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(54) **A hydraulic apparatus for raising and lowering an arm hinged to a work vehicle**

Hydraulische Vorrichtung zum Heben und Senken eines an einer Arbeitsmaschine schwenkbaren Arms

Dispositif hydraulique pour lever et baisser un bras articulé à un véhicule de travail

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(73) Proprietor: **Bosch Rexroth Oil Control S.p.A.**
**20149 Milano (MI) (IT)**

(72) Inventor: **Storci, Andrea**
**41015 Nonantola (Modena) (IT)**

(74) Representative: **Gotra, Stefano**
**BUGNION S.p.A.**
**Via Vellani Marchi, 20**
**41100 Modena (IT)**

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## Description

**[0001]** The invention relates in particular to vehicles having elastic wheels (for example rubber wheels) and provided with a loading tool (eg a spade or a fork or the like) supported by an arm hinged on the vehicle structure. The arm is rotatable between a lowered position, in which the loading tool is before the vehicle, to a raised position. The arm is raised and lowered by means of a hydraulic cylinder to which a hydraulic accumulator is connected through a conduit provided with a block valve. The block valve can be electrically or hydraulically controlled so as to enable two-way fluid passage between the cylinder and the accumulator, or in order to block the flow from the cylinder towards the accumulator in one or both directions. The two chambers of the arm raising and lowering cylinder are connected to a selector valve or three-way distributor. In two extreme positions the distributor is configured in such a way as to send pressurised fluid to one of the two chambers and to receive the fluid at a lower pressure which has been discharged from the opposite chamber.

**[0002]** A flow block and/or control valve can be installed on the conduit supplying the cylinder chamber for raising the arm. This valve is generally commanded to open by a hydraulic pilot or by means of electrical or electronic commands when the distributor is in the position in which the pressurised fluid is sent to the chamber for lowering the arm. The accumulator is directly connected to the cylinder raising chamber, or to the conduit that connects the raising chamber to the distributor at an intermediate point between the flow rate block and/or control valve and the raising valve.

**[0003]** It is well known that safety and comfort benefits derive from having the load arm free to controlledly oscillate due to inertia forces when the vehicle is in motion, especially when the vehicle is loaded. Vehicles of this type are usually without suspension, so that if during motion the arm were solidly constrained to the vehicle structure, the inertia forces during transit on uneven terrain or during braking and acceleration phases would be transmitted to the vehicle, which would absorb them only through deformation of the wheels. This would lead to disadvantages for the stability of the vehicle, with pitching oscillations, a most undesired situation especially during movement of a load positioned on the tool at the end of the arm.

**[0004]** With the accumulator in communication with the raising cylinder chamber the conditions of the vehicle in motion can be considerably improved, with special reference to good braking, stability around bends and operator comfort.

**[0005]** In known-type apparatus, for example like the apparatus disclosed in document EP 1 157 963, the connection between the raising chamber of the cylinder and the hydraulic accumulator is realised by commanding the opening of the block valve interpositioned between the cylinder and the accumulator. When the raising chamber is in communication with the hydraulic accumulator it is necessary to connect the cylinder lowering chamber with a low-pressure zone or with the apparatus reservoir tank: for lowering oscillations of the arm the lowering chamber increases its volume by recalling fluid from the tank; for raising oscillations of the arm, the lowering chamber reduces its volume by expelling the fluid which is collected in the tank.

**[0006]** For this purpose, the lowering chamber of the cylinder is directly connected to the low-pressure environment or reservoir tank by a further conduit, which is provided with a block valve. This is necessary because in known-type apparatus the selector valve or distributor which controls the lowering and raising of the cylinder, when in the central position closes the supply conduits for the fluid to the cylinder. The supply conduit to the lowering chamber, if closed, opposes free oscillation of the arm, which can only happen if the cylinder, apart from being shortened and sending fluid into the hydrostatic accumulator, can also lengthen, thus receiving fluid from the accumulator. The arrangement of a further conduit connecting the lowering chamber of the cylinder with the tank and enabling the discharge of the fluid contained internally of the lowering chamber represents a drawback in known-type apparatus, as it often constitutes a considerable constructional complication.

**[0007]** The main aim of the present invention is to provide a hydraulic apparatus for raising and lowering an arm which is hinged to a work vehicle, which does not require a further conduit for connecting the tank of the apparatus, i.e. a lower-pressure environment, with one of the hydraulic cylinder chambers in order to enable an oscillation of the arm itself.

**[0008]** Further characteristics and advantages of the apparatus of the invention will better emerge from the detailed description that follows, made with reference to the appended figures of the drawings, included as a non-limiting example, and in which:

Figure 1 shows a first use of the apparatus according to the invention, arranged on a work vehicle of a first type;

Figure 2 is a second use of the apparatus according to the invention, arranged on a work vehicle of a second type;

Figure 3 is a hydraulic diagram of the apparatus according to the invention.

**[0009]** The apparatus of the invention can be used either on work vehicles where the arm 2 is hinged to a posterior zone of the vehicle 20, as in the case of figure 1 in which a lift truck is shown, provided with a telescopic arm 2, or on vehicles in which the arm 2 is hinged to a median or front zone of the vehicle 20, as in the case of figure 2 in which a machine for earth movement is illustrated. In both cases the arm 2 is provided with a loading tool 1 positioned at the opposite end with respect to the end that is hinged on the vehicle 20. In both cases, also,

the arm 2 is rotatable between a lowered position in which the tool 1 is in front of the vehicle 20, and a raised position, in which it is above a lowered position thereof. The form of the arm 2 bearing the tool 1 can be different, depending on the type of use envisaged: it can be a single structure or can be made up of several parts which are interconnected and parallel (figure 2), or in series, or the parts can be telescopically connected, one inside another (figure 1).

**[0010]** With reference to the figures of the drawings, the apparatus comprises at least a hydraulic cylinder 3 hinged to the vehicle 20 and the arm 2 in such a way that, by extending, it activates the arm in rotation towards the raised position, and by retracting it activates the arm in rotation towards the lowered position. In figure 1 the piston liner is hinged to the vehicle 20 and the stem to the arm 2, while the opposite is true of the configuration of figure 2. The hydraulic cylinder 3 is provided with a first chamber 7 and a second chamber 8 which are separated by the piston 3a of the cylinder. The first chamber 7, on receiving fluid, increases its volume and the cylinder 3 extends, i.e. the piston 3a displaces towards the second chamber 8 pushing the stem outwards and causing the arm 2 to be raised. If the second chamber 8 receives fluid, the cylinder 3 shortens, i.e. the stem is drawn by the piston 3a inside the cylinder and the arm 2 lowers.

**[0011]** A three-way distributor 11, connected to the first and the second chambers of the cylinder 3 respectively by a first conduit 9 and a second conduit 10 connects the first chamber 7 and the second chamber 8 of the cylinder 3 to a fluid supply and a discharge. The fluid supply is generally supplied by a positive displacement pump 21 which is served by a fluid tank 22, while the discharge is constituted by a conduit which extends between the distributor 11 and the tank 22. In a first position the distributor 11 connects the first chamber 7 to the fluid supply and the second chamber 8 to the discharge; in a second position it connects the second chamber 8 to the fluid supply and the first chamber 7 to the discharge; in a central, or neutral, position it does not connect the first chamber 7 to the fluid supply and enables the discharge of the fluid from the second chamber 8 of the cylinder 3 to the tank 22. In figure 3 the central position (or neutral) of the distributor is illustrated, in which it can be observed that the first conduit 9 is not in communication with the pump 21, while the second chamber 8, through the second conduit 10, is in communication with the tank 22.

**[0012]** A first control valve 12, interpositioned between the first chamber 7 of the cylinder 3 and the distributor 11, enables the flow of the fluid from the distributor 11 to the first chamber 7 and prevents the inverse flow due to pressures internally of the first chamber 7 below a predetermined value. The first control valve 12 is positioned along the first conduit 9 and is conformed in such a way that, while it always enables the fluid flow from the distributor 11 to the first chamber 7, it prevents flow of fluid from the chamber 7 to the distributor 11 until the pressure internally of the first chamber 7 reaches a predetermined value. The first control valve 12 can be commanded to open in order to enable the fluid flow from the first chamber towards the distributor 11 at the moment in which the distributor 11 displaces into the second position. The command to open the valve can be made by hydraulic piloting removed from the second chamber 8 or by means of an electric signal. The first control valve 12 has the function of restraining and controlling the downwards movement of the arm 2 should the first conduit 9 be faulty. For this reason it is generally arranged very close to the cylinder 3 or indeed is inserted in a flanged body on the cylinder 3 itself. The first control valve 12 however represents a normal safety device and is not a determining element for the operability of the apparatus of the invention.

**[0013]** The apparatus further comprises a hydraulic accumulator 4 which is interpositioned between the first chamber 7 and the first control valve 12. The accumulator 4 is constituted by one or more containers which oppose a predetermined resistance against the inlet of fluid. The container or containers can contain, for example, an expanding chamber which is able elastically to vary its volume, between a maximum expansion and a minimum expansion, where the configuration of maximum expansion is the rest configuration. The inlet of the fluid internally of the accumulator compresses the expanding chamber, which tends to oppose and push the fluid externalwise.

**[0014]** The accumulator 4 is connected to the first chamber 7 of the cylinder 3 through a third conduit 5 along which a block valve 6 is positioned, which can be activated by means of a command unit 16 to move between a first configuration, in which it does not allow passage of fluid between the first chamber 7 and the hydraulic accumulator 4, and a second configuration in which the fluid passage from the first chamber 7 to the accumulator 4 is possible in both directions. As will better emerge herein after, the block valve 6 is activated in the second configuration when the distributor 11 is in the central position and when it is required that the arm oscillate.

**[0015]** The apparatus also comprises a second control valve 14 interpositioned between the second chamber 8 of the cylinder 3 and the distributor 11. The second control valve 14 is predisposed to enable the flow of fluid from the distributor 11 to the second chamber 8 of the cylinder 3 and to prevent the inverse flow from the chamber 8 to the distributor 11 due to pressures internal of the first chamber 7 of below a certain value.

**[0016]** The second control valve 14 is positioned along the second conduit 10 and is conformed in such a way that, while it always permits the fluid flow from the distributor 11 to the second chamber 8, it enables the fluid flow from the chamber 8 towards the distributor 11 only when the pressure internally of the first chamber 7 reaches a predetermined value. The second control valve 14 can be commanded to open to enable the fluid flow from the second chamber 8 towards the distributor 11 at the

moment when the distributor 11 displaces into the first position or the central position. The command to open the valve can be made by hydraulic piloting taken from the first chamber, or by an electrical signal. For this purpose the second control valve 14 can be made as a balancing valve piloted to open by a pressure signal taken from the first chamber 7 of the cylinder 3, or alternatively it can be constituted by a two-way solenoid valve commanded to open by a pressure switch 15 which detects the pressure existing in the first chamber 7 of the cylinder 3.

**[0017]** The apparatus operates as follows.

**[0018]** When the distributor 11 is in the first position, the fluid sent by the pump 21, crossing the first control valve 12, reaches the first chamber 7 and the cylinder 3 extends. The fluid in the second chamber 8 is pushed out by the piston 3a and, controlledly crossing the second control valve 14 and the distributor, is discharged into the tank 22. The second control valve 14 is kept open by the pressure of the fluid in the first chamber 7.

**[0019]** When the distributor 11 is in the second position, the fluid sent by the pump 21, crossing the second control valve 14, reaches the second chamber 8 and the cylinder 3 shortens. The fluid in the first chamber 7 is pushed out by the piston 3 a and, controlledly crossing the first control valve 12 and the distributor 11, is discharged into the tank 22. In both operating conditions the block valve 6 remains in the closed position (first position), in which the fluid from the chamber 7 cannot reach the accumulator 4.

**[0020]** To enable the controlled oscillations of the arm 2 by effect of the inertia effects during the movement of the vehicle 20, while the distributor 11 is in the central position or the first position (corresponding to the raising of the arm 2), the block valve 6 is activated into the second position in which the first chamber 7 of the cylinder 3 is in communication with the accumulator 4.

**[0021]** An upwards rotation of the arm 2 requires a translation of the piston 3a towards the second chamber 8 of the cylinder 3. The chamber 8 reduces its volume while the first chamber 7 increases its volume. The increase in volume of the chamber 7 recalls the fluid from the accumulator 4 through the block valve 6, while the reduction in volume of the second chamber 8 pushes the fluid contained therein to discharge to the tank 22 through the second control valve 14 and the distributor 11. The discharge of the fluid from the second chamber 8 is done controlledly, and is possible every time there is a pressure internally of the first chamber 7. This pressure is chosen or determined according to the needs of the machine. As already mentioned, the opening of the second control valve 14 for the discharge of the fluid from the second chamber 8 to the tank 22 can be controlled both by calibration of an internal spring which acts on the valve obturator, and by a pilot pressure taken from the first chamber 7 of the cylinder 3. In this way the second control valve 14 can produce a counterpressure to the discharge of the fluid from the second chamber 8 of the cylinder 3 which increases progressively over a predetermined time interval.

**[0022]** A downwards inertia rotation of the arm 2 induces a translation of the piston 3a towards the first chamber 7 of the cylinder 3 which consequently reduces its volume, while the second chamber 8 increases its volume. The increase in volume of the second chamber 8 recalls fluid which leaves from the tank 22 and freely crosses the distributor 11 and the second control valve 14. The reduction in volume of the first chamber 7 leads to the expulsion of the fluid contained therein which then follows the only path available thereto, i.e. the third conduit 5, across the block valve 6 up to the accumulator 4. The accumulator 4 produces a counterpressure which is opposed to the fluid inlet, so that in this case the oscillation of the arm 2 is not free but absorbed somewhat.

**[0023]** The apparatus of the present invention leads to important advantages. It is of considerably simpler construction with respect to known-type apparatus, as, thanks to the use of a distributor which in the central position does not connect the first chamber 7 to the fluid supply while enabling the discharge of fluid from the second chamber 8 of the cylinder, the need for a third connection conduit between the second chamber 8 and the tank 22 is obviated. The presence of the second control valve 14 on the second conduit 10 makes the apparatus very safe and precise in all operational conditions, and in particular it enables the arm 2 to oscillate in a controlled way by effect of inertia loads due to the movement of the vehicle. The described device also has the considerable advantage of being applicable to a circuit with a distributor of standard type.

## Claims

1. A hydraulic apparatus for raising and lowering an arm (2) hinged to a work vehicle (20), comprising: a hydraulic cylinder (3), rotatingly to the vehicle (20) and to the arm (2), provided with a first chamber (7) and a second chamber (8); a three-way distributor (11) which, in a first position thereof, is able to connect the first chamber (7) to a fluid supply and the second chamber (8) to a discharge, which in a second position is able to connect the second chamber (8) to the fluid supply and the first chamber (7) to the discharge, which in a central position can not connect the first chamber (7) to the fluid supply; a hydraulic accumulator (4), connected to the first chamber (7) of the cylinder (3) through a block valve (6) which block valve (6) can be activated between a configuration thereof in which it allows passage of fluid between the first chamber (7) and the hydraulic accumulator (4) and a configuration in which it blocks passage of the fluid from the first chamber (7) to the accumulator (4); the apparatus being **characterised in that** in the central position the distributor (11) allows discharge of the fluid from the second chamber

(8) of the cylinder (3), and **in that** a second control valve (14) is interpositioned between the second chamber (8) of the cylinder (3) and the distributor (11) and is predisposed to enable a flow of the fluid from the distributor (11) to the second chamber (8) of the cylinder (3), while allowing an inverse flow only when pressures internally of the first chamber (7) are above a predetermined value.

**2.** The apparatus of claim 1, wherein the second control valve (14) is a balancing valve piloted to open to enable the fluid flow from the second chamber (8) to the distributor (11) by means of a pressure signal taken from the first chamber (7) of the cylinder (3).

**3.** The apparatus of claim 1, wherein the second control valve (14) is a two-way solenoid valve which is commanded to open in order to allow a flow of the fluid from the second chamber (8) to the distributor (11) by means of a pressure switch which detects an existing pressure in the first chamber (7) of the cylinder (3).

**4.** The apparatus of any one of the preceding claims, wherein a first control valve (12) is interpositioned between the first chamber (7) of the cylinder (3) and the distributor (11), the first control valve (12) being predisposed to enable the flow of the fluid from the distributor (11) to the first chamber (7) of the cylinder (3) and to prevent an inverse flow because of pressures internally of the first chamber (7) below a predetermined value, **characterised in that** the accumulator (4) is connected to the first chamber (7) of the cylinder (3) at an intermediate point between the first control valve (12) and the first chamber (7).

**Patentansprüche**

**1.** Hydraulische Vorrichtung zum Heben und Senken eines Armes (2), angelenkt an ein Arbeitsfahrzeug (20), enthaltend: einen Hydraulikzylinder (3), schwenkbar anzuschliessen an das Fahrzeug (20) und an den Arm (2) und versehen mit einer ersten Kammer (7) und einer zweiten Kammer (8); ein Dreiwege-Ventil (11), welches in einer seiner ersten Position in der Lage ist, die erste Kammer (7) mit einer Flüssigkeitszufuhr und die zweite Kammer (8) mit einem Ablass zu verbinden, und welches in einer zweiten Position in der Lage ist, die zweite Kammer (8) mit der Flüssigkeitszufuhr und die erste Kammer (7) mit dem Ablass zu verbinden, und welches in einer mittleren Position die erste Kammer (7) nicht mit der Flüssigkeitszufuhr verbinden kann; einen hydraulischen Akkumulator (4), angeschlossen an die erste Kammer (7) des Zylinders (3) über ein Trennventil (6), welches Trennventil (6) aktiviert werden kann zwischen einer Konfiguration, in welcher es den Durchlauf der Flüssigkeit zwischen der ersten Kammer (7) und dem hydraulischen Akkumulator (4) erlaubt, und einer Konfiguration, in welcher es den Durchlauf der Flüssigkeit von der ersten Kammer (7) zu dem hydraulischen Akkumulator (4) absperrt; wobei die Vorrichtung **dadurch gekennzeichnet ist, dass** das Ventil (11) in der mittleren Position das Ablassen der Flüssigkeit aus der zweiten Kammer (8) des Zylinders (3) erlaubt, und **dadurch**, dass ein zweites Steuerventil (14) zwischen der zweiten Kammer (8) des Zylinders (3) und dem Ventil (11) eingesetzt und dazu vorgesehen ist, ein Strömen der Flüssigkeit von dem Ventil (11) zu der zweiten Kammer (8) des Zylinders (3) zu ermöglichen, während ein Strömen in umgekehrter Weise nur ermöglicht wird, wenn die Drücke im Inneren der ersten Kammer (7) über einem vorgegebenen Wert liegen.

**2.** Vorrichtung nach Patentanspruch 1, bei welcher das zweite Steuerventil (14) ein Ausgleichsventil ist, öffnungsgesteuert, um das Strömen der Flüssigkeit aus der zweiten Kammer (8) zu dem Ventil (11) zu erlauben, und zwar mit Hilfe eines Drucksignals, entnommen der ersten Kammer (7) des Zylinders (3).

**3.** Vorrichtung nach Patentanspruch 1, bei welcher das zweite Steuerventil (14) ein Zweiwege-Magnetventil ist, welches öffnungsgesteuert ist, um ein Strömen der Flüssigkeit aus der zweiten Kammer (8) zu dem Ventil (11) zu erlauben, und zwar mit Hilfe eines Druckschalters, welcher einen in der ersten Kammer (7) des Zylinders (3) vorhandenen Druck erfasst.

**4.** Vorrichtung nach einem beliebigen der vorstehenden Patentansprüche, bei welcher ein erstes Steuerventil (12) zwischen der ersten Kammer (7) des Zylinders (3) und dem Ventil (11) eingesetzt ist, wobei das erste Steuerventil (12) dazu vorgesehen ist, das Strömen der Flüssigkeit von dem Ventil (11) zu der ersten Kammer (7) des Zylinders (3) zu ermöglichen und ein Strömen in umgekehrter Weise wegen Drücken im Inneren der ersten Kammer (7) unter einem vorgegebenen Wert zu verhindern, **dadurch gekennzeichnet, dass** der Akkumulator (4) an die erste Kammer (7) des Zylinders (3) angeschlossen ist, und zwar an einem mittleren Punkt zwischen dem ersten Steuerventil (12) und der ersten Kammer (7).

**Revendications**

**1.** Dispositif hydraulique pour lever et baisser un bras (2) articulé à un véhicule de travail (20), comprenant: un vérin hydraulique (3), pouvant être connecté en rotation au véhicule (20) et au bras (2), pourvu d'une première chambre (7) et d'une seconde chambre (8); un distributeur à trois voies (11) qui, dans une première position, peut connecter la première chambre

(7) à une alimentation de fluide et la seconde chambre à une échappement, dans une seconde position peut connecter la seconde chambre (8) à l'alimentation de fluide et la première chambre (7) à l'échappement, et dans une position centrale ne peut pas connecter la première chambre (7) à l'alimentation de fluide; un accumulateur oléo-dynamique (4), connecté à la première chambre (7) du vérin (3) par l'intermédiaire d'une valve de blocage (6), laquelle valve de blocage (6) pouvant être activée entre une configuration dans laquelle elle permet le passage du fluide entre la première chambre (7) et l'accumulateur hydraulique (4) et une configuration dans laquelle elle bloque le passage du fluide de la première chambre (7) à l'accumulateur (4); le dispositif étant **caractérisé en ce que** dans la position centrale le distributeur (11) permet un échappement du fluide de la seconde chambre (8) du vérin (3), et **en ce qu'**une seconde valve de contrôle (14) est interposée entre la seconde chambre (8) du vérin (3) et le distributeur (11) et est prédisposée pour permettre un flux de fluide du distributeur (11) à la seconde chambre (8) du vérin (3), tout en permettant un flux inverse seulement lorsque les pression intérieures à la première chambre (7) sont supérieures à une valeur prédéterminée.

**2.** Dispositif selon la revendication 1, dans lequel la seconde valve de contrôle (14) est une valve d'équilibrage commandée pour permettre le flux de fluide de la seconde chambre (8) au distributeur (11) au moyen d'un signal de pression relevé dans la première chambre (7) du vérin (3).

**3.** Dispositif selon la revendication 1, dans lequel la seconde valve de contrôle (14) est une électrovalve à deux voies commandée en ouverture de manière à permettre un flux de fluide de la seconde chambre (8) au distributeur (11) au moyen d'un pressostat détectant une pression existant dans la première chambre (7) du vérin (3).

**4.** Dispositif selon n'importe laquelle des revendications précédentes, dans lequel une première valve de contrôle (12) est interposée entre la première chambre (7) du vérin (3) et le distributeur (11), la première valve de contrôle (12) étant prédisposée pour permettre le flux de fluide du distributeur (11) à la première chambre (7) du vérin (3) et pour prévenir un flux inverse à cause des pressions internes à la première chambre (7) au-dessous d'une valeur prédéterminée, **caractérisé en ce que** l'accumulateur (4) est connecté à la première chambre (7) du vérin (3) en correspondance d'un point intermédiaire entre la première valve de contrôle (12) et la première chambre (7) .

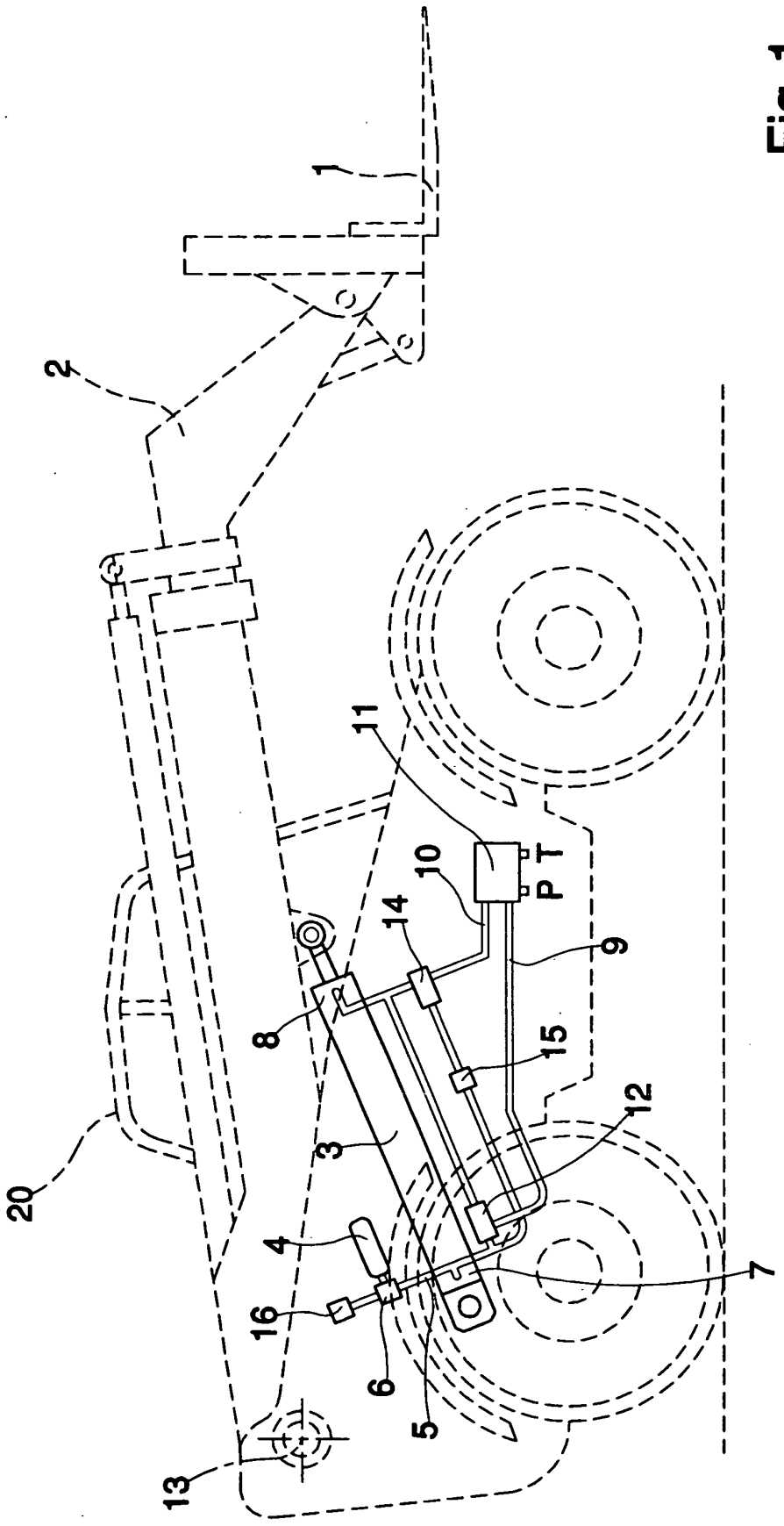


Fig.1

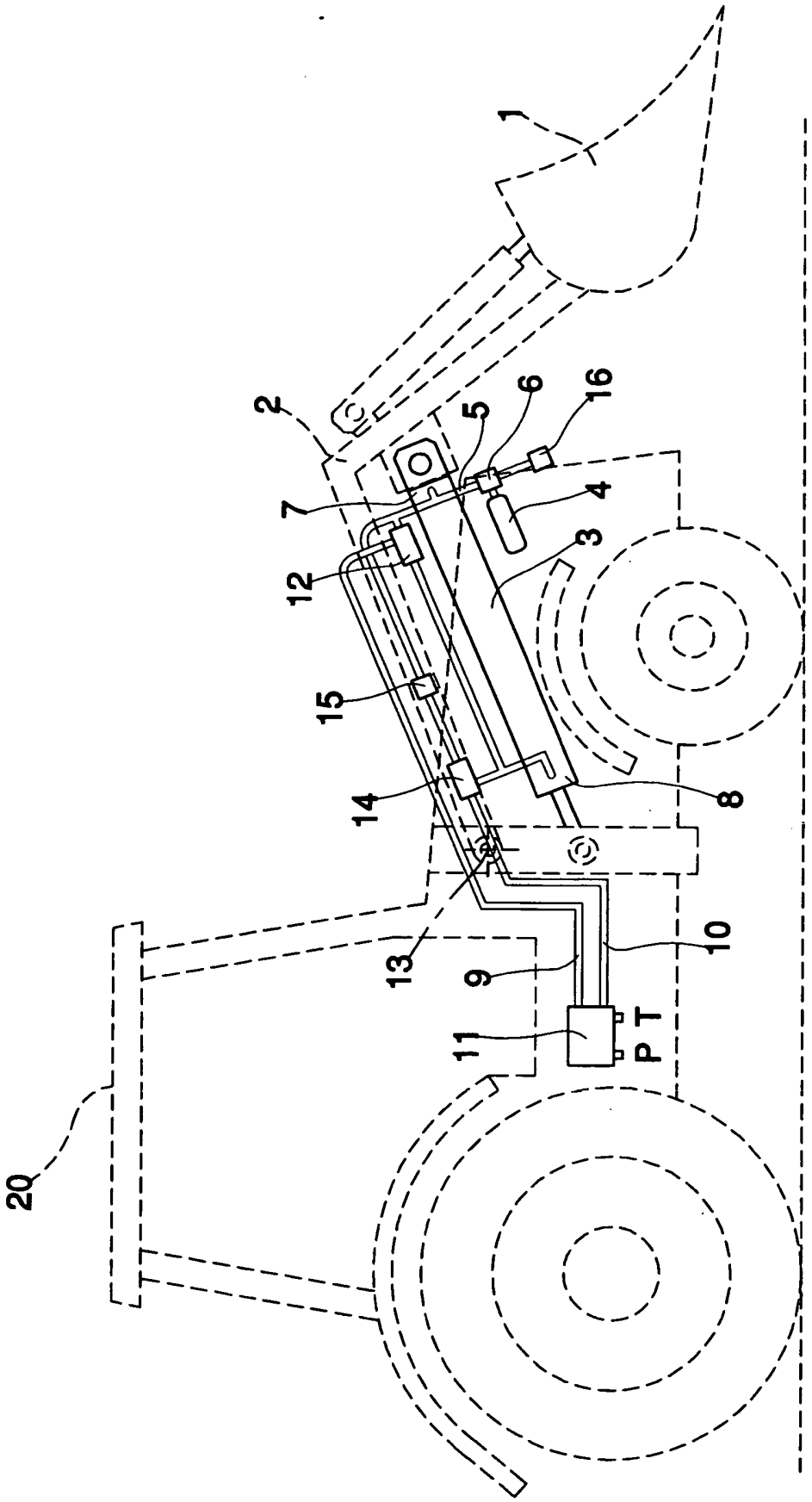


Fig. 2

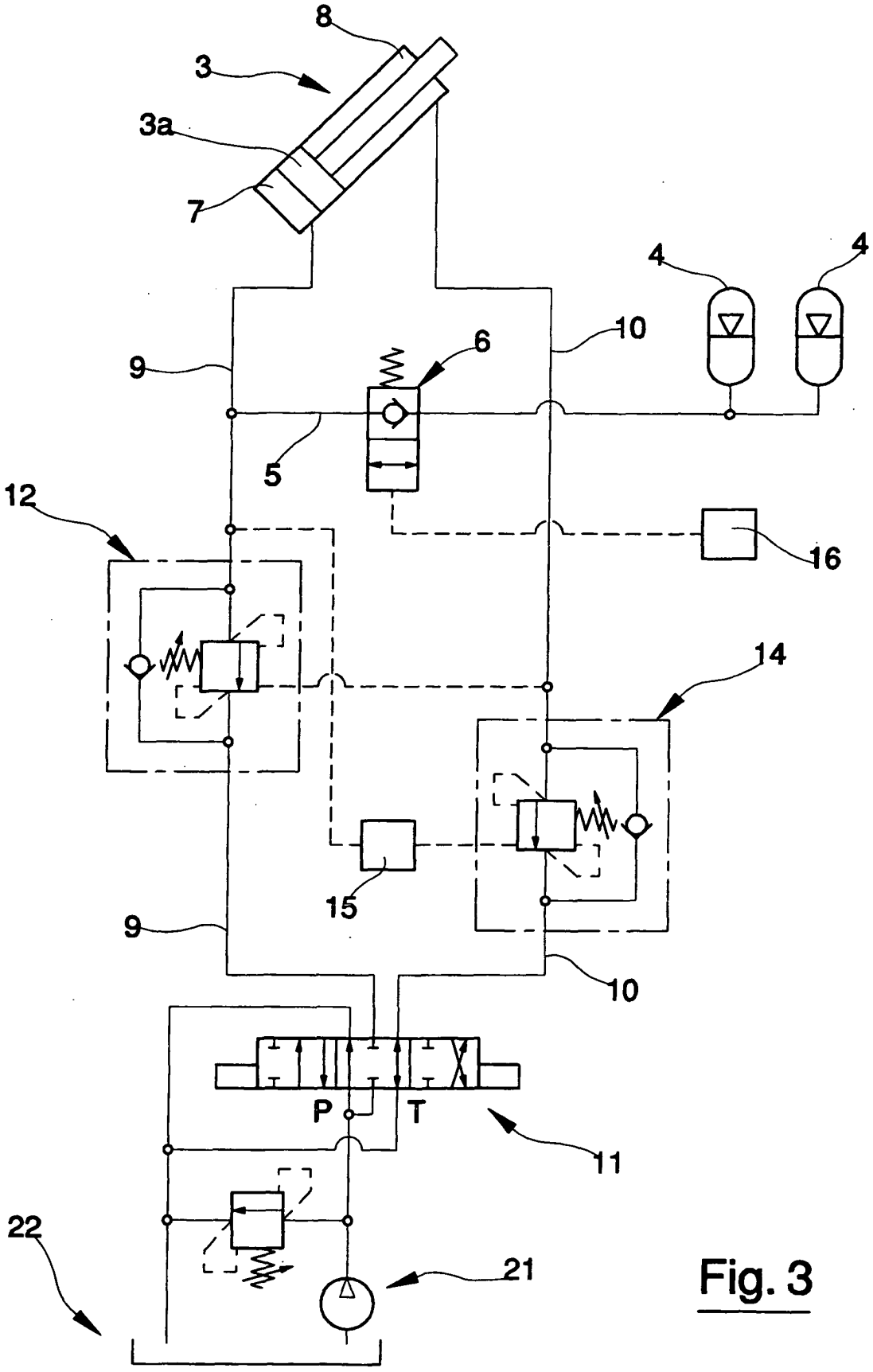


Fig. 3

## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description


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