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(54) **Improved open circuit oleodynamic system to actuate and control a concrete piston pump**

(57) An actuating oleodynamic system for pumps pumping viscous material, and in particular concrete, of the open-circuit and high-pressure type supplied by one or more hydraulic pumps, with direct, automatic-sequence driving system for the actuation of the hydraulic cylinders which displace the pistons in the liners of said pump and of the cylinders of a deviation valve through which said liners are alternately put in communication with a loading hopper and with a supply pipe. The system comprises a hydraulic valve assembly to control the displacement direction of said pistons, consisting of two hydraulic distributors, each actuated by a 5-way electrovalve to invert said direction between a pumping function and an intake function.

The hydraulic circuit driving the hydraulic cylinders of the pump is symmetrical with respect to a plane transversal to the centreline of the two cylinders arranged side by side, in correspondence of which the hydraulic supply assembly is also arranged, resulting in a simple and quick switching of the supply from "shaft side" to "piston side" and viceversa.

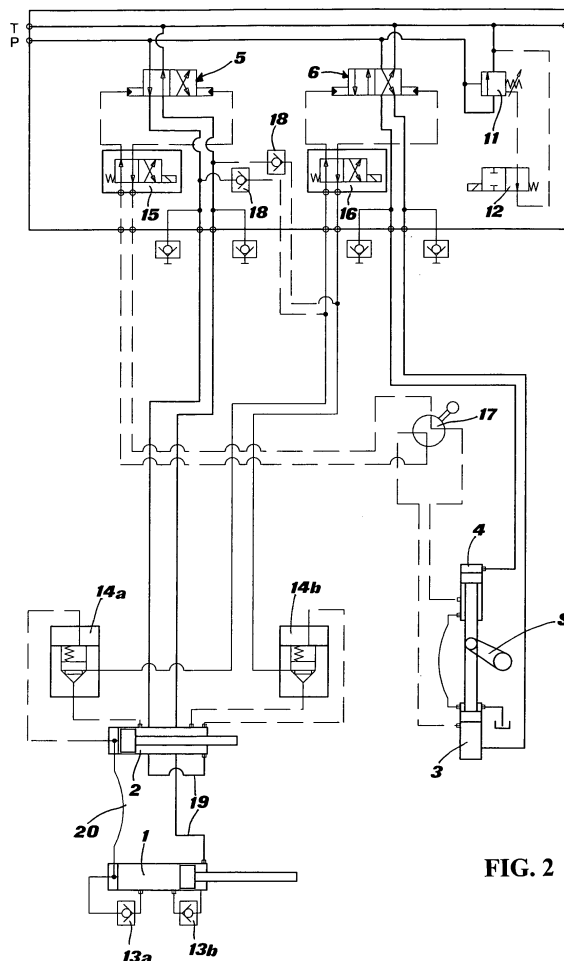


FIG. 2

Description

[0001] The present invention refers to an open-circuit, oleodynamic system, with direct, automatic-sequence, driving system for the actuation and control of alternate-piston pumps, particularly of pumps for pumping concrete or other viscous materials.

[0002] In particular, said pumps are generally of the type comprising two cylindrical liners which receive the material to be pumped, within which slide corresponding pistons capable of pushing the viscous material along the liners. Each of the above-mentioned pistons represents the working member of a hydraulic jack whose driving member is the piston of a corresponding hydraulic cylinder/piston assembly, the two pistons of each jack (the one moving in the liner and the one of the hydraulic cylinder) being mounted at the opposite ends of a same shaft.

[0003] The pump is operated by actuating the two hydraulic cylinders, so that the respective shafts may have an alternate, opposite-direction movement, so that while the piston in one of the pump liners is returning back and sucking viscous material into the liner, the other piston is simultaneously advancing, causing the expulsion of the material from the liner, i.e. precisely the desired pumping action.

[0004] An outflow deviation valve mechanism, known in the field as S-valve, is used in combination with the shafts/pistons and in synchronisation with the movement thereof to achieve the alternate connection of the outlets of the liners through a hopper feeding the material to be pumped and, respectively, through the pump supply pipe, thereby guaranteeing a substantially constant exit flow of the pumped material (concrete).

STATE OF THE ART

[0005] In order to drive the movement of hydraulic cylinders of piston pumps, complex oleodynamic systems have long been known, characterised by suitably-controlled automatic work sequences. Such systems may be divided into two main categories, according to the type of hydraulic circuit employed therein, and precisely:

- closed-circuit oleodynamic systems;
- open-circuit oleodynamic systems.

[0006] Open-circuit oleodynamic systems are the most-frequently adopted ones due to their relative construction simplicity, easy finding of components, easy maintenance, and finally owing to the fact that repair operations, in case of malfunctioning, may be carried out also by non-qualified staff and with the basic equipment normally available on-board.

[0007] The automatic work sequences of open-circuit hydraulic systems are generally controlled by means of an auxiliary hydraulic circuit, capable of automatically switching between the two pistons the flow of pressurised

fluid, on the basis of signals received from electric or preferably hydraulic limit devices, capable of detecting the displacement of the hydraulic pistons of the pump, precisely in the proximity of their top and bottom dead centres.

[0008] In particular, one can distinguish two different types of such control circuits: a first low-pressure type uses a fluid characterised by an auxiliary pressure, generally in the order of 40 bar; a second type of such control circuits exploits instead the same supply pressure of the main control circuit of the hydraulic cylinders of the pump, and is therefore a high-pressure circuit, the pressure of which may reach for example 350 bar.

[0009] In low-pressure control systems there is the need to create and maintain a fluid at a reduced auxiliary pressure by means of a separate, dedicated circuit and generally consisting of a pump, a pressure-relief valve, a pressure-regulating valve, and possibly an accumulator. All this increases system complexity and the resulting costs, both for purchase and for installation. Another method to obtain a fluid at a reduced auxiliary pressure consists in reducing the pressure of the main supply fluid to the hydraulic cylinders by means of a pressure-regulating valve. A substantial drawback of this system is that auxiliary pressure remains constant only as long as the pressure of the main supply fluid lies above the calibration value of the pressure-regulating valve. When this is not the case - for example generally during the intake phase of the concrete pump in which concrete is returned into the supply hopper to attempt freeing an obstruction in the concrete supply pipe - the pressure of the auxiliary fluid drops below the calibration value impairing the correct performance of the control functions.

[0010] This drawback does not naturally occur in high-pressure control circuits, wherein the same pressurised fluid of the main supply to the hydraulic cylinders is in fact exploited to feed the control circuit which drives the inversion of the hydraulic distributors and, cascading therefrom, that of the pumping cylinders and of the outflow deviation valve. However, in this case it is necessary to select hydraulic components suitable to withstand the maximum pressure that the auxiliary pressure can reach which, matching the exercise pressure of the operating machine, may be in the order of 350 bar.

[0011] The operation of a concrete pump always provides two different characteristic work steps, and precisely:

- a concrete-supply step, which is the proper operative step of the pump; and
- a concrete-intake step which takes place either at the end of the supply step, to carry out pipe cleaning, or even during such step, to attempt freeing an obstruction which may have clogged the pipe.

[0012] The two above-mentioned steps are accomplished, according to the current state of the art, in two different ways.

[0013] According to a first arrangement, between the hydraulic pump which supplies with pressurised fluid the circuit and the distributors of the hydraulic cylinders of the pump (pumping cylinders and cylinders for the switching of the deviation S valve) a deviation directional valve is installed, by means of which it is possible to directly invert supply and return to the distributors when one wants to change from one to the other of the work steps of the pump. This solution, however, implies that said deviation directional valve consists of a 4-way distributor capable of withstanding 350 bar at its four ports.

[0014] A hydraulic distributor of this type is not normally available on the market and it is hence necessary to provide to a specific design of the same. This solution is hence not currently preferred, both due to its higher costs, but also because maintenance requirements make it far more practical and appealing for users to employ standard components which are easily available on the market.

[0015] In a second design arrangement, switching between the intake and supply phases of the pump is instead achieved by inverting the flow direction in the driving lines from the hydraulic cylinders which actuate the concrete pump to the distributor of the deviation valve and in those from the cylinders of the deviation valve to the distributor of the pump cylinders. This inversion is generally achieved in correspondence of the hydraulic supply distributors of said cylinders by means of two commercial-type electrovalves, normally installed for the sake of convenience on a single base block, which is in turn mechanically connected with its respective hydraulic distributor.

[0016] The need to use two electrovalves for each hydraulic distributor (and consequently four electrovalves in total to control the two hydraulic distributors of the circuit) depends on the fact that in commercial electrovalves the four existing ports - referred to by the standard letters P (pressurised fluid inlet), T (fluid return port to the collection tank), A and B (pressurised fluid supply and return ports to the appliances) may not all be used interchangeably for high-pressure flows.

[0017] As a matter of fact, precisely due to the specific mechanical structure of commercial electrovalves, ports P, A, B, are all suited to withstand the valve nominal pressure, for example 350 bar for the electrovalve type used in the systems described here. Port T instead may generally withstand a pressure below 50% the nominal pressure of the valve, for example in this case a maximum pressure of 160 bar; such port cannot consequently be used to receive one of the flows of the working fluid which, as has been shown, can reach a pressure of 350 bar. For this reason, in each electrovalve only ports P, A and B are used, so that in order to govern the four flow streams provided in each of the two hydraulic distributors which supply a respective cylinder, two coupled electrovalves must necessarily be used.

[0018] This design arrangement is widely adopted today because it allows to accomplish the desired control of the oleodynamic system using commercial, cheap, and

easily available electrovalves. However, it is not devoid of drawbacks, since the use of two electrovalves, which must be electrically and hydraulically interconnected, determines a large bulk of the components, greater circuit complexity, and a consequent risk of malfunctioning due to incorrect mounting or connection of the components during maintenance operations on the building site.

[0019] Finally, a last circumstance must be highlighted, in connection with the methods of use of concrete pumps, i.e. that they are used in a variety of applications in the building industry. In particular, pumps may be used in combination with a distributor arm mounted on the same vehicle as the pump to supply concrete to medium-height buildings or to large raft foundations. In other cases instead, especially in tall buildings, the distributor arm is detached from the pump-mounting vehicle and installed on a specific tower. In such case, the concrete pump must pump the concrete up to the distributor arm, through a suitably-installed connection pipe.

[0020] In the first case - characterised by modest heights and small hydraulic head losses on the pipe, which in fact is only the distributor arm one - the concrete pump is generally required to have a high flow rate and a relatively low pressure. In the second case - characterised by great heights and high head losses on the pipe, which in fact comprises also the connection pipe - the concrete pump on the contrary must develop a high pressure and a relatively low flow rate.

[0021] This working flexibility is normally obtained by moving the supply of the hydraulic cylinders driving the pump, from the "shaft side" to the "piston side" and vice-versa. As a matter of fact, by feeding the "shaft-side" hydraulic cylinders, i.e. on the side of the annular chamber formed between the cylinder and the piston shaft, and maintaining the displacement synchronism between the two cylinders through the connection between the respective piston chambers, high flow rates and a relatively low pressure are achieved. By feeding the "piston-side" hydraulic cylinders, instead, i.e. on the side of the cylindrical chamber formed above the piston, and maintaining the synchronism between the two cylinders by means of the connection between the respective annular chambers, high pressures with a relatively low flow rate are achieved.

[0022] The option of switching the pump into one or the other of these two supply configurations is hence a need strongly felt by the users of concrete pumps, which can thereby always operate next to the maximum pump efficiency, albeit in very different operating conditions. Particularly felt is further the need for such switching of the point of supply to the hydraulic cylinders to occur as quickly and easily as possible.

[0023] The main object of the present invention is hence to provide an oleodynamic system which allows to overcome the above-mentioned drawbacks, typical of the solutions known so far in the market.

[0024] In particular, a first object of the present invention is to provide an oleodynamic system for the actuation

and control of an open-circuit piston pump for pumping concrete, and comprising automatic sequences for supply inversion driven by hydraulic distributors actuated by hydraulic stops, wherein the bulk of the electrovalve assemblies associated with said distributors is substantially reduced and the hydraulic connections thereof are simplified.

[0025] A second object of the present invention is to provide an oleodinamic system of the above-mentioned type, which further allows to switch the supply from the "shaft side" to the "piston side" very quickly and easily.

[0026] According to the present invention, such objects are achieved through an oleodinamic system for the actuation and control of a piston pump for pumping concrete having the features defined in the accompanying claim 1.

[0027] Further features of the invention are defined in the subsidiary claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] Further features and advantages of the present invention will in any case be more evident from the following description of an embodiment of the same, provided only as a non-limiting example, with reference to the accompanying drawings, wherein:

fig. 1 shows in a diagrammatic view the circuit diagram of an oleodinamic system, according to the prior art;

fig. 2 is a diagram of the oleodinamic system for the actuation and control of a concrete pump according to the invention, with a "shaft-side" supply, during a working step;

fig. 3 is a diagram similar to fig. 2, in the same working step, however, with a "piston-side" supply;

fig. 4 is a section view of a known 4-way electrovalve; and

fig. 5 is a section view of the 5-way electrovalve according to the present invention shown, in the two opposite halves, in its two working positions.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

[0029] With reference to fig. 1, an oleodinamic system according to the prior art consists of: two main hydraulic cylinders 1 and 2, the pistons of which are rigidly connected with the pistons (not shown) which push the pumped viscous material (normally concrete) into the cylindrical liners of the pump; two hydraulic cylinders 3 and 4 which drive the movement of the distributor valve, by means of a lever S hinged in the centre of their shared shaft; a first mobile-cursor hydraulic valve 5 to supply hydraulic cylinders 1 and 2 of the pump; a second mobile-cursor hydraulic valve 6 to supply hydraulic cylinders 3 and 4 of the distributor valve; four electrovalves 7, 8, and 9, 10, for the remote-actuation of distributors 5 and 6,

respectively, in the pumping and intake cycles; a hydraulic pump P for circuit supply; a pressure-limiting valve 11 with a respective electrovalve 12 connected to the drain, for the control and protection of the oleodinamic circuit; a filter F, generally installed on the drain; one-way valves 13 and logical seat valves 14 of the auxiliary circuit, capable of ensuring operating synchronism of the hydraulic cylinders 1, 2 and 3, 4 and replenishment of the oil leaks. A known oleodinamic system which has this type of general architecture is for example the one shown in EP-0 167 635, the contents of which are hereby incorporated by reference, as far as useful for a better comprehension of general system functionality and of the different working steps of the same which will hence not be further detailed here.

[0030] Fig. 2 shows an oleodinamic system according to the invention, wherein the components having the same function are referred to by the same numerals used in fig. 1.

[0031] As can be immediately appreciated by a comparative analysis of the two diagrams, the oleodinamic system according to the present invention also shares the general architecture of prior known systems as far as arrangement and hydraulic connections of the main hydraulic circuit are concerned, i.e. pump P and filter F, hydraulic cylinders 1 and 2 of the pump, hydraulic cylinders 3 and 4 of the distributor valve, hydraulic distributors 5 and 6.

[0032] Substantial differences are instead found in the accomplishment of the auxiliary circuit which provides to automatically determine the synchronised displacement sequences of the hydraulic cylinders and which allows to switch concrete pump operation in the opposite pumping/intake cycles to one side, as well as to quickly change the point of supply thereof from "shaft side" to "piston side".

[0033] Concerning the switching of pump operation between the pumping and intake cycle, the function performed in the conventional system by the two pairs of 4-way electrovalves is now performed instead by two innovative 5-way electrovalves 15 and 16, directly mounted on hydraulic distributors 5 and 6.

[0034] The structure of such electrovalves is diagrammatically shown in fig. 5, and is characterised by a larger number of inner compartments than that of conventional electrovalves, an example of which is shown in fig. 4. In particular, said known electrovalves comprise five V-shaped inner compartments V, the central one V_P , connected to pressure source P, being capable of being alternately put in communication with one of the two side compartments V_A and V_B connected to appliances A and B, respectively. Finally, the two peripheral compartments V_T are interconnected and connected to drain T, as well as being alternately put in communication with the one of the two compartments V_A and V_B which at that time is not in communication with compartment V_P . As known, the shifting from the AP/BT connection to the AT/BP connection is achieved by sliding a cursor C whereon two

cylindrical members R are formed with a double perimeter seal, capable of alternately seal one or the other of corresponding cylindrical seats which delimit the compartments V_{Ae} V_B wherein the cylindrical members are housed.

[0035] The 5-way valve structure according to the present invention differs from the above-described one in that it comprises seven compartments V, rather than the five above-mentioned ones, as well as a cursor C equipped with four cylindrical sealing members R, of which the end ones R_Y are twofold. From a functional point of view, the 5-way valve of the invention repeats, in the five central compartments VP, VA, VB and VT the same function of the above-described, known-type 4-way valve. Unlike the conventional electrovalve, however, compartments V_T are divided from the chamber of solenoid D and from that of return spring M by twofold cylindrical sealing members R_Y which are in permanent sealing contact with the cylindrical seats which delimit the two outmost valve compartments V_Y . Such compartments are further interconnected and communicate with the drain branch by a drainage channel Y formed in hydraulic distributors 5 and 6, to drain the excess oil which leaks into the same from adjacent compartments V_T .

[0036] Thanks to this valve arrangement, also port T can operate at the maximum nominal pressure, being in fact divided from the chambers of solenoid D and from return spring M by the two pairs of inner cylindrical sealing members R_Y which bear in a symmetrical and balanced way the pressure received through cursor C and allow to maintain a higher working pressure in ports A, B, P and T and a reduced allowable pressure in the outer chambers of solenoid D and of return spring M. The different connections required by hydraulic distributors 5 and 6 can hence be performed by the only above-mentioned electrovalve member 15, 16, with significant advantages from the point of view of the streamlining of the electrical and hydraulic systems which, in the prior art, are necessary to accomplish the correct connection between the two 4-way electrovalves which actuate each hydraulic distributor. In a preferred configuration, electrovalves 15 and 16 have three out of their five ports arranged on a plane machined according to ISO/CETOP 03 rule suited to be arranged matching a similar plane of the hydraulic distributors, so that there are only two outstanding connections to be set up, through pipes outside the block formed by the electrovalve and by its respective distributor. Conveniently, the components of the 5-way electrovalves which are different from cursor C are identical to the ones of the commercial 4-way electrovalves, so as to reduce the cost and to ease maintenance thereof.

[0037] Furthermore, as concerns the option of quickly varying the point of supply of the pump from "shaft side" to "piston side", according to the present invention the hydraulic circuit driving hydraulic cylinders 1 and 2 which actuate the pump is accomplished in a symmetrical way to a plane transversal to the centreline of the two cylinders arranged side by side, rather than to a plane parallel to

the axes of the cylinders and arranged between the same. In other words, while in the known art both cylinders 1 and 2 are equipped with an identical control circuit, in the system of the present invention each cylinder is equipped with a control circuit identical at the two ends thereof and different from the one of the adjacent cylinder. Thereby, the pair of same-side ends of the two cylinders altogether have the same control structure and hence switching of the point of supply can be performed very quickly and easily, as will be shown below.

[0038] As a matter of fact, in particular the first hydraulic cylinder 1 is equipped at its two opposite ends with two one-way valves 13a and 13b, capable of automatically guaranteeing the synchronism of the pumping cylinders, while the second cylinder 2 is equipped at its two opposite ends with two logical seat valves 14a and 14b, preferably gathered in a single small block, capable of actuating the flow inversion of hydraulic distributor 6 of cylinders 3 and 4 of the deviation valve. Flow inversion of distributor 5 of hydraulic cylinders 1 and 2 of the pump is instead actuated by means of two driving lines coming from the cylinders of the deviation valve which run through a mechanical-switching, 4-way valve 17.

[0039] The above-described hydraulic circuit allows to effect the regular flow inversion to pump cylinders 1 and 2 and to cylinders 3 and 4 of the deviation valve without the need to overfeed the slave circuit as occurred in the previous state of the art, thanks to the fact that two one-way valves 13a and 13b are provided, of which one replenishes oil to the slave circuit and the other drains oil from the slave circuit, automatically maintaining the synchronism of the pumping cylinders. Two further one-way valves 18, arranged on bypass branches which connect the driving branches of hydraulic distributor 6 (coming from valves 14) with the supply branches of cylinders 1 and 2 of the pump, provide to alternately drain a driving branch on the supply branch of cylinders 1 and 2 which is alternately in communication with drainage (T). In the prior state of the art, the driving branch which is intended to go into the drain was forced to run through the logical valves under considerable counterpressure. One-way valves 18 hence reduce pressure peaks and speed up the switching of hydraulic distributor 6.

[0040] Moreover, the specific symmetry imparted to the control circuit allows to switch the supply from "shaft side" (fig. 2) to "piston side" (fig. 3) in a particularly uncomplicated way. As a matter of fact, causing pressurised fluid supply to arrive at a central location on cylinders 1 and 2, it is sufficient - in order to achieve supply switching - to shift the two flexible connections which connect the supply from a pair of cylinder ends 1 and 2 (the right-hand one in fig. 2) to the opposite one, simultaneously shifting by-pass pipe 20 in order to connect the pair of cylinder ends disconnected from the supply. This shifting is extremely quick, intuitive, does not require to have different special components for the two types of supply and, above all, makes it virtually impossible to connect the pump incorrectly.

[0041] From the preceding description it is evident how the present invention has fully achieved the set objects, of construction streamlining in the management of the switching between pumping and intake functions, and of ease of use and speed in the management of the change of supply from "piston side" to "cylinder side" and vice-versa.

[0042] It is clear, however, that, although the present invention has been described with reference to a specific embodiment, a number of changes and improvements may be made to the same by a person skilled in the field, even by employing already-known equivalent devices for hydraulic systems for piston pumps, all falling within the scope of protection of the present invention as defined in the accompanying claims.

Claims

1. Oleodynamic actuating system for pumps pumping viscous material, of the open-circuit, high-pressure type, supplied by one or more hydraulic pumps, with direct, automatic-sequence driving system for the actuation of the hydraulic cylinders which displace the pistons in the liners of said pump and of the cylinders of a deviation valve through which said liners are alternately put in communication with a loading hopper and with a supply pipe, comprising a hydraulic valve assembly to control the displacement direction of said pistons, consisting of two hydraulic distributors actuated by electrovalves to invert said direction between a pumping function and an intake function, **characterised in that** said hydraulic distributors are actuated by 5-way electrovalves, four ways of which are connected to corresponding distributor driving lines and the fifth one is intended for reduced-pressure fluid circulation to the solenoid and to the electrovalve return spring chambers.
2. Oleodynamic system as claimed in claim 1), wherein said electrovalves are installed directly in contact with a surface of said hydraulic distributors.
3. Oleodynamic system as claimed in claim 2), wherein three of the communication ports of said electrovalves open out on an even, machined surface according to ISO/CETOP 03 rule, said surface being intended to be mounted in contact with said surface of the hydraulic distributors which carries a corresponding number of matching ports.
4. Oleodynamic system as claimed in claim 3), wherein two of the communication ports of said electrovalves are threaded ports arranged on a side of the electrovalve.
5. Oleodynamic system as claimed in claim 1), wherein said electrovalve comprises seven coaxial compartments wherein a single cursor slides, equipped with cylindrical sealing members apt to seal corresponding seats which separate said compartments.
6. Oleodynamic system as claimed in claim 5), wherein the three central compartments are connected to respective electrovalve ports, the fourth port being jointly connected to the pair of compartments adjacent to the three central compartments.
7. Oleodynamic system as claimed in claim 6), wherein said electrovalves comprise, outside said series of seven compartments and on opposite sides, a solenoid chamber and a spring chamber, both in an oil bath, and wherein the compartments respectively lying between said solenoid chamber or said return spring chamber and the five central compartments, are interconnected and communicating with a circuit draining branch by means of a draining channel provided in the hydraulic distributor actuated by said electrovalve.
8. Oleodynamic system as claimed in claim 7), wherein each of the compartments respectively adjacent to the solenoid chamber and to the return spring chamber is separated from the internally adjacent compartment by one of said cylindrical sealing members of the cursor, said member being constantly in contact with the corresponding housing in any cursor position.
9. Oleodynamic system as claimed in anyone of the previous claims, wherein the hydraulic circuit driving the hydraulic cylinders which actuate the pump is symmetrical with respect to a plane transversal to the centreline of the two cylinders arranged side by side, i.e. each cylinder is equipped with an identical actuation circuit at the two opposite ends thereof.
10. Oleodynamic system as claimed in claim 9), wherein a former one of the two hydraulic cylinders which actuate the pump is equipped at its two opposite ends with one-way valves for controlling the slave circuit, whereas the latter of said cylinders is equipped at its two opposite ends with logical seat valves capable of actuating the flow inversion of the hydraulic distributor of the cylinders of the deviation valve.
11. Oleodynamic system as claimed in claim 10), wherein said logical seat valves are grouped together in a single block.
12. Oleodynamic system as claimed in claim 9), wherein from the cylinders of the deviation valve two driving lines are taken actuating the flow inversion of the distributor of the hydraulic cylinders of the pump by means of a 4-way, mechanical switching valve.

13. Oleodynamic system as claimed in the preceding claims from 9) to 12), wherein two one-way valves are further provided arranged on bypass branches which connect the driving branches of the hydraulic distributor of the deviation valve cylinders, coming from said logical seat valves, with the supplying branches of the cylinders which actuate the pump. 5
14. Oleodynamic system as claimed in claim 9), wherein supply of the pressurised fluid to the pump cylinders occurs by means of a main hydraulic block arranged in correspondence of the centreline of said cylinders arranged side by side. 10
15. Oleodynamic system as claimed in claim 14), wherein the supply switching from "shaft side" to "piston side", and viceversa, occurs by shifting the two flexible supply connections from one pair of the pump cylinder ends to the opposite one, inversely shifting the bypass pipe which interconnects the pair of pump cylinder ends not connected to the supply. 15 20

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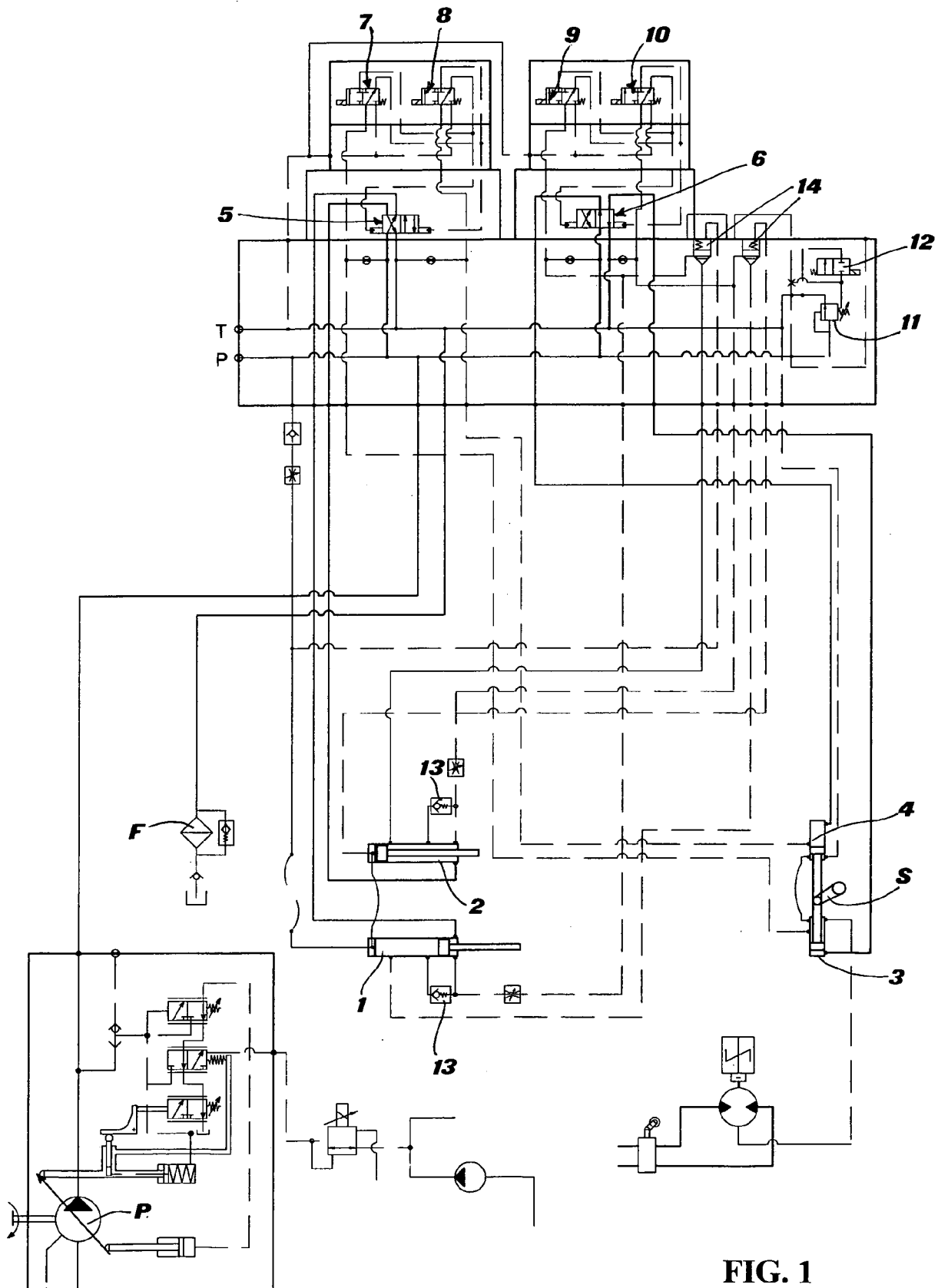


FIG. 1

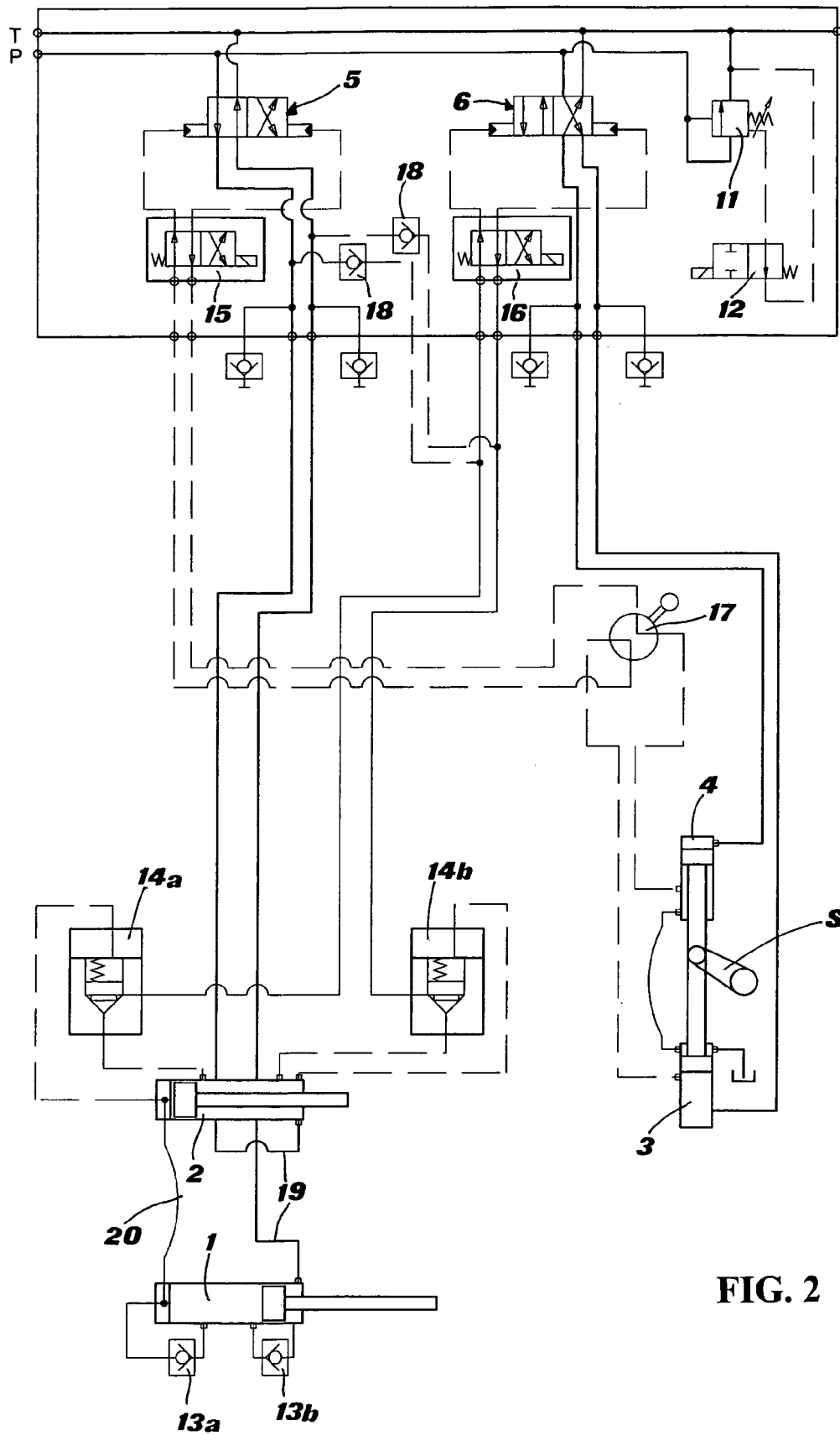


FIG. 2

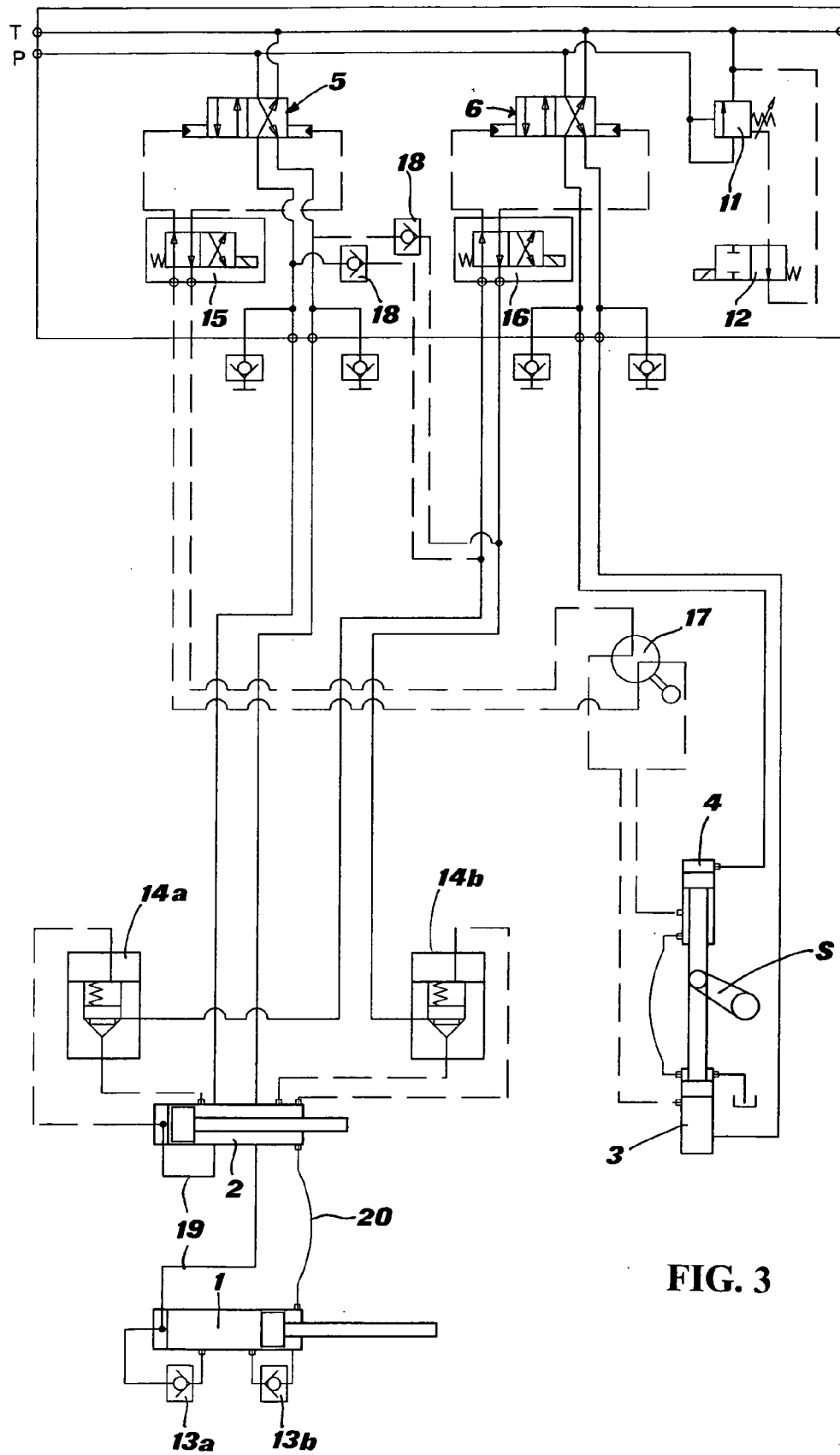


FIG. 3

FIG. 4

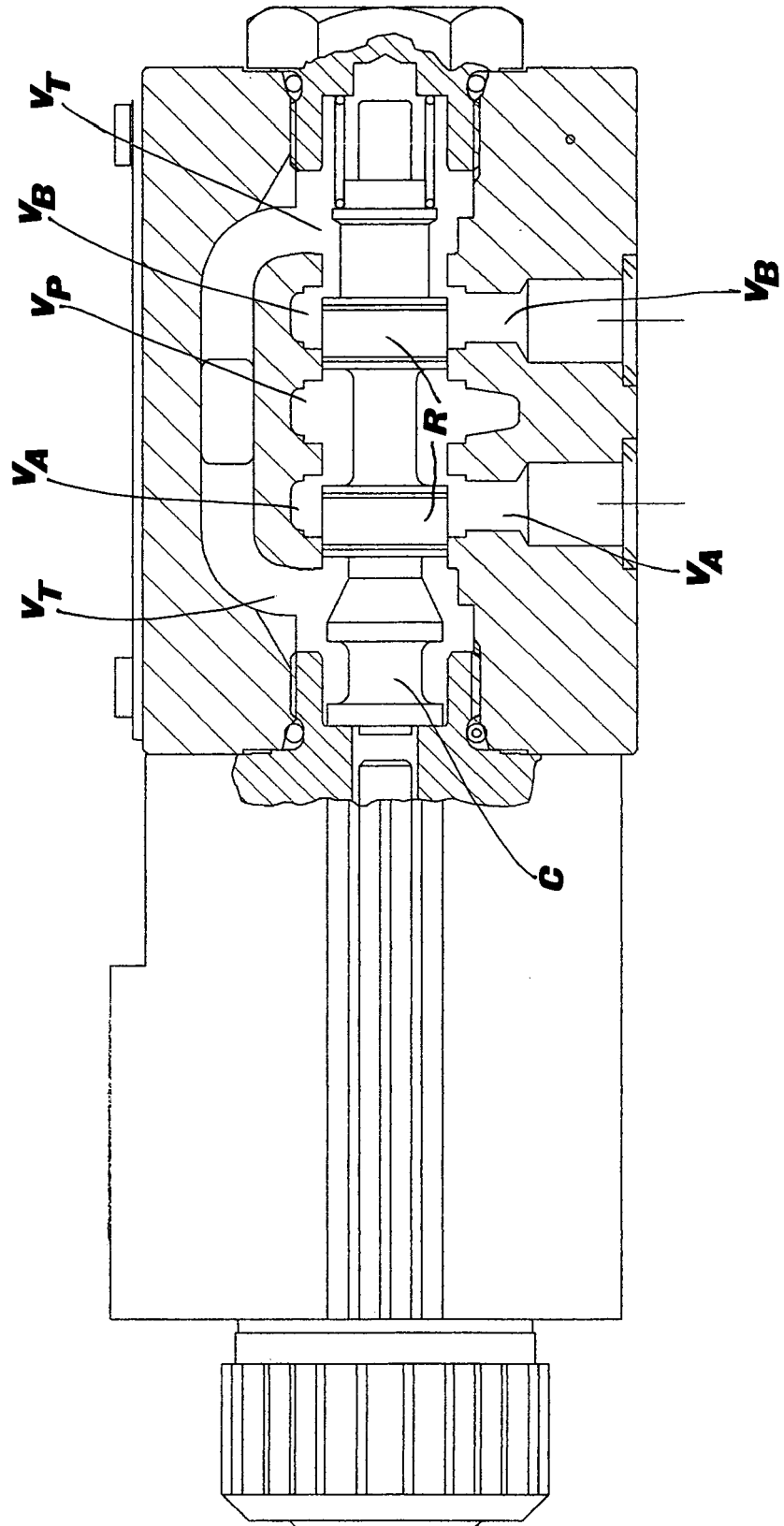
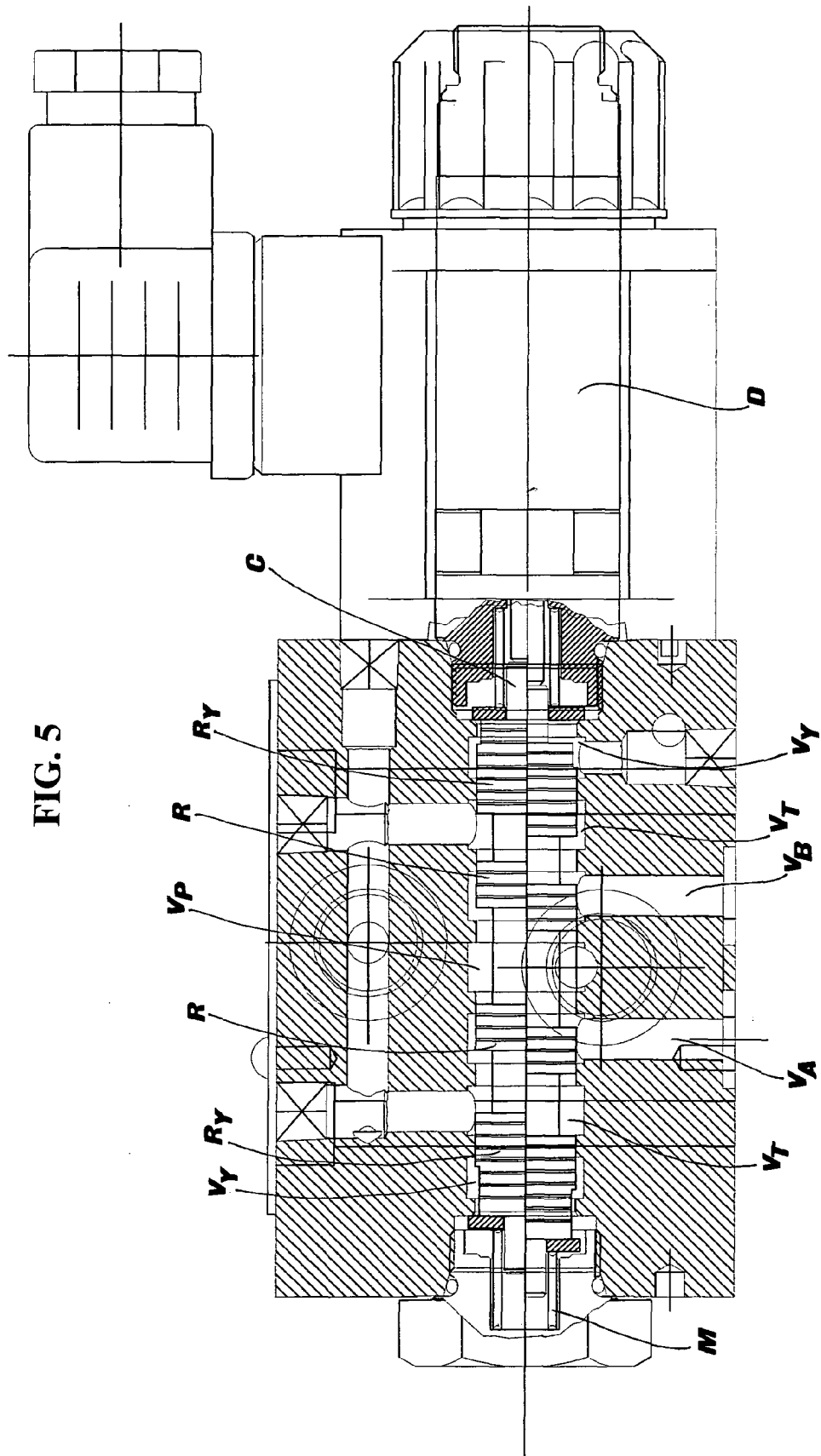


FIG. 5





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 42 5273

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Place of search Munich		Date of completion of the search 28 September 2006	Examiner Richmond, Robin
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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 06 42 5273

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