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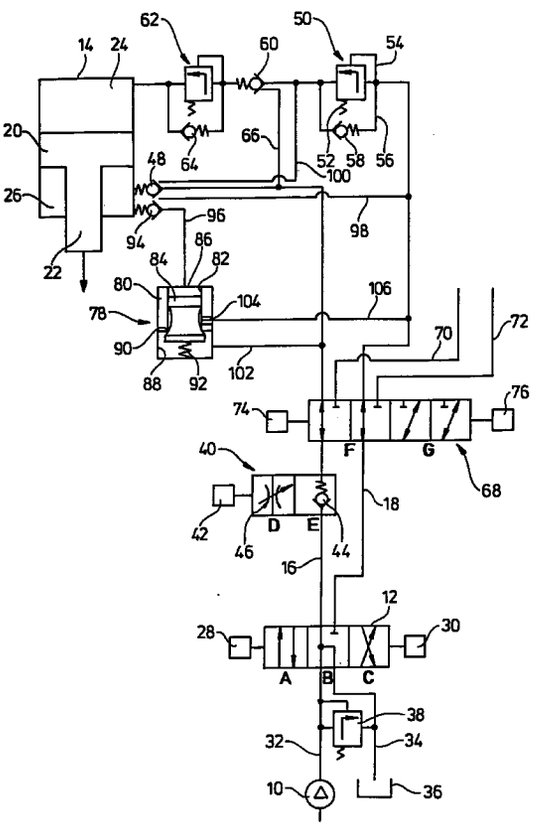
(71) Applicant: **IVECO MAGIRUS AG**
D-89070 Ulm (DE)

(72) Inventor: **Link, Helmut**
89079 Ulm (DE)

(74) Representative: **Boggio, Luigi et al**
STUDIO TORTA S.r.l.,
Via Viotti, 9
10121 Torino (IT)

(54) Hydraulic system

(57) A hydraulic system comprises at least one control unit (10,12) and at least one actuator (14) which is connected via conduits (16,18) to the control unit and which can be driven via the latter in reciprocating motion against and with a load acting on the actuator, in particular upwards and downwards against gravity. The system further comprises a pressure-compensating valve (78) for matching the pressure in the conduit (16), which serves as a return conduit during movement of the actuator (14) with the load, to the load pressure by replenishing the return conduit from the feed conduit (18).



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Description

The invention concerns a hydraulic system with at least one control unit and at least one actuator which is connected via conduits to the control unit and which can be driven via the latter in reciprocating motion against and under a load acting on the actuator, in particular upwards and downwards against gravity.

Hydraulic systems of this type are used particularly for a very wide variety lifting devices, for example lifting platforms, articulated arms, for example articulated arms at the end of firefighting ladders, lifting towers, etc. In devices of this type, in particular in which there are long conduit paths between the control unit and the actuator and/or distributor valves for further actuators, before commencement of the downward movement a brief settling initially occurs, which is especially detrimental if the object to be raised and lowered is a platform occupied by persons or if it is intended to effect accurate approach to a point situated slightly lower down. This settling is caused by the fact after being raised by hydraulic oil feed through one of the two conduits the latter is shut off by non-return valves and the platform or the like is held at a given height. In this case the corresponding conduit, which serves as a lowering conduit during the subsequent descent, is substantially pressureless. If the lowering conduit is opened for the commencement of the lowering operation, oil suddenly enters the lowering conduit under the pressure determined by the raised device so that because of the elasticity of conduit hoses, a certain amount leakage loss occurs at valves and connection points etc., i.e. there is a not inconsiderable "compression effect". Therefore, the lifting platform, the articulated arm or the like suddenly descends by a not inconsiderable amount until the load pressure in the lowering conduit is attained and the actual lowering operation can be carried out uniformly. High load pressures and long conduits with hoses increase this effect to a considerable extent.

The invention is based on the object of devising a hydraulic system of the type mentioned in the introduction, which makes it possible, after the stoppage, to control the downward movement from the outset uniformly and without any brief settling.

According to the invention, this object is achieved in a hydraulic system of the above type by a pressure-compensating valve for matching the pressure in the conduit, which serves as a return conduit during movement of the actuator with the load, to the load pressure by replenishing the return conduit from the feed conduit.

The return or lowering conduit is therefore already at load pressure before the actual lowering operation commences. The undesired descent or settling of the lifting platform or the like cannot take place.

In the following description the starting point is for the most part intended to be a lifting and lowering operation, in which the load corresponds to the gravity of the raised or lowered structural members. However, the application of the invention is not restricted to hydraulic systems which work against gravity but it can also be used for hydraulic expanding or supporting devices or hydraulic systems which operate against a spring force or other resistance.

Preferably, the actuator is a double-acting hydraulic cylinder, the piston of which is connected to the structural member to be raised or lowered and which, on either side of the piston, has pressure chambers which are connected to the control unit via conduits. Reciprocating motion can readily be produced by a double-acting piston. As long it merely involves raising a lifting platform against gravity or displacing an article against another force, for example a spring force, the actuator may also be single-acting piston and the counter-movement of the article with gravity or the spring force can be omitted. In this case only one connecting line is required between the single pressure chamber of the actuator and the control valve. During the lowering movement this single connecting line forms the lowering conduit concerned in the present context. The feed conduit is replaced by a separate conduit supplied by the pressure source of the system.

Preferably, the pressure-compensating valve has a valve piston which can be displaced under reciprocating movement in a valve bore and which at one end is exposed to the load pressure of the actuator and at the other to the line pressure of the return conduit, and which additionally has a sealing edge which under preponderant load pressure of the actuator opens a connection between the feed conduit and the side of the valve piston facing the pressure of the return conduit.

Instead of a pressure-compensating valve of this type it is also possible to use a known valve having a slide member with a control edge. The type of valve is not significant but merely the fact that the pressure in the lowering conduit is raised to the full operating pressure.

Accordingly, as long as the pressure in the return conduit is lower than the load pressure, the return conduit is replenished with hydraulic oil from the hydraulic oil feed via the sealing edge until the load pressure is reached in the return conduit. In this case the valve piston is displaced so that the connection at the sealing edge is interrupted so that it is not possible for any more hydraulic oil to flow into the return duct. For pressure compensation the feed conduit can also be connected directly to the return conduit.

According to a preferred embodiment a first check valve is provided between the load-pressure side of the actuator and load-pressure side of the valve piston of the pressure-compensating valve. When a lowering movement is started this check valve as a result of the pressure in the conduit which serves in this case as a feed conduit is switched at a pre-set pressure to allow the load pressure in the actuator to reach the valve piston. In the feed conduit a pressure-relief valve, for example in the form of a back-pressure valve, is situated downstream of the aforementioned control line. A second control line branches off downstream of this pres-

sure-relief valve, which control line leads to a second check valve on the load-pressure side of the actuator, which firstly closes the return conduit and opens only with delay in relation to the first check valve and thus releases the return flow to the initiate the lowering movement. As already mentioned, the time lag in the opening procedure of the two check valves, which is essential for the compensation of the pressure in the return conduit, can be achieved via a pressure-relief valve or back-pressure valve connected between the two control lines but also via different transmission ratios of the check valves, i.e. different ratios between control pressure and valve pressure. It is also possible to provide both measures. How long the time delay has to be depends on the time which is required for the pressure compensation in the return conduit.

Preferably, further downstream another pressure-relief valve or back-pressure valve is additionally provided, which further reduces the pressure. Therefore, the pressure acting in lowering direction is reduced with respect to the pressure acting in lifting direction, since in lowering direction the action of gravity is available and an additional strong pressure would further increase the aforementioned settling effect.

Preferred examples of embodiment of the invention will be illustrated in more detail below with reference to the accompanying drawings.

The single Figure shows a schematic circuit diagram of the hydraulic system according to the invention.

The hydraulic system comprises a pump 10, a control valve 12 with three positions and an actuator in the form of a double-acting hydraulic cylinder 14. Two conduits 16 and 18 connect control valve 12 to the hydraulic cylinder 14. The hydraulic cylinder accommodates a displaceable piston 20, the piston rod 22 of which is connected, in a manner not shown, to a load to be raised. In the example illustrated the piston 20 can be displaced vertically so that it is evident that the load induced by gravity acts in a downward direction. However, other positions of the hydraulic cylinder 14 are also possible.

Above and below the piston 20 pressure chambers 24 and 26 are disposed in the hydraulic cylinder 14. The aforementioned conduit 16 is connected to the lower pressure chamber 26 and the conduit 18 is connected to the upper pressure chamber 24.

The control valve can be moved to and fro between three positions A, B and C by operating magnets 28,30. The middle position B is the neutral position, in which pressure medium is fed back via a conduit 32 through the valve and a further conduit 34 into an oil reservoir 36. A pressure-relief valve 38 is disposed between the two conduits 32 and 34.

If the control valve 12 is shifted into the position A shown on the left in the drawing, hydraulic oil is fed from the pump 10 via the conduit 16 into the lower pressure chamber 26 of the hydraulic cylinder 14 and the piston is raised. At the same time, hydraulic oil returns from the upper pressure chamber 24 via the conduit 18 and the control valve 12 into the oil reservoir 36. In position C, shown on the right in the drawing, the flow path is reversed. Oil is pumped via the conduit 18 into the upper pressure chamber 24 and is discharged into the oil reservoir 36 from the lower pressure chamber 26 via the conduit 16.

Downstream of the control valve 12 in the conduit 16 there is disposed a change-over valve 40 which can be moved to and fro between two positions D and E by an operating magnet 42 or the like. In the position E shown on the right in the drawing the change-over valve 40 comprises a non-return valve 44 which prevents hydraulic oil from flowing back unintentionally through the conduit 16 during a lifting operation. In the position D shown on the left, the change-over valve 40 has a variable restrictor 46 which during a lowering operation throttles and thus retards the flow in the conduit 16 towards the oil reservoir 36. The lowering speed is controlled by means of this variable restrictor (lowering-brake-valve).

Immediately upstream of the lower pressure chamber 26 a check valve 48 in the form of a controlled non-return valve is provided in the conduit 16, which prevents any flow of hydraulic oil from the lower pressure chamber 26 in the inoperative position of the hydraulic cylinder.

In the other conduit 18, which is connected to the upper pressure chamber 24 of the hydraulic cylinder 14, there is initially a first pressure-relief valve 50 which is biased into the closed position by a spring 52 and only opens when the line pressure in the conduit 18 overcomes the force of the spring. This is indicated by a control line 54 branching off from the conduit 18, by way of which the line pressure acts on the valve against the spring 52 in opening direction. In a bypass line 56 bypassing the pressure-relief valve 50 there is disposed a non-return valve 58 opening in return-flow direction. A check valve 60 in the form of a controlled non-return valve, which opens in feed direction, follows the further path of the conduit 18, and also a further assembly comprising a pressure-relief valve 62 in the form of a back-pressure valve and a non-return valve 64, as has already been described with reference to the pressure-relief valve 50 and the non-return valve 58. The two pressure-relief valves 50 and 62 serve to reduce the oil pressure prevailing in the upper pressure chamber 24 with respect to the oil pressure prevailing in the lower pressure chamber 26 during the lifting operation, since the load pressure is already acting in lowering direction. An additional high pressure in the upper pressure chamber 24 would result in inward deflection of the piston during the lowering movement by expansion of hoses in the system of the conduit 16 and in it springing back upon relaxation into the inoperative position.

The aforementioned check valve 60 disposed in the conduit 18 is opened via a control conduit 66 which branches off from the other conduit 16 so that the check valve can be opened by the pressure prevailing in the conduit 16 during the lifting operation and the hydraulic

oil can be discharged from the upper pressure chamber 24.

When the piston enters the inoperative position after a lifting operation, the pressure medium is retained in the lower pressure chamber 26 by the check valve 48. The conduit 16 is thus unpressurised, since there is no longer the loading applied by the load. If a lowering operation is now initiated, after the opening of the check valve 48 there is initially a certain amount of settling of the piston 20, which impairs the accuracy of the control of the piston 20 and, therefore, the accuracy of the movement of the raised component, for example a lifting platform. This settling is partly caused by a certain degree of unavoidable elasticity in the line of the conduit 16, particularly if long sections are formed by hoses, and partly by leakage loss which can occur at the different connection points and, in particular, if further consumer appliances are connected to the control valve 12 via a change-over means.

A change-over means of this type is merely indicated in the drawing. It comprises a change-over valve 68 with two positions F and G. The change-over valve 68 is inserted equally in both conduits 16 and 18. In position F, the two conduits 16 and 18 are switched to passage, so that the system described here remains unchanged in operation. In position G, the pump 10 is connected to the control valve 12, the two-position valve 40 and the lower portion of the conduits 16 and 18 with two conduits 70 and 72 which lead to another lifting system, with other lifting systems (not shown) with actuator and associated assemblies. The switching-over of the change-over valve 68 is effected by two operating magnets 74 and 76. These operating magnets are only mentioned here by way of example. Of course, they may replaced with pneumatic or hydraulic actuators. An actuator is also sufficient which acts against a spring. Details of this nature are of no consequence here.

The change-over valve 68 is merely shown to illustrate the fact that the hydraulic system can in general have more branches than is necessary to describe the present invention, and therefore that a certain degree of elasticity in this system, in particular if relatively long hose sections are used as conduits, cannot be entirely obviated. Therefore, if during a lowering operation the conduit serving as the lowering line is suddenly brought from its previously unpressurised condition to the load pressure, the previously mentioned settling cannot be excluded.

Uniform settling is possible only if the load pressure in the lower pressure chamber 26 is transmitted to the conduit 16 which serves as the lowering line.

Therefore, according to the invention, a pressure-compensating valve 78 is provided. The latter has a valve housing 30 with a valve bore 82, in which a valve piston 84 is displaceably mounted. The end of the valve bore 82 situated at the top in the drawing forms a first control pressure chamber 86. The valve piston 84 is waisted arcuately in its longitudinal central region and around its entire circumference. The lower end of the valve piston 84 is situated in a portion 88 of the valve bore of widened diameter and is of larger diameter than the upper end region of the valve piston. An annular sealing edge 90 is formed at the step-like widening from the upper valve bore 82 to the lower, widened portion 88, which sealing edge cooperates with the valve piston 84 which is substantially conical in this region. The valve piston 84 is biased upwardly in the drawing by a spring situated in the upper portion 88 of the bore, until the widened lower portion of the valve piston 84 abuts against the annular sealing edge. The spring 92 is relatively weak and merely serves to retain the valve piston 84 in a given position. More precisely, the position of the valve piston is determined by the pressures in the upper control pressure chamber 86 and a lower control pressure chamber which is formed by the widened portion 88 of the valve bore. The effective pressure area is the same on both sides of the valve piston 84. With equal pressures in both chambers the valve piston 84 is applied against the sealing edge 90, since the force of the spring 92 acts from below as an addition force on the valve piston.

Substantially the load pressure of the lower pressure chamber 26 of the hydraulic cylinder 14 prevails in the upper control pressure chamber 86, since this lower pressure chamber 26 is connected via a check valve 94 and a conduit 96 to the upper control pressure chamber 86 of the pressure-compensating valve 78. The check valve 94 is a controlled non-return valve which is opened via control conduit 98 which branches off from the conduit 18. The opening pressure is formed by the pressure which is formed in the conduit 18 when the lowering operation is commenced and hydraulic oil enters the upper pressure chamber 24 of the hydraulic cylinder.

As is evident from the drawing, said control conduit 98, which actuates the check valve 94, branches off upstream of the first pressure-relief valve 50 from the conduit 18. On the other hand, a further control conduit 100, which actuates the previously mentioned check valve 48 which is disposed in the conduit 16, branches off from the conduit 18 downstream of the pressure-relief valve 50. This arrangement of the control conduits 98 and 100 has the result that the check valve 94 connected upstream of the pressure-compensating valve 78 opens at an interval of time before the check valve 48 connected upstream of the conduit 16. The sequence is essential for the operation of the invention, as will be explained in more detail later on.

The lower control pressure chamber of the pressure-compensating valve 78, which is formed by said portion 88 of the valve bore, is connected via a conduit 102 to the conduit 16 which serves as a lowering conduit during the lowering operation. Firstly, the load pressure in the lower pressure chamber 26 of the hydraulic cylinder 14 and, secondly, the pressure in the lowering conduit 16 act on the valve piston 84, the lowering conduit being substantially unpressurised before the start of the lowering operation. It results from this that the

valve piston 84 is urged downwards initially by the predominant pressure on the upper side, against the force of the spring 92, so that a clearance is formed between the sealing edge 90 and the valve piston.

In the vicinity of the waisted portion (not separately denoted) of the valve piston 84, which substantially occupies the entire longitudinal central zone, an inlet bore 104 discharges into the valve housing 80 which is connected via a conduit 106 to the conduit 18 which during the lowering operation serves as an oil supply duct for the upper pressure chamber 24 of the hydraulic cylinder. Hydraulic oil from the conduit 106 can enter into the valve housing 80 in the vicinity of the waisted of the valve piston 84 and from here it can enter the lower control pressure chamber of the pressure-compensating valve 80. From this control pressure chamber in the vicinity of the portion 88 of the valve bore the hydraulic oil enters the lowering conduit 16 via the conduit 102.

This means that as long as the load pressure in the lower pressure chamber 26 of the hydraulic cylinder 14 is higher than the pressure in the conduit 16, hydraulic oil passes via the other conduit 18, the branch conduit 106, the inlet bore 104, the waisted portion of the valve piston 84, the clearance at the sealing edge 90 and the lower control pressure chamber and also the conduit 102 to enter the lowering conduit 16. Therefore, the lowering conduit 16 is brought to the pressure of the feed conduit 18 before the actual lowering operation can start.

The mode of operation of the hydraulic system according to the invention will be explained below.

Firstly, the piston 20 is to be raised with the assemblies connected thereto. For this purpose, the control valve 12 is switched into position A. Hydraulic oil is fed from the pump 10 via the conduit 16, the non-return valve 44 and the check valve 48, which in this case acts as a non-return valve, into the lower pressure chamber 26 of the hydraulic cylinder 14. The piston 20 is raised. The pressure in the conduit 16 opens via the control line 66 the check valve 60 in the other conduit 18, so that hydraulic oil can flow out of the upper pressure chamber 24 of the hydraulic cylinder. When the desired height is reached, the control valve 12 is switched over into the neutral position B. The hydraulic oil supplied by the pump 10 is fed via the conduit 34 back into the oil reservoir 36. The check valve 48 is closed under the load pressure in the pressure chamber 26. In this situation, for example, work can be performed on a raised work platform.

If a lowering operation is now to be commenced, firstly the control valve 12 is switched over into position C. The two-position valve 40 is then switched to position D, in which the restrictor 46 in the conduit 16 is situated. Hydraulic oil is fed via the conduit 18. As soon as the preset pressure is attained, the check valve 94 is opened via the control conduit 98 at the pressure in the conduit 18.

As soon as the check valve 94 is opened, the load pressure of the lower pressure chamber 26 arrives in the control pressure chamber 86 of the pressure-compensating valve 80. Since the relatively low pressure of the conduit 16 prevails in the lower control pressure chamber, which is formed by the portion 88 of the valve bore, the valve piston 84 is displaced downwards with reference to the drawing. Pressure oil from the conduit 18 can pass via the branch conduit 106, the input bore 104, the waisted of the valve piston 84 and the clearance present at the sealing edge 90 to enter the lower control pressure chamber, and from the latter via the conduit 102 into the conduit 16. This continues until the pressure in the lowering conduit 16 has reached the load pressure of the lower pressure chamber 26 of the hydraulic cylinder 14. In the embodiment illustrated, this relatively high pressure is attained only to a considerable extent, since the spring 92 acts in the same direction as the pressure in the conduit 16, therefore the pressure-compensating valve 80 closes before the relatively high pressure is fully attained. However, by suitably weak design of the spring 92 it is possible for the remaining difference to be kept very small.

In the meantime a relatively high pressure has also built up downstream of the first pressure-relief valve 50 in the conduit 18, so that the check valve 48 then opens via the control conduit 100 and the lowering conduit 16 is released for the return flow of the hydraulic from the lower pressure chamber 26. At the same time, the hydraulic oil flows via the check valve 60 in the conduit 16 and the further pressure-relief valve 62 into the upper pressure chamber 24 of the hydraulic valve.

Since the full operating pressure prevails in the lowering conduit 16 already at the start of the lowering operation, i.e. at the opening of the check valve 48, the detrimental effect of the initial settling of the piston 24 continues to be excluded.

Claims

1. A hydraulic system with at least one control unit (10,12) and at least one actuator (14) which is connected via conduits (16,18) to the control unit and which can be driven via the latter in reciprocating motion against and with a load acting on the actuator, in particular upwards and downwards against gravity, characterised by a pressure-compensating valve (78) for matching the pressure in the conduit (16), which serves as a return conduit during movement of the actuator (14) with the load, to the load pressure by replenishing the return conduit from the feed conduit (18).

2. A hydraulic system according to Claim 1, characterised in that the pressure-compensating valve (78) has a valve piston (84) which can be displaced under reciprocating movement in a valve bore (82) and which at one end is exposed to the load pressure of the actuator (14) and at the other to the line pressure of the return conduit (16), which valve bore (82) has a sealing edge (90) which under pre-

ponderant load pressure of the actuator (14) opens a connection between the feed conduit (18) and the side of the valve piston (84) facing the pressure of the return conduit (16).

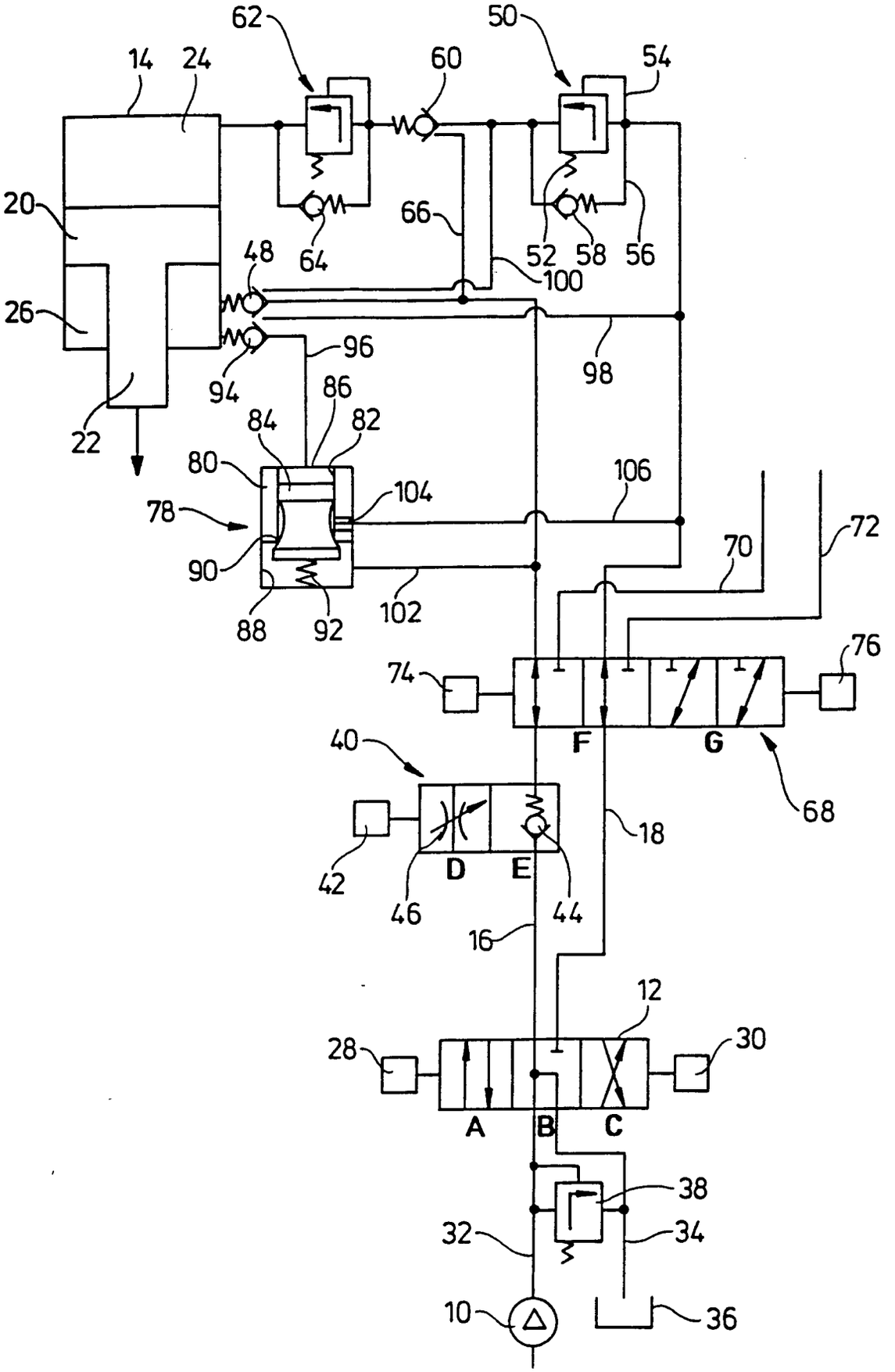
3. A hydraulic system according to Claim 2, characterised by a check valve (94) between the load-pressure side of the actuator (14) and the load-pressure side of the valve piston (84) of the pressure-compensating valve (78), which can be switched over to passage before the start of movement of the actuator under the load, in particular of a lowering movement under gravity.

4. A hydraulic system according to Claim 3, characterised by a second check valve (48) between the load-pressure side of the actuator (14) and the return conduit (16), which can be switched over to passage with a time lag with respect to the first check valve (94) to initiate the movement of the actuator under the load, in particular of a lowering movement.

5. A hydraulic system according to Claims 3 and 4, characterised in that a pressure-relief valve (50) is disposed in the conduit (18) serving as feed conduit during the lowering operation, and in that the pressure upstream of the pressure-relief valve (50) is used as a control pressure for opening the first check valve (94) and the pressure downstream of the pressure-relief valve (50) is used as a control pressure for opening the second check valve (48).

6. A hydraulic system according to any one of the preceding Claims, characterised in that the actuator is a double-acting hydraulic cylinder (14), the piston (20) of which is connected to the structural member to be raised or lowered and which, on either side of the piston (20), has pressure chambers (24,26) which are respectively connected to one of the two conduits (16,18) supplied by the control unit (10,12).

7. A hydraulic system according to Claim 5 or Claim 6, characterised in that in the conduit (18) serving as feed conduit during the lowering operation and downstream of the first pressure-relief valve (50) there is provided another pressure-relief valve (62) and between the two pressure-relief valves (50,62) a controlled non-return valve (60) is provided which closes in return direction and which can be switched over to passage using the pressure in the other conduit (16) as a control pressure.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EUROPEAN SEARCH REPORT

Application Number
EP 97 10 3137

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	FR 2 312 676 A (CATERPILLAR TRACTOR) * page 8, line 1 - page 11, line 14; claim 13; figures *	1,3,6	F15B13/01
A	US 4 008 731 A (KATZ) * claims; figures *	1	
A	EP 0 468 944 A (ANDERSSON) * claims; figures *	1	
A	PATENT ABSTRACTS OF JAPAN vol. 017, no. 430 (M-1460), 10 August 1993 & JP 05 092896 A (KOMATSU FORKLIFT CO LTD), 16 April 1993, * abstract *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

F15B
E02F
B66F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	10 June 1997	Ernst, R

CATEGORY OF CITED DOCUMENTS

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