage of the oil through the valve 114 is blocked, in order to maintain the hydraulic actuator 15 blocked in the attained position; a first movement position 114B, in which the oil passage through the valve 114 occurs in order to move the hydraulic actuator 15 in its travel approaching the work axis A; a free movement position 114C, in which the hydraulic actuator 15 is free to be moved along the transverse axis R; finally a second movement position 114D, in which the oil passage through the valve 114 occurs in the direction opposite the passage in the second position, in order to move the hydraulic actuator 15 in its travel moving away from the work axis A.

[0081] The common terminal section 211 of the two supply connectors 202, 203 is intercepted by a third interception valve 110, manually driven, which is used in case of malfunctioning, for example of the accumulators 106, 107. Hence, in operation, if the third interception valve 110 is closed, the oil is conveyed towards a discharge group 111, composed of three valves in parallel, which discharge the oil into the storage tank 200.

[0082] The oil exiting from the hydraulic actuators 15 is conveyed into a return duct 212 to the storage tank 200. For such purpose, the return duct is provided with three outlet branches 212', each of which connected to the outlet of a corresponding hydraulic actuator 15, and a common return section 212" connected at one end to the aforesaid three branches and at the other end to the storage tank 200.

[0083] The common return section 212" is also intercepted by a filtering unit 117, which filters the oil in order to eliminate possible impurities collected by the oil flow in the advancing thereof along the system ducts.

[0084] The rolling machine with hydraulic actuation 1 also advantageously comprises two or more detection means 115, in particular obtained with rigid optics, each of which associated with a corresponding hydraulic actuator 15 in order to detect the position thereof along the respective transverse axis R.

[0085] The rolling machine 1 is also provided with a logic control unit in signal connection with the detection means 115, with the control valves 114 and with the interception valves 108, 109 mentioned above in order to supply the actuators 15 from the first and second accumulator 106, 107 and consequently drive them to be moved according to the first approaching/moving away travel or according to the second work travel.

[0086] Advantageously, the logic control unit of the machine 1 drives - through the aforesaid interception valves 108, 109 - the supply of the actuators 15 with the oil flow coming from the first accumulator 106, for the first approaching/moving away travel, or (alternatively) from the second accumulator 107, for the second work travel.

[0087] The logic control unit processes the signals coming from the position detection means 115, and subsequently, based on the control logic set by the user, drives the operation of the control valves 114 and of the interception valves 108, 109.

[0088] Advantageously, the logic control unit is in signal connection also with the sensor means 116 and with the first and the second delivery valve 104, 105 in order to switch them into their charge position 104A or into their blocking position 104B.

[0089] The logic control unit processes the signals coming from the sensor means 116, and based on the oil pressure detected drives the operation of the delivery valves 204, 205 in order to allow the charging of the accumulators 106, 107.

[0090] Also forming the object of the present invention is a rolling process for forming impressions on cylindrical bodies with a rolling machine, in particular of the above-described type; the same reference numbers will be maintained hereinbelow for the sake of description simplicity.

[0091] Once the cylindrical body to be formed is arranged on the suitable support of the machine 1 susceptible of supporting the same cylindrical body centered on the work axis of the machine 1, the forming process starts.

[0092] Usually, for arranging the cylindrical body on the machine 1, the forming rollers 6 are placed in a distal position thereof susceptible of allowing the positioning of the body to be formed.

[0093] The process provides for a movement step, in which the hydraulic actuators 15 are supplied by the first accumulator 106 with the first flow having the first operative pressure, in order to drive them along the first approaching/moving away travel so as to move each corresponding forming roller 6 from the distal position to the proximal position. During such movement of the forming rollers 6, the body to be formed is not subjected to any machining.

[0094] At this point, a work step follows in which the hydraulic actuators 15 are supplied by the second accumulator 107 with the second flow less than the first flow, having the second operative pressure greater than the first operative pressure, in order to drive them along the second work travel.

[0095] During such work travel, the shaped profile of

each forming roller 6 operates under pressure, pushed in a controlled manner by the corresponding hydraulic actuator 15 and rotating around its axis due to the motion imparted by the motor means 16 on the external surface of the cylindrical body to be formed, shaping it according to the conformation. The forming of the cylindrical body occurs due to the combined and synchronized action of the forming rollers 6, which are susceptible of small movements along the aforesaid work travel in order to cut the cylindrical body to be formed. During such work step, the pressure exerted by the forming rollers 6 is extremely high while the movements are extremely reduced. It is therefore necessary to supply the hydraulic actuators with the second flow having the very high second operative pressure even if with a very small second oil flow, given that very limited movements are required, on the order of millimeters.

[0096] During the movement step of the forming rollers, the logic control unit actuates a first supply mode of the hydraulic actuators 15, and for such purpose drives the first interception valve 108 to be moved into the first operative position 108A, in which the first oil flow flows through the first interception valve 108 from the first accumulator 106 to the hydraulic actuators 15, and drives the second interception valve 109 to be moved into the second operative position 108B, in which the passage of the second flow is blocked.

[0097] During the work step of the forming rollers, the logic control unit actuates a second supply mode, in which it drives the second interception valve 109 to be moved into the first operative position 108A, in which the second oil flow flows through the second interception valve 109 from the second accumulator 107 to the hydraulic actuators 15, and drives the first interception valve 108 to be moved into the second operative position 108B in which the passage of the first flow is blocked.

[0098] More in detail, the passage from the movement step to the work step takes place when the position detection means 115 send a signal to the logic control unit indicating that in the approaching travel, the hydraulic actuator 15 has reached the position proximal to the work axis A. At this point, the logic control unit switches the first interception valve 108 into the second operative position 108B and moves the second interception valve 109 into the first operative position 108A, thus determining the passage to the second supply mode which in this manner allows the start of the work step.

[0099] At the end of the work step, the logic control unit switches the second interception valve 109 into the second operative position 108B and drives the first interception valve 108 to be moved into the first operative position 108A, thus allowing the start of the movement step, in which the hydraulic actuators 15 are driven to advance in their travel moving away from the proximal position towards a distal position.

[0100] Advantageously, during the movement and work steps of the machine, the circulation pump 101 does not have to remain continuously in operation; it starts operation for charging the first and second accumulator 106, 107 when these have, following their at least partial emptying, an oil pressure less than a minimum threshold value, which is for example 10 bar more than the minimum operating pressure of the accumulator.

[0101] More in detail, at the end of the movement step, in which at least part of the oil of the first accumulator 106 has been employed, the work step starts with the use of the oil of the second accumulator 107.

[0102] Advantageously, while the work step takes place, i.e. in which the hydraulic actuators employ the oil of the second accumulator 107, a first charging step of the first accumulator 106 can take place, the latter at least partly previously emptied, in order to carry out the movement of the hydraulic actuators 15 in the advancing travel thereof.

[0103] For such purpose, the logic control unit switches, in such first charging step, the first delivery valve 104 into the charge position 104A, in order to make the oil flow through the first delivery valve 104 towards the first accumulator 106.

[0104] The aforesaid first charging step can also start during the movement step of the hydraulic actuators before then continuing during the work step.

[0105] The time necessary for carrying out the first charging step is advantageously less than the time for carrying out the work step, such that at the end of the work step the first accumulator 106 is filled to the maximum set level.

[0106] At the end of the first charging step of the first accumulator 106, the logic control unit switches the first delivery valve 104 into the blocking position 104B, blocking the passage of the oil towards the first accumulator 106.

[0107] At the end of the work step, with the start of the movement step, a second charging step is present, wherein the logic control unit switches the second delivery valve 105 into the charge position 104A in order to make the oil flow through the second delivery valve, thus charging the second accumulator 107; at the end of the charging of the second accumulator 107, the logic control unit moves the second delivery valve 105 into the blocking position 104B.

[0108] The aforesaid second charging step can also start during the work step of the hydraulic actuators in order to then continue during the movement step.

[0109] In accordance with a preferred embodiment of the invention, the logic control unit drives the movement of the delivery valves 104, 105 into the charge position 104A when the sensor means 116 detect an oil pressure less than the set threshold value.

[0110] The logic control unit then determines the stop of the charging of the accumulators 106, 107 and for such purpose switches the delivery valves 104, 105 into the blocking position 104B when the sensor means 116 detect an oil pressure equal to the maximum operating pressure of the accumulators 106, 107.

[0111] Advantageously, during the work step, in order

to maintain the position reached by the compressor rollers 6, with the pressure necessary for cutting the cylindrical body, the logic control unit can switch the control valve 114 into the maintenance position 114A; in this manner, it is possible to block the hydraulic actuator 15 in the compression position, which, being blocked, will maintain the operating pressure provided thereto by the second accumulator 107.

[0112] In particular, by blocking the hydraulic actuator 15, it is not necessary to maintain a supply oil flow coming from the second accumulator 107 given that the hydraulic pressure - in the absence of substantial movements of the hydraulic actuators 15 which in fact must only maintain the forming rollers 6 in position - is maintained substantially constant.

[0113] In addition, advantageously, once the first accumulator 106 is recharged with the first charging step, as long as the pressure in the second accumulator 107 remains greater than the threshold value, the second charging step is not restarted and, in this case, the circulation pump 101 does not start operation and also remains for long periods deactivated with considerable electrical energy savings.

[0114] During the first starting of the machine 1, an initial charging step of the first and second accumulator 106, 107 is provided, in which the first and second delivery valve 104, 105 are both situated in a charge position 104A and in which the oil flows from the circulation pump 101 to the first and second accumulator 106, 107 through the first and second delivery duct 208, 209.

Claims

1. Rolling machine with hydraulic actuation (1), which comprises:

- a support structure (2);
- two or more forming rollers (6) provided with a shaped profile;
- motor means (16) associated with said support structure (2), mechanically connected to said forming rollers (6) in order to drive them in rotation around the rotation axis (Z) thereof on a cylindrical body available along a central work axis (A) of said machine (1);
- two or more hydraulic actuators (15) mechanically associated with said support structure (2), each of which supporting a corresponding said forming roller (6) in order to move it along a respective first transverse axis (R) perpendicular to said work axis (A) by means of:

  o at least one first approaching/moving away travel, in which said forming roller (6) is moved from a distal position with respect to said central work axis (A) to a position proximal to said central work axis (A);

  o at least one second work travel, in which said forming roller (6) operates in compression on said cylindrical body to be formed in order to plastically deform it according to its shaped profile;

- a hydraulic system (100) connected to said hydraulic actuators (15) in order to drive them to be moved along their said first and second travel;

characterized in that said hydraulic system (100) comprises:

- at least one first accumulator (106) hydraulically connected to said hydraulic actuators (15) by means of at least one first supply duct (202) in order to supply them with a first flow having a first operative pressure and susceptible of moving them along said first approaching/moving away travel;
- at least one second accumulator (107) hydraulically connected to said hydraulic actuators (15) by means of at least one second supply duct (203) in order to supply them with a second flow less than the first flow, having a second operative pressure greater than the first operative pressure, and susceptible of moving them in order to move them along said second work travel.

2. Rolling machine according to claim 1, **characterized in that** said hydraulic system (100) also comprises:

- at least one first interception valve (108) mounted on said first supply duct (202) and susceptible of controlling the hydraulic supply from said first accumulator (106) to said hydraulic actuators (15);
- at least one second interception valve (109) mounted on said second supply duct (203) and susceptible of controlling the hydraulic supply from said second accumulator (107) to said hydraulic actuators (15).

3. Rolling machine according to claim 2, **characterized in that** said hydraulic system (100) also comprises, mounted to intercept a common terminal section (211) of said first and second supply duct (202, 203) at each said hydraulic actuator (15), a control valve (114) which is susceptible of changing the oil traversing direction in said hydraulic actuators (15) in order to modify the movement direction thereof along said first transverse axis (R).

4. Rolling machine according to claim 1, **characterized in that** said hydraulic system (100) also comprises:

- at least one storage tank (200);

- at least one circulation pump (101) hydraulically connected to said oil storage tank (200) and to said first and second accumulator (106, 107) in order to supply them with the oil of said storage tank (200).

5. Rolling machine according to claim 4, **characterized in that** said hydraulic system (100) also comprises:

- at least one first and second delivery valve (104, 105) respectively mounted on a first delivery duct (208) and a second delivery duct (209) respectively placed to connect between said circulation pump (101) and said accumulators (106, 107), in order to control the passage of the oil exiting from said circulation pump (101) towards said accumulators (106, 107).

6. Rolling machine according to claim 3, **characterized in that** it also comprises:

- two or more detection means (115), each associated with a corresponding hydraulic actuator (15) in order to detect the position thereof along the respective first transverse axis (R);
- a logic control unit in signal connection with said detection means (115) of said hydraulic actuators (15), with said control valves (114) and with said first and second interception valve (108, 109).

7. Rolling machine according to claim 1, **characterized in that** said accumulators (106, 107) are bladder accumulators filled with inert gas, in particular nitrogen.

8. Rolling machine according to claim 4, **characterized in that** said first accumulator (106) has a difference between the maximum operating pressure and the minimum operating pressure greater than 100 bar.

9. Rolling machine according to claim 4, **characterized in that** said second accumulator (107) has a difference between the maximum operating pressure and the minimum operating pressure less than 50 bar.

10. Rolling process for forming impressions on cylindrical bodies by means of a rolling machine in accordance with claim 1, **characterized in that** it comprises the following operative steps:

- a movement step, in which said hydraulic actuators (15) are supplied by said first accumulator (106) with said first flow having said first operative pressure, in order to drive them along said first approaching/moving away travel;
- a work step, in which said hydraulic actuators (15) are supplied by said second accumulator (107) with said second flow less than the first flow, having said second operative pressure greater than the first operative pressure, in order to drive them along said second work travel.

11. Rolling process for forming impressions on cylindrical bodies according to claim 10, by means of a rolling machine according to claim 2 and provided with a logic control unit, in which during said movement step of said hydraulic actuators (15), said logic control unit actuates a first supply mode by driving said first interception valve (108) to be moved into a first operative position (108A), in which said first oil flow flows through said first interception valve (108) from said first accumulator (106) to said hydraulic actuators (15), and by driving said second interception valve (109) to be moved into a second operative position (108B) in which the passage of said second flow is blocked.

12. Rolling process for forming impressions on cylindrical bodies according to claim 11 by means of a rolling machine according to claim 2 and provided with a logic control unit, in which during said work step of said hydraulic actuators (15) said logic control unit actuates a second supply mode by driving said second interception valve (109) to be moved into said first operative position (108A), in which said second oil flow flows through said second interception valve (109) from said second accumulator (107) to said hydraulic actuators (15), and by driving said first interception valve (108) to be moved into said second operative position (108B) in which the passage of said first flow is blocked.

13. Rolling process for forming impressions on cylindrical bodies according to claim 10, by means of a rolling machine according to claim 5 and provided with a logic control unit, which process comprising:

- a first charging step, in which said logic control unit drives said first delivery valve (104) to be moved into a charge position (104A), in which the oil flows through said first delivery valve (104) from said circulation pump (101) to said first accumulator (106), and in which said logic control unit drives said second delivery valve (105) to be moved into a blocking position (104B) in which the passage of the oil through said second delivery valve (105) is blocked;
- a second charging step, in which said logic control unit drives said second delivery valve (105) to be moved into said charge position (104A), in which the oil flows through said second delivery valve (105) from said circulation pump (101) to said second accumulator (107), and in which said logic control unit drives said first delivery valve (104) to be moved into said blocking position (104B) in which the passage

of the oil through said first delivery valve (104) is blocked.

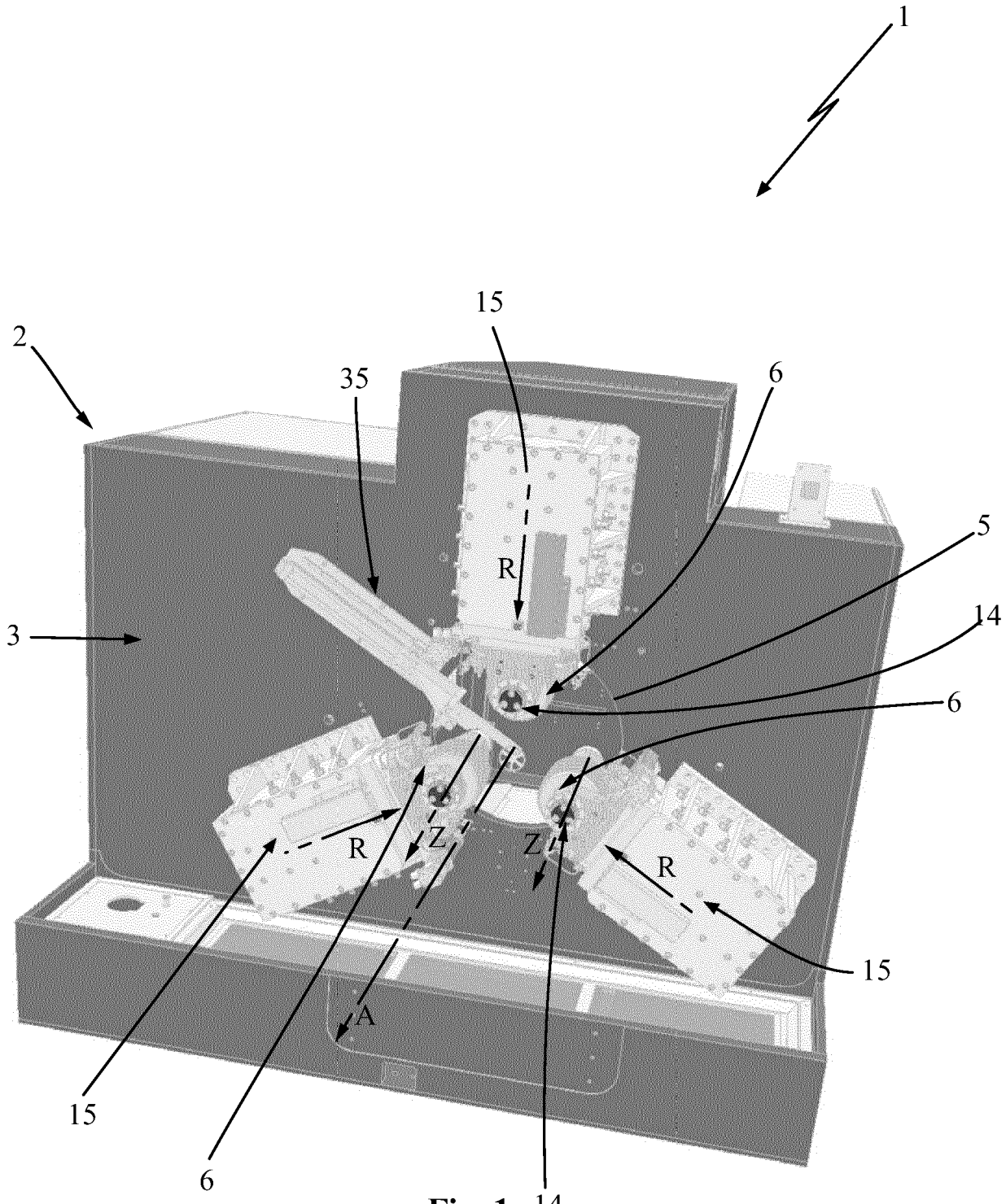

Fig. 1

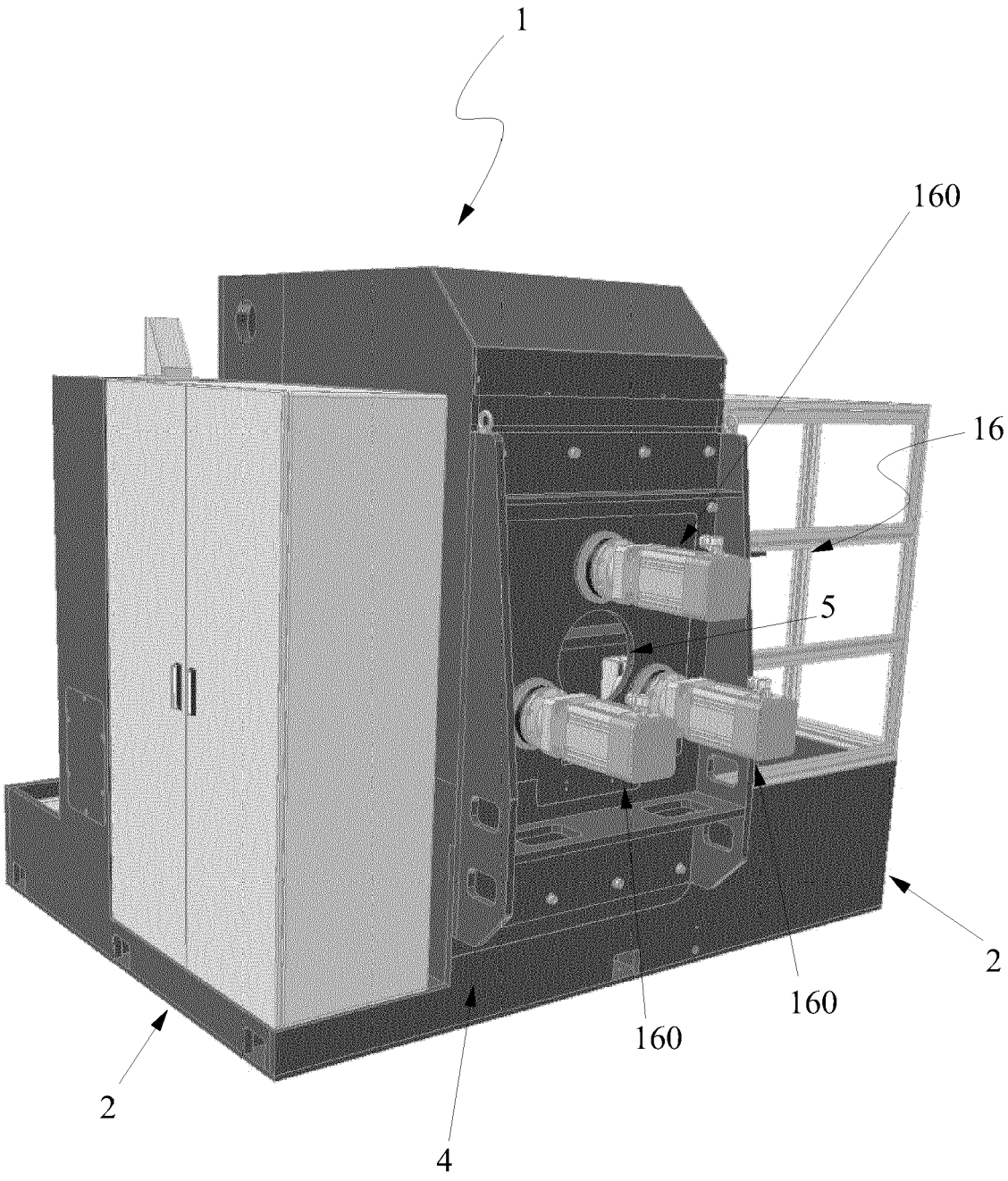

Fig. 2

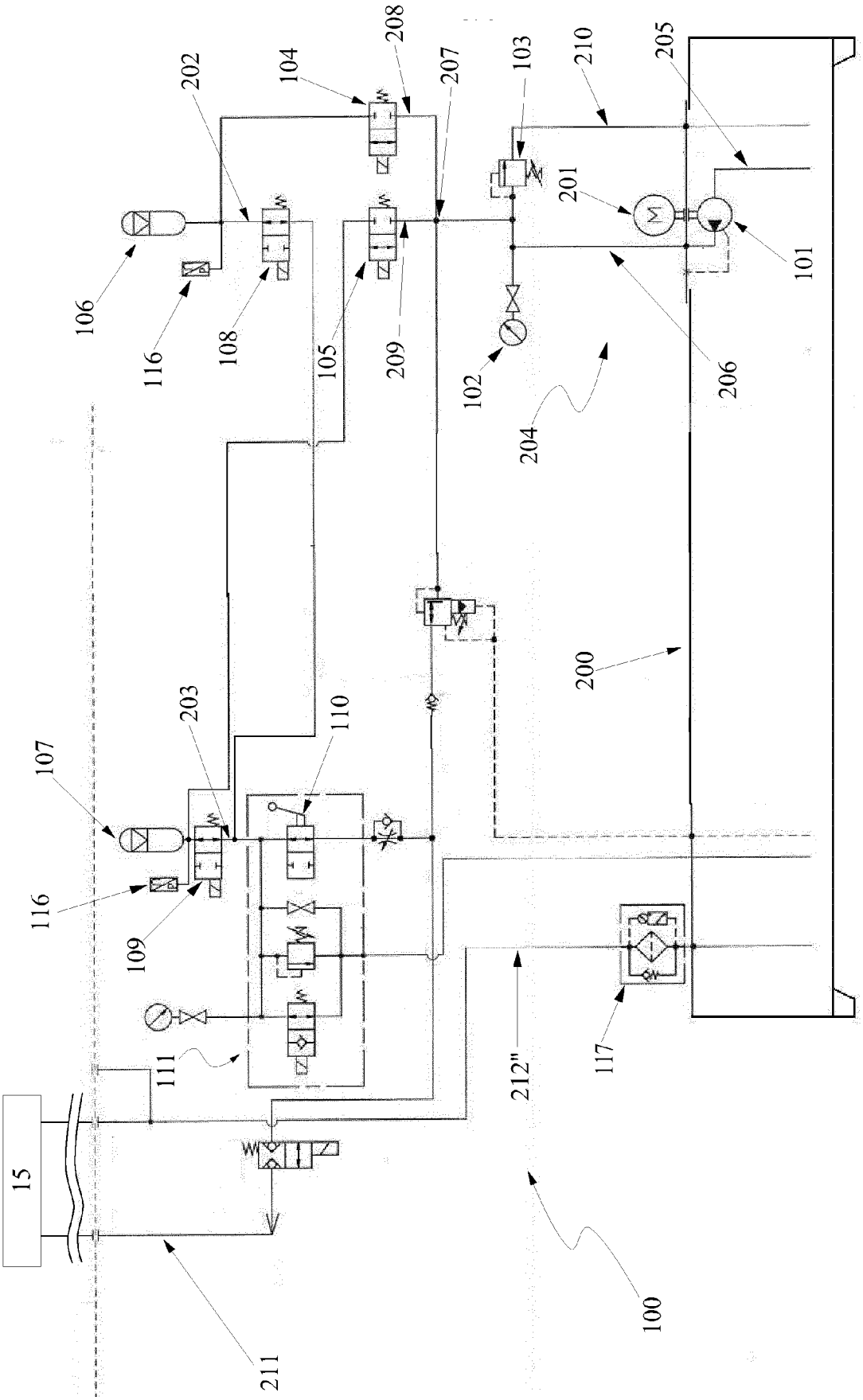
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Fig. 3

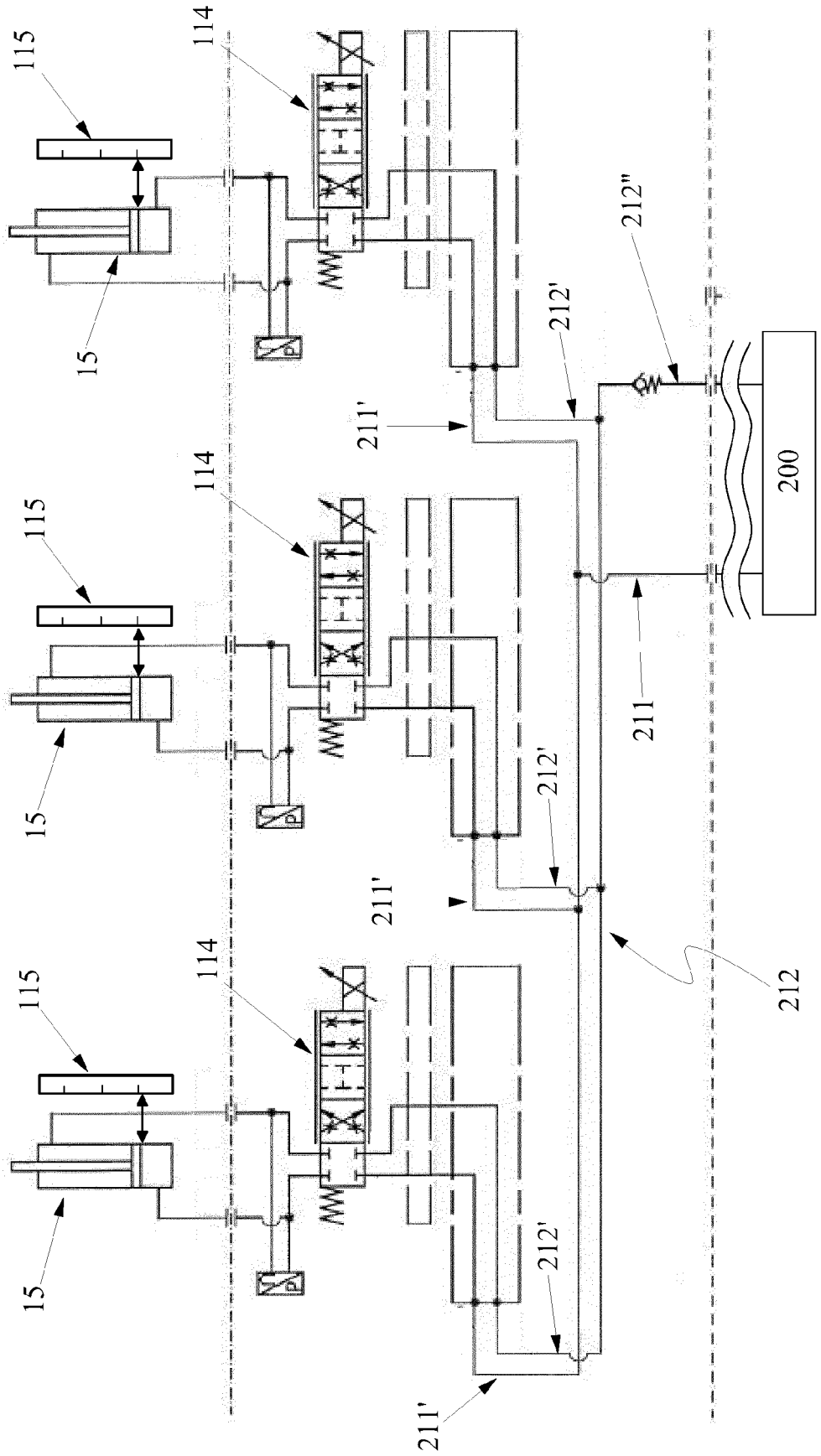

Fig. 4

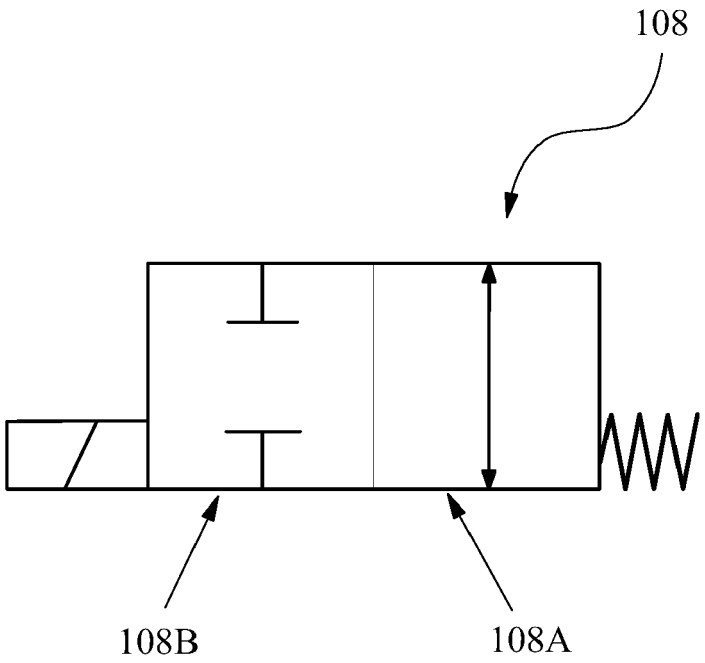

Fig. 5

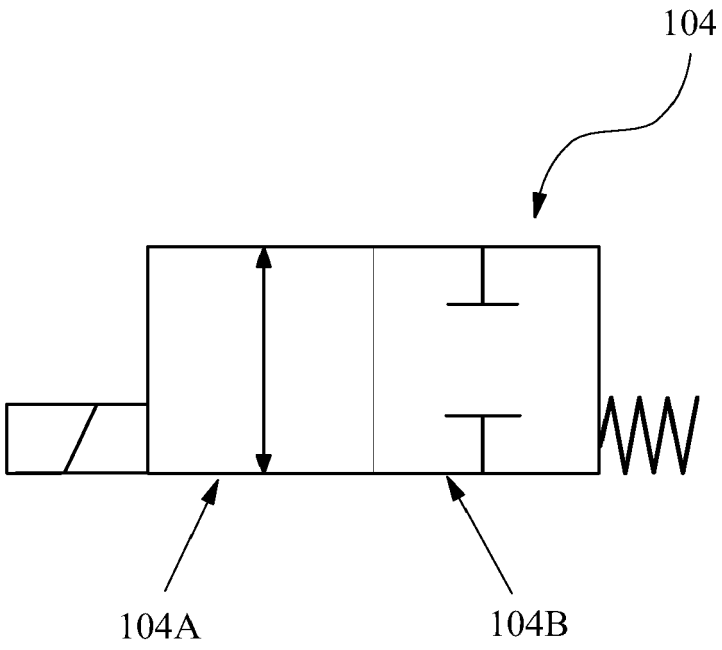

Fig. 6

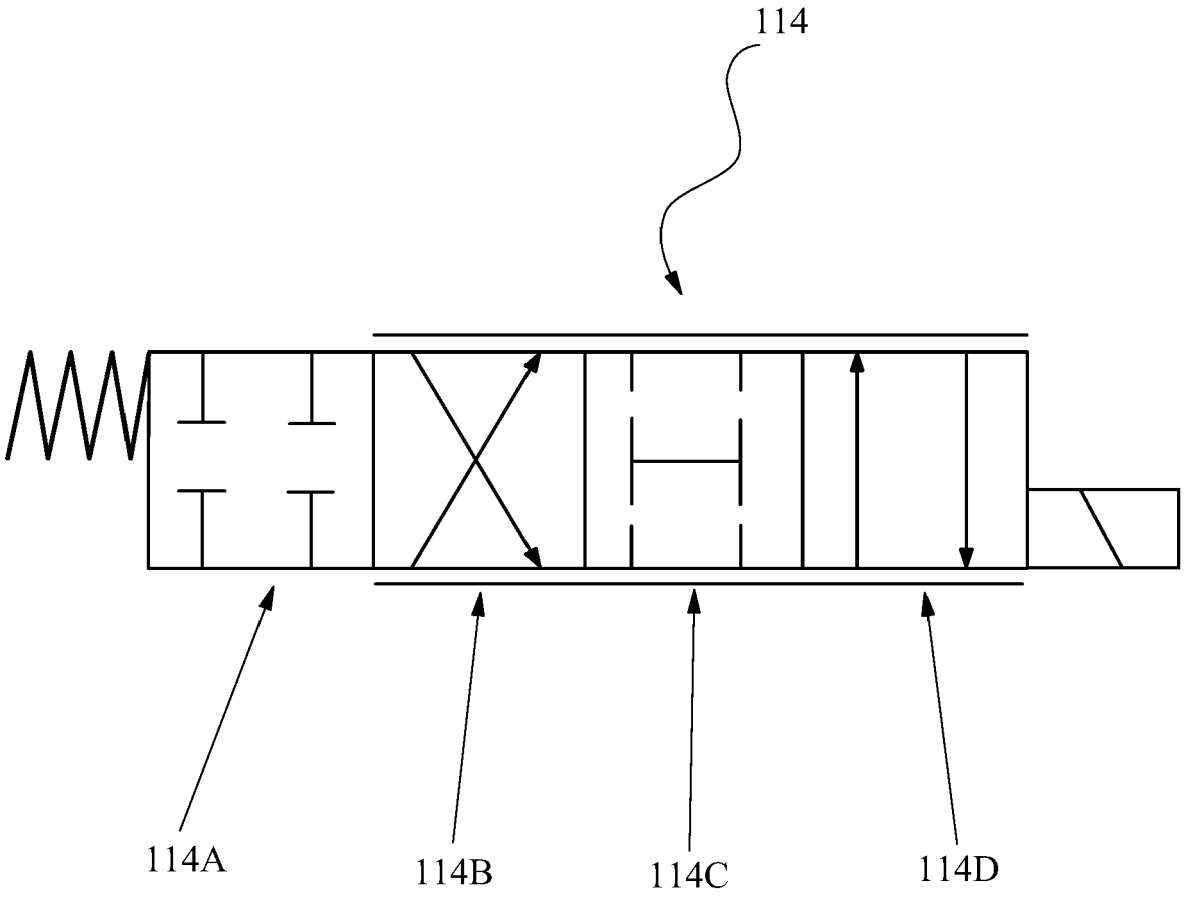

Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 16 17 8705

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	GB 933 132 A (JURGEN PLAGEMANN) 8 August 1963 (1963-08-08) * page 1, line 10 - line 17 * * page 2, line 67 - page 3, line 32 * * page 4, line 33 - page 5, line 31; figures 1-8 *	1-13	INV. B21H3/04 B21H5/02
A	DE 767 894 C (PEE WEE MASCHINEN UND APPBAU) 26 July 1954 (1954-07-26) * the whole document *	1	

TECHNICAL FIELDS SEARCHED (IPC)

B21H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	28 November 2016	Ritter, Florian

CATEGORY OF CITED DOCUMENTS

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28-11-2016

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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