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(54) **HYDRAULIC EXCAVATOR MAIN VALVE AND HYDRAULIC EXCAVATOR HAVING SAME**

(57) A main control valve for a hydraulic excavator and a hydraulic excavator having the same. The hydraulic excavator main control valve comprises: a straight travel valve unit (1), a rotary unit (2), a dozer blade unit (3), a boom 2hammer unit (5), an arm 1 unit (6), a travel left unit (7), an oil inlet unit, a travel right unit (8), a boom 1 unit (9), a bucket unit (10), an arm 2 unit (11), and an oil return passage (T2). The main control valve for hydraulic excavator is oil supplied by three pumps (P1, P2, P3) comprising a first pump (P1), a second pump (P2), and a third pump (P3). The first pump (P1) and the second pump (P2) are two variable pumps having the same displacement, and the third pump is standalone. The three pumps (P1, P2, P3) are under total power control, and the rated pressure of the third pump (P3) is less than the rated pressure of the first pump (P1) and that of the second pump (P2). The main control valve for hydraulic excavator further comprises a level-mode oil supply circuit, though which the first pump (P1), the second pump (P2) and third pump (P3) supply oil confluent to the arm cylinder of the hydraulic excavator. The main control valve for hydraulic excavator makes single-movements more rapid, and oil flow distribution is done appropriately during

composite-movements. The valve also has the advantages of high work efficiency when in a level position and energy-saving when excavating.

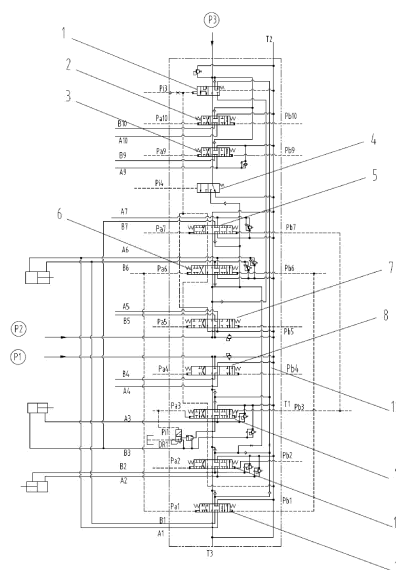


Fig. 3

Description

Field of the Invention

[0001] The invention relates to a throttle type main control valve of a hydraulic system of small hydraulic excavator, and more particularly to a high-efficiency and energy-saving main control valve for hydraulic excavator of the small hydraulic excavator and a hydraulic excavator having the main control valve for hydraulic excavator.

Background of the Invention

[0002] Small hydraulic excavator, which is broadly applied, is a highly-efficient and energy-saving multifunctional small machine with high technical integration degree, high operability and friendly human-machine environment etc. However, a main control valve functioning as the control device of the small hydraulic excavator is featured with high functional integration degree, fine flowing distribution and multi-movement compositing etc. compared with multi-way valves of other engineering machines. Two functions, i.e. excavation and levelling, are the major tasks of the small hydraulic excavator. Correspondingly, the hydraulic circuit of the small hydraulic excavator, especially the performance quality of the circuit when excavation is performed by the arm and the bucket at the same time, and the rapid movement mode of arm in and out during levelling, will directly influence the energy-saving effect and efficiency of the working of the small excavator, thus the above-mentioned performance quality of the circuit and the rapid movement is one of the key technologies of the excavator.

[0003] Generally, the hydraulic control circuit of the hydraulic excavator is driven by two or three hydraulic variable pumps and total power-controlled to achieve rapid empty action, rapid levelling, rapid excavation, and good energy-saving effect during excavation. Currently in the hydraulic circuit for hydraulic excavator of which three pumps being under total power control, a pump P1 and a pump P2 are two variable pumps having the same displacement and a pump P3 is standalone. The three pumps are under total power control, wherein the rated pressure of the pump P3 is less than the rated pressure of the pump P1 and that of the pump P2. The hydraulic circuit has several major control methods as follows: the hydraulic circuit has the same oil supply route during excavation and levelling, being oil supplied by the pump P1 and the pump P2 for boom lifting, being oil supplied by the pump P1 for boom dropping, being oil supplied by the pump P2 and the pump P3 for arm in and out, and being oil supplied by the pump P1 for bucket in and out. Since the rated pressure of the pump P3 is less than the rated pressure of the pump P1 and that of the pump P2, the pump P3 may overflows in advance during excavation for hard soil, thus causing energy loss. Moreover, during levelling, the engine power cannot be fully used, and the arm in and out is relatively slow because the flow

from the pump P3 is relatively small. During single-movements of arm in and out, a bypass diffidence control is applied, which results in great bypass diffidence energy loss. During composite-movements of arm in and bucket in as well as composite-movements of arm in, bucket in and boom lifting, the overflowing flow will return to the oil tank directly when overflow occurs during a certain action, which results in great overflow loss and waste.

Summary of the Invention

[0004] The technical problem to be solved by the invention is to provide a main control valve for a hydraulic excavator with rapid single-movements and highly-efficient levelling performance and a hydraulic excavator having the same.

[0005] To solve the technical problem above, a main control valve for hydraulic excavator is provided according to an aspect of the invention, comprising: a straight travel valve unit, a rotary unit, a dozer blade unit, a boom 2\hammer unit, an arm 1 unit, a left travel unit, an oil inlet unit, a travel right unit, a boom 1 unit, a bucket unit, an arm 2 unit, and an oil return passage. The main control valve for hydraulic excavator is oil supplied by three pumps comprising a first pump, a second pump, and a third pump, wherein the first pump and the second pump are two variable pumps having the same displacement, and the third pump is standalone. The three pumps are under total power control, and the rated pressure of the third pump is less than the rated pressure of the first pump and that of the second pump. The main control valve for hydraulic excavator further comprises a level-mode oil supply circuit, through which the first pump, the second pump and the third pump supply oil confluent to the arm cylinder of the hydraulic excavator.

[0006] Further, the first pump and the second pump supply oil confluent to the arm 1 unit and the arm 2 unit in order to control the arm cylinder, and the stretching and retracting speed of the piston rod of the arm cylinder is controlled by adjusting the displacement of the first pump and the second pump.

[0007] Further, the main control valve for hydraulic excavator of the invention further comprises: a first overflow recovery circuit configured to recover the overflow of the arm cylinder and make the overflow from the arm cylinder flowing into the bucket cylinder of the hydraulic excavator.

[0008] Further, the first overflow recovery circuit comprises: an arm control valve and a first check valve. The inlet of the arm control valve is connected with the oil outlet of the large cavity of the arm 1 unit, and the inlet of the first check valve is connected with the outlet of the arm control valve. The outlet of the first check valve is connected with an oil passage.

[0009] Further, the hydraulic excavator main control valve of the invention further comprises: a second overflow recovery circuit configured to recover the overflow of the bucket cylinder and make the overflow of the bucket

cylinder of the hydraulic excavator flowing into the arm cylinder and/or the boom cylinder of the hydraulic excavator.

[0010] Further, the second overflow recovery circuit further comprises: a bucket control valve. The inlet of the bucket control valve is connected with the oil passage and the outlet of the bucket control valve is connected with the oil inlet of the bucket unit.

[0011] Further, the level-mode oil supply circuit comprises: a level-mode selecting valve, the inlet of which is connected with the dozer blade unit, one outlet of which is connected with the boom 2\hammer unit and another outlet of which is connected with the oil return passage; a passage, one end of which is connected with the arm 1 unit and the other end thereof is connected with the bucket unit.

[0012] Further, the passage is provided with a throttle hole before entering the bucket unit.

[0013] Further, the level-mode selecting valve is a hydraulically-controlled two-position three-way valve.

[0014] Further, a second check valve and a third check valve are provided in the parallel oil circuits of the bucket unit and the arm 2 unit, respectively.

[0015] A hydraulic excavator is provided according to another aspect of the invention, comprising: a first pump, a second pump, a third pump and a main control valve for hydraulic excavator which is the main control valve for hydraulic excavator above, wherein the first pump is connected with the oil inlet unit of the main control valve for hydraulic excavator, the second pump is connected with the oil inlet unit of the main control valve for hydraulic excavator and the third pump is connected with the straight travel valve unit of the main control valve for hydraulic excavator.

[0016] The main control valve for the hydraulic excavator employing the technical solution above adds the level-mode oil supply circuit in the main control valve so that the first pump, the second pump and the third pump supply oil confluent though the level-mode oil supply circuit to the arm cylinder of the hydraulic excavator, thus efficiently increasing the levelling speed.

[0017] Considering that single-movement of arm in accounts for about 15% of the whole excavation time, composite-movement of bucket in and arm in accounts for about 70% of the whole excavation time and single-movement of bucket in accounts for about 15% of the whole excavation time during general excavation operation, the boom makes fine adjustments to cooperate with the movements of the arm and the bucket during this period. In a general three-pump system, a pump P1 and a pump P2 are two completely-identical variable pumps. A pump 3 is standalone. The rated pressure of the pump P3 is less than the rated pressure of the pump P1 and that of the pump P2, and the rated flow of the pump P3 is also less than the rated flow of the pump P1 and the pump P2. In the case of heavy excavation load, the pump P3 may overflow too early if the existing hydraulic circuit is applied, thus causing energy waste and

resulting in relatively low excavation speed. In the technical solution above, an excavation-mode oil supply route is that the pump P1 and the pump P2 supply oil for single-movements of arm in and out, after throttling, the pump P1 and the pump P2 supply oil for bucket in and out, and the pump P1 and the pump P2 supply oil for the boom. Compared with the existing system, since the pump P1 and the pump P2 are two completely-identical pumps, energy loss can be avoided in the case that the rated pressure is not exceeded during composite-movements of arm in and bucket in. Moreover, the pump P1 and the pump P2 supply oil for the bucket at the same time during single-movements of bucket in, which accelerates excavation speed of the bucket. After the level-mode is turned on, since the load is relatively small during levelling, quick arm in and out are required, and the boom and the bucket move gently. The pump P3 supplies oil to the arm preferentially through the level-mode selecting valve and then supplies oil to the bucket after throttling via a throttle hole. Moreover, the oil supply routes of the pump P1 and the pump P2 are not changed, i.e. the pump P1 supplies oil to the boom preferentially and then supplies oil to the arm and the bucket after throttling is performed via the throttle hole. Because the load of the arm is relatively small, the pump P2 supplies oil to the arm preferentially through the parallel oil passage, and the boom and the bucket are oil supplied diffuently by a small portion of oil, so that the arm is oil supplied by large-flow oil from the pump P1, the pump P2 and the pump P3, the arm is oil supplied by two pumps comprising the pump P1 and the pump P2 and the bucket is oil supplied by the pump P1, the pump P2 and the pump P3, thus accelerating levelling.

[0018] According to actual tests and theoretical analysis on different working conditions of small hydraulic excavator, the invention provides a dual-pump confluence circuit during excavation of the arm and the bucket, and three-pump large-flow oil supply circuit of the arm in a level-mode, thus forming a highly-efficient and energy-saving main control valve with smart oil passage design, rapid single-movements, and appropriate oil flow distribution during composite-movements to well reflect the energy-saving performance during excavation and the high efficiency during levelling.

Brief Description of the Drawings

[0019] The accompanying drawings in the specification, which constitute a part of the application, are used for providing further understanding to the invention. The exemplary embodiments of the invention and the illustrations thereof are used for explaining the invention, instead of constituting an improper limitation to the invention. In the accompanying drawings:

Fig. 1 is a principle diagram of a main control valve of the hydraulic excavator SWE70 of Sunward Intelligent Equipment Co., Ltd.;

Fig. 2 is a principle diagram of a main control valve of the hydraulic excavator DH60 of DEAWOO;

Fig. 3 is a hydraulic principle diagram of a main control valve for hydraulic excavator in an embodiment of the invention;

Fig. 4 is a principle diagram of a main control valve for hydraulic excavator in another embodiment of the invention;

Fig. 5 is a principle diagram of a level-mode selecting valve of the main control valve for hydraulic excavator in Fig. 3;

Fig. 6 is a diagram illustrating a hydraulic circuit of an arm in an excavation mode of the main control valve for hydraulic excavator in Fig. 4;

Fig. 7 is diagram illustrating a hydraulic circuit of composite-movements of arm in and bucket in in an excavation mode of the main control valve for the hydraulic excavator in Fig. 4; and

Fig. 8 is diagram illustrating a hydraulic circuit of composite-movements of arm in, bucket in, and boom lifting in an excavation mode of the main control valve for hydraulic excavator in Fig. 4.

Detailed Description of the Embodiments

[0020] It should be noted that, if there is no conflict, the embodiments of the application and the characteristics in the embodiments can be combined with one another. The invention will be described in details below with reference to the accompanying drawings and in combination with the embodiments.

[0021] Fig. 1 and Fig. 2 are principle diagrams of two common small hydraulic excavator three-pump systems. In the three-pump systems, a pump P1 and a pump P2 are two completely-identical piston pumps, and a pump P3 is a gear pump having smaller flow and rated pressure than that of the pump P1. The main control valve system in Fig. 1 comprises: a straight travel valve unit M1, a rotary unit M2, a dozer blade unit M3, a hammer unit M4, an arm unit M5, a boom 2 unit M6, a travel right unit M7, a travel left unit M8, a boom 1 unit M9 and a bucket unit M10. In the system, the pump P2 and the pump P3 supply oil through confluence-inside-valve for arm in and out, the pump P1 supplies oil for bucket in and out, and the pump P1 and the pump P2 supply oil confluent through two units for the boom lifting. In heavy excavation load, the pump P3 may overflow too early, which causes waste and deceleration. In levelling, the flow of the pump P3 is relatively small, which results in relatively slow arm in and out, and low levelling efficiency.

[0022] The main control valve system as shown in Fig. 2 comprises a straight travel valve unit S1, a rotary unit S2, a dozer blade unit S3, a boom deflection unit S4, a boom 2\hammer unit S5, an arm 1 unit S6, a travel left unit S7, a travel right unit S8, a boom 1 unit S9, a bucket unit S10 and an arm 2 unit S11. In the three-pump system, the pump P1 and the pump P2 supply oil through confluence-outside-valve of two units for arm in and out,

and the pump P1 and the pump P2 also supply oil through confluence-outside-valve of two units for the boom lifting. In excavation working conditions, since the pump P1 and the pump P2 are two completely-identical pumps, either of them will not overflow too early during confluence and oil supply, thus avoiding energy loss. In levelling working conditions, however, since the load is small, the pump P3 does not supply oil to working devices, therefore the engine power is not fully used and the levelling speed is relatively slow.

[0023] Fig. 3 is a hydraulic principle diagram of a main control valve for hydraulic excavator in an embodiment of the invention. The main control valve of the embodiment is a multi-way plate valve structure comprising: a straight travel valve unit 1, a rotary unit 2, a dozer blade unit 3, a level-mode selecting valve unit 4, a boom 2\hammer unit 5, an arm 1 unit 6, a travel left unit 7, an oil inlet unit, a travel right unit 8, a boom 1 unit 9, a bucket unit 10, and an arm 2 unit 11, wherein the level-mode selecting valve unit 4 is a hydraulically-controlled two-position three-way valve. As shown in Fig. 5, the inlet M of the level-mode selecting valve unit 4 is connected with the dozer blade unit 3. One outlet N of the level-mode selecting valve unit 4 is connected with the boom 2\hammer unit 5 and another one W is connected with an oil return passage T2. When a pilot oil pressure Pi4 is established, the level-mode is started. When the pilot oil pressure Pi4 is not established, the level-mode is closed and a normal excavation mode is started, and connection mode of the oil passage thereof is as shown in Fig. 3. The boom 2\hammer unit 5 is the common valve unit for the confluence of the boom and the hammer, which is being as the confluence of the boom unit when the pilot oil pressure is connected to the left side and which is being as the hammer unit when the pilot oil pressure is connected to the right side. The confluence of the boom applies an external pipe for confluence, which is a confluence-outside - valve mode. As shown in Fig. 3, the arm 1 unit 6 and the arm 2 unit 11 also supply oil through a confluence-outside-valve mode for movements of the arm. A path 12 is provided in the main control valve body. One end of the path 12 is connected with the arm 1 unit 6 and the other end of the path 12 is connected with the bucket unit 10. The path 12 is provided with a throttle before entering the bucket unit 10 to add a passage for the oil from pump P2 and pump P3 to enter the bucket unit 10.

[0024] Fig. 4 is a hydraulic principle diagram and a hydraulic circuit diagram of a main control valve for hydraulic excavator in another embodiment of the invention. The main control valve is a plate valve structure comprising: a straight travel valve unit 1, a rotary unit 2, a dozer blade unit 3, a level-mode selecting valve unit 4, a boom 2\hammer unit 5, an arm control valve 13, a first check valve 14, an arm 1 unit 6, a travel left unit 7, an oil inlet unit, a travel right unit 8, a boom 1 unit 9, a bucket control valve 15, a bucket unit 10, an arm 2 unit 11, a second check valve 17, and a third check valve 16 etc., wherein the level-mode selecting valve unit 4 is a hydraulically-con-

trolled two-position three-way valve. As shown in Fig. 5, the inlet M of the level-mode selecting valve unit 4 is connected with the dozer blade unit 3. One outlet N of the level-mode selecting valve unit 4 is connected with the boom 2/hammer unit 5 and another one W is connected with an oil return passage T2. When a pilot oil pressure P_{i4} is established, the level-mode is started. When the pilot oil pressure P_{i4} is not established, the level-mode is closed and a normal excavation mode is started and connection mode of the oil passage thereof is as shown in Fig. 4. The boom 2/hammer unit 5 is the common valve unit for the confluence of the boom and the hammer, which is being as the confluence of the boom unit when the pilot oil pressure is connected to the left side and which is being as the hammer unit when the pilot oil pressure is connected to the right side. The confluence of the boom applies an external pipe for confluence, which is a confluence-outside-valve mode. As shown in Fig. 4, the arm 1 unit 6 and the arm 2 unit 11 also supply oil though a confluence-outside-valve mode for movements of the arm. A path 12 is provided in the main control valve body. One end of the path 12 is connected with the arm 1 unit 6 and the other end of the path 12 is connected with the bucket unit 10. The path 12 is provided with a throttle before entering the bucket unit 10 to add a passage for the oil from the pump P2 and the pump P3 to enter the bucket unit 10. The difference between the embodiment illustrated by Fig. 4 and the embodiment illustrated by Fig. 3 is that the embodiment illustrated by Fig. 4 is further energy-saving in excavation besides the advantage of highly-efficient levelling, mainly due to the reason that when a certain operation overflows, the overflow can be recovered to achieve better energy-saving effect. The specific solution will be reflected in the following part of the description.

[0025] Preferably, as shown in Fig. 4, the arm and the boom are supplied with oil by two units respectively under the excavation mode and are supplied with a confluence-outside-valve mode. As shown in Fig. 4, oil is supplied by the pump 1 and the pump 2 for boom lifting. Oil is supplied by the pump 1 and the pump 2 for arm in and out. Oil is supplied by pump 1 and pump 2 for bucket in and out. The oil passage flowing of the three pumps is as follows: the hydraulic oil output by pump P1 passes through the middle-position passage of the travel right unit 8, and is then supplied to the boom 1 unit 9, the bucket unit 10 and the arm 2 unit 11 through parallel passages. The hydraulic oil output by pump P2 passes through the middle-position passage of the travel left unit 7, and is then supplied to the arm 1 unit 6, the boom 2/hammer unit 5 and the bucket unit 10 through parallel passages. The pump P3 is unloaded to an oil return tank through the straight travel valve unit 1, the rotary unit 2, the middle-position passage of the dozer blade unit 3 and the outlet W of the level-mode selecting unit 4.

[0026] Preferably, in the excavation mode, an oil supply circuit for the arm cylinder of the main control valve for excavator hydraulic is as shown in Fig. 6. The oil sup-

ply circuit for the arm cylinder comprises two pumps P1 and P2, an arm cylinder 18, an oil tank 21, an arm 1 unit 6, and an arm 2 unit 11. As shown in Fig. 6, the pump P1 and the pump P2 supply oil confluent for arm in and out. The arm 1 unit 6 and the arm 2 unit 11 do not employ bypass diffuence control during single-movements of arm in and out so as to reduce bypass diffuence loss. The speed of the arm cylinder can be controlled by adjusting the displacement change of the pumps.

[0027] Preferably, Fig. 7 shows a diagram illustrating an oil supply circuit of composite-movements of arm in and bucket in in an excavator hydraulic circuit which is energy-saving in excavation and highly-efficient in levelling. The oil supply circuit of composite-movements of arm in and bucket in comprises two pumps P1 and P2, an arm cylinder 18, a bucket cylinder 20, an oil tank 21, an arm control valve 13, a first check valve 14, an arm 1 unit 6, a bucket unit 10 and an arm 2 unit 11. The pump P1 and the pump P2 supply oil confluent for arm in. The pump P1 and the pump P2 supply oil diffuently for bucket in after throttling. As shown in Fig. 7, during the composite-movements of arm in and bucket in, when the arm cylinder overflows, i.e. pressure of large cavity of the arm cylinder reaches the predetermined pressure of the system relieve valve, the arm control valve also reaches the opening pressure at the moment and is changed and located at the upper position, thus the hydraulic oil of the pump P2 does not overflow through the system safety valve any longer, and passes through the upper position of the arm control valve and the first check valve 14 instead, and enters into the bucket cylinder through the bucket unit 10 so as to change the overflowing direction, so that the overflow enters into a circuit of bucket in through the first check valve 14. Therefore, the overflow does not return to the oil tank directly, which reduces the overflow energy loss.

[0028] Preferably, in the excavation mode, Fig. 8 shows an oil supply circuit for composite-movements of arm in, bucket in and boom lifting of a hydraulic circuit which is energy-saving in excavation and highly-efficient in levelling of an excavator. The oil supply circuit for composite-movements of arm in, bucket in and boom lifting comprises three pumps P1 and P2, an arm cylinder 18, a boom cylinder 19, a bucket cylinder 20, an oil tank 21, a boom 2/hammer unit 5, an arm 1 unit 6, a boom 1 unit 9, a bucket control valve 15, a bucket unit 10, and an arm 2 unit 11. The pump P1 and the pump P2 supply oil confluent for the boom lifting. The pump P1 and the pump P2 supply oil confluent for arm in, and the pump P1 and the pump P2 supply oil diffuently for bucket in after throttling. As shown in the figure, i.e. during the composite-movements of arm in, bucket in and boom lifting, when overflow occurs in the bucket cylinder, namely the bucket cylinder large cavity pressure reaches the predetermined pressure of the system safety valve, the bucket control valve 15 also reaches the opening pressure at the moment, and is changed to the right position. Thus, the hydraulic oil of the pump P1 does not enter the bucket cyl-

in the any longer, and enters into the boom 1 unit 9 and the arm 2 unit 10 through parallel passages instead, and is supplied to the boom circuit and the arm circuit respectively, thus changing the overflow direction and reducing the overflow energy loss.

[0029] Preferably, in the levelling mode, the arm and the boom are supplied with oil by two units respectively and are supplied with a confluence-outside-valve mode. As shown in Fig. 3 and Fig. 4, oil is supplied by the pump P1, the pump P2 and the pump P3 for the boom lifting. Oil is supplied by the pump P1 for the boom dropping. Oil is supplied by the pump P1, the pump P2 and the pump P3 for arm in and out, and oil is supplied by the pump P1, the pump P2 and the pump P3 for bucket in and out. The oil passage flowing of the three pumps is as follows: the hydraulic oil output by pump P1 passes through the middle-position passage of the travel right unit 8, and is then supplied to the boom 1 unit 9, the bucket unit 10 and the arm 2 unit 11 through parallel passages. The hydraulic oil output by the pump P2 passes the middle-position passage of the travel left unit 7, and is then supplied to the arm 1 unit 6, the boom 2/hammer unit 5 and the bucket unit 10 through parallel passages. The pump P3 passes through the straight travel valve unit 1, the rotary unit 2, the middle-position passage in the dozer blade unit 2 and the outlet N of the level-mode selecting valve unit 4 and supplies oil to the boom 2/hammer unit 5, the arm 1 unit 6 and the bucket unit 10 by parallel passages. During levelling, the resistance is small and the power curves of the pumps are within constant power control curves. Large-flow confluence and oil supply can be achieved by the three pumps P1, P2 and P3 for arm in and out through the level-mode oil supply method during levelling, thus realizing rapid movement of single-movements of the stick. Oil is supplied by the pump P1, the pump P2 and the pump P3 for bucket in and out, oil is supplied by pump P1, pump P2 and pump P3 for the boom lifting and oil is supplied by pump P1 for the boom dropping, thus realizing high levelling efficiency.

[0030] Preferably, as shown in Fig. 4, a second check valve 17 and a third check valve 16 are provided in the parallel oil circuits of the bucket unit 10 and the arm 2 unit 11, respectively. In the level-mode, the throttle holes of the second check valve 17 and the third check valve 16 are adjusted to adjust the flow distribution appropriately during composite-movements of the boom, the arm and the bucket.

[0031] The above are only preferred embodiments of the invention and should not be used to limit the invention. For those skilled in the art, the invention may have various modifications and changes. Any modifications, equivalent replacements, improvements and the like within the spirit and principle of the invention shall fall within the scope of protection of the invention.

Claims

1. A main control valve for hydraulic excavator, comprising:

a straight travel valve unit (1), a rotary unit (2), a dozer blade unit (3), a boom 2/hammer unit (5), an arm 1 unit (6), a travel left unit (7), an oil inlet unit, a travel right unit (8), a boom 1 unit (9), a bucket unit (10), an arm 2 unit (11), and an oil return passage (T2);

the main control valve for hydraulic excavator is oil supplied by three pumps (P1, P2, P3) comprising a first pump (P1), a second pump (P2), and a third pump (P3), wherein the first pump (P1) and the second pump (P2) are two variable pumps having the same displacement, and the third pump (P3) is standalone; the three pumps (P1, P2, P3) are under total power control, and the rated pressure of the third pump (P3) is less than the rated pressure of the first pump (P1) and that of the second pump (P2);

characterized in that the main control valve for hydraulic excavator further comprises:

a level-mode oil supply circuit, through which the first pump (P1), the second pump (P2) and third pump (P3) supply oil confluent to the arm cylinder of the hydraulic excavator.

2. The main control valve for hydraulic excavator according to claim 1, **characterized in that** the first pump (P1) and the second pump (P2) supply oil confluent to the arm 1 unit (6) and the arm 2 unit (11) in order to control the arm cylinder, and the stretching and retracting speed of the piston rod of the arm cylinder is controlled by adjusting the displacement of the first pump (P1) and the second pump (P2).
3. The main control valve for hydraulic excavator according to claim 2, **characterized in that** it further comprises: a first overflow recovery circuit configured to recover the overflow from the arm cylinder and make the overflow from the arm cylinder flowing into the bucket cylinder of the hydraulic excavator.
4. The main control valve for hydraulic excavator according to claim 3, **characterized in that** the first overflow recovery circuit comprises: an arm control valve (13) and a first check valve (14); the inlet of the arm control valve (13) is connected with the oil outlet of the large cavity of the arm 1 unit (6), and the inlet of the first check valve (14) is connected with the outlet of the arm control valve (13); the outlet of the first check valve (14) is connected with an oil passage (A).

5. The main control valve for hydraulic excavator according to claim 2, **characterized in that** it further comprises: a second overflow recovery circuit configured to recover the overflow from the bucket cylinder and make the overflow from the bucket cylinder of the hydraulic excavator flowing into the arm cylinder and/or the boom cylinder of the hydraulic excavator.
6. The main control valve for hydraulic excavator according to claim 5, **characterized in that** the second overflow recovery circuit further comprises: a bucket control valve (15); the inlet of the bucket control valve (15) is connected with the oil passage (A) and the outlet of the bucket control valve (15) is connected with the oil inlet of the bucket unit (10).
7. The main control valve for hydraulic excavator according to claim 1, **characterized in that** the level-mode oil supply circuit comprises:
 - a level-mode selecting valve (4), the inlet of which is connected with the dozer blade unit (3), one outlet of which is connected with the boom 2\hammer unit (5) and another outlet of which is connected with the oil return passage (T2);
 - a passage (12), one end of which is connected with the arm 1 unit (6) and the other end thereof is connected with the bucket unit (10).
8. The main control valve for hydraulic excavator according to claim 7, **characterized in that** the path (12) is provided with a throttle hole before entering the bucket unit (10).
9. The main control valve for hydraulic excavator according to claim 8, **characterized in that** the level-mode selecting valve (4) is a hydraulically-controlled two-position three-way valve.
10. The main control valve for hydraulic excavator according to claim 1, **characterized in that** a second check valve (17) and a third check valve (16) are provided in the parallel oil circuits of the bucket unit (10) and the arm 2 unit (11), respectively.
11. A hydraulic excavator, **characterized in that** it comprises: a first pump (P1), a second pump (P2), a third pump (P3) and a main control valve for hydraulic excavator which is the main control valve for hydraulic excavator according to any one of claims 1 to 10, wherein the first pump (P1) is connected with the oil inlet unit of the main control valve for hydraulic excavator, the second pump (P2) is connected with the oil inlet unit of the main control valve for hydraulic excavator, the third pump (P3) is connected with the straight travel valve unit (1) of the main control valve for hydraulic excavator.

draulic excavator.

Amended claims in accordance with Rule 137(2) EPC.

1. A main control valve for small hydraulic excavator being energy-saving in excavation and highly-efficient in levelling, comprising:

a straight travel valve unit (1), a rotary unit (2), a dozer blade unit (3), a boom 2\hammer unit (5), an arm 1 unit (6), a travel left unit (7), an oil inlet unit, a travel right unit (8), a boom 1 unit (9), a bucket unit (10), an arm 2 unit (11), and an oil return passage T2,

characterized in that

the inlet of a level-mode selecting valve (4) is connected with the dozer blade unit (3), one outlet of the level-mode selecting valve (4) is connected with the boom 2\hammer unit (5) and another outlet of the level-mode selecting valve (4) is connected with the oil return passage T2; one end of a path (12) is connected with the arm 1 unit (6) and the other end of the path (12) is connected with the bucket unit (10).

2. The main control valve for small hydraulic excavator being energy-saving in excavation and highly-efficient in levelling according to claim 1, **characterized in that** the path (12) is provided with a throttle hole before entering the bucket unit (10).

3. The main control valve for small hydraulic excavator main control valve being energy-saving in excavation and highly-efficient in levelling according to claim 1 or 2, **characterized in that** the level-mode selecting valve unit (4) is a hydraulically-controlled two-position three-way valve.

4. A main control valve for hydraulic excavator, comprising:

a straight travel valve unit (1), a rotary unit (2), a dozer blade unit (3), a boom 2\hammer unit (5), an arm 1 unit (6), a travel left unit (7), an oil inlet unit, a travel right unit (8), a boom 1 unit (9), a bucket unit (10), an arm 2 unit (11), and an oil return passage (T2);

the main control valve for hydraulic excavator is oil supplied by three pumps (P1, P2, P3) comprising a first pump (P1), a second pump (P2), and a third pump (P3), wherein the first pump (P1) and the second pump (P2) are two variable pumps having the same displacement, and the third pump (P3) is standalone; the three pumps (P1, P2, P3) are under total power control, and the rated pressure of the third pump (P3) is less

than the rated pressure of the first pump (P1) and that of the second pump (P2);

characterized in that the main control valve for hydraulic excavator further comprises: a level-mode oil supply circuit, through which the first pump (P1), the second pump (P2) and third pump (P3) supply oil confluent to the arm cylinder of the hydraulic excavator.

5. The main control valve for hydraulic excavator according to claim 4, **characterized in that** the first pump (P1) and the second pump (p2) supply oil confluent to the arm 1 unit (6) and the arm 2 unit (11) in order to control the arm cylinder, and the stretching and retracting speed of the piston rod of the arm cylinder is controlled by adjusting the displacement of the first pump (P1) and the second pump (P2).

6. The main control valve for hydraulic excavator according to claim 5, **characterized in that** it further comprises: a first overflow recovery circuit configured to recover the overflow from the arm cylinder and make the overflow from the arm cylinder flowing into the bucket cylinder of the hydraulic excavator.

7. The main control valve for hydraulic excavator according to claim 6, **characterized in that** the first overflow recovery circuit comprises: an arm control valve (13) and a first check valve (14); the inlet of the arm control valve (13) is connected with the oil outlet of the large cavity of the arm 1 unit (6), and the inlet of the first check valve (14) is connected with the outlet of the arm control valve (13); the outlet of the first check valve (14) is connected with an oil passage (A).

8. The main control valve for hydraulic excavator according to claim 5, **characterized in that** it further comprises: a second overflow recovery circuit configured to recover the overflow from the bucket cylinder and make the overflow from the bucket cylinder of the hydraulic excavator flowing into the arm cylinder and/or the boom cylinder of the hydraulic excavator.

9. The main control valve for hydraulic excavator according to claim 8, **characterized in that** the second overflow recovery circuit further comprises: a bucket control valve (15); the inlet of the bucket control valve (15) is connected with the oil passage (A) and the outlet of the bucket control valve (15) is connected with the oil inlet of the bucket unit (10).

10. The main control valve for hydraulic excavator according to claim 4, **characterized in that** the level-mode oil supply circuit comprises:

a level-mode selecting valve (4), the inlet of

which is connected with the dozer blade unit (3), one outlet of which is connected with the boom 2\hammer unit (5) and another outlet of which is connected with the oil return passage (T2); a passage (12), one end of which is connected with the arm 1 unit (6) and the other end thereof is connected with the bucket unit (10).

11. The main control valve for hydraulic excavator according to claim 10, **characterized in that** the path (12) is provided with a throttle hole before entering the bucket unit (10).

12. The main control valve for hydraulic excavator according to claim 11, **characterized in that** the level-mode selecting valve (4) is a hydraulically-controlled two-position three-way valve.

13. The main control valve for hydraulic excavator according to claim 4, **characterized in that** a second check valve (17) and a third check valve (16) are provided in the parallel oil circuits of the bucket unit (10) and the arm 2 unit (11), respectively.

14. A hydraulic excavator, **characterized in that** it comprises: a first pump (P1), a second pump (P2), a third pump (P3) and a main control valve for hydraulic excavator which is the main control valve for hydraulic excavator according to any one of claims 1 to 13, wherein the first pump (P1) is connected with the oil inlet unit of the main control valve for hydraulic excavator, the second pump (P2) is connected with the oil inlet unit of the main control valve for hydraulic excavator, the third pump (P3) is connected with the straight travel valve unit (1) of the main control valve for hydraulic excavator.

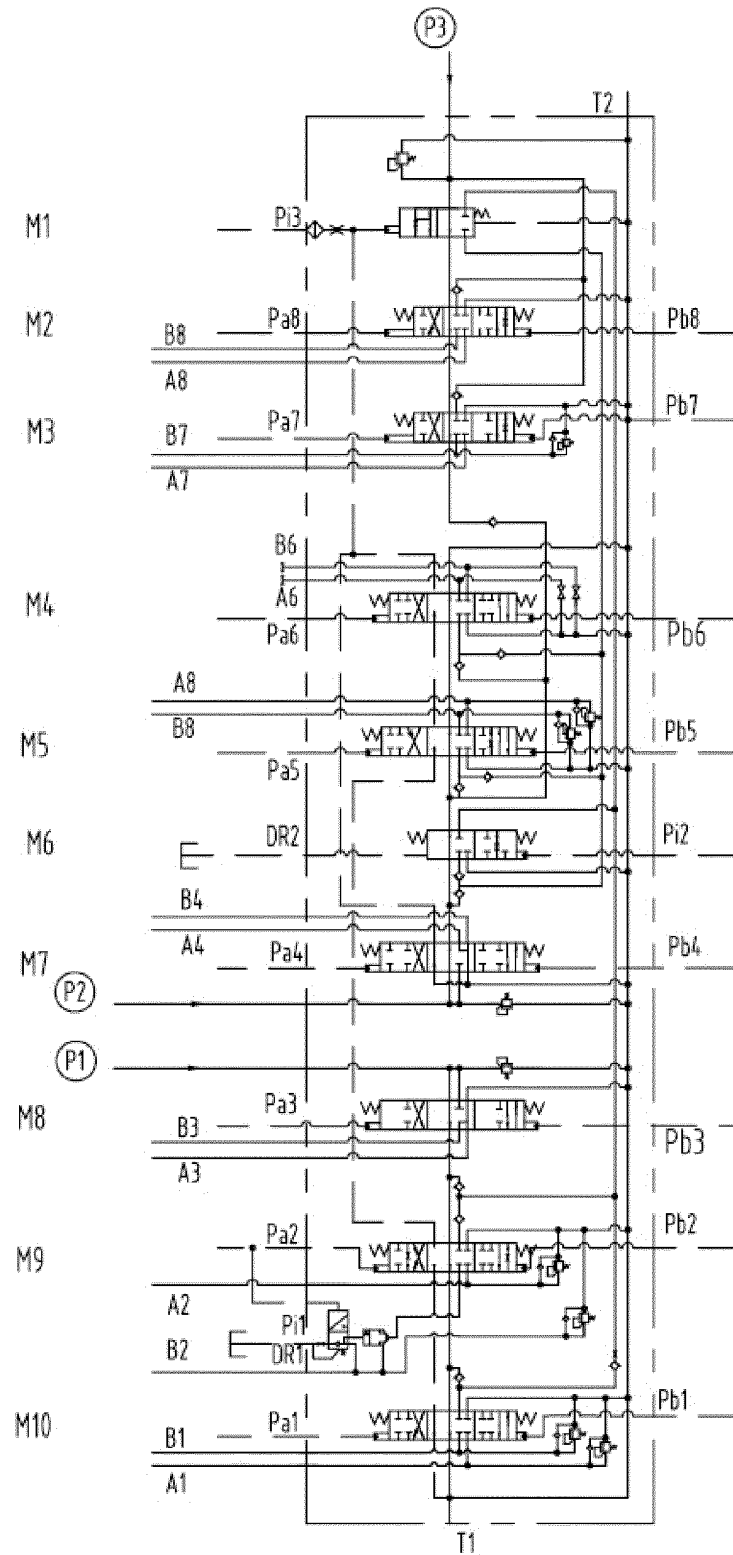


Fig. 1

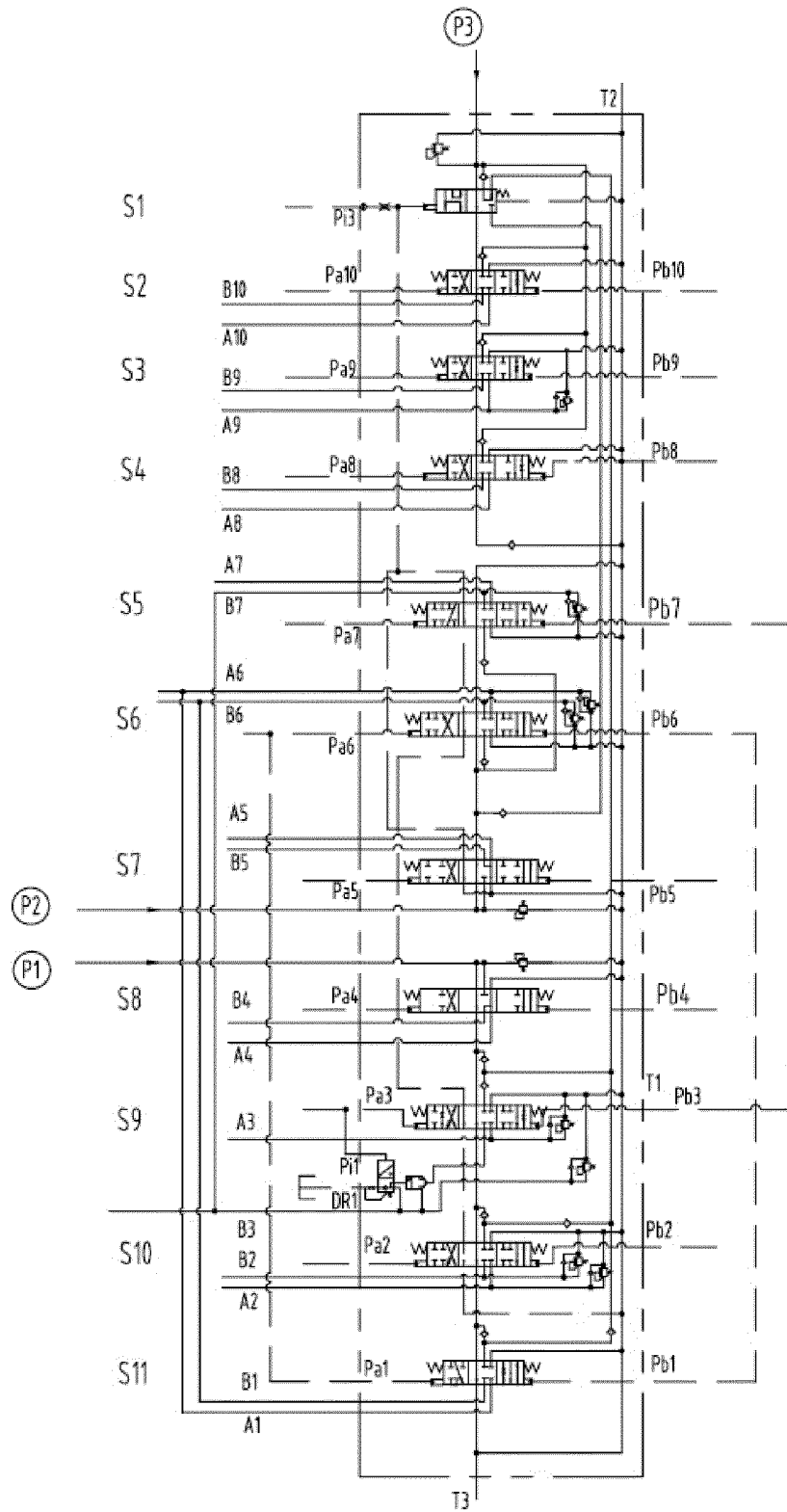


Fig. 2

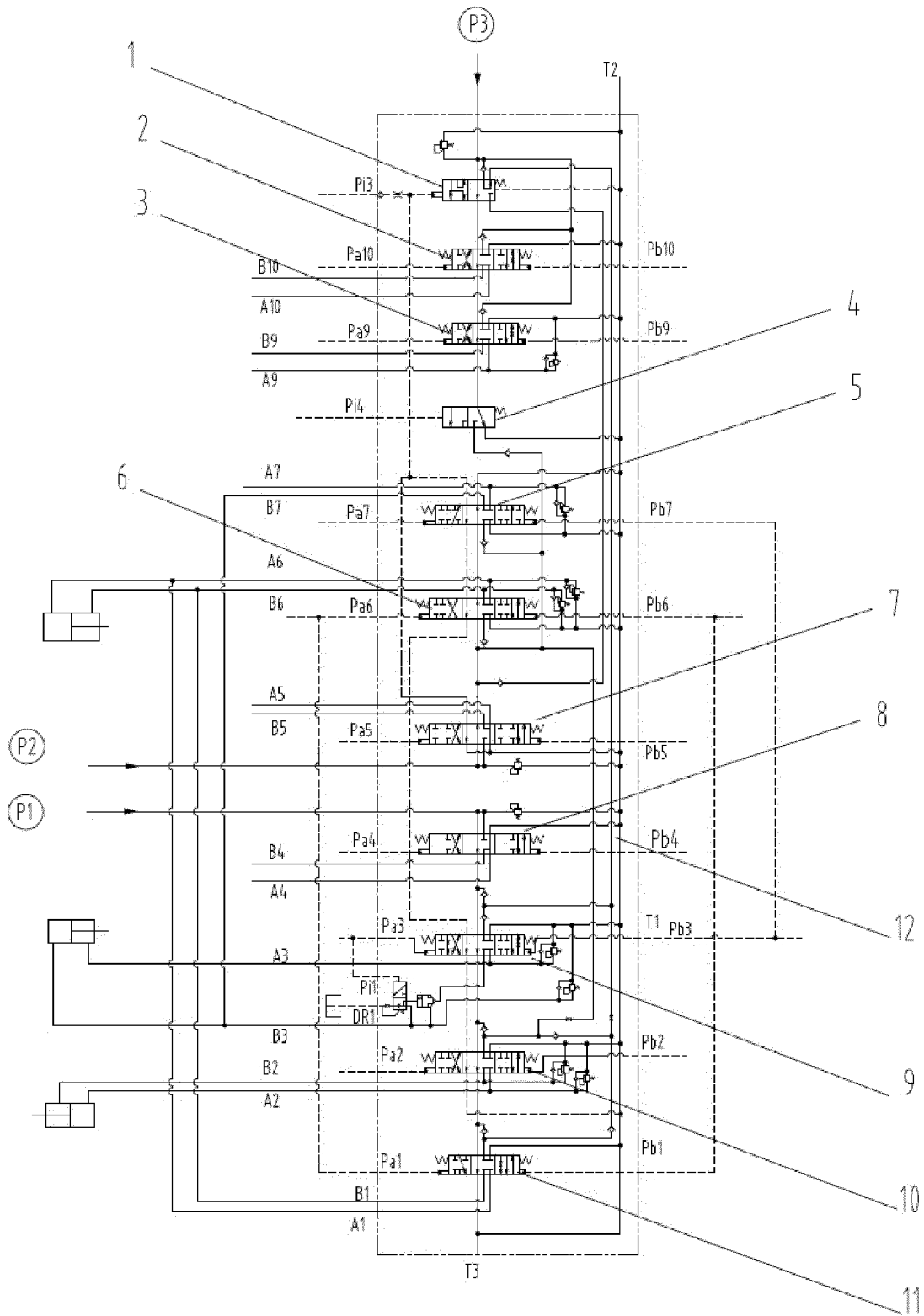


Fig. 3

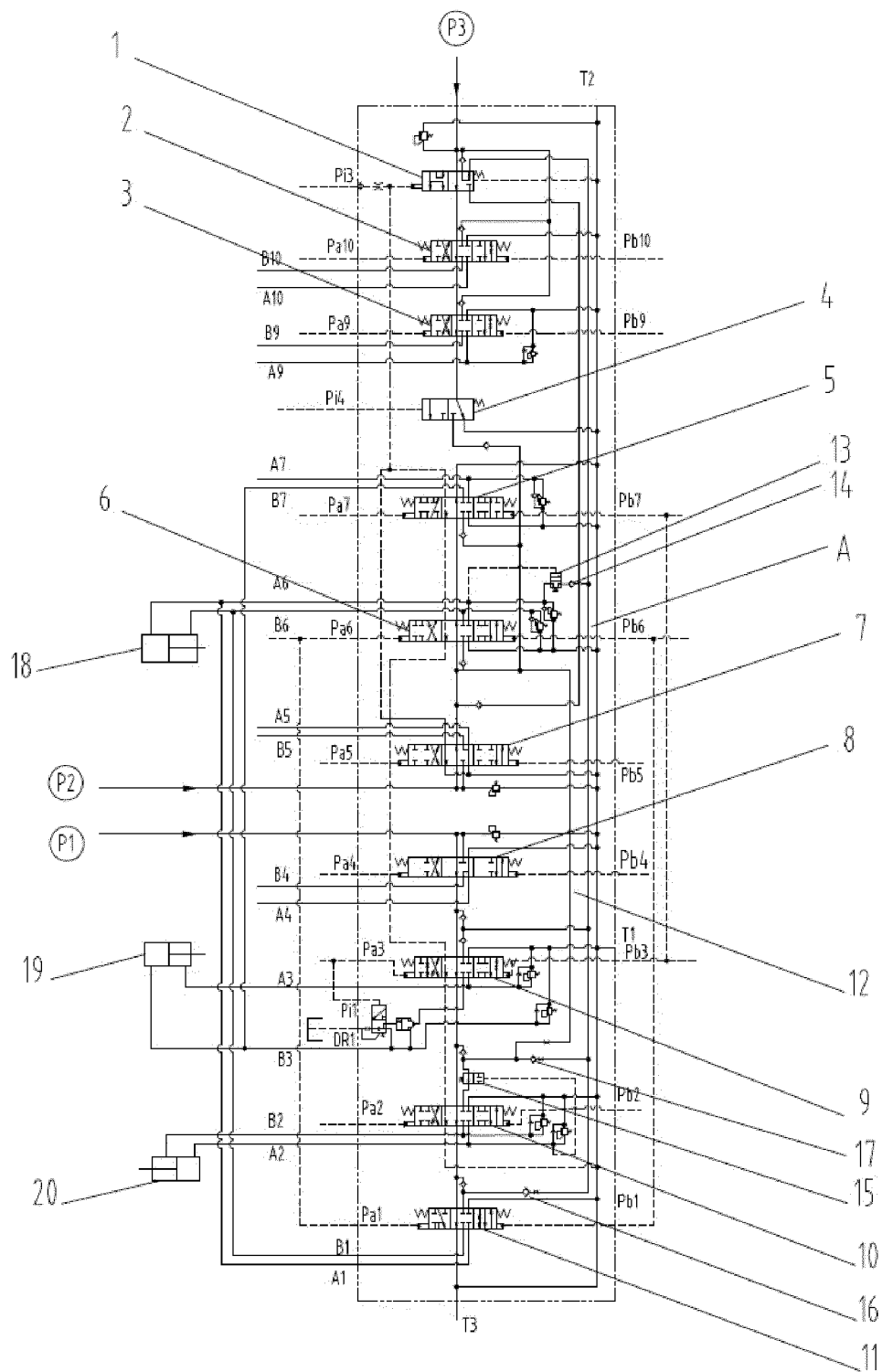


Fig. 4

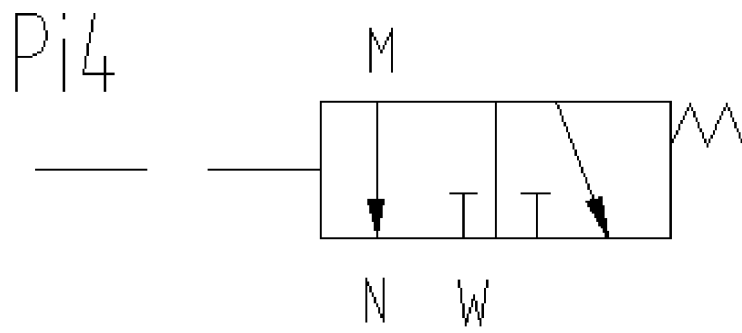


Fig. 5

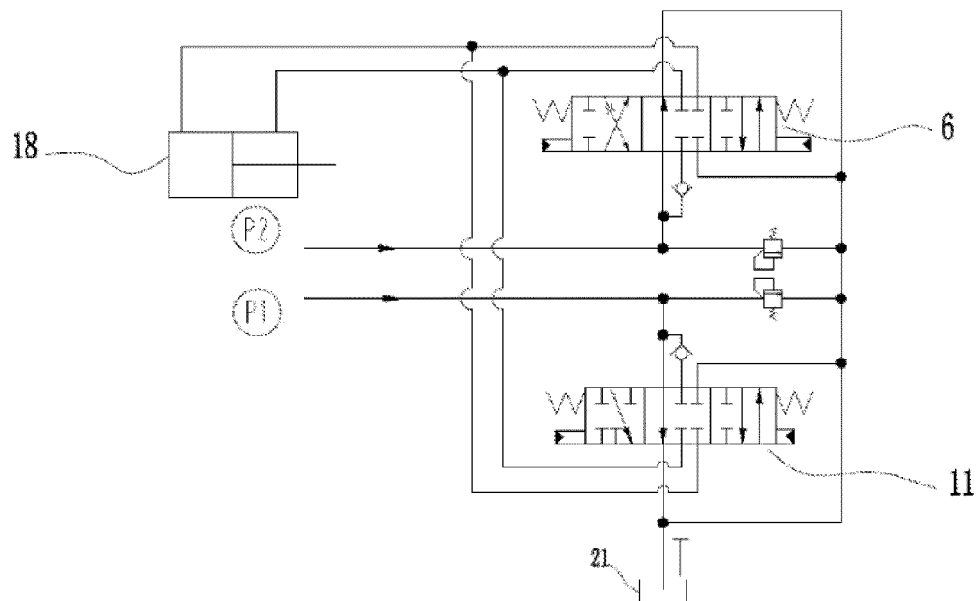


Fig. 6

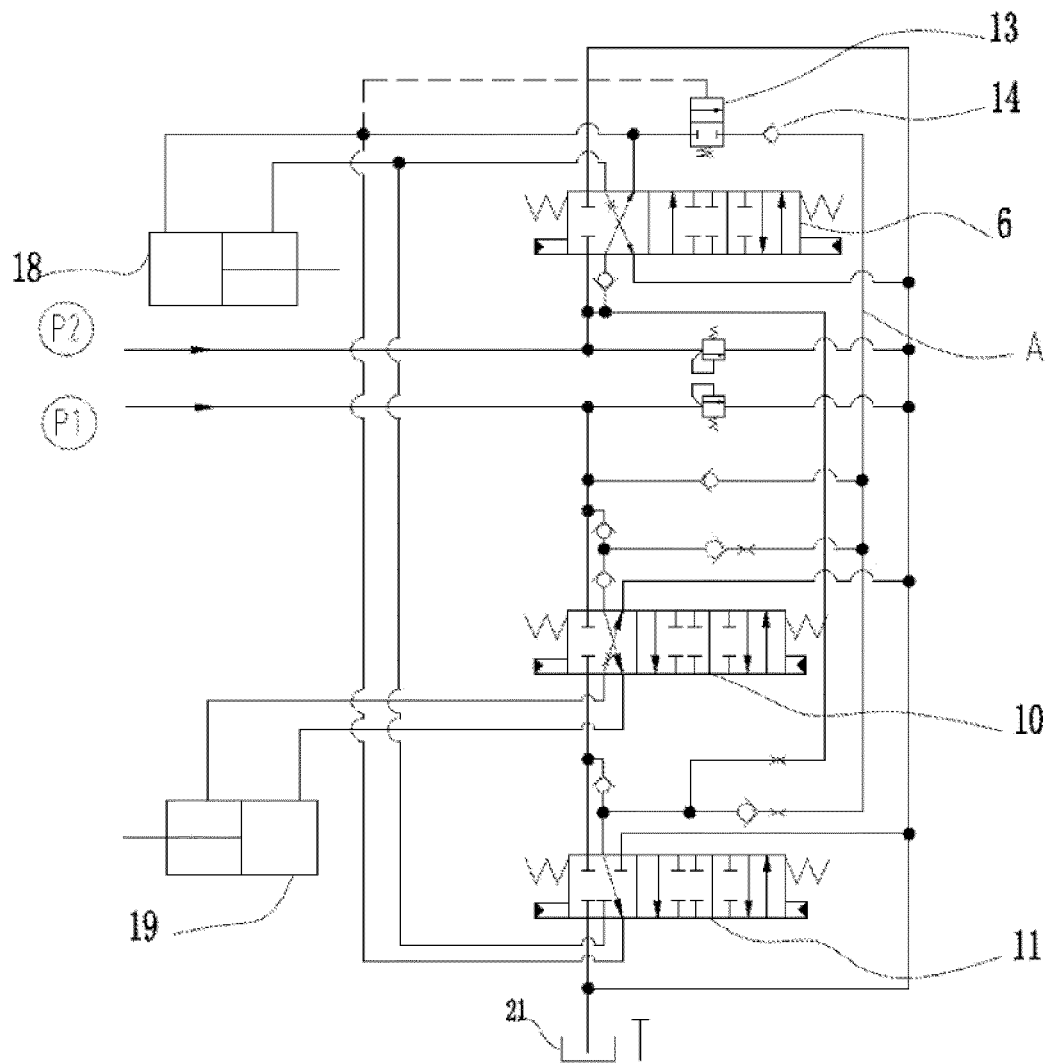


Fig. 7

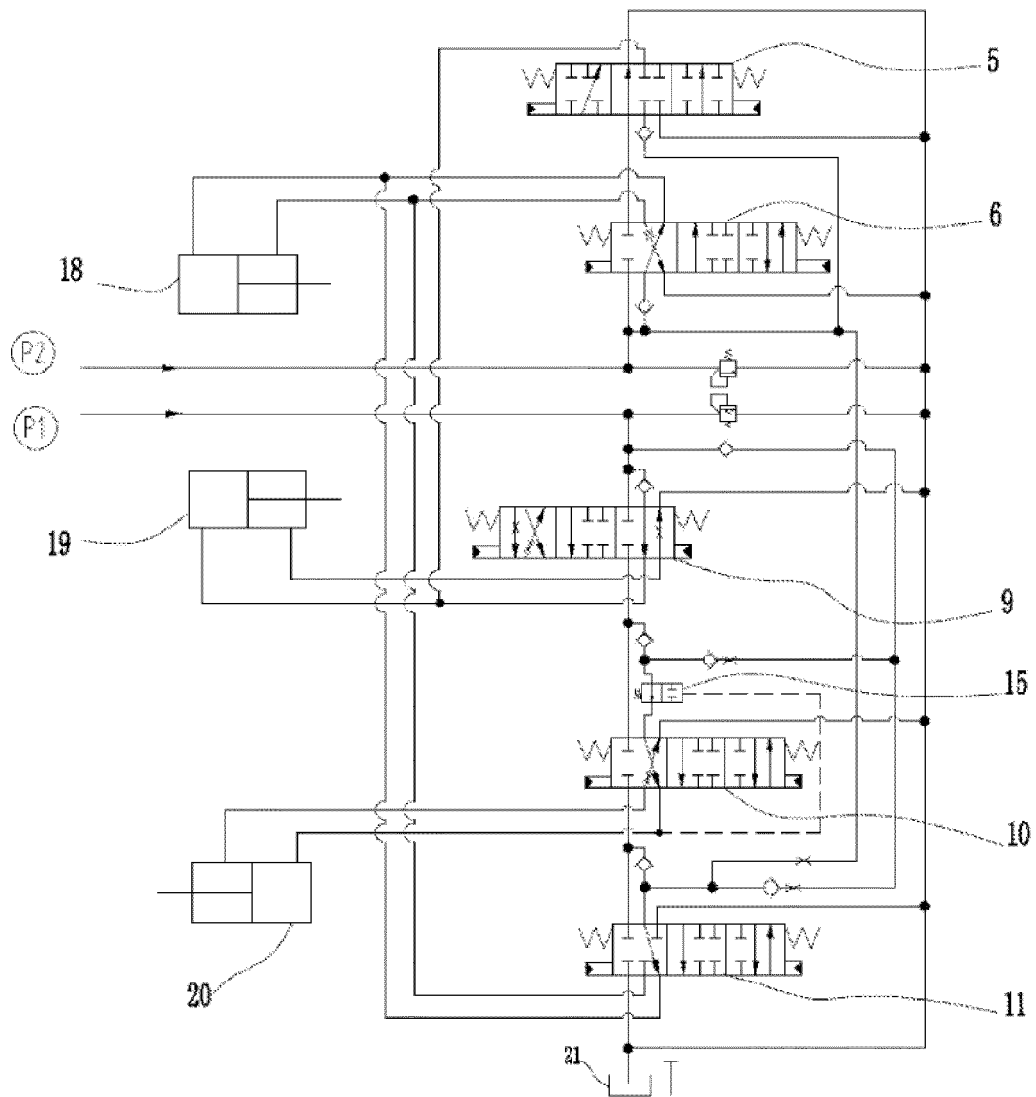


Fig. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2011/077403**A.CLASSIFICATION OF SUBJECT MATTER**

See the extra sheet.

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: E02F9, E02F3, 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)

CNPAT, CNKI, WPI, EPODOC: HUNAN SUNWARD INTELLIGENT MACHINERY CO., LTD., He Qinghua, Guo Yong, Zhang Shiyong, Chen Guifang, valve, rod, arm, bucket, ground, hydraulic, confluence, converge, lever?, bar?, boom, land, merg+, join+, combin+

C.DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claims
PX	CN101886405 A (HUNAN SUNWARD INTELLIGENT MACHINERY CO., LTD.) 17 November 2010 (17.11.2010) see paragraphs [0019] to [0021] in the description and figure 3-6.	1-11
PX	CN201738353 U (HUNAN SUNWARD INTELLIGENT MACHINERY CO., LTD.) 9 February 2011 (09.02.2011) see paragraphs [0019] to [0021] in the description and figures 3-6.	1-11
A	CN101509266 A (SANY HEAVY MACHINERY CO., LTD.) 19 August 2009(19.08.2009) the entire document	1-11
A	WO2008/078930 A1 (DOOSAN INFRACORE CO LTD) 3 July 2008(03.07.2008) the entire document	1-11
A	EP1691084 A2 (DEERE&CO)16 August 2006 (16.08.2006) the entire document	1-11
A	JP2000-144805 A (KOMATSU SEISAKUSHO KK) 26 May 2000 (26.05.2000) the entire document	1-11

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

*Special categories of cited documents:

“A” document defining the general state of the prior art which is not considered to be of particular relevance

“E” earlier application or patent but published on or after the international filing date

“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

“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

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“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
27 September 2011 (27.09.2011)Date of mailing of the international search report
3 November 2011 (03.11.2011)

Name and mailing address of the ISA/CN:

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100088, China

Authorized officer

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Facsimile No.: (86-10) 62019451

Form PCT/ISA/210 (Page 2) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2011/077403

A. CLASSIFICATION OF SUBJECT MATTER

E02F 9/22(2006.01)i

E02F 3/43(2006.01)i

EP 2 597 211 A1

INTERNATIONAL SEARCH REPORT Information on patent family members

International application No.
PCT/CN2011/077403

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Form PCT/ISA/210 (Patent Family Annex) (July 2009)