



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
12.04.2017 Bulletin 2017/15

(51) Int Cl.:
B66F 9/065 (2006.01) **B66F 11/04** (2006.01)
B66F 9/22 (2006.01) **F15B 1/02** (2006.01)
E02F 9/22 (2006.01)

(21) Application number: **16192068.1**

(22) Date of filing: **03.10.2016**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

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(30) Priority: **09.10.2015 IT UB20154253**

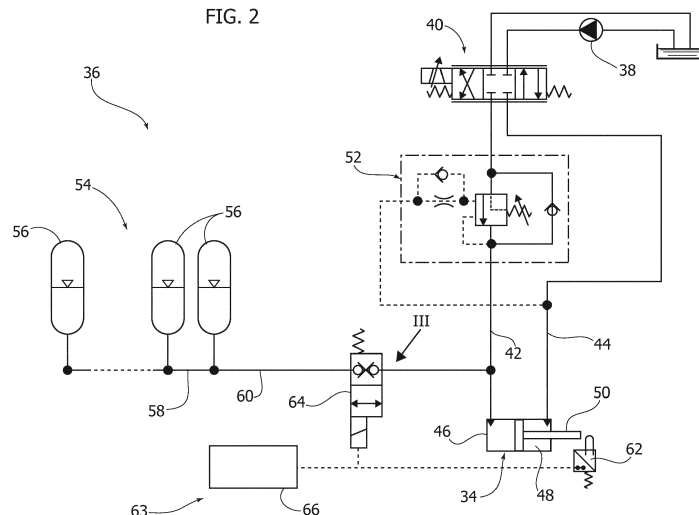
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(54) **A LIFTING VEHICLE WITH A TELESCOPIC LIFTING ARM PROVIDED WITH A SHOCK ABSORBER SYSTEM**

(57) A lifting vehicle comprising:
- a self-propelled chassis (12),
- a telescopic arm (18) provided at a distal end with a implement-mounting attachment (22) and including a base section (30) articulated to the chassis (12) and at least one telescopic section (32),
- at least one lifting cylinder (28) arranged between the telescopic arm (18) and the chassis (12),
- at least one extension cylinder (34) arranged to control the movement of said at least one telescopic section (32) between a retracted position and a plurality of extracted positions,

- a hydraulic circuit (36) including a hydraulic distributor (40) connected to said extension cylinder (34) via a first and a second hydraulic line (42, 44) connected, respectively, to a first and to a second chamber (46, 48) of the extension cylinder (34), wherein a pressure-controlled block valve (52) is arranged on said first hydraulic line (42),
wherein the hydraulic circuit (36) comprises a shock absorber system (54) including at least one gas accumulator (56) connected to a portion of said first hydraulic line (42) comprised between said first chamber (46) of the extension cylinder (34) and said block valve (52).

FIG. 2



DescriptionField of the invention

5 **[0001]** The present invention relates to a lifting vehicle with a telescopic lifting arm provided with an implement-mounting attachment.

Description of the prior art

10 **[0002]** Lifting vehicles of this type can be equipped with different types of implements, for example, forks, shovels, aerial platforms, etc. When the vehicle operates with a shovel, a fork, or a similar implement that carries out loading at the ground, it is possible that the implement collides against rigid obstacles located at a close distance from the vehicle, such as walls, pavements or protruding manholes. The lifting vehicles have a high momentum or kinetic energy, essentially due to the substantial mass of the vehicle, so that the frontal collisions, even at slow speeds, cause high stresses of the vehicle structure, in particular of the arm, of the chassis and of the articulation pin of the arm, and expose the operator to dangerous situations.

15 **[0003]** Lifting vehicles, loaders and tractors with a front loader currently on the market do not have any type of protection against collisions, and this can cause injuries to the operator as well as damage to the machines.

20 Object and summary of the invention

[0004] The present invention aims to provide a lifting vehicle with a telescopic lifting arm that allows it to mitigate the effects of frontal collisions.

25 **[0005]** According to the present invention, this object is achieved by a lifting vehicle having the characteristics forming the subject of claim 1.

[0006] As will become clear in the following description, the vehicle according to the invention is equipped with a shock absorber system associated with the extension cylinder of the telescopic arm. The shock absorber system allows a gradual return of the telescopic section of the arm in the event of a frontal collision, with a consequent reduction of the inertial effects on the vehicle. Thanks to the shock absorber system, the damage to the vehicle is limited and the risks to which the driver would be subjected in the event of a frontal collision are reduced. The shock absorber system according to the present invention is also particularly useful in all the thrust steps with a shovel, blade or similar implements, as it mitigates the stresses imposed in the normal work cycle, even in the absence of frontal collisions.

35 Brief description of the drawings

[0007] The present invention will now be described in detail with reference to the attached drawings, given purely by way of non-limiting example, wherein:

- Figure 1 is a perspective view of a lifting vehicle with a telescopic arm,
- 40 - Figure 2 is a diagram of the hydraulic circuit associated with the telescopic arm of a vehicle according to the present invention,
- Figure 3 is a cross-section of a solenoid valve indicated by the arrow III in Figure 2,
- Figure 4 is a perspective view of an accumulator assembly, and
- 45 - Figure 5 is a diagram showing the pressure variation as a result of a frontal collision in a system according to the present invention.

Detailed description

50 **[0008]** With reference to Figure 1, numeral 10 indicates a lifting vehicle comprising a self-propelled chassis 12 having a front axle 14 and a rear axle 16. The vehicle 10 comprises a telescopic arm 18 articulated in the rear section of the chassis 12 about a transverse axis 20. The telescopic arm 18 is provided at one end with an attachment 22 for connecting different types of implements.

[0009] The telescopic arm 18 is located at the center of the chassis 12, between a driving cab 24 and an engine assembly 26. The vehicle 10 comprises a lifting cylinder 28 with ends articulated to the chassis 12 and the arm 18. The lifting cylinder 28 is operable to control the tilt of the arm 18 about the transverse axis 20 between a lowered position in which the arm 18 extends in the horizontal or lower direction and a plurality of raised positions.

[0010] The telescopic arm 18 comprises a base section 30 that is articulated to the chassis 12 about the transverse axis 20 and a telescopic section 32, which is movable within the base section 30 along a direction parallel to the longitudinal

axis of the arm 18. The telescopic arm 18 comprises an extension cylinder 34 that controls the telescopic movement of the telescopic section 32 along the longitudinal axis of the arm 18 between a retracted position and a plurality of extracted positions.

[0011] In the example illustrated in Figure 1, the telescopic arm 18 has a single telescopic section. Alternatively, the telescopic arm can have a plurality of telescopic sections, each of which is associated with a respective extension cylinder, or with one or more cylinders with cable or chain drives for their movement.

[0012] With reference to Figure 2, the vehicle 10 has a hydraulic circuit 36, which comprises a main pump 38 driven by the thermal engine of the vehicle 10. The hydraulic circuit 36 comprises a hydraulic distributor 40 that receives fluid under pressure from the pump 38 and controls the extension cylinder 34 by means of a first hydraulic line 42 and a second hydraulic line 44, connected, respectively, to a first chamber 46 and to a second chamber 48 of the extension cylinder 34. The pressure in the first chamber 46 controls the extraction of the rod 50 of the hydraulic cylinder 34 and the pressure in the second chamber 48 controls the return of the rod 50.

[0013] A pressure-controlled block valve 52 is arranged on the first hydraulic line, which prevents a return of fluid from the first chamber 46 towards the distributor 40 in the absence of a pressure in the second hydraulic line 44 that is higher than a preset value.

[0014] The hydraulic circuit 36 comprises a shock absorber system 54 associated with the extension cylinder 34. The shock absorber system 54 comprises at least one gas accumulator 56. In a preferred embodiment, the shock absorber system 54 comprises a plurality of gas accumulators 56 having different respective working pressures and connected in parallel with each other to a manifold 58. Figure 4 shows a constructive example of an embodiment of the assembly of accumulators 56.

[0015] The manifold 58 of the shock absorber system 54 is connected to the first hydraulic line 42 via a line 60 connected to a section of the first hydraulic line 42 between the first chamber 46 and the block valve 52.

[0016] The shock absorber system 54 can be associated with a safety device 63 that comprises an extension sensor 62, a solenoid valve 64 arranged on the line 60 and an electronic unit 66. Figure 3 shows a constructive example in which the valve 64 has a disc 66 rotatable in a block 68, having a channel 70 connected to the line 60 and a hole 72 connected to the manifold 58 of the accumulators 56. The solenoid valve 64 is an ON/OFF valve that is normally closed, and is opened by the electronic unit 66 when the extension sensor 62 signals that the extension of the cylinder 34 is below a predetermined threshold. When the extension of the cylinder 34 exceeds the predetermined threshold, the solenoid valve 64 is in a closed position.

[0017] The operation of the shock absorber system 54 is as follows.

[0018] In conditions of normal operation, the extension cylinder 34 is fed through the distributor 40. When the extension cylinder 34 has reached a required extension, corresponding to a required length of the telescopic arm 18, the distributor 40 is in a central position. In the central position, the distributor blocks the passage of oil. In addition, if there is no pressure in the second line 44, the block valve 52 is closed and blocks the passage of fluid along the first line 42 between the extension cylinder 34 and the distributor 40.

[0019] The extension sensor 62, formed of a micro-switch or an equivalent sensor, detects whether the extension of the cylinder 34 is less than or greater than a threshold limit. If the extension of the cylinder 34 is lower than the threshold limit, the electronic unit 66 switches the solenoid valve 64 into the open position. When the solenoid valve 64 is open, the accumulators 56 are in hydraulic communication with the first chamber 46 of the cylinder 34.

[0020] In the event of a frontal collision with an obstacle, the rod 50 of the cylinder 34 is retracted. The volume of hydraulic fluid coming out from the first chamber 46 is sent to the accumulators 56. When the pressure of the hydraulic fluid in the accumulators 56 exceeds their preload pressure, the hydraulic fluid compresses the gas in the accumulators 56. The accumulators 56 are loaded with the hydraulic fluid coming from the cylinder 34 and gradually slow down the return of the arm, and therefore decelerate the forward movement of the vehicle. The number of accumulators 56 depends on the maximum braking stroke that is required, or rather, on the return length of the arm within which the arm stops the machine.

[0021] When the extension length of the cylinder 34 exceeds a threshold limit, the safety device 63 inhibits the shock absorber device 54 by closing the solenoid valve 64. The safety device 63 performs a safety function in that if the volume of hydraulic fluid directed towards the accumulators 56 becomes too high, there would be a risk of bursting the accumulators. In an alternative embodiment, in addition to or in replacement of the solenoid valve 64 and of the extension sensor 62, a pressure-limiting valve could be arranged on the line 60, which laminates the hydraulic fluid towards the discharge if the pressure exceeds the maximum allowable pressure of the accumulators.

[0022] The calibration pressure of the accumulators 56 must not be too low otherwise the telescopic section 32 of the arm 18 would retract under low loads that do not correspond to a collision situation. At the same time, the calibration pressure of the accumulators must not be too high otherwise the vehicle would still have a dangerous initial collision.

[0023] The trend of the pressure during the operation of the shock absorber system 54 is schematically shown in the graph of Figure 5.

[0024] Time t_0 indicates the instant in which the frontal collision occurs. Before the collision, the vehicle is in motion

and the pressure in the chamber 46 of the cylinder 34 is equal to the base value p_0 . Immediately after the collision there is an almost instantaneous increase in the pressure of the hydraulic fluid. When the pressure of the fluid reaches a value p_1 equal to the value of the calibration pressure p^* of the accumulators, the gas inside the accumulators starts to compress. In this step, between the instants t_1 and t_2 , the telescopic section 32 of the arm 18 retracts, opposing a progressively increasing force to the movement of the vehicle. This force gradually slows the vehicle, until the vehicle stops at time t_2 , which corresponds to a pressure p_2 . The pressure p_2 must be less than the maximum pressure of the accumulators (p_{max}).

[0025] The safety device 63 serves to prevent the fluid pressure in the line 60 exceeding the maximum pressure of the accumulators.

[0026] Below, the method of sizing of the shock absorber system 54 will be provided. The diameter of the cylinder d , and the maximum stroke x within which the vehicle in motion should be stopped, are known. The maximum volume ΔV of fluid to be dissipated can therefore be calculated:

$$A = \frac{d^2 \pi}{4} \quad \Delta V = A \cdot x$$

[0027] The vehicle that collides frontally against a fixed obstacle has a kinetic energy that must be dissipated in order to brake the vehicle. The kinetic energy E is calculated as a function of the mass m of the vehicle and of its collision speed v_{max} that is hypothesized in the design step:

$$E = \frac{1}{2} m v_{max}^2$$

[0028] In other words, the shock absorber system 54 is sized in order to brake the machine up to a certain speed v_{max} , without shocks.

[0029] The kinetic energy is dissipated largely by the accumulators by means of a very fast compression of the gas (nitrogen). It therefore has an adiabatic transformation:

$$p_1 V_1^\gamma = p_2 V_2^\gamma = k \quad \Rightarrow \quad p = k V^{-\gamma}$$

[0030] Where p_1 and p_2 are the initial and final pressures of the gas (and of the oil) and V_1 and V_2 are the initial and final volumes of the gas.

[0031] The energy stored in the accumulator is equal to the work of compression that the hydraulic fluid can exert on the gas pocket:

$$L = \int_{V_1}^{V_2} p dV = k \int_{V_1}^{V_2} V^{-\gamma} dV = k \left[-\frac{V^{1-\gamma}}{1-\gamma} \right]_{V_1}^{V_2}$$

$$L = \frac{k}{\gamma - 1} (V_2^{1-\gamma} - V_1^{1-\gamma}) = \frac{1}{\gamma - 1} (p_2 V_2 - p_1 V_1)$$

[0032] Once the initial volume is set, the final volume is calculated as $V_2 = V_1 - \Delta V$. The final pressure p_2 is imposed as equal to the maximum value bearable by the accumulator (about 250 bars), while the initial pressure is calculated as:

$$p_1 = p_2 \left(\frac{V_2}{V_1} \right)^\gamma$$

[0033] If $L > E$ then the system is able to dissipate all the kinetic energy. The volume V_1 must be set to the lowest possible value to reduce the necessary volume of gas and therefore the number of accumulators, always maintaining

a certain margin of safety able to ensure the dissipation of all the energy even in off-design conditions.

[0034] Having identified the necessary maximum parameters, the data needed for the sizing and the choice of the number of accumulators can then be identified.

[0035] As the transformation is non-linear, the compression of the gas must start at a precise value of pressure defined by p_1 according to which the preload of the accumulator is chosen. In catalogs it is recommended to use a pre-load pressure for the accumulators equal to 90% of the minimum for reasons of wear, therefore

$$p^* = 0.9 \cdot p_1$$

[0036] In reality, in this case, the wear does not represent a big problem because the air pockets are compressed occasionally and not cyclically. Furthermore, as said, to dissipate the energy provided, it is necessary that the oil starts to compress the pocket at the set pressure and not before, because a work performed at a lower pressure for the same volume dissipates less energy and there would be a risk of arriving at the stroke-end without having braked the vehicle and therefore with a speed not equal to zero. For this reason, the preload value of the accumulators is maintained equal to that of the initial compression:

$$p^* = p_1$$

[0037] The nominal volume $V_{0,TOT}$ needed in total can be calculated as for catalog of the accumulators:

$$V_{0,TOT} = \frac{\Delta V}{\left(\frac{p^*}{p_1}\right)^{\frac{1}{\gamma}} - \left(\frac{p^*}{p_2}\right)^{\frac{1}{\gamma}}}$$

[0038] At this point, it is easy to calculate the minimum number of accumulators required n_{acc} as:

$$n_{acc} = \frac{V_{0,TOT}}{V_{acc}}$$

[0039] Where V_{acc} is the volume of the single accumulator.

[0040] Once these system parameters have been defined, the maximum pressure that is actually achieved and the effective stroke of the arm before the machine stops can then be calculated, and then the safety margin can be evaluated.

[0041] Load losses are also present in the system, which function as damping of the system. Therefore, the slowing down of the arm will be partly helped by the dissipations within the hydraulic components.

[0042] The shock absorption system described above, as well as being deactivated by the safety device 63 according to the extension of the telescopic arm 18, can also be deactivated by a command from the operator or automatically by an angle sensor that detects the inclination of the telescopic arm 18.

[0043] Of course, without prejudice to the principle of the invention, the details of construction and the embodiments can be widely varied with respect to those described and illustrated, without thereby departing from the scope of the invention as defined by the claims that follow.

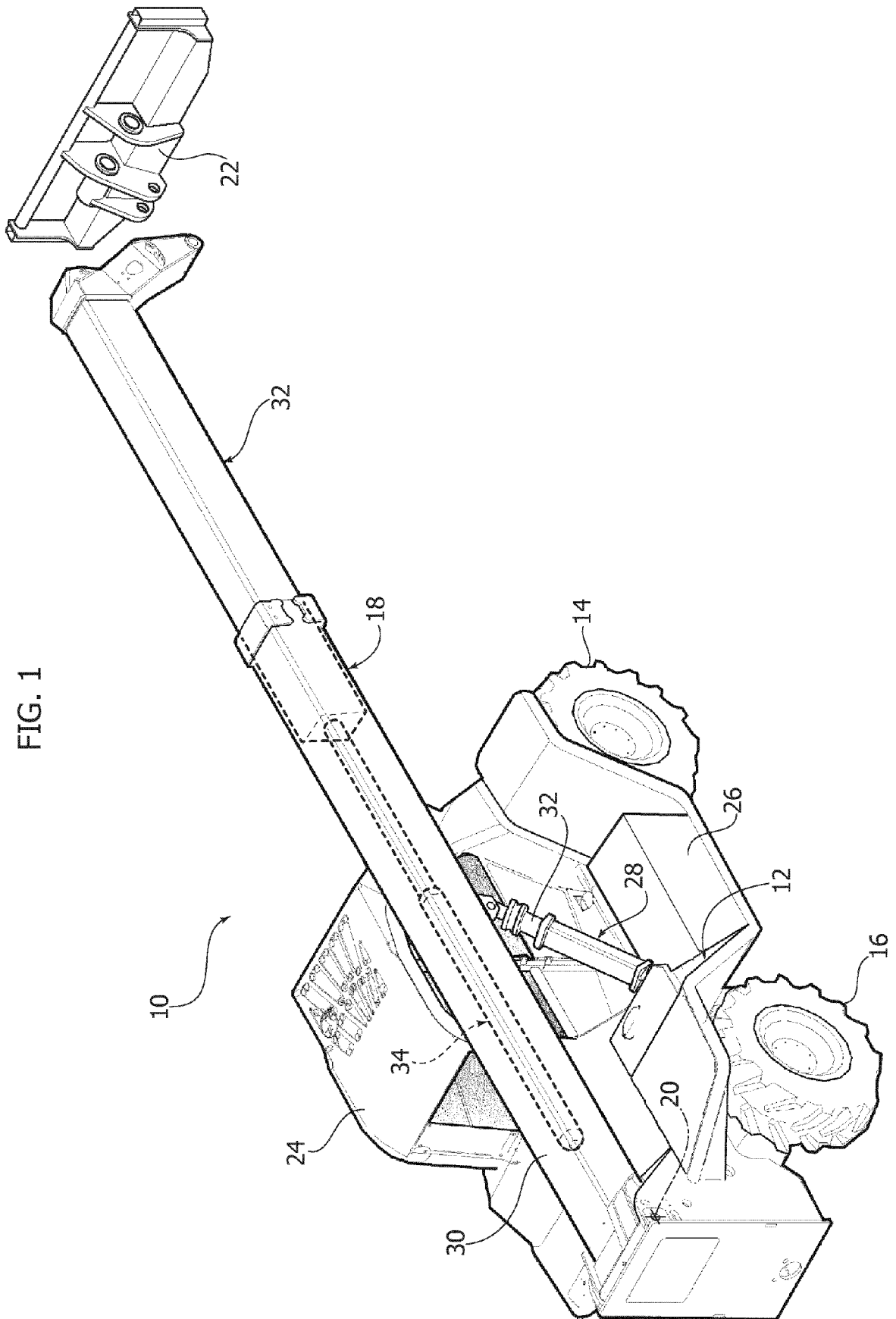
Claims

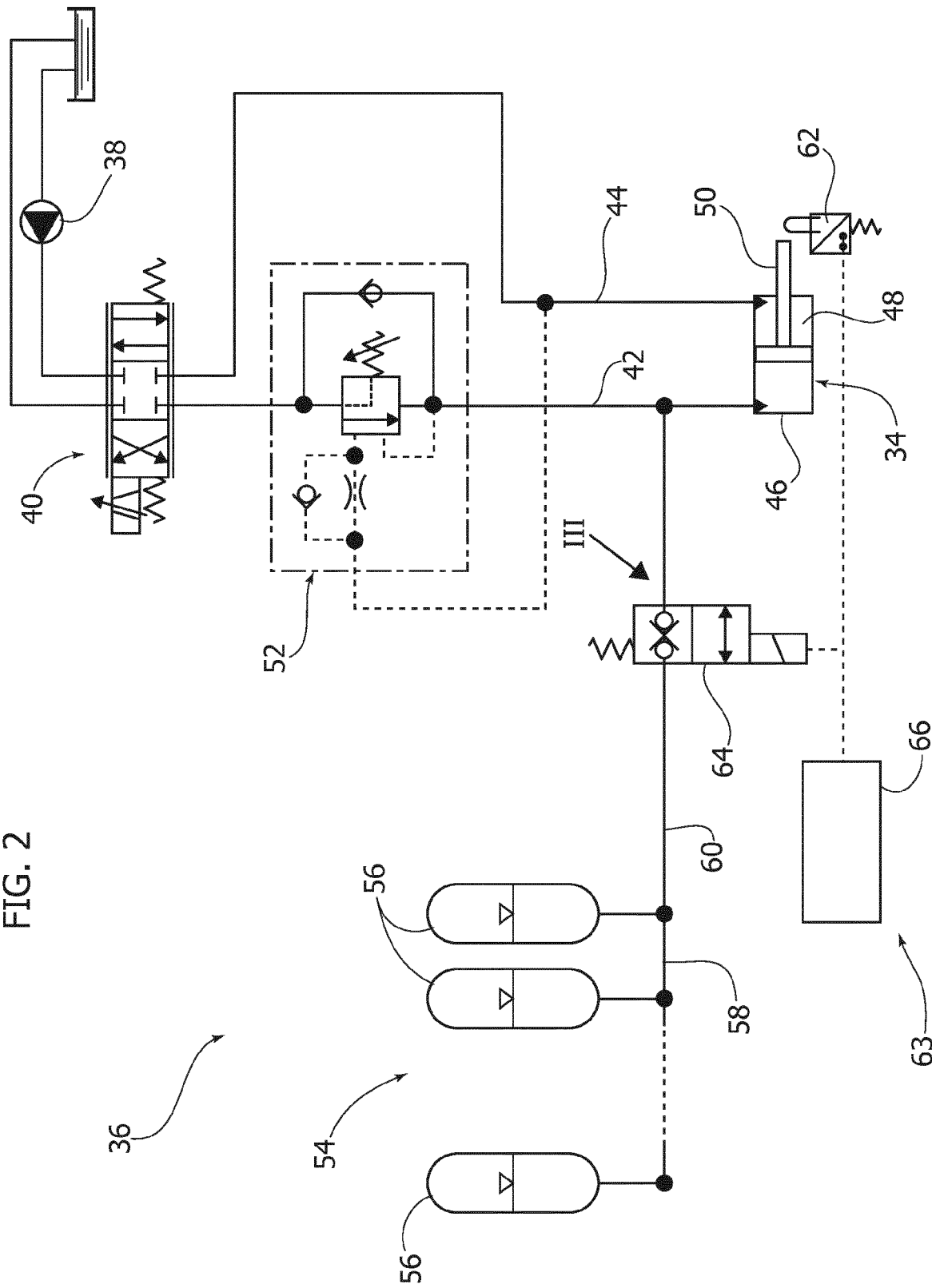
1. A lifting vehicle comprising:

- a self-propelled chassis (12),
- a telescopic arm (18) provided at a distal end with a implement-mounting attachment (22), and including a base section (30) articulated to the chassis (12) and at least one telescopic section (32),
- at least one lifting cylinder (28) arranged between the telescopic arm (18) and the chassis (12),
- at least one extension cylinder (34) arranged to control the movement of said at least one telescopic section

(32) between a retracted position and a plurality of extracted positions,
 - a hydraulic circuit (36) including a hydraulic distributor (40) connected to said extension cylinder (34) via a first
 and a second hydraulic line (42, 44) connected, respectively, to a first and to a second chamber (46, 48) of the
 extension cylinder (34), wherein a pressure-controlled block valve (52) is arranged on said first hydraulic line
 (42), **characterized in that** the hydraulic circuit (36) comprises a shock absorber system (54) including at least
 one gas accumulator (56) connected to a portion of said first hydraulic line (42) comprised between said first
 chamber (46) of the extension cylinder (34) and said block valve (52).

2. A lifting vehicle according to claim 1, **characterized in that** said shock absorber system (54) comprises a plurality
 of accumulators (56) connected in parallel to a common manifold (58).
3. A lifting vehicle according to claim 2, **characterized in that** said accumulators have respective calibration pressures
 that are different from each other.
4. A lifting vehicle according to any one of the preceding claims, **characterized in that** said shock absorber system
 (54) comprises an ON/OFF valve (64) that blocks the connection between said at least one accumulator (56) and
 said first hydraulic line (42) when the extension of said cylinder (34) is higher than a predetermined threshold, or
 when the angle of the telescopic arm (18) is greater than a predetermined value, or when the shock absorber system
 (54) is deactivated by the operator.
5. A lifting vehicle according to any one of claims 1-4, **characterized in that** said shock absorber system (54) comprises
 a pressure-limiting valve, which laminates the hydraulic fluid towards a discharge when the pressure in the accu-
 mulator exceeds a predetermined limit value.





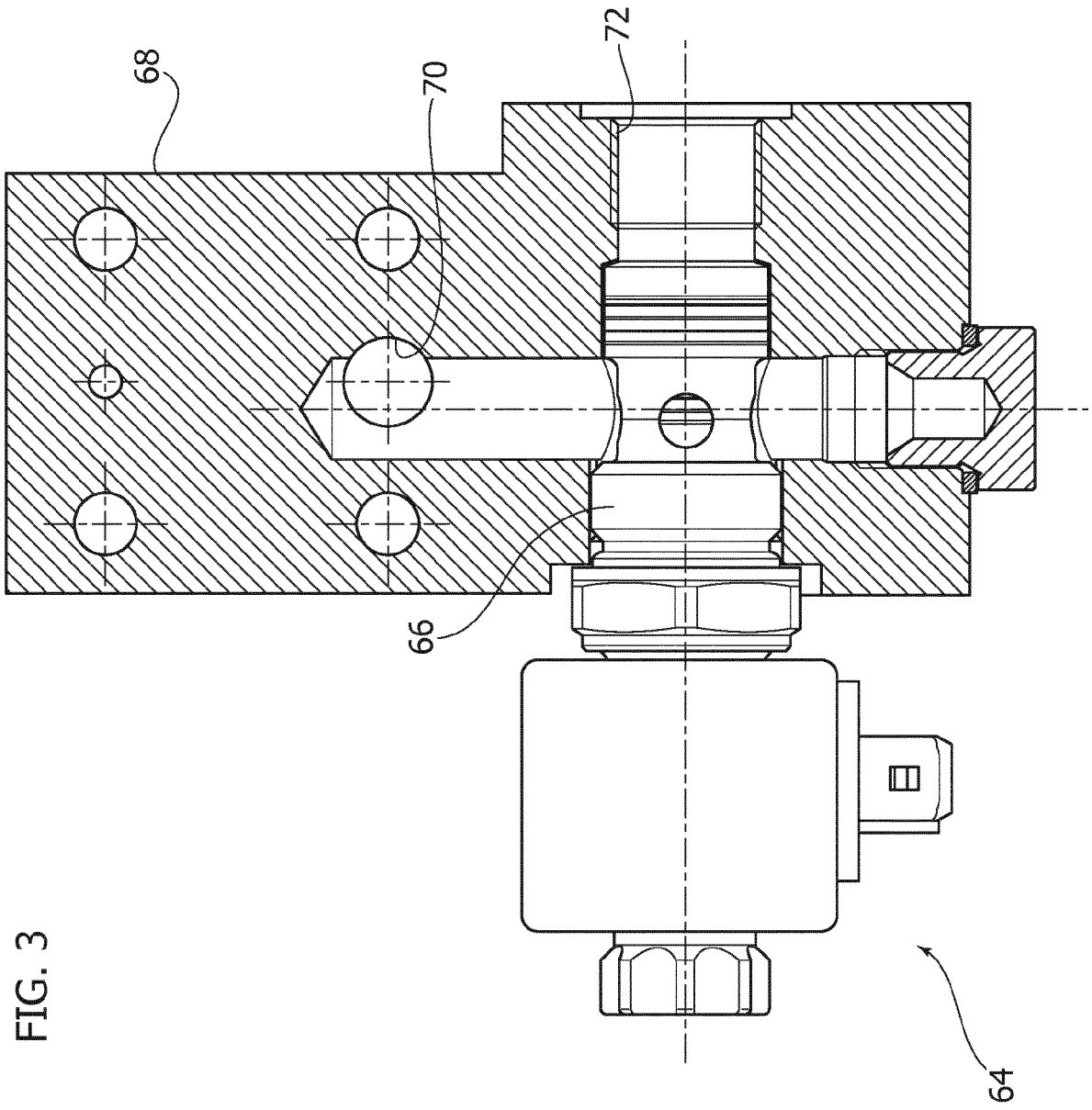


FIG. 4

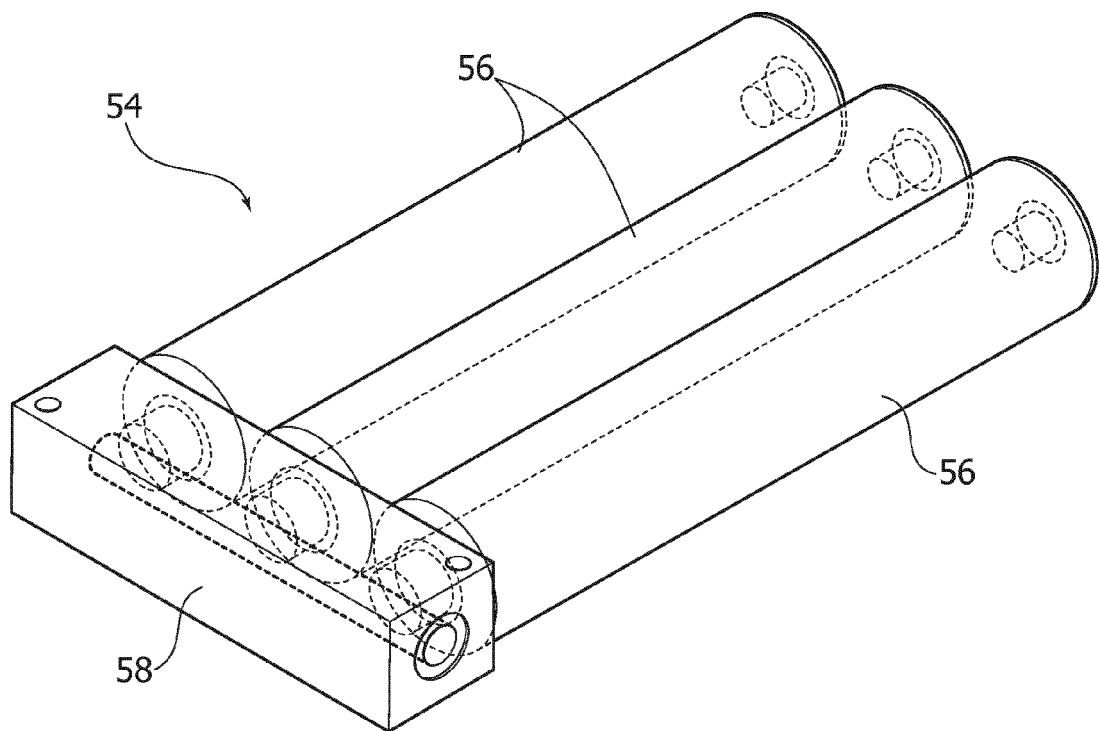
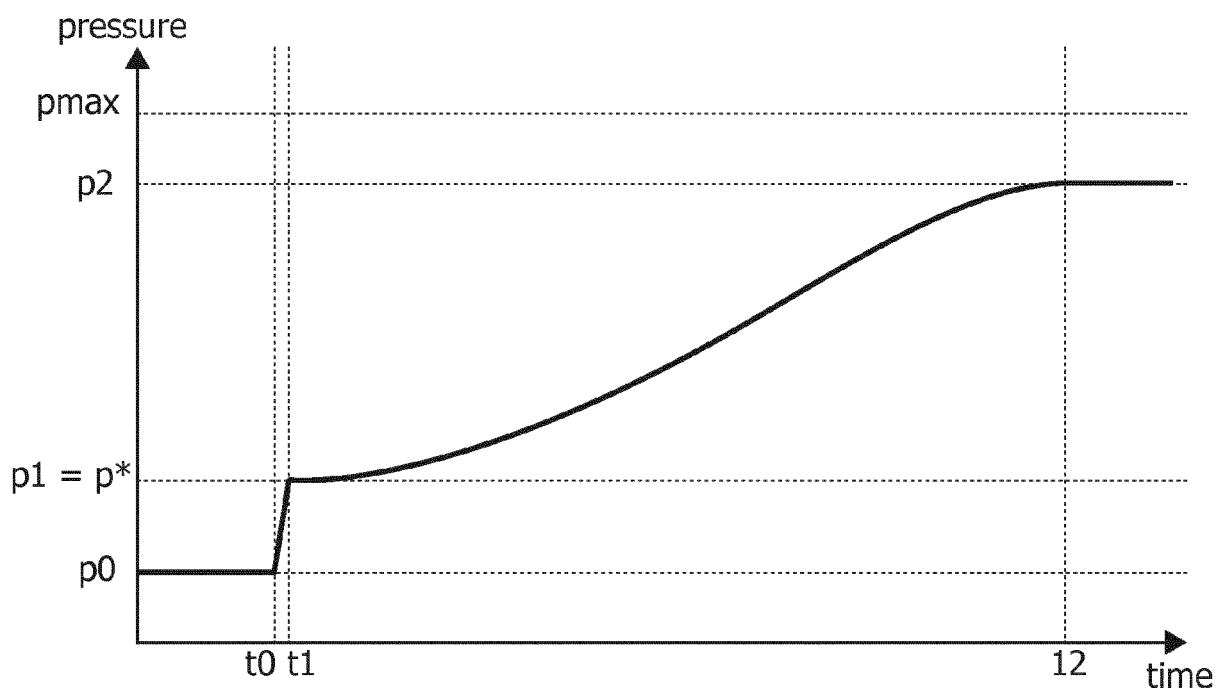


FIG. 5





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 Application Number
 EP 16 19 2068

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 27 February 2017	Examiner Özsoy, Sevda
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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