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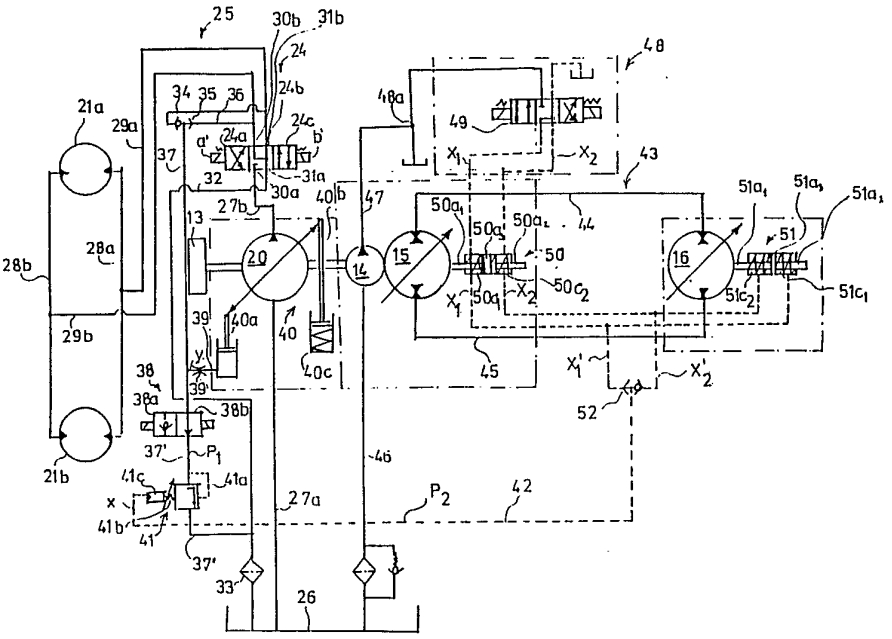
(54) Title: AUTOMATIC CONTROL SYSTEM FOR THE TRANSFER OF THE DRIVE POWER BETWEEN A TRACTOR AND A TRAILER

(57) Abstract

The invention concerns an automatic control system for the transfer of the drive power between a tractor (10) and a trailer (11), which said system comprises a closed hydraulic circuit (43) that operates the drive wheels of the tractor (10) and an open hydraulic circuit (25) that operates the drive wheels (17a, 17b) of the trailer. In the system, the closed hydraulic circuit (43) of the tractor (10) comprises a pump (15) and a hydraulic motor (16) driven by the pump and, in a corresponding way, the open hydraulic circuit (25) of the trailer (11) comprises a motor or motors (21a, 21b) driven by a pump (20). The control system comprises a line (42) that transmits a control pressure (P_2) from the closed circuit (43) of the tractor (10) to the open circuit (25) of the trailer (11). When the resistance to traction increases, e.g. when driving up a steep hill, the pressure (P_2) in said transmitting line (42) increases and, by means of said pressure (P_2), the hydraulic pump (20) of the trailer (11), which is advantageously an adjustable-displacement pump, is controlled to produce a higher pressure to the motor or motors (21a and/or 21b) driven by the pump. In a corresponding way, when the drive power requirement of the tractor (10) becomes lower, the operating pressure in the hydraulic circuit (27b, 29a, 29b, 28a, 28b) of the drive power transmission in the trailer (11) is lowered.



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Automatic control system for the transfer of the drive power between a tractor and a trailer

The invention concerns an automatic control system for the transfer of the drive power between a tractor and a trailer.

High requirements are imposed on the systems for the transmission of drive power of vehicles intended for operation in severe cross-country conditions. The basic starting point is that, in a tractor-trailer combination that hauls heavy loads of timber, both the tractor and the trailer are provided with drive gears of their own. Thereat, in particular when there are hills in the terrain, a difficulty is how to make the drive power transmission systems of the tractor and of the trailer operate interdependently. When the requirement of drive power is lowered in the tractor, the drive power must also be lowered in the trailer. In the contrary case, the trailer pushes and, in the case of a combination provided with an articulated joint, there is a risk that the combination is folded at the middle. In a corresponding way, when the power requirement becomes higher in the trailer, the drive power must also increase in the trailer.

For example, from the Finnish Pat. Appl. 863464, a system for the control of the drive power transmission is known, wherein the system consists of two circuits that are closed. Said arrangement of equipment requires separate means that produce a signal for automatic effecting of the control. From the Danish Patent 1150/80, a system is known wherein the tractor and the trailer do not have separate hydraulic circuits. The trailer employs the hydraulic system of the tractor, and the invention is based on a hydraulic clutch between the hydraulic motor and the drive wheels and on the control of said clutch. On the other hand, from the British Patent 1,260,438, a hydraulic circuit is known wherein the control of the trailer drive takes place mechanically depending on the difference in speed between the tractor and the trailer. From the Swedish Patent 396,323, a power transmission solution for a trailer is known wherein the trailer is provided with a combustion engine of its own.

The object of the present invention is a power transmission system of an entirely novel type, wherein only one drive engine is used. The object is a power transmission system wherein it is possible to regulate the drive powers of the trailer and the tractor automatically and interdependently and so that, when the requirement of drive power becomes higher in the tractor, the drive power is increased accordingly in the trailer and, in a corresponding way, when the power requirement becomes lower in the tractor, the drive power is also lowered in the trailer.

The drive power transmission system in accordance with the invention is mainly characterized in that the control system comprises a line that transmits a control pressure from the closed circuit of the tractor to the open circuit of the trailer, whereby, when the resistance to traction increases, e.g. when driving up a steep hill, the pressure in said transmitting line increases and, by means of said pressure, the hydraulic pump of the trailer, which is advantageously an adjustable-displacement pump, is controlled to produce a higher pressure to the motor or motors driven by the pump and, in a corresponding way, when the drive power requirement of the tractor becomes lower, the operating pressure in the hydraulic circuit of the drive power transmission in the trailer is lowered.

In the following, the invention will be described with reference to some preferred embodiments of the invention shown in the figures in the accompanying drawings, the invention being, however, not supposed to be confined to said embodiments alone.

Figure 1 is a side view of a tractor-trailer combination.

Figure 2 shows the tractor-trailer combination of Fig. 1 viewed from above, and the essential components of the drive power transmission system have been added to the figure schematically.

Figure 3 shows the circuitry diagram of the hydraulic system of the drive power transmission system in accordance with the invention.

Figure 4 illustrates the principle of a solution in which a closed

circuit transfers the closed-circuit pressure, resulting from the loading, to the control-pressure circuit.

Figure 5 shows the circuitry diagram of a second embodiment of the hydraulic system of the drive power transmission system in accordance with the invention.

Figs. 1 and 2 show a tractor-trailer combination. The tractor 10 and the trailer 11 are interconnected by means of an articulated joint 12. The drive engine 13, e.g. a combustion engine, favourably a diesel engine, is fitted to rotate the adjustable-displacement pump 15 of the power transmission of the tractor as well as the constant-displacement pump 14 that produces the feed and control pressure. The adjustable-displacement pump 15 is further fitted to rotate the adjustable-displacement motor 16 of the tractor. The adjustable-displacement motor 16 rotates the drive shaft 17a and the drive wheels 17b of the tractor 10.

The drive wheels 17b rotate and drive a crawler 19 or equivalent.

The drive engine 13 is also fitted to rotate the adjustable-displacement pump 20 of the drive power transmission of the trailer 11. The adjustable-displacement pump 20 communicates through hydraulic lines with constant-displacement motors 21a and 21b, advantageously hydraulic hub motors. The constant-displacement motors 21a and 21b drive the drive wheels 22a and 22b. The drive wheel 22a is fitted to rotate and to drive a crawler 23a or equivalent, and, correspondingly, the drive wheel 22b is fitted to rotate and to drive the crawler 23b or equivalent at the other side of the trailer 11.

Fig. 3 is a schematical illustration of the automatic control system for the drive power transmission of the tractor and the trailer. The open pressure-medium circuit 25, preferably a hydraulic circuit, of the drive power transmission of the trailer 11 is provided with a directional valve 24 for the direction of rotation of the constant-displacement motors 21a and 21b.

The valve 24 is advantageously a 4/3 directional valve. This means

that the valve is provided with four connections and the valve comprises three blocks of operation: the blocks 24a,24b and 24c. The valve 24 may be spring-loaded, whereby, when acting upon the controls a' and b', the valve spindle is displaced in either one direction. When the control side a' is activated, e.g., by introducing the control voltage to the coil, the valve spindle is displaced so that the block 24a is switched on and, in a corresponding way, when the control side b' is activated, the valve block 24c is switched on. In the middle position the springs keep the central valve block 24b switched on, i.e. in communication with the connections 30a, 30b,31a and 31b.

A pressure medium line 27a passes to the adjustable-displacement pump 20 of the drive power transmission of the trailer. From the pump, a pressure medium line 27b passes further to the valve 24. Between the constant-displacement motors 21a and 21b of the trailer, there are a first pressure line 28a and a second pressure line 28b. From the line 28a a line 29a is branched, and from the line 28a a line 29b is branched. The lines 29a and 29b communicate with the connections 30b and 31b of the valve 24.

When the middle block 24b in the valve 24 is on, the lines 29a and 29b are connected in the valve itself, and a return line 32 passes from the block 24b in the valve 24 to the fluid tank 26 through the filter 33. Thereat the line 27b from the adjustable-displacement pump 20 is blocked.

When the valve 24 block 24a is on, a flow is passed from the adjustable-displacement pump 20 from the line 27b to the line 29a. The return flow from the hub motors 21a and 21b comes along the line 29b to the return line 32.

Correspondingly, when the block 24b is on and connected to the connections 30a,30b;31a and 31b, the flow runs in the opposite direction, and the sense of rotation of the hub motors 21,21b is now reversed as compared with the former case.

Further, from the line 29a there is a pressure line 34 to the change-

counter valve 35, and from the line 29b there is a pressure line 36 to the change-counter valve 35. From the change-counter valve 35 there is a pressure line 37, and the line 37 passes further to the blocking valve 38.

The blocking valve 38 comprises the blocks 38a and 38b. When the block 38a is switched on, the flow is blocked and the entire power is taken from the pump 20 at its maximum. Correspondingly, when the block 38b is switched on, the valve allows flow to pass through the valve. The control of the blocking valve 38 may be electric.

From the pressure line 37 that precedes the blocking valve 38 a line 39 is arranged which transfers the control pressure to the adjustable-displacement pump. The line 39 comprises a throttle 39', through which the control pressure is passed to the regulating unit 40 of the adjustable-displacement pump 20.

The regulating unit 40 may comprise an arrangement of equipment illustrated schematically in Fig. 3. The control pressure p_1 is passed to the piston device 40a regulating the output of the pump, which said piston device 40a displaces the regulating disc in the pump, e.g. a disc that regulates the stroke volume of a piston pump, against the spring force of the spring 40c in the second piston device 40b, as a control (y) into the position determined by the control pressure p_1. When the control pressure p_1 is at its maximum, e.g., in a case in which the blocking valve 38 allows a maximum control pressure to flow into the line 39, the adjustable-displacement pump 20 yields the maximum pressure.

In the line 37, after the blocking valve 38, there is a pre-controlled pressure-regulation valve 41. The pressure present in the line portion 37' opens the valve into the hydraulic line portion 37" placed after the valve. Said pre-control is transmitted to the valve spindle of the pressure-limiter valve 41 or to its control along the line 41a. The pressure p_1 acts against the spring force of the spring 41b. The spring force of the spring 41b is separately adjustable. The valve spindle is acted upon further against the pre-control pressure p_1 by means of a regulating piston 41c, to which the control

pressure p_2 is passed as a control quantity (x) along a pressure line, preferably a hydraulic pressure line 42. The pressure line 42 communicates with the control circuit x_1 or x_2 of the closed pressure medium circuit 43 of the drive power of the tractor 10 through the change-counter valve 52 and the pressure medium lines x_1' and x_2'. In this way, the control message (x) is transmitted as a modified control message (y) to the adjustable-displacement pump 20.

The closed circuit 43 of the drive power transmission of the tractor comprises an adjustable-displacement pump 15 and a constant-displacement-pump 14 rotated by the drive engine 13. The constant-displacement pump 14 transmits the feed pressure and the so-called pilot pressure, i.e. the control pressure, to the adjustable-displacement pump 15 of the power transmission of the tractor and to the adjustable-displacement motor 16. The adjustable-displacement pump 15 is fitted to operate the adjustable-displacement motor 16 of the power transmission of the tractor. In this way the adjustable-displacement pump and the adjustable-displacement motor are connected parallel, and they are interconnected as a closed circuit of high operating pressure by means of the pressure medium lines 44 and 45.

The pressure medium line 46 passes to the constant-displacement pump 14 from the fluid tank 26. From the pump 14 the pressure line 47 passes further. The pressure line 47 passes to the valve system 48 of the drive power transmission circuit of the tractor. The valve system 48 comprises a distribution point 48a, through which part of the flow is taken through a pressure distributor valve to the fluid tank 26'. From the distribution point 48a, the control pressure is taken further for the actuators 15 and 16 in the closed circuit 43. Said control pressure is taken through the directional valve 49, which is a 4/3 directional valve and by means of which the control pressure p_2 is passed to the line x_1 or x_2. The control pressure p_2 is passed both to the adjustable-displacement pump 15 and to the adjustable-displacement motor 16. The control pressure arrives either in the line x_1 or in the line x_2. The control pressure p_2 is applied to the adjustable-displacement pump 15 of the closed circuit 43 and to the adjustable-displacement motor 16 at the same time.

The adjustable-displacement pump 15 comprises a regulation unit 50, which regulates the output and the pressure of the adjustable-displacement pump 15, and, correspondingly, the adjustable-displacement motor 16 comprises a regulation unit 51, which regulates the blade angle or equivalent, for example in the case of a piston motor, the stroke length of the piston, of the adjustable-displacement motor. Said regulation units are illustrated schematically in Fig. 3. They may consist, e.g., of the following basic components of construction. The adjustable-displacement unit 50 may comprise a piston device shown in the figure, which comprises a piston rod $50a_1$ and $50a_2$ and, between them, a piston $50a_3$. Each piston rod $50a_1$ and $50a_2$ is fitted to be surrounded by a spring. When the control pressure p_2 is applied neither to the line x_1 nor to the line x_2, the piston $50a_3$ is kept by the springs in its middle position, and thereat the displacement of the adjustable-displacement pump 15 is at the minimum and it produces the minimum flow quantity. The direction of the flow of the fluid that is made to flow by means of the pump is affected by whether the control pressure is applied to the line x_1 or to the line x_2. The adjustable-displacement motor 16 connected parallel is regulated in a corresponding way. The regulating unit 51 for the adjustable-displacement motor 16 may comprise components of construction corresponding to those in the adjustable-displacement unit 50. As is shown in the figure, the adjustable-displacement unit 51 comprises a piston $51a_3$ and the piston rods $51a_1$,$51a_2$, around which there is a spring. The regulating unit 50 comprises medium spaces $50c_1$ and $50c_2$, wherein the spring elements are placed. In a corresponding way, the regulating unit 51 of the motor 16 comprises medium spaces $51c_1$ and $51c_2$, wherein the spring elements are placed. The control pressure is passed along the pressure line x_1 both into the medium space $50c_1$ of the regulating unit 50 and into the medium space $51c_1$ of the regulating unit 51, or along the line x_2 into the medium spaces $50c_2$ and $51c_2$. The pressure from the line x_1 is passed along the line x_1' to the change-counter valve 52 and from the line x_2 along the line x_2' to the change-counter valve 52. From the change-counter valve 52, a pressure line 42 passes further to the pressure-limiter valve 41, to its regulating piston 41c.

Fig. 4 is an illustration of the principle of the transmission of the

change in the pressure, resulting from the loading, to the control pressure circuit. The arrangement of equipment is in itself known, and said regulating can be accomplished by means of various arrangements of equipment. The devices 53a and 53b that transmit the change in pressure in the circuit comprise a piston device to one of whose sides the pressure in the closed circuit is passed, whereas the pressure of the control circuit is passed to the other side. The control circuit is fitted to press the piston against the spring force. When the pressure is increased in the closed circuit, said pressure is applied to the piston. The piston moves and causes a pressure increase in the control circuit x_1 or x_2. In this way, a change in pressure resulting from the loading is transmitted directly to the drive-power regulating circuit of the trailer.

The pressure prevailing in the lines x_1 and x_2 is proportional to the drive resistance of the tractor. When the drive resistance increases, e.g. when driving steeply uphill, the pressure in the line x_1, when driving forwards, increases and acts upon the regulating piston 41c so that the pressure value in the pressure-limiter valve 41 increases. Thereat the pressure in the line 39 increases and acts upon the regulator of the pump 20 so that the pressure value produced by the pump becomes higher, whereby the torque of the motors 21a and 21b is increased. In a corresponding way, the opposite takes place when the drive resistance is lowered. When operating in the way described above, the regulating system takes care that, when necessary, the power transmission of the trailer automatically contributes to the pushing force, and lowers the pushing force, respectively, when the drive resistance becomes lower. In the invention, in the way described above, the closed and the open hydraulic circuits are interconnected so that the pump displacement per revolution and the pressure in the open circuit are regulated by means of a pressure-controlled pressure-limiter valve 41. Said valve 41 receives its control from the circuit x_1 or x_2 that regulates the displacement per revolution of the pump and the motor in the closed circuit. The pressure prevailing in said circuits is also proportional to the drive resistance of the tractor 10. Thus, by means of the system in accordance with the invention, a regulation of the torques of the hub motors 21a and 21b of the trailer in

proportion to the drive resistance is obtained.

Fig. 5 illustrates a second advantageous embodiment of the automatic control system for the transfer of drive power in accordance with the invention as well as a hydraulic circuitry diagram for same. The embodiment shown in Fig. 5 differs from the embodiment of Fig. 3 in the respect only that the control data from the closed circuit to the open circuit are transferred from the main hydraulic line 44,45 between the pump 15 of the closed hydraulic circuit and the motor 16.

From the change-counter valve 52, there is a line x_1" to the line 45 between the pump 15 and the hydraulic motor 16 and a line x_2" to the line 44 between the pump 15 and the motor 16.

Thus, the control pressure is transmitted either from the line 44 or from the line 45 to the pressure-limiter valve 41 and to its regulating piston 41c. The pressure-limiter valve 41 closes and opens the main flow that flows through the valve. When the valve 41 is being closed, the pressure is increased in the line 39 that passes to the pump 20 control unit 40, and the pressure produced by the pump 20 is increased and, in a corresponding way, when the control pressure becomes lower in the line x_1" or x_2", the control pressure in the line 39 also becomes lower, and thereat the pump 20 is fitted to transmit a lower pressure to the motors 21a,21b of the drive wheels. Thus, the control system illustrated in Fig. 5 differs from the control system shown in Fig. 3 in the respect only that the control data are transmitted to the valve 41 directly from the operating-pressure line between the pump 15 and the motor 16 in the closed hydraulic circuit.

WHAT IS CLAIMED IS:

1. Automatic control system for the transfer of the drive power between a tractor (10) and a trailer (11), which said system comprises a closed hydraulic circuit (43) that operates the drive wheels of the tractor (10) and an open hydraulic circuit (25) that operates the drive wheels (17a,17b) of the trailer and in which said system the closed hydraulic circuit (43) of the tractor (10) comprises a pump (15) and a hydraulic motor (16) driven by the pump and, in a corresponding way, the open hydraulic circuit (25) of the trailer (11) comprises a motor or motors (21a,21b) driven by a pump (20), c h a r a c t e r i z e d in that the control system comprises a line (42) that transmits a control pressure (P_2) from the closed circuit (43) of the tractor (10) to the open circuit (25) of the trailer (11), whereby, when the resistance to traction increases, e.g. when driving up a steep hill, the pressure (P_2) in said transmitting line (42) increases and, by means of said pressure (P_2), the hydraulic pump (20) of the trailer (11), which is advantageously an adjustable-displacement pump, is controlled to produce a higher pressure to the motor or motors (21a and/or 21b) driven by the pump and, in a corresponding way, when the drive power requirement of the tractor (10) becomes lower, the operating pressure in the hydraulic circuit (27b,29a,29b,28a,28b) of the drive power transmission in the trailer (11) is lowered.

2. Control system as claimed in claim 1, c h a r a c t e r i z e d in that the control system comprises a pressure-limiter valve (41) placed in the open circuit (25) of the trailer (11), into which said valve (41) the control pressure (P_2) is passed from the closed circuit (43) of the tractor (10).

3. Control system as claimed in claim 1 or 2, c h a r a c t e r - i z e d in that the control system comprises lines (x_1 and x_2) that transmit the control pressure to the pump (15) and to the motor (16) and from which said lines the control pressure is also transmitted as a control message (x) along the pressure line (x_1' or x_2' and 42) to the pressure-limiter valve (41) of the open circuit (25) and to the regulating piston (41c) in said valve, whereby, when the pressure

value becomes higher, the pressure-limiter valve (41c) closes some of the main flow passing through said valve, whereby, when the valve (41) is being closed, the pressure rises in the line (39) passing to the pump (20) regulation unit (40), and the pressure produced by the pump (20) becomes higher and, in a corresponding way, as the control pressure becomes lower in the line (x_1 or x_2), the control pressure in the line (39) also becomes lower, and thereat the pump (20) is fitted to produce a lower pressure for the drive wheel motors (21a,21b).

4. Control system as claimed in any of the preceding claims, c h a r a c t e r i z e d in that, in the closed hydraulic circuit (43) of the tractor (10), the adjustable-displacement pump (15) is connected to rotate the adjustable-displacement motor (16) and that the adjustable-displacement pump is fitted to be rotated by the drive engine (13) of the tractor (10), which said engine also rotates the constant-displacement pump (14), which is fitted to produce the control pressure for the actuator (15 and 16) of the closed circuit (43) along the line (x_1 or x_2).

5. Control system as claimed in any of the preceding claims, c h a r a c t e r i z e d in that the working pressure for the open circuit (25) of the trailer (11) is produced by an adjustable-displacement pump (20), which is fitted to rotate the hub motors (21a, 21b), and that the drive of rotation for the pump (20) is brought from the drive engine (13) of the tractor (10).

6. Control system as claimed in any of the preceding claims, c h a r a c t e r i z e d in that the control of the adjustable-displacement pump (15) and of the connected adjustable-displacement motor (16) in the closed circuit of the tractor is fitted to be transmitted along the control pressure line (x_1 or x_2) to the regulation units (50 and 51) both of the adjustable-displacement pump (15) and of the adjustable-displacement motor (16).

7. Control system as claimed in any of the preceding claims, c h a r a c t e r i z e d in that there is a valve (38), by means of which the line (37) can be blocked, whereby the pump (20) can be made to supply maximum pressure to the hydraulic motors (21a,21b).

8. Control system as claimed in any of the preceding claims 1,2,4,5 or 7, c h a r a c t e r i z e d in that the control pressure is passed to the pressure-limiter valve (41) of the open circuit (25) and to the regulating piston (41c) of said valve from the line (45 or 44) between the pump (15) and the motor (16) in the closed hydraulic circuit, whereby the pressure in the line (44 or 45) whose pressure is higher is transmitted through the change-counter valve (52) to the line (42) and further to the pressure-limiter valve (41) of the open circuit and to its regulating piston (41c), whereby, when the pressure value becomes higher, the pressure-limiter valve (41c) closes some of the main flow flowing through said valve, whereby, when the valve (41) is being closed, the pressure in the line (39) that passes to the control unit (40) of the pump (20) becomes higher and the pressure produced by the pump (20) becomes higher, and, in a corresponding way, when the control pressure becomes lower in the line (42), the control pressure also becomes lower in the line (39), and thereat the pump (20) is fitted to supply a lower pressure to the motors (21a,21b) of the drive wheels.

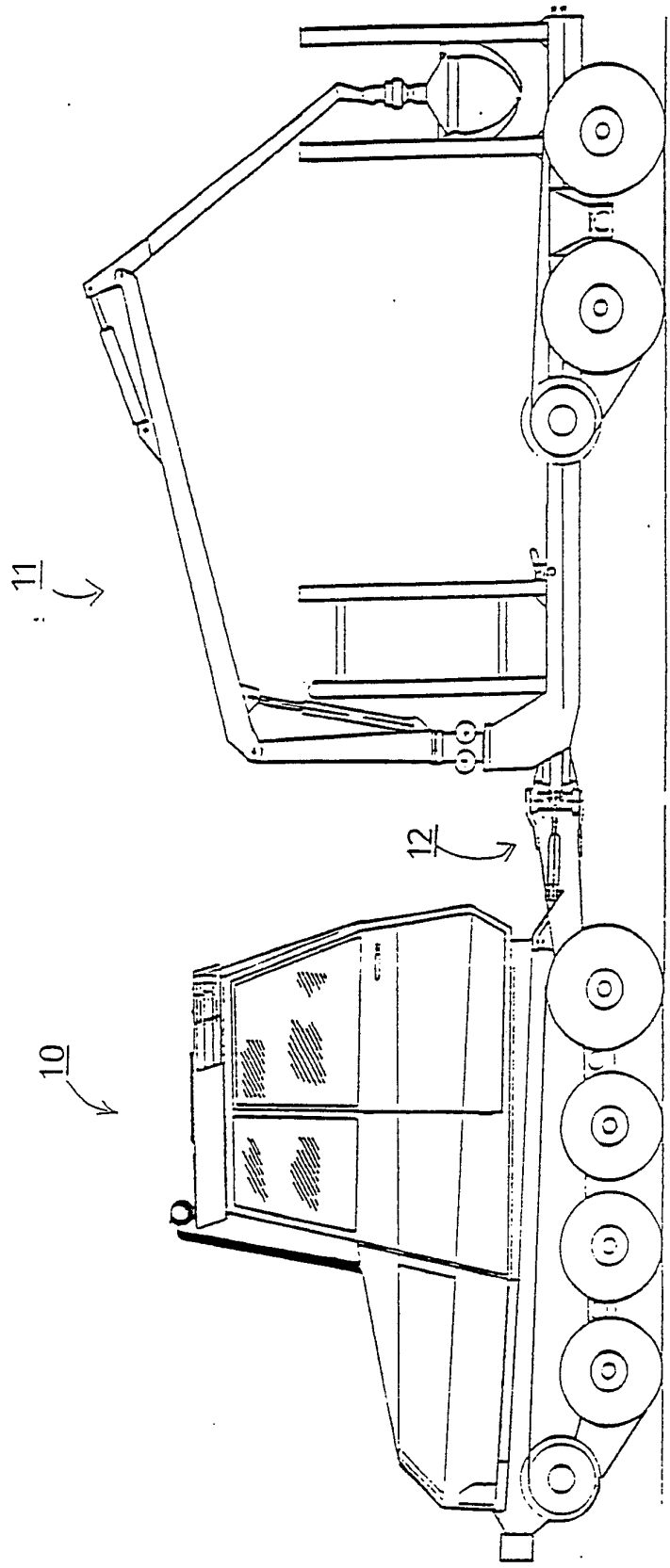


FIG 1

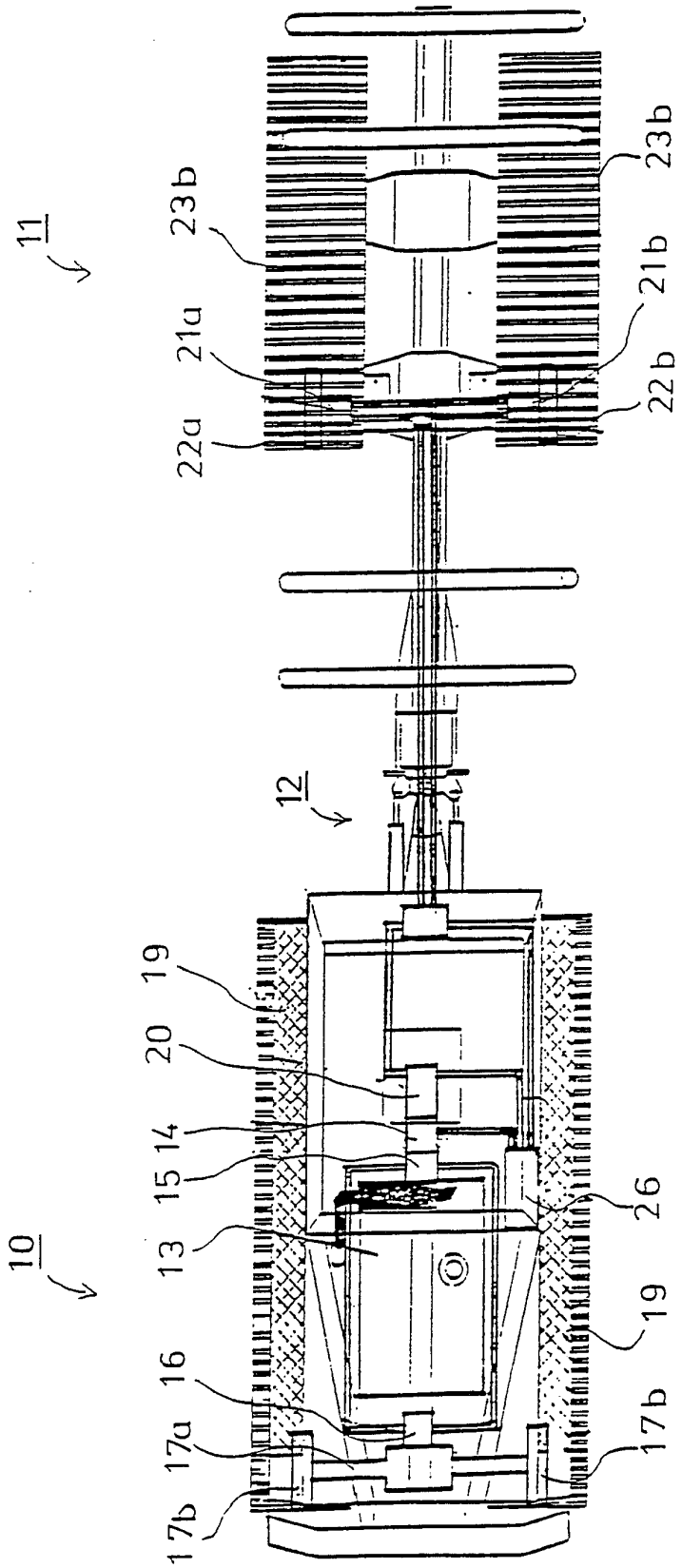
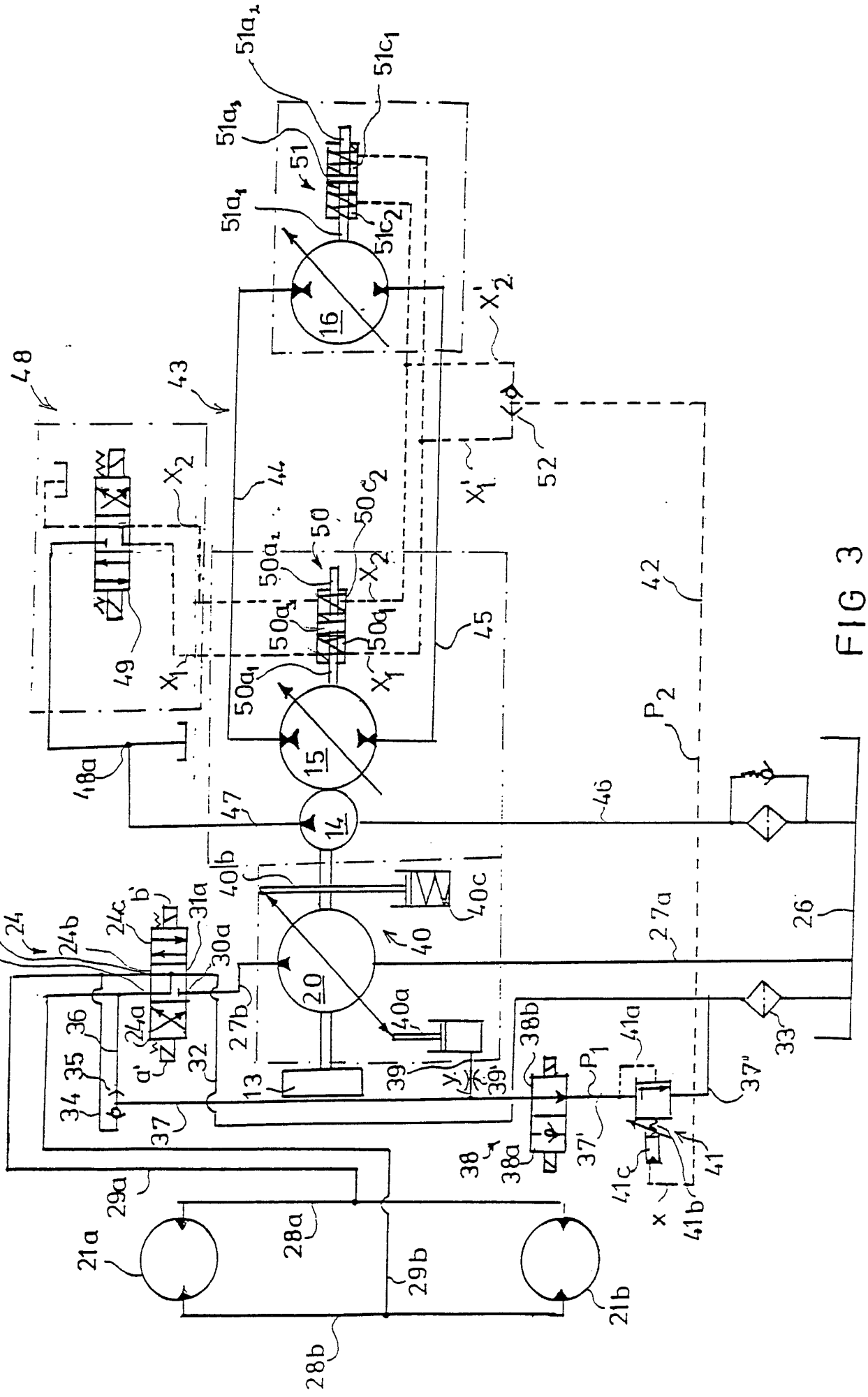


FIG 2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51a2
51c2
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50a2
50a3
X1
45
42
P2
15
18a
47
14
46
40b
40c
31b
30b
24
24b
24c
b'
31a
30a
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27a
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25
36
24a
a'
32
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40a
38b
41a
33
34
35
27b
39
39'
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29b
21a
21b
28b

FIG 3

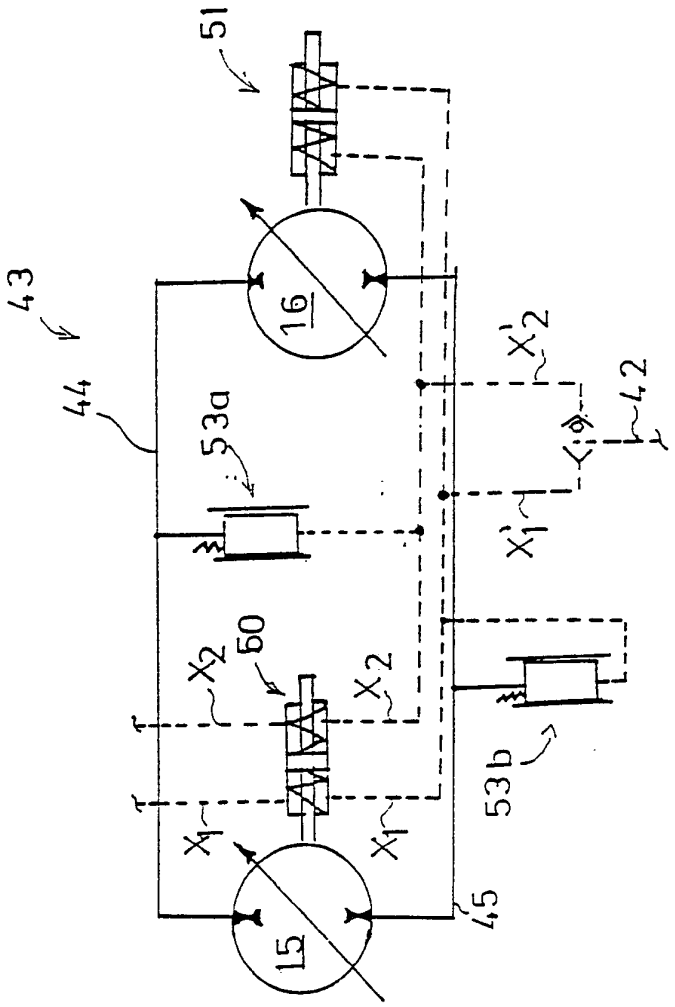

FIG 4

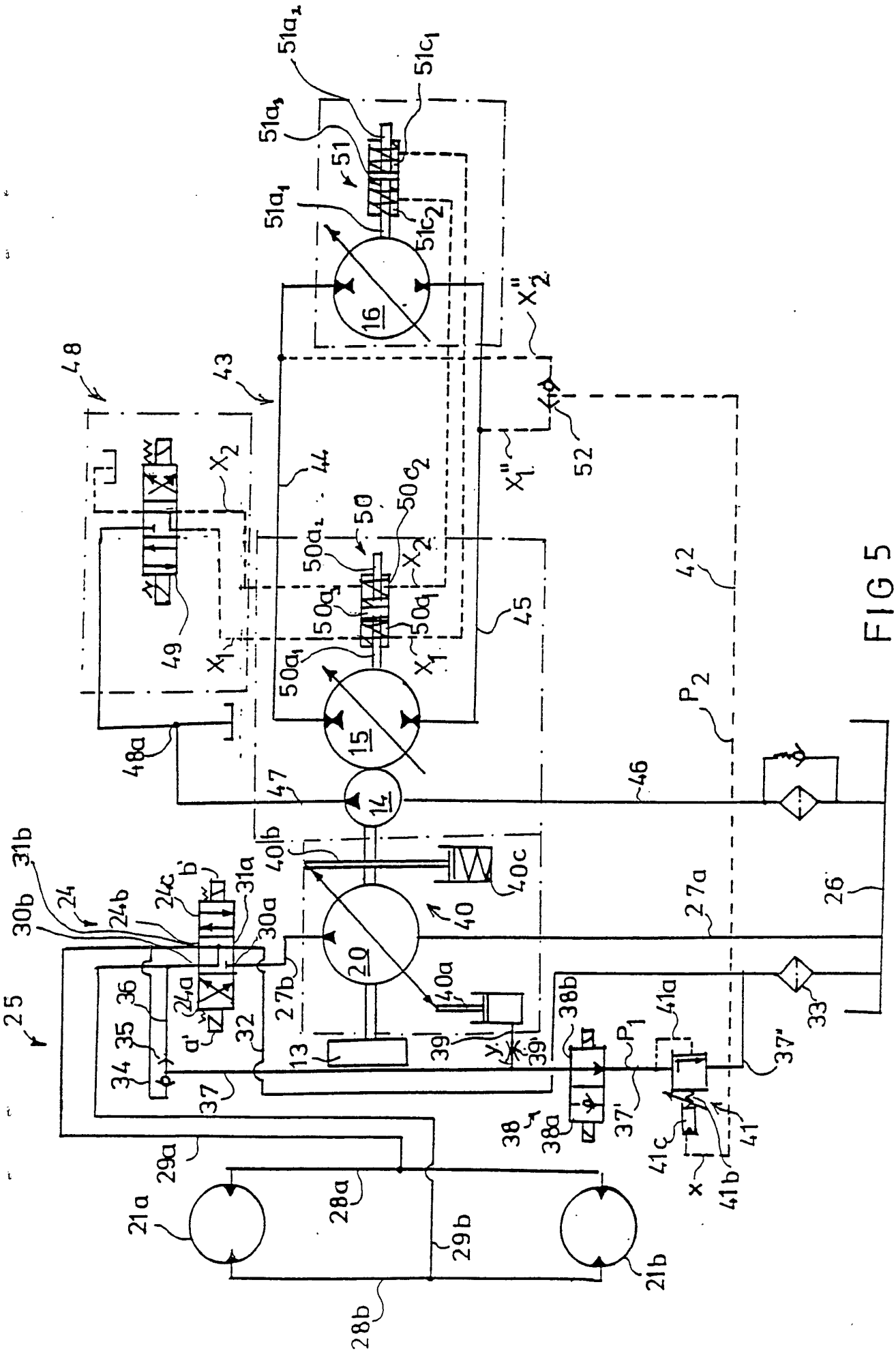

FIG 5

INTERNATIONAL SEARCH REPORT

International Application No PCT/FI89/00044

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC 4

F 16 H 39/50, B 60 K 17/356

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC 4	F 16 H 39/44, /46, /50; B 60 K 17/10, /356
US Cl	60:420, 426, 428, 445; 74:730-733 180:14, 233, 242

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

SE, NO, DK, FI classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
A	US, A, 4 542 990 (FOUQUET) 24 September 1985	
A	US, A, 4 369 855 (BUSCHBOM ET AL) 25 january 1983	
A	DE, C1, 3 628 175 (HYDROMATIK GMBH) 17 December 1987	
A	WO, A1, 88/07150 (PARIKKALAN KONE- JA LAITEHUOLTO KY) 22 September 1988	

* Special categories of cited documents: [10]

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

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

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
1989-06-02	1989 -06- 19
International Searching Authority	**Signature of Authorized Officer**
Swedish Patent Office	P-O Varnbo