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(54) **ELECTRO-HYDRAULIC CONTROL VALVE FOR MULTI-PUMP SYSTEM, VALVE SEGMENT, AND CONTROL METHOD**

(57) The application discloses an electro-hydraulic control valve for a multi-pump system, a valve section, and a control method. The valve section of the electro-hydraulic control valve integrates a cut-off combining valve and a main control spool, and is provided with a supply port, a first working port, a second working port, a supply combining passage, and a return passage communicating with a return port. The cut-off combining valve includes at least a first working position, a second working position, and a third working position. When the cut-off combining valve is in the first working position, a supply port of the cut-off combining valve is in communication with a first port to release a load to the return passage. When the cut-off combining valve is in the second working position, the supply port of the cut-off combining valve is in communication with a second port to supply oil to the main control spool. When the cut-off combining valve is in the third working position, the supply port of the cut-off combining valve is in communication with a third port to supply oil to the supply combining passage in a combined-flow manner. The supply port of the main control spool is connected

to the supply combining passage. The return port of the main control spool is connected to the return passage. The first port and the second port of the main control spool are connected to two working ports of the valve section respectively.

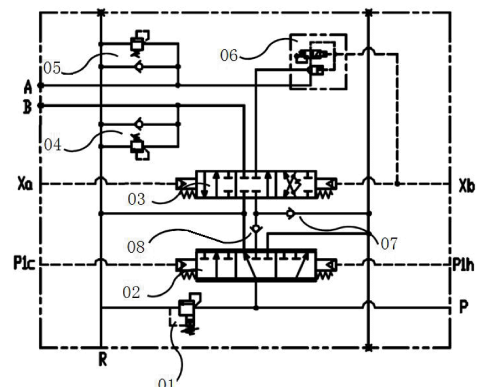


FIG. 1

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Description

TECHNICAL FIELD

[0001] This application relates to the field of hydraulic technologies for construction machinery, and in particular, to an electro-hydraulic control valve, a valve section, and a control method for a multi-pump system.

BACKGROUND

[0002] With the electrification trend in the construction machinery industry, in order to reduce the output power of a single pump and improve the overall operating efficiency of a machine, machine manufacturers have launched their own electric construction machinery products, and the application scope of multi-pump hydraulic systems has been gradually expanding. Currently, most hydraulic multi-way valves used in construction machinery on the market have oil supplied by a single pump or dual pumps, and suffer from issues such as load coupling among a plurality of actuators, significant energy losses, and a low degree of control freedom. Few hydraulic valves are suitable for multi-pump hydraulic systems.

[0003] Currently, the multi-way valves used in construction machinery mainly include monoblock multi-way valves and sectional multi-way valves. A main valve is generally designed with one or two supply ports at a supply section, and may integrate, as needed, a main relief valve, an LS relief valve, a pressure cut-off valve, and the like. Each working section is typically provided with working ports A and B, and may integrate, as needed, a port relief valve, a check valve, an LS shuttle valve, an LS relief valve, a load-holding valve, and the like. An electro-proportional flow cut-off valve is integrated upstream of a main spool, enabling flexible control of the flow delivered to each actuator according to actual requirements. Electro-proportional pressure-reducing valves are integrated into the end caps at both ends of the spool to implement electro-hydraulic drive control. The prior art exhibits the following drawbacks:

- (1) In existing technical solutions, all actuators share a supply passage. During combined operations, pressure coupling occurs, and differences in load lead to significant energy waste.
- (2) Existing technical solutions are applicable to single-pump or dual-pump systems. For multi-pump hydraulic systems with three or more pumps, the main valves need to be combined or substantially modified to be applicable, resulting in large space occupation and complex pipeline connections.

SUMMARY

[0004] Objective: In view of at least one of the above-mentioned technical problems, this application provides an electro-hydraulic control valve, a valve section, and a control method for a multi-pump system.

[0005] Technical solution: To solve the above technical problems, this application puts forward the following technical solutions:

10 According to a first aspect, an electro-hydraulic control valve section is provided. The electro-hydraulic control valve section integrates a cut-off combining valve and a main control spool. The valve section is provided with a supply port, a first working port, a second working port, a supply combining passage, and a return passage communicating with a return port R.

15 **[0006]** A supply port of the cut-off combining valve is connected to the supply port. A first port of the cut-off combining valve is connected to the return passage and to a return port of the main control spool separately. A second port of the cut-off combining valve is connected to a supply port of the main control spool. A third port of the cut-off combining valve is connected to the supply combining passage. The cut-off combining valve includes at least a first working position, a second working position, and a third working position. When the cut-off combining valve is in the first working position, the supply port of the cut-off combining valve communicates with the first port. When the cut-off combining valve is in the second working position, the supply port of the cut-off combining valve communicates with the second port. When the cut-off combining valve is in the third working position, the supply port of the cut-off combining valve communicates with the third port.

20 **[0007]** The main control spool is provided with the supply port, the return port, a first port, and a second port. The supply port of the main control spool is further connected to the supply combining passage. The return port of the main control spool is connected to the return passage. The first port of the main control spool is connected to the first working port. The second port of the main control spool is connected to the second working port.

25 **[0008]** In another embodiment, an electro-hydraulic control valve section is provided. The electro-hydraulic control valve section integrates a cut-off combining valve and a main control spool. The valve section is provided with a supply port, a first working port, a second working port, a supply combining passage, and a return passage communicating with a return port.

30 **[0009]** The cut-off combining valve includes a pressure cut-off valve and a combining valve. A supply port of the pressure cut-off valve and a supply port of the combining valve are both connected to the supply port. An outlet of the pressure cut-off valve is connected to the return passage and to a return port of the main control spool separately. A first port of the combining valve is connected to a supply port of the main control

spool. A second port of the combining valve is connected to the supply combining passage. When the pressure cut-off valve is in a first working position, the supply port of the pressure cut-off valve is not in communication with the outlet. When the pressure cut-off valve is in a second working position, the supply port of the pressure cut-off valve is in communication with the outlet.

[0010] When the combining valve is in a first working position, the supply port of the combining valve is in communication with the first port. When the combining valve is in a second working position, the supply port of the combining valve is in communication with the second port.

[0011] The main control spool is provided with the supply port, the return port, a first port, and a second port. The supply port of the main control spool is further connected to the supply combining passage. The return port of the main control spool is connected to the return passage. The first port of the main control spool is connected to the first working port. The second port of the main control spool is connected to the second working port.

[0012] In some embodiments, the electro-hydraulic control valve section further includes a first check valve. The supply combining passage supplies oil to the main control spool unidirectionally through the first check valve.

[0013] In some embodiments, the electro-hydraulic control valve section further includes a main relief valve. The main relief valve is disposed between the supply port and the return passage.

[0014] In some embodiments, the electro-hydraulic control valve section further includes a first port relief valve and a second port relief valve. The first port relief valve is provided between the first working port A and the return passage. The second port relief valve is provided between the second working port and the return passage.

[0015] In some embodiments, the electro-hydraulic control valve section further includes a load-holding valve. The first port of the main control spool is connected to the first working port through the load-holding valve.

[0016] In some embodiments, the electro-hydraulic control valve section further includes a second check valve, disposed between the supply port P and the supply port of the main control spool, and configured to supply oil to the main control spool unidirectionally through the cut-off combining valve.

[0017] According to a second aspect, this application further provides an electro-hydraulic control valve. The electro-hydraulic control valve includes a plurality of working sections. Each working section adopts the electro-hydraulic control valve section. Return passages of the plurality of working sections communicate with each other and share one return port. Supply combining passages of the plurality of working sections

communicate with each other directly or indirectly.

[0018] In some embodiments, the plurality of working sections of the electro-hydraulic control valve include a bucket section and a boom section. A first working port and a second working port of the bucket section are configured to be connected to a bucket cylinder. A first working port and a second working port of the boom section are configured to be connected to a boom cylinder. Supply combining passages of the bucket section and the boom section communicate with each other.

[0019] When a boom is operated independently, a boom-section cut-off combining valve is controlled to switch to a second working position, so that a supply port of the boom section supplies oil to a boom-section main control spool through the boom-section cut-off combining valve; meanwhile, a bucket-section cut-off combining valve is controlled to switch to a third working position, so that a supply port of the bucket section supplies oil to the boom section in a combined-flow manner through the boom section cut-off combining valve and a supply combining passage to ensure satisfaction of a speed requirement of the boom.

[0020] When a bucket is operated independently, a bucket-section cut-off combining valve is controlled to switch to a second working position, so that a supply port of the bucket section supplies oil to a bucket-section main control spool through the bucket-section cut-off combining valve. Meanwhile, the boom-section cut-off combining valve is controlled to switch to a third working position, so that the supply port of the boom section supplies oil to the bucket section in a combined-flow manner through the boom-section cut-off combining valve and a supply combining passage to ensure satisfaction of a speed requirement of the bucket.

[0021] When the boom and the bucket operate in combination, the bucket-section cut-off combining valve and the boom-section cut-off combining valve are controlled to both switch to the second working position, so that the supply port of the bucket section supplies oil to the bucket-section main control spool through the bucket-section cut-off combining valve, and that the supply port of the boom section supplies oil to the boom-section main control spool through the boom-section cut-off combining valve, so as to ensure that an oil source of the bucket section and an oil source of the boom section are independent of each other without load coupling.

[0022] When in standby mode, the bucket-section cut-off combining valve and the boom-section cut-off combining valve are both in the first working position, the supply port of the bucket section releases a load through the bucket-section cut-off combining valve, and the supply port of the boom section releases a load through the boom-section cut-off combining valve, so as to reduce a main-pump output pressure and system energy loss.

[0023] In other embodiments, in the electro-hydraulic control valve, the plurality of working sections include a first boom section, a right travel section, a left travel section, a first arm section, a second boom section, a bucket section, and a second arm section sequentially. Return passages of the first boom section, the right travel section, the left travel section, the first arm section, the second boom section, the bucket section, and the second arm section are all in communication with a return port of the first boom section. A supply combining passage of the first boom section is in communication with that of the right travel section. A supply combining passage of the left travel section is in communication with that of the first arm section. Supply combining passages of the second boom section, the bucket section, and the second arm section are in communication with each other.

[0024] An outlet port of the first process valve is connected to the supply port of the right travel control spool, and is configured to supply oil to the right travel control valve. A first port of the rectilinear travel valve is connected to a supply port of the left travel control spool. A second port of the rectilinear travel valve is in communication with the supply combining passage of the left travel section. When the rectilinear travel valve is in a first working position, the supply port, the first port, and the second port are not in communication with each other. When the rectilinear travel valve is in a second working position, the supply port is in communication with the first port to supply oil to the left travel control spool. When the rectilinear travel valve is in a third working position, the supply port is in communication with the second port, and the supply ports of the first process valve, the rectilinear travel valve, and the second boom cut-off combining valve are in communication with each other.

[0025] According to a third aspect, a hydraulic system of construction machinery is provided, and the hydraulic system is provided with any one of the electro-hydraulic control valves disclosed above.

[0026] Beneficial effects: This application provides an electro-hydraulic control valve for a multi-pump system, a valve section, and a control method. This application discloses an electro-hydraulic control valve for a multi-pump system, in which the valve section is provided with an independent supply port, and integrates a relief valve and a cut-off combining valve. Each valve section can be used as an independent control valve, making the system layout more flexible. Alternatively, the control valve may be arranged near an actuator as required, thereby improving the response speed. A plurality of valve sections combined together can be used as a sectional multi-way valve, thereby being suitable for hydraulic systems of electric excavators, electric loaders, and the like. Each valve section is provided with a cut-off combining valve, enabling free switching between independent oil supply through combined operations and combined oil supply through a single op-

eration. This effectively reduces the output power of a single pump, eliminates energy waste caused by load coupling, and provides a high degree of control freedom. The valve sections adopt modular independent design, thereby achieving a simple structure and flexible layout, and facilitating implementation of an integrated pump-valve design.

BRIEF DESCRIPTION OF DRAWINGS

[0027]

FIG. 1 is a schematic diagram of principles of valve sections of an electro-hydraulic control valve for a multi-pump system according to an embodiment of this application.

FIG. 2 is a schematic diagram of a first variation of principles of electro-hydraulic control valve sections according to an embodiment of this application.

FIG. 3 is a schematic diagram of a second variation of principles of electro-hydraulic control valve sections according to an embodiment of this application.

FIG. 4 is a schematic diagram of a two-section electro-hydraulic control valve used in a hydraulic system of a loader according to an embodiment of this application.

FIG. 5 is a schematic diagram of a seven-section electro-hydraulic control valve used in a hydraulic system of an electric excavator according to an embodiment of this application.

[0028] List of reference signs: In FIG. 1 to FIG. 3, main relief valve 01, cut-off combining valve 02, main control valve spool 03, second-port relief valve 04, first-port relief valve 05, load-holding valve 06, first check valve 07, second check valve 08; pressure cut-off valve 021, flow-combining valve 022;

In FIG. 4: bucket-section main relief valve 101, bucket-section cut-off combining valve 102, bucket-section main control spool 103, bucket-section first-port relief valve 104, bucket-section second-port relief valve 105, bucket-section first check valve 107, bucket-section second check valve 108; boom-section main relief valve 201, boom-section cut-off combining valve 202, boom-section main control spool 203, boom first-port relief valve 204, boom second-port relief valve 205, boom load-holding valve 206, boom first check valve 207, boom second check valve 208;

In FIG. 5: first-boom main relief valve 1, first-arm main relief valve 2, bucket main relief valve 3, first boom cut-off combining valve 4, first arm cut-off combining valve 5, bucket cut-off combining valve 6, rectilinear travel valve 7, second boom cut-off combining valve 8, first boom control spool 9,

right-travel control spool 10, left-travel control spool 11, first arm control spool 12, second boom control spool 13, bucket control spool 14, second arm control spool 15, first boom first-port relief valve 16, first boom second-port relief valve 17, first arm first-port relief valve 18, first arm second-port relief valve 19, second boom first-port relief valve 20, second boom second-port relief valve 21, bucket first-port relief valve 22, bucket second-port relief valve 23, second arm first-port relief valve 24, second arm second-port relief valve 25, second arm load-holding valve 26, second boom load-holding valve 27, first arm load-holding valve 28, first boom load-holding valve 29, second-arm first check valve 30, second-arm second check valve 31, bucket first check valve 32, bucket second check valve 33, second-boom first check valve 34, second-boom second check valve 35, first-arm first check valve 36, first-arm second check valve 37; left-travel check valve 38, right-travel check valve 39, first-boom first check valve 40, first-boom second check valve 41, first process valve 42, second process valve 43.

DETAILED DESCRIPTION

[0029] The following clearly describes the technical solutions in the embodiments of the present invention in full with reference to the accompanying drawings in the embodiments of the present invention. Apparently, the described embodiments are merely some of but not all of the embodiments of the present invention. The following description of at least one exemplary embodiment is merely illustrative, and is in no way intended as a limitation on this application or the use thereof. All other embodiments derived by a person of ordinary skill in the art based on the embodiments of this application without making any creative efforts fall within the protection scope of this application.

[0030] Unless otherwise expressly specified, the relative arrangement of parts and steps, numerical expressions, and numerical values set forth in the embodiments do not limit the scope of this application. Understandably, for ease of description, the sizes of various parts shown in the drawings are not drawn to actual scale. The technologies, methods, and devices known to a person of ordinary skill in the related art may be described without going into details, but as appropriate, such technologies, methods, and device are regarded as a part of the specification. In all the examples shown and discussed herein, any specific values are construed as merely exemplary rather than restrictive. Therefore, values in other examples in an exemplary embodiment may be different. It is noted that similar reference numerals and letters indicate similar items in the following drawings. Therefore, once an item is defined in one drawing, the item does not need to be further discussed in subsequent drawings.

[0031] In the description of this application, the term "several" means one or more, and the term "a plurality of" means two or more. Terms such as "greater than", "less than", or "exceeding" are understood to exclude the specified number, whereas terms such as "not less than", "not more than", or "within" are understood to include the specified number. Any reference to "first" or "second" herein are merely intended for distinguishing technical features, but are not to be interpreted as indicating or implying relative importance, or interpreted as implicitly stating the number of the indicated technical features, or interpreted as implicitly stating the order of the indicated technical features.

[0032] In the description of this application, any reference to the terms "one embodiment", "some embodiments", "illustrative embodiment", "example", "specific example", "some examples", and the like means that a particular feature, structure, material, or characteristic described with reference to the embodiment or example is included in at least one embodiment or example of this application. In this embodiment, illustrative expressions of such terms do not necessarily refer to the same embodiment or example. In addition, the particular features, structures, materials, or characteristics may be combined in an appropriate manner in any one or more embodiments or examples.

Embodiment 1

[0033] As shown in FIG. 1, this embodiment provides an electro-hydraulic control valve section. The electro-hydraulic control valve section integrates a cut-off combining valve 02 and a main control spool 03. The valve section is provided with a supply port P, a first working port A, a second working port B, a supply combining passage, and a return passage communicating with a return port R.

[0034] A supply port of the cut-off combining valve 02 is connected to the supply port P. A first port of the cut-off combining valve 02 is connected to the return passage and to a return port of the main control spool 03 separately. A second port of the cut-off combining valve 02 is connected to a supply port of the main control spool 03. A third port of the cut-off combining valve 02 is connected to the supply combining passage. The cut-off combining valve 02 includes at least a first working position, a second working position, and a third working position. When the cut-off combining valve 02 is in the first working position (middle position), the supply port of the cut-off combining valve 02 communicates with the first port (to release a load). When the cut-off combining valve 02 is in the first working position (left position), the supply port of the cut-off combining valve 02 communicates with the second port. When the cut-off combining valve 02 is in the third working position (right position), the supply port of the cut-off combining valve 02 communicates with the third port (to implement oil supply in a combined-flow manner).

[0035] The main control spool 03 is provided with the supply port, the return port, a first port, and a second port. The supply port of the main control spool 03 is further connected to the supply combining passage. The return port of the main control spool 03 is connected to the return passage. The first port of the main control spool 03 is connected to the first working port A. The second port of the main control spool 03 is connected to the second working port B.

[0036] In this embodiment, as shown in FIG. 1, the electro-hydraulic control valve section further includes a first check valve 07. The supply combining passage supplies oil to the main control spool 03 unidirectionally through the first check valve 07.

[0037] In this embodiment, as shown in FIG. 1, the electro-hydraulic control valve section further includes a main relief valve 01. The main relief valve 01 is disposed between the supply port P and the return passage. More specifically, the first port of the main relief valve 01 is connected to the supply port P, and the second port of the main relief valve 01 is connected to the return port R through the return oil passage.

[0038] In this embodiment, as shown in FIG. 1, the electro-hydraulic control valve section further includes a first port relief valve 05 and a second port relief valve 04. The first port relief valve 05 is provided between the first working port A and the return passage. The second port relief valve 04 is provided between the second working port B and the return passage.

[0039] In this embodiment, as shown in FIG. 1, the electro-hydraulic control valve section further includes a load-holding valve 06. The first port of the main control spool 03 is connected to the first working port A through the load-holding valve 06.

[0040] In some embodiments, as shown in FIG. 1, the main control spool 03 includes at least a first working position, a second working position, and a third working position. When the main control spool 03 is in the first working position (left position), the supply port of the main control spool 03 communicates with the first port, and the second port of the main control spool 03 communicates with the return port. When the main control spool 03 is in the second working position (middle position), the supply port, the first port, the second port, and the return port of the main control spool 03 do not communicate with each other. When the main control spool 03 is in the third working position (right position), the supply port of the main control spool 03 communicates with the second port, and the first port of the main control spool 03 communicates with the return port. In this embodiment, the main control spool 03 is a three-position four-way valve.

[0041] In some embodiments, the electro-hydraulic control valve further includes a second check valve 08, disposed between the supply port P and the supply port of the main control spool 03, and configured to supply oil to the main control spool 03 unidirectionally through the cut-off combining valve 02.

[0042] In this embodiment, as shown in FIG. 1, the second check valve 08 is disposed between the second port of the cut-off combining valve 02 and the supply port of the main control spool 03.

[0043] In this application, the flow rate at the supply port P of the valve section can be freely switched, through the cut-off combining valve 02, between releasing a load to the return passage (oil tank), supplying oil independently to this valve section, and supplying oil to other valve sections in a combined-flow manner.

Embodiment 2

[0044] Based on Embodiment 1, Embodiment 2 differs from Embodiment 1 in that the second check valve 08 may be disposed between the supply port of the cut-off combining valve 02 and the second port, that is, integrated in the cut-off combining valve 02.

[0045] More specifically, as shown in FIG. 2, in this embodiment, the cut-off combining valve 02 further includes a fourth working position, located between the first working position and the second working position. When the cut-off combining valve 02 is in the fourth working position, the supply port of the cut-off combining valve 02 communicates unidirectionally with the second port through the second check valve 08.

Embodiment 3

[0046] Based on Embodiment 1, Embodiment 3 differs from Embodiment 1 in that the cut-off combining valve 02 in Embodiment 3 includes a pressure cut-off valve 021 and a combining valve 022.

[0047] As shown in FIG. 3, this embodiment provides an electro-hydraulic control valve section. The electro-hydraulic control valve section integrates a cut-off combining valve 02 and a main control spool 03. The valve section is provided with a supply port P, a first working port A, a second working port B, a supply combining passage, and a return passage communicating with a return port R.

[0048] The cut-off combining valve 02 includes a pressure cut-off valve 021 and a combining valve 022. A supply port of the pressure cut-off valve 021 and a supply port of the combining valve 022 are both connected to the supply port P. An outlet of the pressure cut-off valve 021 is connected to the return passage and to a return port of the main control spool 03 separately. A first port of the combining valve 022 is connected to a supply port of the main control spool 03. A second port of the combining valve 022 is connected to the supply combining passage. When the pressure cut-off valve 021 is in a first working position (left position), the supply port of the pressure cut-off valve is not in communication with the outlet. When the pressure cut-off valve 021 is in a second working position (right position), the supply port of the pressure cut-off valve is in

communication with the outlet.

[0049] When the combining valve 022 is in a first working position (left position), the supply port of the combining valve 022 is in communication with the first port. When the combining valve 022 is in a second working position (right position), the supply port of the combining valve 022 is in communication with the second port.

[0050] The main control spool 03 is provided with the supply port, the return port, a first port, and a second port. The supply port of the main control spool 03 is further connected to the supply combining passage. The return port of the main control spool 03 is connected to the return passage. The first port of the main control spool 03 is connected to the first working port A. The second port of the main control spool 03 is connected to the second working port B.

[0051] In some embodiments, the electro-hydraulic control valve section further includes a first check valve 07. The supply combining passage supplies oil to the main control spool 03 unidirectionally through the first check valve 07.

[0052] In some embodiments, the electro-hydraulic control valve section further includes a main relief valve 01. The main relief valve 01 is disposed between the supply port P and the return oil passage. Specifically, the first port of the main relief valve 01 is connected to the supply port P, and the second port of the main relief valve 01 is connected to the return port R through the return oil passage.

[0053] In some embodiments, the electro-hydraulic control valve section further includes a first port relief valve 05 and a second port relief valve 04. The first port relief valve 05 is provided between the first working port A and the return passage. The second port relief valve 04 is provided between the second working port B and the return passage.

[0054] In some embodiments, the electro-hydraulic control valve section further includes a load-holding valve 06. The first port of the main control spool 03 is connected to the first working port A through the load-holding valve 06.

[0055] In some embodiments, the main control spool 03 includes at least a first working position, a second working position, and a third working position. When the main control spool 03 is in the first working position (left position), the supply port of the main control spool 03 communicates with the first port, and the second port of the main control spool 03 communicates with the return port. When the main control spool 03 is in the second working position (middle position), the supply port, the first port, the second port, and the return port of the main control spool 03 do not communicate with each other. When the main control spool 03 is in the third working position (right position), the supply port of the main control spool 03 communicates with the second port, and the first port of the main control spool 03 communicates with the return port. In this em-

bodiment, the main control spool 03 is a three-position four-way valve.

[0056] In some embodiments, the electro-hydraulic control valve section further includes a second check valve 08, disposed between the supply port P and the supply port of the main control spool 03, and configured to supply oil to the main control spool 03 unidirectionally through the cut-off combining valve 02.

[0057] In this embodiment, as shown in FIG. 3, the second check valve 08 is disposed between the first port of the combining valve 022 and the supply port of the main control spool 03.

[0058] It is to be noted that in the electro-hydraulic control valve section of this application, the positions of plug-ins such as the port relief valve and the load-holding valve may be changed, or the number of the corresponding plug-ins may be increased or decreased. At least one of the following control methods may be added at either end of the electro-hydraulic control valve section: hydraulic control, electric control, electro-hydraulic control, or CAN bus control.

Embodiment 4

[0059] Based on Embodiments 1 to 3, Embodiment 4 further provides an electro-hydraulic control valve for a multi-pump system. The electro-hydraulic control valve includes a plurality of working sections. Each working section adopts the electro-hydraulic control valve section disclosed in any one of Embodiments 1 to 3. Return passages of the plurality of working sections communicate with each other and share one return port. Supply combining passages of the plurality of working sections communicate with each other directly or indirectly.

[0060] In some embodiments, a two-section electro-hydraulic control valve is provided. The two-section electro-hydraulic control valve is commonly used in a loader hydraulic system, and mainly configured to control the lifting and lowering of a loader boom as well as the inward curling and outward tilting of the bucket. A schematic diagram of the principles is shown in FIG. 4. In this embodiment, the plurality of working sections of the two-section electro-hydraulic control valve include a bucket section and a boom section. The bucket section is provided with supply port P1, a return port R, a first working port A1, and a second working port B1. The valve section of the bucket section integrates a bucket-section main relief valve 101, a bucket-section cut-off combining valve 102, a bucket-section main control spool 103, a bucket-section first-port relief valve 104, a bucket-section second-port relief valve 105, a bucket-section first check valve 107, and a bucket-section second check valve 108. The boom section is provided with a supply port P2, a first working port A2, and a second working port B2. The valve section of the boom section integrates a boom-section main relief valve 201, a boom-section cut-off combining valve 202, a

boom-section main control spool 203, a boom first-port relief valve 204, a boom second-port relief valve 205, a boom-section load-holding valve 206, a boom first check valve 207, and a boom second check valve 208. The first working port and the second working port of the bucket section are configured to be connected to a bucket cylinder. The first working port and the second working port of the boom section are configured to be connected to a boom cylinder.

[0061] An operation process of the two-section electro-hydraulic control valve is as follows:

When a boom is operated independently, a boom-section cut-off combining valve 202 is controlled to switch to a left position (a second working position), so that a supply port P2 of the boom section supplies oil to a main control spool 203 of the boom section through the boom-section cut-off combining valve 202. Meanwhile, a bucket section cut-off combining valve 102 is controlled to switch to a right position (a third working position), so that a supply port P1 of the bucket section supplies oil to the boom section in a combined-flow manner through the boom-section cut-off combining valve 202 and a supply combining passage to ensure satisfaction of a speed requirement of the boom.

[0062] When a bucket is operated independently, a bucket-section cut-off combining valve 102 is controlled to switch to a left position (a second working position), so that a supply port of the bucket section supplies oil to a bucket-section main control spool through the bucket-section cut-off combining valve. Meanwhile, the boom-section cut-off combining valve 202 is controlled to switch to a right position (a third working position), so that the supply port of the boom section supplies oil to the bucket section in a combined-flow manner through the boom-section cut-off combining valve and a supply combining passage to ensure satisfaction of a speed requirement of the bucket.

[0063] When the boom and the bucket operate in combination, the bucket-section cut-off combining valve 102 and the boom-section cut-off combining valve 202 are controlled to both switch to the left position (the second working position), so that the supply port P1 of the bucket section supplies oil to the bucket-section main control spool through the bucket-section cut-off combining valve 102, and that the supply port P2 of the boom section supplies oil to the boom-section main control spool through the boom-section cut-off combining valve 202, so as to ensure that an oil source of the bucket section and an oil source of the boom section are independent of each other without load coupling.

[0064] When in standby mode, the bucket-section cut-off combining valve 102 and the boom-section cut-off combining valve 202 are both in the middle position (the first working position), the supply port P1 of the bucket section releases a load through the bucket-section cut-off combining valve 102, and the supply port P2 of the boom section releases a load through the boom-section cut-off combining valve 202, so as to reduce a

main-pump output pressure and system energy loss.

[0065] In some embodiments, this embodiment provides a seven-section electro-hydraulic control valve. The seven-section electro-hydraulic control valve is primarily applicable to a hydraulic system of an electric excavator, and is primarily configured to control the boom, arm, bucket, and travel movements of the excavator. The schematic diagram of the principles thereof is shown in FIG. 5. In this embodiment, the plurality of working sections of the seven-section electro-hydraulic control valve include a first boom section, a right travel section, a left travel section, a first arm section, a second boom section, a bucket section, and a second arm section sequentially;

The first boom section is provided with a supply port P1 and a return port R1. The valve section thereof integrates a first-boom main relief valve 1, a first-boom cut-off combining valve 4, a first boom control spool 9, a first-boom first-port relief valve 16, a first-boom second-port relief valve 17, a first boom load-holding valve 29, a first-boom first check valve 40, and a first-boom second check valve 41.

[0066] The valve section of the right travel section integrates a first process valve 42, a right travel control spool 10, and a right travel check valve 39.

[0067] The valve section of the left travel section integrates a rectilinear travel valve 7, a left travel control spool 11, and a left travel check valve 38, and is configured to control rectilinear travel of the excavator.

[0068] The first arm section is provided with a supply port P2. The valve section thereof integrates a first-arm main relief valve 2, a first-arm cut-off combining valve 5, a first arm control spool 12, a first-arm first-port relief valve 18, a first-arm second-port relief valve 19, a first arm load-holding valve 28, a first-arm first check valve 36, and a first-arm second check valve 37.

[0069] The valve section of the second boom section integrates a second-boom cut-off combining valve 8, a second boom control spool 13, a second-boom first-port relief valve 20, a second-boom second-port relief valve 21, a second boom load-holding valve 27, a second-boom first check valve 34, and a second-boom second check valve 35.

[0070] The bucket section is provided with a supply port P3. The valve section thereof integrates the bucket main relief valve 3, the bucket cut-off combining valve 6, the bucket control spool 14, the bucket first-port relief valve 22, the bucket second-port relief valve 23, the bucket first check valve 32, and the bucket second check valve 33.

[0071] The valve section of the second arm section integrates the second process valve 43, the second arm control spool 15, the second-arm first-port relief valve 24, the second-arm second-port relief valve 25, the second arm load-holding valve 26, the second-arm first check valve 30, and the second-arm second check valve 31. In this embodiment, the second process valve 43 is always in the first working position (middle posi-

tion).

[0072] Return passages of the first boom section, the right travel section, the left travel section, the first arm section, the second boom section, the bucket section, and the second arm section are all in communication with a return port R1 of the first boom section. A supply combining passage of the first boom section is in communication with that of the right travel section. A supply combining passage of the left travel section is in communication with that of the first arm section. Supply combining passages of the second boom section, the bucket section, and the second arm section are in communication with each other.

[0073] An outlet port of the first process valve 42 is connected to a supply port of the right travel control spool 10, and is configured to supply oil to the right travel control spool 10.

[0074] The first port of the rectilinear travel valve 7 is connected to a supply port of the left travel control spool 11. A second port of the rectilinear travel valve is in communication with the supply combining passage of the left travel section. When the rectilinear travel valve 7 is in a first working position (middle position), the supply port, the first port, and the second port are not in communication with each other. When the rectilinear travel valve 7 is in a second working position (left position), the supply port is in communication with the first port to supply oil to the left travel control spool 11; and when the rectilinear travel valve 7 is in a third working position (right position), the supply port is in communication with the second port, and the supply ports of the first process valve 42, the rectilinear travel valve 7, and the second boom cut-off combining valve 8 are in communication with each other.

[0075] An operation process of the seven-section electro-hydraulic control valve is as follows:

When a boom operates alone, the first boom control spool 9 and the second boom control spool 13 are opened simultaneously. The first boom cut-off combining valve 4 is switched to a second working position (a left position). The supply port P1 of the first boom section supplies oil to a first boom through the first boom cut-off combining valve 4 and the first-boom second check valve 41. The bucket cut-off combining valve 6 is switched to a third working position (a right position). The supply port P3 of the bucket section supplies oil to a second boom through the third working position (the right position) of the bucket cut-off combining valve 6 and the supply combining passage by means of the second-boom first check valve 34. The supply port P2 of the first arm section chooses, based on an actual flow demand of the boom, to release a load through a first working position (a middle position) of the first arm cut-off combining valve 5 or to supply oil in a combined-flow manner to the second boom through a third working position (a right position) of the first arm cut-off combining valve 5 by means of a third working position (a right position) of the rectilinear travel valve 7 and a

third working position (a right position) of the second boom cut-off combining valve 8 and by means of the supply combining passage, so as to ensure satisfaction of a motion speed requirement of the boom.

[0076] When an arm operates alone, the first arm control spool 12 and the second arm control spool 15 are opened simultaneously. The first arm cut-off combining valve 5 is switched to a second working position (a left position). The supply port P2 of the first arm section supplies oil to a first arm through a second working position (a left position) of the first arm cut-off combining valve 5 and the first-arm second check valve 37. The bucket cut-off combining valve 6 is switched to a third working position (a right position). The supply port P3 of the bucket section supplies oil to a second arm through a third working position (a right position) of the bucket cut-off combining valve 6 and the supply combining passage by means of the second-arm first check valve 30. The supply port P1 of the first boom section chooses, based on an actual flow demand of the arm, to release a load through a first working position (a middle position) of the first boom cut-off combining valve 4 or to supply oil to the second arm through a third working position (a right position) of the first boom cut-off combining valve 4 by means of the right travel check valve 39 and a third working position (a right position) of the second boom cut-off combining valve 8, so as to ensure satisfaction of an arm motion speed requirement.

[0077] When a bucket operates alone, the bucket control spool 14 is opened. The bucket cut-off combining valve 6 is switched to a second working position (a left position). The supply port P3 of the bucket section supplies oil to the bucket through a second working position (a left position) of the bucket cut-off combining valve 6 and the bucket second check valve 33. Meanwhile, the first boom cut-off combining valve 4 is switched to a third working position (a right position). The supply port P1 of the first boom section supplies oil to the bucket in a combined-flow manner through the right travel check valve 39 by means of a third working position (a right position) of the second boom cut-off combining valve 8 and the bucket first check valve 32, so as to ensure satisfaction of a motion speed requirement of the bucket.

[0078] When a boom and an arm operate in combination, the supply port P1 of the first boom section supplies oil to the boom through the first boom control spool 9. The supply port P2 of the first arm section supplies oil to the arm through the first arm control spool 12. The supply port P3 of the bucket section supplies oil to the arm in a combined-flow manner through the second arm control spool 15, such that oil sources of the boom and the arm are independent of each other without load coupling.

[0079] When an arm and a bucket operate in combination, the supply port P2 of the first arm section supplies oil to the arm through the first arm control spool

12. The supply port P3 of the bucket section supplies oil to the bucket through the bucket control spool 14. The supply port P1 of the first boom section supplies, based on a demand of the arm, oil to the arm in a combined-flow manner through a third working position (a right position) of the first boom cut-off combining valve 4 by means of a third working position (a right position) of the rectilinear travel valve 7 and the first-arm first check valve 36, such that oil sources of the arm and the bucket are independent of each other without load coupling.

[0080] When the boom and the bucket operate in combination, the supply port P1 of the first boom section supplies oil to the boom through the first boom control spool 9. The supply port P3 of the bucket section supplies oil to the bucket through the bucket control spool 14. The supply port P2 of the first arm section releases a load through a first working position (a middle position) of the first arm cut-off combining valve 5, such that oil sources of the boom and the bucket are independent of each other without load coupling.

[0081] When a boom, a bucket, and an arm operate in combination, the supply port P1 of the first boom section supplies oil to the boom through the first boom control spool 9. The supply port P2 of the first arm section supplies oil to the arm through the first arm control spool 12. The supply port P3 of the bucket section supplies oil to the bucket through the bucket control spool 14, such that oil sources of the boom, the bucket, and the arm are independent of each other without load coupling.

[0082] When a lower structure of a construction machine travels alone, both the first boom cut-off combining valve 4 and the first arm cut-off combining valve 5 are switched to a third working position (a right position). The supply port P1 of the first boom section supplies oil to a right travel section through the right travel check valve 39 by means of a third working position (a right position) of the first boom cut-off combining valve 4 and the supply combining passage. The supply port P2 of the first arm section supplies oil to the left travel section through the left travel check valve 38 by means of a third working position (a right position) of the first arm cut-off combining valve 5 and the supply combining passage, such that the supply port P1 of the first boom section and the supply port P2 of the first arm section jointly supply a dual-pump flow for traveling to ensure satisfaction of a travel speed requirement. When traveling along a straight line, the rectilinear travel valve 7 is switched to a second working position (a left position) such that the supply port P1 of the first boom section and the supply port P2 of the first arm section communicate with each other to simultaneously supply oil to both the left travel and the right travel to ensure rectilinear travel of an excavator.

[0083] When an upper structure and a lower structure of a construction machine operate in combination, the bucket cut-off combining valve 6 is switched to a

third working position (a right position). The supply port P3 of the bucket section supplies oil to the second boom, the second arm, and the bucket simultaneously through the supply combining passage to ensure that the upper structure completes required corresponding actions.

[0084] In summary, in this application: (1) by employing a multi-pump electro-hydraulic control valve section structure, this application can implement free switching between independent oil-source control for each actuator and combined oil supply from a plurality of pumps depending on actual operating condition requirements, thereby solving the problem of energy waste caused by load coupling during combined operations of a plurality of actuators in conventional multi-way valves and increasing the degree of control freedom; (2) in the sectional multi-way valve formed of the electro-hydraulic control valves designed herein, when a single actuator operates, multi-pump combined oil supply can be implemented to satisfy the speed requirement of a single operation while reducing the output power of each individual pump. Each valve section is independently designed in a modular manner, the casting blanks used are identical, and the conventional supply section of a sectional multi-way valve is omitted, thereby achieving a simple structure and low manufacturing cost; (3) in the sectional multi-way valve formed of the electro-hydraulic control valve designed herein, when a plurality of actuators operate in a combined manner, independent oil-source supply can be achieved, the load of one actuator is independent of that of another, and pump-control regulation can be implemented for each actuator, thereby avoiding coupling energy loss and facilitating implementation of an integrated pump-valve design; (4) in the sectional multi-way valve formed of the electro-hydraulic control valves designed herein, when a valve section is used as a travel section, the cutoff combining spool may be replaced with a rectilinear travel spool, thereby ensuring that the machine can implement the rectilinear travel function, and at the same time, the valve section no longer requires a separately designed rectilinear travel circuit, thereby simplifying the structure of the main valve and reducing the manufacturing cost; (5) in the sectional multi-way valve formed of the electro-hydraulic control valves designed herein, when the valve section requires cross-circuit combined oil supply, the cutoff combining spool may be replaced with a combining spool, thereby enabling the main valve to achieve cross-circuit flow combining and ensuring satisfaction of the flow demand of the corresponding actuator, and at the same time, the valve section no longer requires a separately designed cross-circuit combining circuit, thereby simplifying the structure of the main valve and reducing the manufacturing cost; (6) a CAN bus end cap may be designed for the main valve, and the control mode may be CAN bus control, electro-hydraulic hybrid control, or other control modes.

Embodiment 5

[0085] This embodiment provides a hydraulic system for construction machinery, equipped with any one of the electro-hydraulic control valves disclosed in Embodiment 4.

[0086] In some embodiments, a loader hydraulic system is provided, equipped with the above-described two-section electro-hydraulic control valve.

[0087] In some embodiments, an excavator hydraulic system is provided and equipped with the above-described seven-section electro-hydraulic control valve.

[0088] Understandably, in the description of this application, a directional or positional relationship indicated by the terms such as "center", "longitudinal", "transverse", "front", "rear", "left", "right", "vertical", "horizontal", "top", "bottom", "in", and "out" is a directional or positional relationship based on the illustration in the drawings, and is merely intended for ease or brevity of description of this application, but does not indicate or imply that the indicated device or component must be located in the specified direction or constructed or operated in the specified direction. Therefore, such terms are not to be understood as a limitation on the protection scope of this application.

[0089] The above descriptions are merely preferred embodiments of this application. It is to be noted that various improvements and refinements, which may be made by a person of ordinary skill in the art without departing from the technical principles of this application, shall still fall within the protection scope of this application.

Claims

1. An electro-hydraulic control valve section, **characterized in that** the electro-hydraulic control valve section integrates a cut-off combining valve (02) and a main control spool (03); the valve section is provided with a supply port P, a first working port A, a second working port B, a supply combining passage, and a return passage communicating with a return port R;

a supply port of the cut-off combining valve (02) is connected to the supply port P; a first port of the cut-off combining valve (02) is connected to the return passage and to a return port of the main control spool (03) separately; a second port of the cut-off combining valve (02) is connected to a supply port of the main control spool (03); a third port of the cut-off combining valve (02) is connected to the supply combining passage; the cut-off combining valve (02) comprises at least a first working position, a second working position, and a third working position; when the cut-off combining

valve (02) is in the first working position, the supply port of the cut-off combining valve (02) communicates with the first port; when the cut-off combining valve (02) is in the second working position, the supply port of the cut-off combining valve (02) communicates with the second port; and when the cut-off combining valve (02) is in the third working position, the supply port of the cut-off combining valve (02) communicates with the third port; and the main control spool (03) is provided with the supply port, the return port, a first port, and a second port; the supply port of the main control spool (03) is further connected to the supply combining passage; the return port of the main control spool (03) is connected to the return passage; the first port of the main control spool (03) is connected to the first working port A; and the second port of the main control spool (03) is connected to the second working port B.

2. An electro-hydraulic control valve section, **characterized in that** the electro-hydraulic control valve section integrates a cut-off combining valve (02) and a main control spool (03); the valve section is provided with a supply port P, a first working port A, a second working port B, a supply combining passage, and a return passage communicating with a return port R;

the cut-off combining valve (02) comprises a pressure cut-off valve (021) and a combining valve (022); a supply port of the pressure cut-off valve (021) and a supply port of the combining valve (022) are both connected to the supply port P; an outlet of the pressure cut-off valve (021) is connected to the return passage and to a return port of the main control spool (03) separately; a first port of the combining valve (022) is connected to a supply port of the main control spool (03); and a second port of the combining valve (02) is connected to the supply combining passage; when the pressure cut-off valve (021) is in a first working position, the supply port of the pressure cut-off valve is not in communication with the outlet; when the pressure cut-off valve (021) is in a second working position, the supply port of the pressure cut-off valve is in communication with the outlet;

when the combining valve (022) is in a first working position, the supply port of the combining valve (022) is in communication with the first port; and when the combining valve (022) is in a second working position, the supply port of the combining valve (022) is in communication with the second port; and

- the main control spool (03) is provided with the supply port, the return port, a first port, and a second port; the supply port of the main control spool (03) is further connected to the supply combining passage; the return port of the main control spool (03) is connected to the return passage; the first port of the main control spool (03) is connected to the first working port A; and the second port of the main control spool (03) is connected to the second working port B.
3. The electro-hydraulic control valve section according to claim 1 or 2, **characterized in that** the electro-hydraulic control valve section further comprises a first check valve (07), and the supply combining passage supplies oil to the main control spool (03) unidirectionally through the first check valve (07).
 4. The electro-hydraulic control valve section according to claim 1 or 2, **characterized in that** the electro-hydraulic control valve section further comprises a main relief valve (01), and the main relief valve (01) is disposed between the supply port P and the return passage.
 5. The electro-hydraulic control valve section according to claim 1 or 2, **characterized in that** the electro-hydraulic control valve section further comprises a first port relief valve (05) and a second port relief valve (04), the first port relief valve (05) is provided between the first working port A and the return passage, and the second port relief valve (04) is provided between the second working port B and the return passage.
 6. The electro-hydraulic control valve section according to claim 1 or 2, **characterized in that** the electro-hydraulic control valve section further comprises a load-holding valve (06), and the first port of the main control spool (03) is connected to the first working port A through the load-holding valve (06).
 7. The electro-hydraulic control valve section according to claim 1 or 2, **characterized in that** the electro-hydraulic control valve section further comprises a second check valve (08), disposed between the supply port P and the supply port of the main control spool (03), and configured to supply oil to the main control spool (03) unidirectionally through the cut-off combining valve (02).
 8. An electro-hydraulic control valve, **characterized in that** the electro-hydraulic control valve comprises a plurality of working sections, each working section adopts the electro-hydraulic control valve

section according to any one of claims 1 to 7, return passages of the plurality of working sections communicate with each other and share one return port, and supply combining passages of the plurality of working sections communicate with each other directly or indirectly.

9. The electro-hydraulic control valve according to claim 8, **characterized in that** the plurality of working sections comprise a bucket section and a boom section, a first working port and a second working port of the bucket section are configured to be connected to a bucket cylinder, a first working port and a second working port of the boom section are configured to be connected to a boom cylinder, and supply combining passages of the bucket section and the boom section communicate with each other;

when a boom is operated independently, a boom-section cut-off combining valve is controlled to switch to a second working position, so that a supply port of the boom section supplies oil to a boom-section main control spool through the boom-section cut-off combining valve; meanwhile, a bucket-section cut-off combining valve is controlled to switch to a third working position, so that a supply port of the bucket section supplies oil to the boom section in a combined-flow manner through the boom-section cut-off combining valve and a supply combining passage to ensure satisfaction of a speed requirement of the boom; when a bucket is operated independently, the bucket-section cut-off combining valve is controlled to switch to a second working position, so that a supply port of the bucket section supplies oil to a bucket-section main control spool through the bucket-section cut-off combining valve; meanwhile, the boom section cut-off combining valve is controlled to switch to a third working position, so that the supply port of the boom section supplies oil to the bucket section in a combined-flow manner through the boom-section cut-off combining valve and a supply combining passage to ensure satisfaction of a speed requirement of the bucket; when the boom and the bucket operate in combination, the bucket-section cut-off combining valve and the boom-section cut-off combining valve are controlled to both switch to the second working position, so that the supply port of the bucket section supplies oil to the bucket-section main control spool through the bucket-section cut-off combining valve, and that the supply port of the boom section supplies oil to the boom-section main control spool through the boom-section cut-off combining

valve, so as to ensure that an oil source of the bucket section and an oil source of the boom section are independent of each other without load coupling; and

when in standby mode, the bucket-section cut-off combining valve and the boom-section cut-off combining valve are both in the first working position, the supply port of the bucket section releases a load through the bucket-section cut-off combining valve, and the supply port of the boom section releases a load through the boom-section cut-off combining valve, so as to reduce a main-pump output pressure and system energy loss.

10. The electro-hydraulic control valve according to claim 8, **characterized in that** the plurality of working sections comprise a first boom section, a right travel section, a left travel section, a first arm section, a second boom section, a bucket section, and a second arm section sequentially;

the first boom section is provided with a supply port P1 and a return port R1, and a valve section of the first boom section integrates a first boom combining valve (4), a first boom control spool (9), and a first-boom first check valve (40);

the valve section of the right travel section integrates a first process valve (42), a right travel control spool (10), and a right travel check valve (39);

the valve section of the left travel section integrates a rectilinear travel valve (7), a left travel control spool (11), and a left travel check valve (38);

the first arm section is provided with a supply port P2, and a valve section of the first arm section integrates a first arm cut-off combining valve (5), a first arm control spool (12), and a first-arm first check valve (36);

a valve section of the second boom section integrates a second boom cut-off combining valve (8), a second boom control spool (13), and a second-boom first check valve (34);

the bucket section is provided with a supply port P3, and a valve section of the bucket section integrates a bucket cut-off combining valve (6), a bucket control spool (14), and a bucket first check valve (32);

a valve section of the second arm section integrates a second process valve (43), a second arm control spool (15), and a second-arm first check valve (30), wherein the second process valve (43) is always located at a first working position;

return passages of the first boom section, the right travel section, the left travel section, the

first arm section, the second boom section, the bucket section, and the second arm section are all in communication with a return port R1 of the first boom section; a supply combining passage of the first boom section is in communication with that of the right travel section; a supply combining passage of the left travel section is in communication with that of the first arm section; and supply combining passages of the second boom section, the bucket section, and the second arm section are in communication with each other;

an outlet port of the first process valve (42) is connected to a supply port of the right travel control spool (10), and is configured to supply oil to the right travel control spool (10); and

a first port of the rectilinear travel valve (7) is connected to a supply port of the left travel control spool (11); a second port of the rectilinear travel valve is in communication with the supply combining passage of the left travel section; when the rectilinear travel valve (7) is in a first working position, the supply port, the first port, and the second port are not in communication with each other; when the rectilinear travel valve (7) is in a second working position, the supply port is in communication with the first port to supply oil to the left travel control spool (11); and when the rectilinear travel valve (7) is in a third working position, the supply port is in communication with the second port, and the supply ports of the first process valve (42), the rectilinear travel valve (7), and the second boom cut-off combining valve (8) are in communication with each other.

11. A control method for the electro-hydraulic control valve according to claim 10, **characterized in that** the method comprises:

opening, when a boom operates alone, the first boom control spool (9) and the second boom control spool (13) simultaneously; switching the first boom cut-off combining valve (4) to a second working position; supplying, by the supply port P1 of the first boom section, oil to a first boom through the first boom cut-off combining valve (4); switching the bucket cut-off combining valve (6) to a third working position; supplying, by the supply port P3 of the bucket section, oil to a second boom through the bucket cut-off combining valve (6) and the supply combining passage by means of the second-boom first check valve (34); choosing, by the supply port P2 of the first arm section, based on an actual flow demand of the boom, to release a load through a first working position of the first arm cut-off combin-

ing valve (5) or to supply oil in a combined-flow manner to the second boom through a third working position of the first arm cut-off combining valve (5) by means of a third working position of the rectilinear travel valve (7) and a third working position of the second boom cut-off combining valve (8) and by means of the supply combining passage, so as to ensure satisfaction of a motion speed requirement of the boom;

and/or, opening, when an arm operates alone, the first arm control spool (12) and the second arm control spool (15) simultaneously; switching the first arm cut-off combining valve (5) to a second working position; supplying, by the supply port P2 of the first arm section, oil to a first arm through the first arm cut-off combining valve (5); switching the bucket cut-off combining valve (6) to a third working position; supplying, by the supply port P3 of the bucket section, oil to a second arm through the bucket cut-off combining valve (6) and the supply combining passage by means of the second-arm first check valve (30); choosing, by the supply port P1 of the first boom section, based on an actual flow demand of the arm, to release a load through a first working position of the first boom cut-off combining valve (4) or to supply oil to the second arm through a third working position of the first boom cut-off combining valve (4) by means of the right travel check valve (39) and a third working position of the second boom cut-off combining valve (8), so as to ensure satisfaction of an arm motion speed requirement;

and/or, opening, when a bucket operates alone, the bucket control spool (14); switching the bucket cut-off combining valve (6) to a second working position; supplying, by the supply port P3 of the bucket section, oil to the bucket through the bucket cut-off combining valve (6); meanwhile, switching the first boom cut-off combining valve (4) to a third working position; supplying, by the supply port P1 of the first boom section, oil to the bucket in a combined-flow manner through the right travel check valve (39) by means of a third working position of the second boom cut-off combining valve (8) and the bucket first check valve (32), so as to ensure satisfaction of a motion speed requirement of the bucket;

and/or, supplying, by the supply port P1 of the first boom section when a boom and an arm operate in combination, oil to the boom through the first boom control spool (9); supplying, by the supply port P2 of the first arm section, oil to the arm through the first arm control spool (12); and supplying, by the sup-

ply port P3 of the bucket section, oil to the arm in a combined-flow manner through the second arm control spool (15), such that oil sources of the boom and the arm are independent of each other without load coupling;

and/or, supplying, by the supply port P2 of the first arm section when an arm and a bucket operate in combination, oil to the arm through the first arm control spool (12); supplying, by the supply port P3 of the bucket section, oil to the bucket through the bucket control spool (14); and supplying, by the supply port P1 of the first boom section based on a demand of the arm, oil to the arm in a combined-flow manner through a third working position of the first boom cut-off combining valve (4) by means of a third working position of the rectilinear travel valve (7) and the first-arm first check valve (36), such that oil sources of the arm and the bucket are independent of each other without load coupling;

and/or, supplying, by the supply port P1 of the first boom section when the boom and the bucket operate in combination, oil to the boom through the first boom control spool (9); supplying, by the supply port P3 of the bucket section, oil to the bucket through the bucket control spool (14); and releasing, by the supply port P2 of the first arm section, a load through a first working position of the first arm cut-off combining valve (5), such that oil sources of the boom and the bucket are independent of each other without load coupling;

and/or, supplying, by the supply port P1 of the first boom section when a boom, a bucket, and an arm operate in combination, oil to the boom through the first boom control spool (9); supplying, by the supply port P2 of the first arm section, oil to the arm through the first arm control spool (12); and supplying, by the supply port P3 of the bucket section, oil to the bucket through the bucket control spool (14), such that oil sources of the boom, the bucket, and the arm are independent of each other without load coupling;

and/or, switching, by both the first boom cut-off combining valve (4) and the first arm cut-off combining valve (5), to a third working position when a lower structure of a construction machine travels alone; supplying, by the supply port P1 of the first boom section, oil to a right travel section through the right travel check valve (39) by means of the first boom cut-off combining valve (4) and the supply combining passage; supplying, by the supply port P2 of the first arm section, oil to the left travel section through the left travel check valve (38) by means of the first arm cut-off combining valve

(5) and the supply combining passage, such that the supply port P1 of the first boom section and the supply port P2 of the first arm section jointly supply a dual-pump flow for traveling to ensure satisfaction of a travel speed requirement; switching, by the rectilinear travel valve (7) when traveling along a straight line, to a second working position such that the supply port P1 of the first boom section and the supply port P2 of the first arm section communicate with each other to simultaneously supply oil to both the left travel and the right travel to ensure rectilinear travel of an excavator; and/or, switching, by the bucket cut-off combining valve (6), to a third working position when an upper structure and a lower structure of a construction machine operate in combination, and supplying, by the supply port P3 of the bucket section, oil to the second boom, the second arm, and the bucket simultaneously through the supply combining passage to ensure that the upper structure completes required corresponding actions.

12. A hydraulic system of construction machinery, **characterized in that** the hydraulic system is provided with the electro-hydraulic control valve according to any one of claims 8 to 10.

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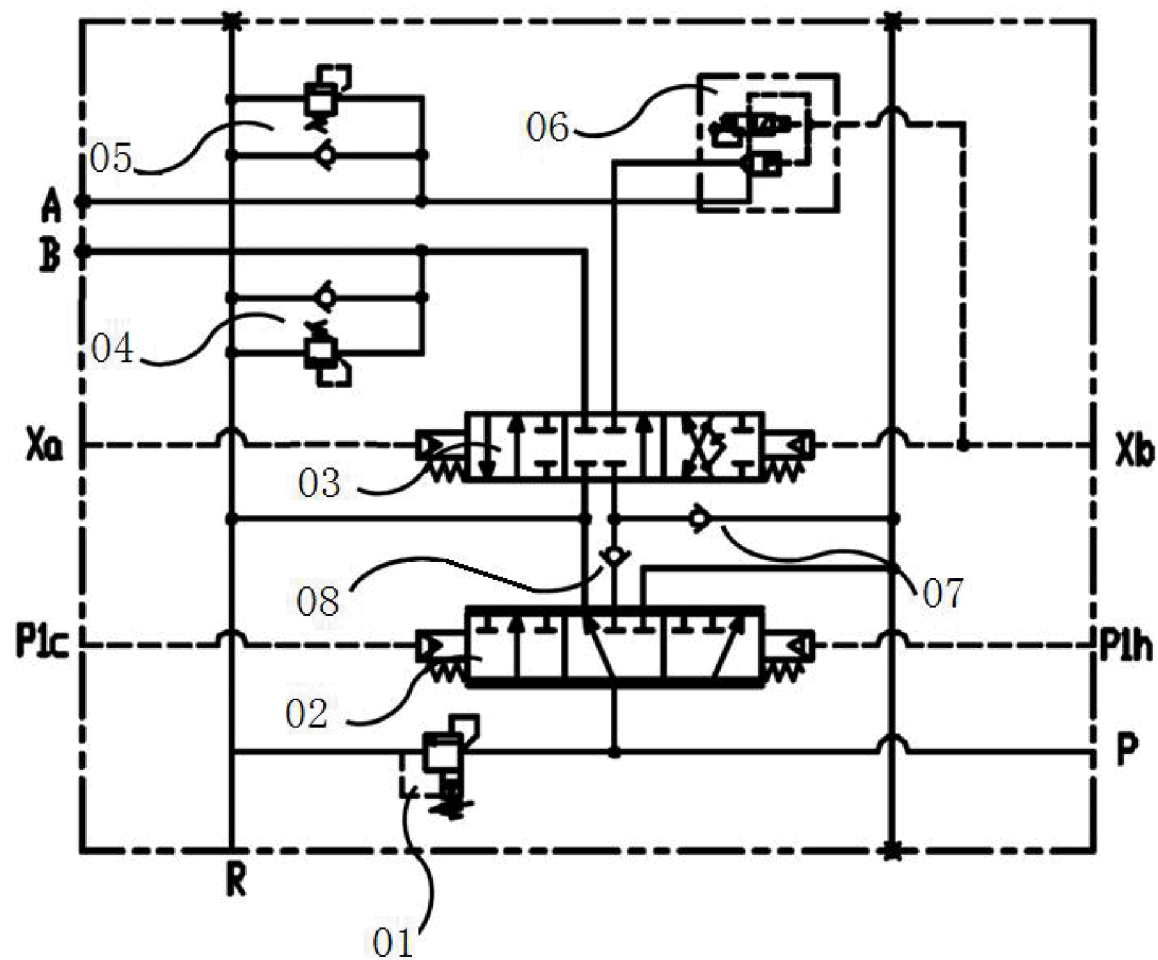


FIG. 1

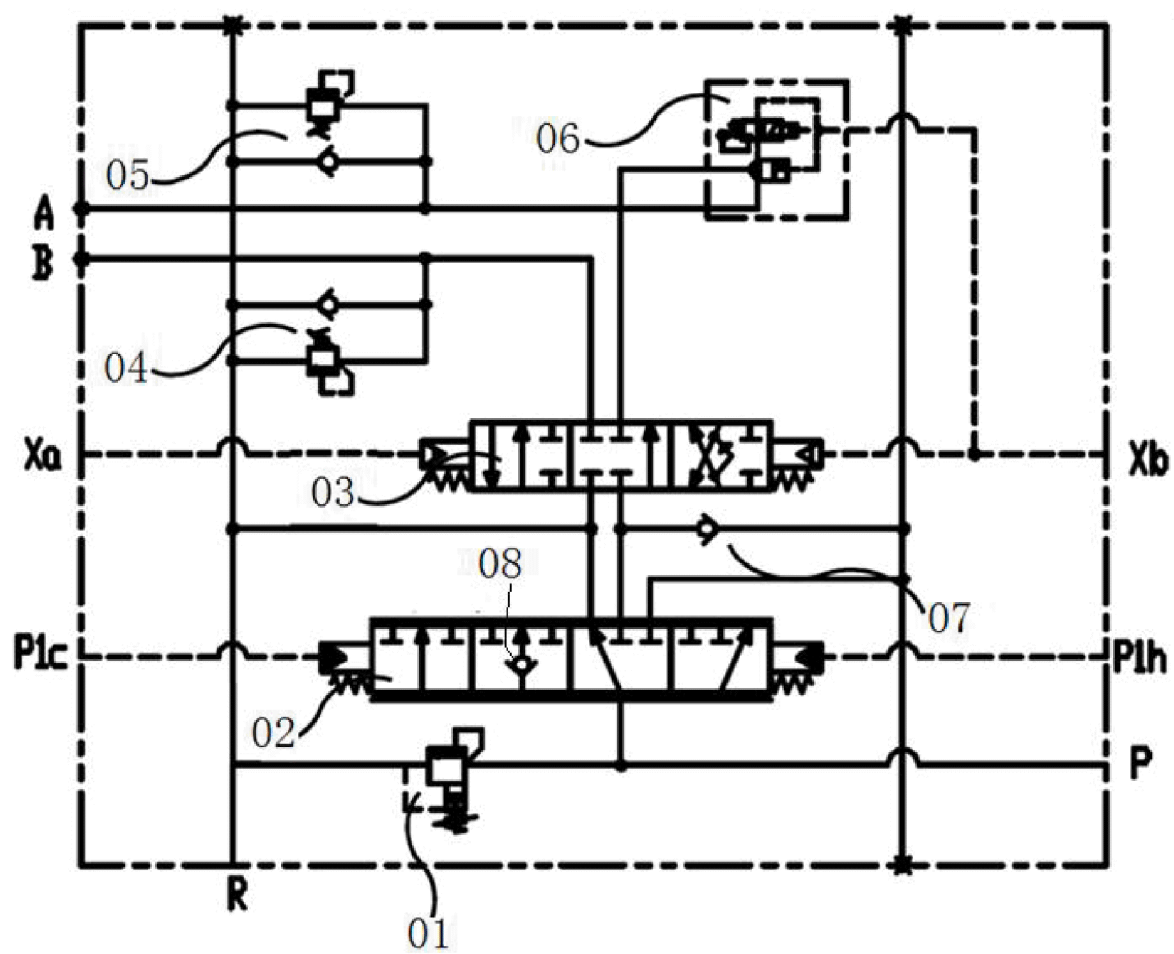


FIG. 2

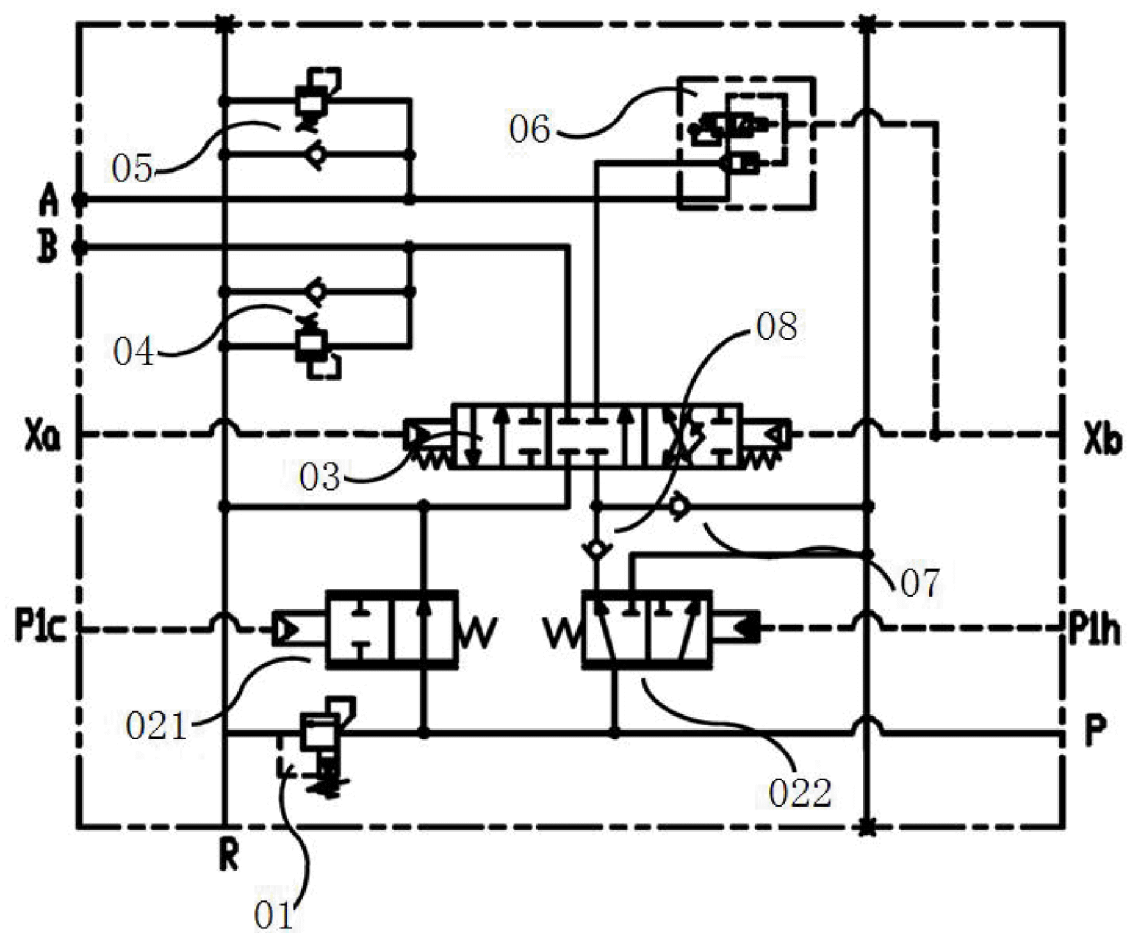


FIG. 3

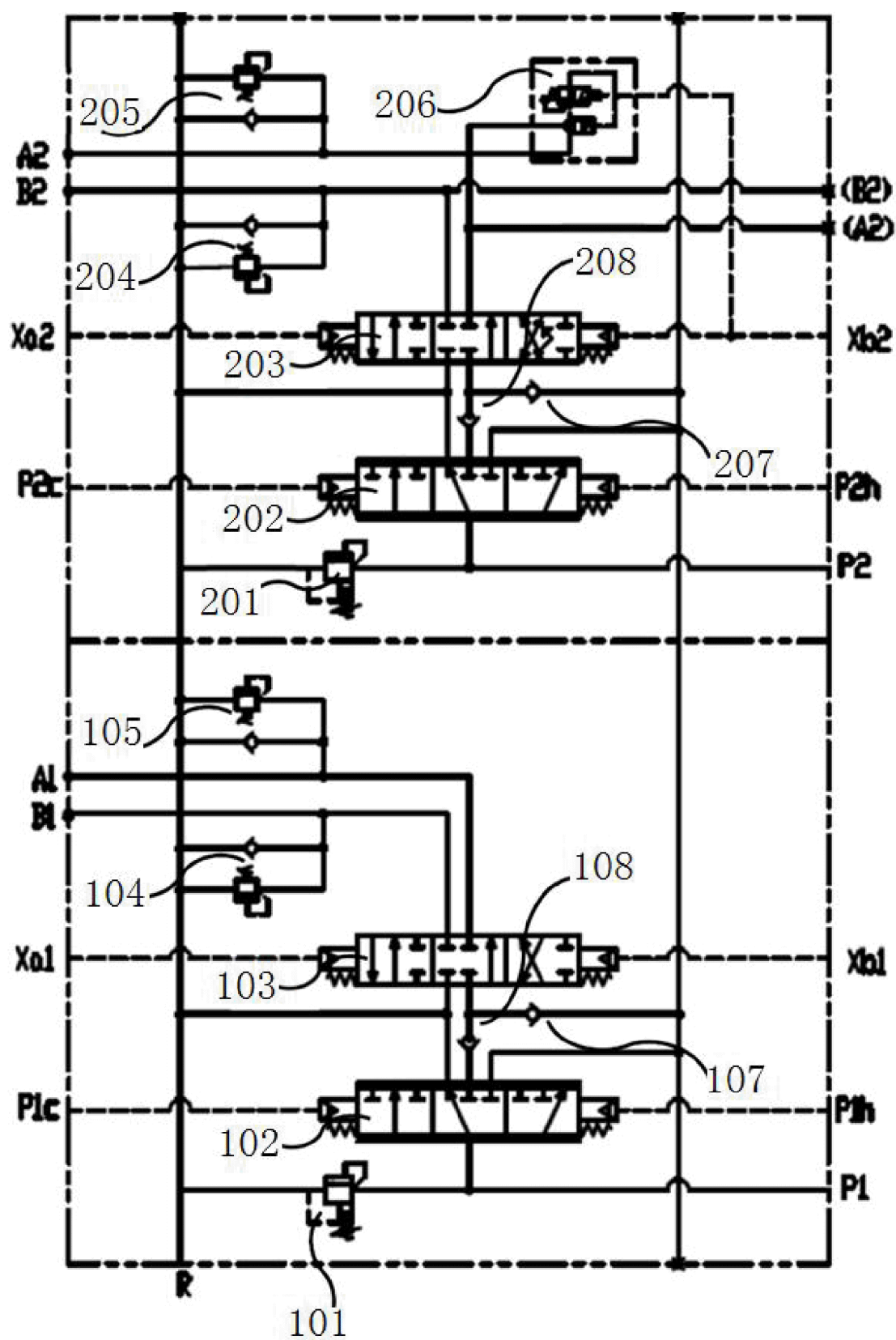


FIG. 4

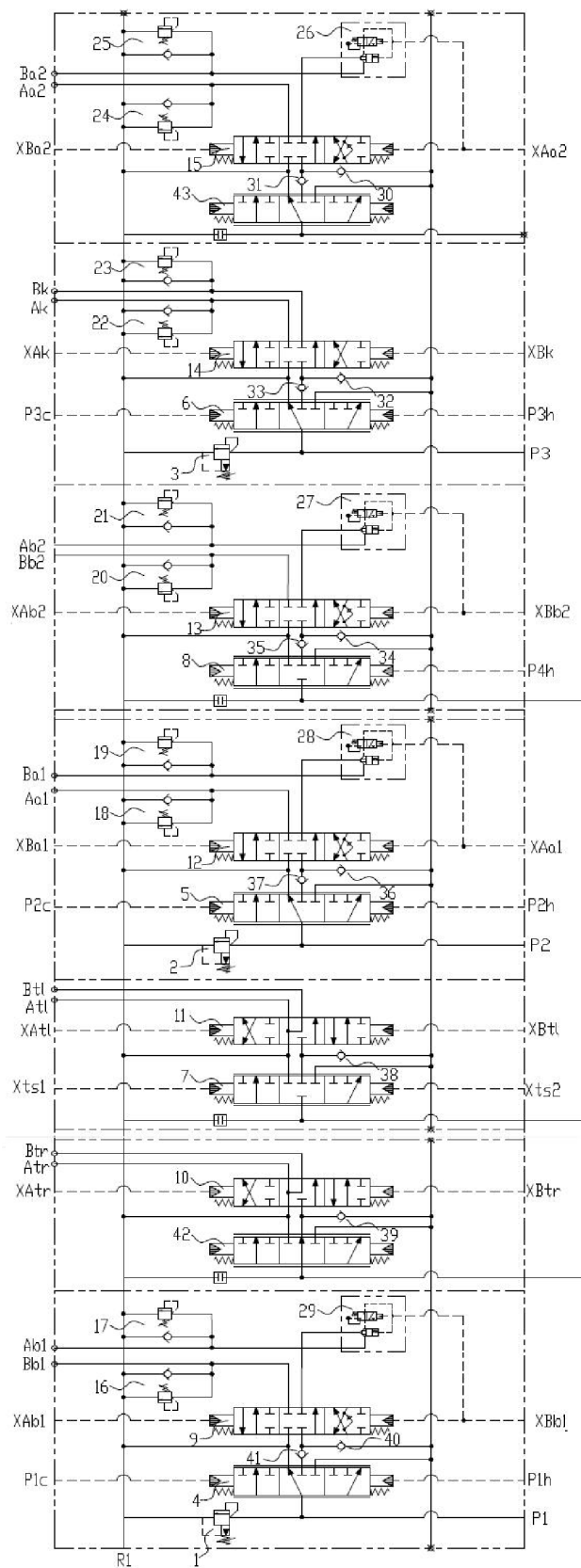


FIG. 5

TRANSLATION

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2024/137420

A. CLASSIFICATION OF SUBJECT MATTER

F15B13/02(2006.01)i; F15B21/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: F15B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNTXT; CNABS; VEN; CNKI: 电液, 阀, 合流, 切断, 回油, 进油, 三位四通, electrohydraulic, valve, combined, confluence, cut+, return+, inlet, four, three, way

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 119244598 A (JIANGSU ICACM ADVANCED CONSTRUCTION MACHINERY INNOVATION CENTER LTD. et al.) 03 January 2025 (2025-01-03) claims 1-12	1-12
X	CN 115341615 A (JIANGSU ADVANCED CONSTRUCTION MACHINERY INNOVATION CENTER LTD.) 15 November 2022 (2022-11-15) description, specific embodiments, and figures 1-5	1-12
A	CN 118757473 A (RIZHAO HAIZHUO HYDRAULIC CO., LTD.) 11 October 2024 (2024-10-11) entire document	1-12
A	CN 118407951 A (HANGZHOU XCMG INTELLIGENT TECHNOLOGY RESEARCH INSTITUTE CO., LTD. et al.) 30 July 2024 (2024-07-30) entire document	1-12
A	KR 20230119497 A (HYDRAULIC FRIENDS CO., LTD.) 16 August 2023 (2023-08-16) entire document	1-12

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

Date of the actual completion of the international search

01 August 2025

Date of mailing of the international search report

11 August 2025

Name and mailing address of the ISA/CN

China National Intellectual Property Administration (ISA/CN)

China No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088

Authorized officer

Telephone No.

TRANSLATION

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2024/137420

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Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	119244598	A	03 January 2025	None			
CN	115341615	A	15 November 2022	None			
CN	118757473	A	11 October 2024	None			
CN	118407951	A	30 July 2024	None			
KR	20230119497	A	16 August 2023	KR	102750643	B1	09 January 2025