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(71) Applicant *(for all designated States except US)*: **Scania CV AB (publ)** [SE/SE]; S-151 87 Södertälje (SE).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **SVENSSON, Robert** [SE/SE]; Zenitvägen 22, S-646 92 Gnesta (SE). **BJÖRNELUND, Tomas** [SE/SE]; Värdsholmsgatan 1A, S-151 32 Södertälje (SE).

(74) Agent: **ELLIOT, Douglas**; Scania CV AB, S-151 87 Södertälje (SE).

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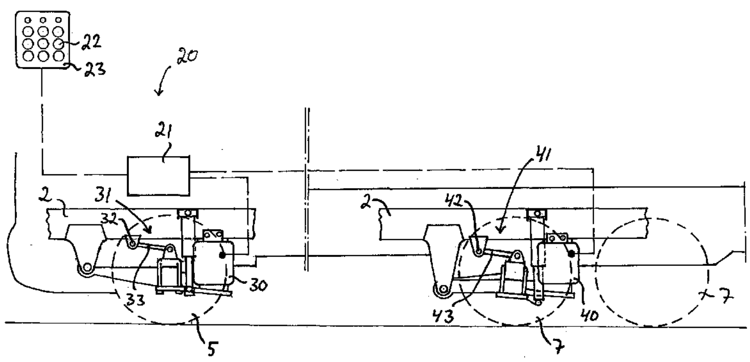


Fig 2

**(57) Abstract**: The invention relates to an air suspension system for a vehicle which is provided with a load changer, and a method for regulating the air pressure in the air bellows of such an air suspension system. A control device (21 ) of the air suspension system determines or receives values pertaining to a f first parameter which represents the distance in the height direction between a forward wheelshaft (4) of the vehicle or the air pressure in the air bellows (40) at a rear wheelshaft (6a) of the vehicle, and values pertaining to a second parameter which represents the distance in the height direction between said rear wheelshaft and the chassis of the vehicle or the air pressure in the air bellows (30) at said forward wheelshaft. The control device inactivates the automatic regulation of the height position of the vehicle's chassis when the control device finds that the following conditions, possibly in combination with one or more further conditions, are simultaneous fulfilled : • the value of said first parameter is increasing, and • the value of said second parameter is decreasing.

WO 2010/104459 A2

# Air suspension system and method for regulating the air pressure in the air bellows of an air suspension system

FIELD OF THE INVENTION, AND PRIOR ART

The present invention relates to an air suspension system according to the preamble of claim 1 and a method according to the preamble of claim 8 for regulating the air pressure in the air bellows of an air suspension system of a vehicle which is provided with a load changer. The invention relates also to a computer programme product comprising computer programme code for implementing a method according to the invention, and an electronic control unit.

A modern freight vehicle is often provided with an air suspension system which comprises air bellows at the vehicle's rear wheel suspension and front wheel suspension. Such an air suspension system may be adapted to being controlled by a so-called ELC (electronic level control) system. The ELC system detects the distance in the height direction between the respective wheelshafts and the chassis of the vehicle by means of sensors and can be set to automatically regulate the air pressure in the air bellows of the air suspension system so that the chassis is kept in a preset height position relative to the wheelshafts irrespective of the load on the wheelshafts. This regulating function is hereinafter called automatic level regulation.

In a freight vehicle provided with a load changer, e.g. in the form of a load changer with hook arm or a load changer with draw wire, the load changer is used for loading a load onto the vehicle and unloading a load from the vehicle via the rear end of the vehicle. In this case the load is placed in or on a freestanding load carrier, e.g. in the form of a container, a container platform, a roller platform or the like. The load carrier is provided with a fastening means intended to engage with a hook provided at the end of a lever arm or draw wire which forms part of the load changer. When the load carrier is to be moved onto the vehicle, the hook of the load changer is hooked firmly in the fastening means of the load carrier, followed by the load changer lifting and/or pulling the front end of the load carrier up over the rear end of the vehicle and thereafter pushing the load carrier forward along the vehicle's chassis. During this loading operation, the centre of gravity of the load will initially be behind the vehicle before subsequently moving progressively forward along the vehicle until the load carrier has been caused to assume its final position on the vehicle. The unloading process involves the opposite, i.e. the centre of gravity of the load will progressively move rearward along the vehicle until the load carrier rests entirely on the ground or some other substrate behind the vehicle. This shifting of the centre of gravity causes the loading on the respective wheelshafts to vary greatly during the respective loading and unloading processes, with the consequence that the automatic level regulation causes compressed air to be supplied to and drawn from the air bellows of the air suspension system a number of times during the respective loading or unloading process before the load carrier reaches its final position. These repeated inputs/discharges of compressed air to/from the respective air bellows lead to a large amount of compressed air going to waste during loading and unloading processes.

US 6 061 615 A proposes various ways of avoiding unnecessary adjustments of the chassis height of a freight vehicle, whereby a given time lag for initiating a chassis height adjustment is extended and/or a given passive range about a preset chassis height is increased when the vehicle is stationary and its ignition switched off.

## OBJECT OF THE INVENTION

The object of the present invention is to provide a novel and advantageous way of avoiding unnecessary adjustments of the chassis height, and hence unnecessary consumption of compressed air, of a freight vehicle while a load carrier is being loaded onto or unloaded from the vehicle by means of a load changer of the vehicle.

## SUMMARY OF THE INVENTION

According to the present invention, said object is achieved by means of an air suspension system having the features defined in claim 1 and a method having the features defined in claim 8.

According to the invention, an electronic control device of an air suspension system of the vehicle provided with a load changer is adapted to determining or receiving values pertaining to a first parameter and values pertaining to a second parameter, such that the first parameter represents the distance in the height direction between a forward wheelshaft and the chassis of the vehicle or the air pressure in the air bellows at a rear wheelshaft of the vehicle, and the second parameter represents the distance in the height direction between said rear wheelshaft and the chassis of the vehicle or the air pressure in the air bellows at said forward wheelshaft of the vehicle.
The control device is further adapted to inactivating the automatic level regulation when the control device finds that the following conditions, possibly in combination with one or more further conditions, are simultaneously fulfilled:

- the value of said first parameter is increasing, and
- the value of said second parameter is decreasing.

Thus the automatic regulation of the vehicle's chassis height is inactivated when the distance in the height direction between the forward wheelshaft and the chassis increases at the same time as the distance in the height direction between the rear wheelshaft and the chassis decreases, or when the air pressure in the air bellows at the rear wheelshaft increases at the same time as the air pressure in the air bellows at the forward wheelshaft decreases. Changes of this kind in the height position of the chassis relative to the wheelshafts or in the air pressure in the air bellows of the air suspension system occur typically in the initial phase of a process for loading a load onto the vehicle or unloading a load from the vehicle involving use of the vehicle's load changer, and are in this case used as an indication that such a loading or unloading process has begun. Inactivating the air suspension system's automatic regulation of the chassis height when the initial phase of a loading or unloading process is detected in this way avoids unnecessary adjustments of the vehicle's chassis height during the loading or unloading process and hence avoids unnecessary consumption of compressed air of the air suspension system, thereby also reducing the vehicle's fuel consumption. The solution according to the invention may be implementing by means of components which are already available in a conventional air suspension system and involves only relatively simple reprogramming of the electronic control device of an air suspension system of a conventional type. The invention can therefore be implemented easily and at low cost. Automatic inactivation of the air suspension system's automatic regulation of the chassis height upon detection of the initial phase of a loading or unloading process also results in a solution which does not call for active involvement of the vehicle's driver and is therefore very reliable.

According to an embodiment of the invention, the vehicle's speed needs to be lower than or equal to a given limit, e.g. of the order of 0-10 km/h, for the automatic regulation of its chassis height to be inactivated. Any possibility of automatic regulation of the chassis height being inactivated by mistake when the vehicle is in motion is thereby prevented.

According to another embodiment of the invention, reactivation of the automatic regulation of the vehicle's chassis height takes place when the following conditions are simultaneously fulfilled:

- said first parameter has stabilised, and
- said second parameter has stabilised.

Stabilisation of each parameter means here that its measured value has substantially ceased to change and has stabilised at a substantially constant level. In a loading operation this occurs when the load carrier has assumed its final position on the vehicle, and in unloading it occurs when the load carrier has assumed its final position on the ground or some other substrate behind the vehicle. Finding that the respective parameters have stabilised is used in this case as an indication that a loading or unloading process has been completed, and triggers a return to the normal state of the automatic regulation of the vehicle's chassis height, whereby the air pressure in the air suspension system's air bellows will therefore be adjusted so that the vehicle's chassis is caused to assume the preset height position relative to the wheelshafts.

According to a further embodiment of the invention, the air suspension system comprises a first set of rear air bellows situated close to a first rear wheelshaft of the vehicle, a second set of rear air bellows situated close to a second rear wheelshaft of the vehicle, and pressure sensors for detecting the air pressure in the air bellows of the respective sets of rear air bellows. The control device is in this case connected to said pressure sensors in order to receive from them measured values of said air pressure, and can be set to effect automatic regulation of the axle pressure of said rear wheelshafts by regulating the air pressure in the air bellows of said sets of rear air bellows in such a way that the axle pressure of the first rear wheelshaft and the axle pressure of the second rear wheelshaft are caused to assume a preset relationship to one another. The control device is in this case also adapted to inactivating the automatic axle pressure regulation when it inactivates the automatic level regulation. Inactivating the air suspension system's automatic regulation of the axle pressure of the rear air bellows when the initial phase of a loading or unloading process is detected avoids unnecessary adjustments of the axle pressure relationship between the vehicle's rear wheelshafts during the loading or unloading process and thereby avoids unnecessary consumption of compressed air of the air suspension system, with consequent reduction of the vehicle's fuel consumption.

Other advantageous features of the air suspension system and the method according to the invention are indicated by the independent claims and the description set out below.

The invention relates also to a computer programme product having the features defined in claim 13 and an electronic control unit having the features defined in claim 15.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is described in more detail below on the basis of embodiment examples with reference to the attached drawings, in which:

Figs. 1a-f depict various stages during a process for loading a load carrier onto a vehicle by means of a load changer of the vehicle,

Fig. 2 is a schematic illustration of parts of the vehicle according to Figs. 1a-f,

Fig. 3 is a schematic diagram of an air suspension system according to a first embodiment of the present invention,

Fig. 4 is a schematic diagram of an air suspension system according to a second embodiment of the present invention,

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| Fig.5 | is a diagram of the change in the distance between the chassis and the forward wheelshaft and the distance between the chassis and a rear wheelshaft of the vehicle illustrated in Figs. 1a-f during a loading process, |
| Fig. 6 | is a diagram of the change in the distance between the chassis and the forward wheelshaft and the distance between the chassis and a rear wheelshaft of the vehicle illustrated in Figs. 1a-f during an unloading process, |
| Fig. 7 | is a schematic diagram of an electronic control unit for implementing a method according to the invention, and |
| Fig. 8 | is a flowchart illustrating a method according to an embodiment of the invention. |

## DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

Figs. 1a-f illustrate schematically a freight vehicle 1 provided with a load changer 10. The load changer 10 is mounted on the vehicle's chassis 2 behind the driving cab 3 and takes the form in the example illustrated of a load changer of conventional type with an L-shaped telescopic hook arm 11. The hook arm 11 is supported at its inner end for pivoting relative to a frame 12 of the load changer and is provided at its outer free end with a gripping means in the form of a hook 13. The hook arm 11 is pivotable relative to the frame 12 and the chassis 2 by a power means in the form of a hydraulic cylinder 14. The hook arm 11 comprises two arm elements 11a, 11b which are movable relative to one another. A first of these arm elements 11a is elongate and supported for pivoting relative to the frame 12, whereas the second arm element 11b is L-shaped and has a first portion accommodated for sliding in the first arm element 11a, and a second portion which extends perpendicularly toward the first portion and which bears at its outer end said hook 13. The two arm elements 11a, 11b are movable relative to one another in the longitudinal direction of the first arm element by a power means in the form of a hydraulic cylinder (not depicted) situated within the first arm element 11a.

The vehicle 1 comprises a forward wheel set which in the example illustrated comprises a forward wheelshaft 4 provided with two wheels 5, and a rear wheel set which in the example illustrated takes the form of a bogie and comprises a first rear wheelshaft 6a and a second rear wheelshaft 6b provided with two or more wheels 7 each. With advantage, the rear wheelshafts 6a, 6b are each provided with four wheels 7 fitted in pairs at the respective ends of the relating wheelshaft. The rear wheel set might alternatively comprise a single rear wheelshaft or three rear wheelshafts and the forward wheel set might alternatively comprise two forward wheelshafts.

The vehicle 1 is provided with an air suspension system 20 (see Figs. 2-4) which comprises a set of air bellows with two or more forward air bellows 30 at the forward wheelshaft 4 and a set of air bellows with two or more rear air bellows 40 at a rear wheelshaft 6a. Where the rear wheel set comprises more than one rear wheelshaft, a set of air bellows is usually provided at each rear wheelshaft. In Fig. 2, however, the one rear wheelshaft 6b is illustrated without air bellows.

The distance in the height direction between the rear wheelshaft 6a and the rear part of the vehicle’s chassis 2 is adjustable by regulating the air pressure in the air bellows 40 at the rear wheelshaft 6a, and the distance in the height direction between the forward wheelshaft 4 and the forward part of the vehicle’s chassis 2 is adjustable by regulating the air pressure in the air bellows 30 at the forward wheelshaft 4. The air pressure of said air bellows 30, 40 is regulated by an electronic control device 21 which is controllable by the vehicle’s driver via manually operable operating means 22 of an operating unit 23. The operating unit 23 may be firmly fitted in the driving cab 3 or be portable. The vehicle's driver can where necessary use the operating unit 23 to cause the control device 21 to change the height position of the chassis 2.

The air suspension system 20 comprises detection means 31 for detecting the distance in the height direction between the forward wheelshaft 4 and the chassis 2 of the vehicle, and detection means 41 for detecting the distance in the height direction between the rear wheelshaft 6a and the chassis 2 of the vehicle. The control device 21 is connected to said detection means 31, 41 in order to receive from them measured values representing said distances. In the example illustrated in Fig. 2, each detection means 31, 41 comprises an electrical sensor 32, 42 which is in a conventional way fastened to the vehicle's chassis 2 and connected to the respective wheelshaft 4, 6a via a link arm 33, 43. These sensors 32, 42 make it possible to determine the distance in the height direction between the chassis 2 and the respective forward and rear wheelshafts 4, 6a.

Fig. 3 illustrates schematically an air suspension system 20 according to a first embodiment of the invention in which the air suspension system comprises two forward air bellows 30 fitted at the vehicle's forward wheelshaft 4 and two rear air bellows 40 fitted at a rear wheelshaft 6a of the vehicle 1. In the example illustrated in Fig. 3, each air bellows 30, 40 has a combined inlet/outlet 34, 44 for input of compressed air to the air bellows and discharge of compressed air from the air bellows. The inlet/outlet 34, 44 of the air bellows is connectable via a regulating valve 35, 45 to a compressed air container 24 to provide input of compressed air to the air bellows from the compressed air container when the distance in the height direction between the vehicle's chassis 2 and the wheelshaft 4, 6a pertaining to the air bellows is to be increased. The inlet/outlet 34, 44 of the air bellows is also connectable via the regulating valve 35, 45 to the surroundings to allow discharge of air from the air bellows when the distance in the height direction between the vehicle's chassis 2 and the wheelshaft 4, 6a pertaining to the air bellows is to be decreased. Alternatively, each air bellows 30, 40 might be provided with a separate inlet and a separate outlet connectable respectively to the compressed air container and the surroundings via respective regulating valves. The electronic control device 21 is adapted to sending control signals to the regulating valve 35, 45 to regulate the air flow to and from the air bellows 30, 40 in order thereby to regulate the height position of the vehicle's chassis 2.

Fig. 4 illustrates schematically an air suspension system 20 according to a second embodiment of the invention, which air suspension system comprises two forward air bellows 30 fitted at the vehicle's forward wheelshaft 4, a first set of rear air bellows 40 fitted close to a first rear wheelshaft 6a of the vehicle 1 and a second set of rear air bellows 40b fitted close to a second rear wheelshaft 6b of the vehicle 1. In the example illustrated in Fig. 4, said rear air bellows sets comprise two air bellows each. In the embodiment according to Fig. 4, the air suspension system 20 comprises a first pressure sensor 46 for detecting the air pressure in the air bellows 40 at the one rear wheelshaft 6a, a second pressure sensor 46b for detecting the air pressure in the air bellows 40b at the second rear wheelshaft 6b, and a third pressure sensor 36 for detecting the air pressure in the air bellows 30 at the forward wheelshaft 4. The control device 21 is connected to the pressure sensors 36, 46, 46b in order to receive from them measured values representing said air pressure.

In the example illustrated in Fig. 4, each air bellows 30, 40, 40b comprises a combined inlet/outlet for input of compressed air to the air bellows and discharge of compressed air from the air bellows. The inlet/outlet of the air bellows is connectable via a regulating valve 35, 45, 45b to a compressed air container 24 to allow input of compressed air to the air bellows from the compressed air container. The inlet/outlet of the air bellows is also connectable to the surroundings via the regulating valve 35, 45, 45b to allow discharge of air from the air bellows. Alternatively, each air bellows 30, 40 might be provided with a separate inlet and a separate outlet connectable respectively to the compressed air container and the surroundings via respective regulating valves. The electronic control device 21 is adapted to sending control signals to the regulating valves 35, 45, 45b to regulate the air flow to and from the air bellows 30, 40, 40b in order thereby to regulate the height position of the vehicle's chassis 2 and/or the distribution of axle pressure between the rear wheelshafts 6a, 6b.

The control device 21 may comprise a single electronic control unit of the vehicle, as illustrated in Figs. 2-4, or two or more mutually cooperating electronic control units.

The control device 21 can be set to effect the automatic level regulation in a conventional manner on the basis of measured values received from the aforesaid detection means 31, 41 and thereby regulate the air pressure in the air suspension system's air bellows in such a way that the vehicle's chassis 2 is caused to assume a preset height position $h_{ref}$ relative to the wheelshafts 4, 6a, 6b irrespective of the loading on them. When the automatic level regulation is active and the control device 21 finds that the distance in the height direction between any of the wheelshaft and the chassis deviates to a certain given extent, usually of the order of 5-10 mm, from the preset height position $h_{ref}$, the control device effects regulation of the air pressure in the air suspension system's air bellows so that this distance is brought back toward the preset height position $h_{ref}$.

In the embodiment illustrated in Fig. 4, the control device 21 can also be set to effect in a conventional way automatic regulation of the axle pressure of the rear wheelshafts 6a, 6b on the basis of measured values received from the aforesaid pressure sensors 46, 46b and thereby regulate the air pressure in the air bellows 40, 40b of the rear wheelshafts in such a way that the axle pressure of the first rear wheelshaft 6a and the axle pressure of the second rear wheelshaft 6b are caused to assume a preset relationship to one another.

The control device 21 is adapted to determining or receiving values pertaining to a first parameter P1 which represents the distance in the height direction between the forward wheelshaft 4 and the chassis 2 of the vehicle or the air pressure in the air bellows 40 at a rear wheelshaft 6a, and values pertaining to a second parameter P2 which represents the distance in the height direction between said rear wheelshaft 6a and the chassis 2 of the vehicle or the air pressure in the air bellows 30 at the forward wheelshaft 4.

In the embodiment illustrated in Fig. 3, the first parameter P1 represents the distance in the height direction between the forward wheelshaft 4 and the chassis 2, while the second parameter P2 represents the distance in the height direction between the rear wheelshaft 6a and the chassis 2. The values of the parameters P1, P2 are obtained in this case from the aforesaid detection means 31, 41.

In the embodiment illustrated in Fig. 4, the first parameter P1 represents either the distance in the height direction between the forward wheelshaft 4 and the chassis 2 of the vehicle or the air pressure in the air bellows 40 at a rear wheelshaft 6a, while the second parameter P2 represents either the distance in the height direction between a rear wheelshaft 6a and the chassis 2 of the vehicle or the air pressure in the forward air bellows 30. The values of parameters P1, P2 are obtained in this case either from the detection means 31, 41 or the pressure sensors 36, 46a.

Figs. 1a-f illustrate various steps during a process for loading a load carrier 50 onto the vehicle 1 by means of the vehicle’s load changer 10. The hook arm 11 is first pivoted rearward and the hook 13 is hooked firmly in a fastening means 51 of the load carrier (see Fig. 1a). Thereafter the hook arm 11 is pivoted forward so that the forward end of the load carrier 50 is lifted from the ground and moved up over the rear end of the vehicle (see Figs. 1b and 1c). As the pivoting of the hook arm 11 proceeds, the underside of the load carrier comes to abut against supporting rollers 15 fitted at the rear end of the frame 12 of the load changer (see Fig. 1d) and will thereafter assume a horizontal position on the frame 12 (see Fig. 1e). Finally, the L-shaped arm element 11a is moved relative to the elongate arm element 11b so that the load carrier 50 is moved forward along the vehicle to its final position (see Fig. 1f).

The control device 21 is adapted to inactivating the automatic level regulation when the control device finds that the following conditions, possibly in combination with one or more further conditions, are simultaneously fulfilled:

- the value of said first parameter P1 is increasing, and
- the value of said second parameter P2 is decreasing.

The control device 21 is thereafter adapted to reactivating the automatic level regulation when the control device finds that one or more predetermined reactivation conditions are fulfilled.

Said inactivation of the automatic level regulation is with advantage effected by the automatic level regulation being completely switched off and remaining switched off until said reactivation.

When the automatic level regulation is active, a small range about the preset height position $h_{ref}$ is defined, and only when the distance detected between a wheelshaft and the chassis deviates from that range will the control device 21 come into action and adjust the air pressure in the air suspension system's air bellows. This range extends from $h_{ref}$-x to $h_{ref}$+x, where x is normally about 5-10 mm. Said inactivation of the automatic level regulation might alternatively be effected by this range being greatly increased, e.g. so that x is increased to a value of the order of 200 mm, in which case x reverts to its normal value of about 5-10 mm upon said reactivation of the automatic level regulation.

The condition for reactivation of the automatic level regulation might for example be that a given amount of time, e.g. of the order of 30-60 seconds, has passed since the automatic level regulation was inactivated. An alternative condition for reactivation of the automatic level regulation might be that the vehicle's speed exceeds a given upper limit value, e.g. of the order of 20 km/h. As a further alternative, the control device might be adapted to reactivating the automatic level regulation when the following conditions are simultaneous fulfilled:

- said first parameter P1 has stabilised, and
- said second parameter P2 has stabilised.

During the loading process illustrated in Figs. 1a-f, the distance between the forward wheelshaft 4 and the chassis 2 and the distance between the rear wheelshaft 6a and the chassis 2 change in the manner illustrated in Fig. 5. In Fig. 5, the continuous curve K1 represents the distance between the forward wheelshaft 4 and the chassis 2 as a function of time during the loading process, while the broken curve K2 represents the distance between the rear wheelshaft 6a and the chassis 2 as a function of time during the loading process. When the forward end of the load carrier 50 is lifted from the ground at time t1, the distance between the forward wheelshaft 4 and the chassis 2 increases, and the distance between the rear wheelshaft 6a and the chassis decreases. At the same time, the air pressure in the forward air bellows 30 decreases, and the air pressure in the rear air bellows 40 increases. Consequently, the aforesaid first parameter P1 increases and the aforesaid second parameter P2 decreases and the control device 21 therefore inactivates the automatic level regulation immediately after time t1. During the remainder of the loading process, the control device 21 effects no regulation of the height position of the chassis 2. When the load carrier 50 reaches its final position on the vehicle at time t2, the distance between the respective wheelshafts 4, 6a and the chassis 2 will stabilise. At the same time, the air pressure in the forward and rear air bellows 30, 40 stabilises. Consequently the aforesaid first and second parameters P1, P2 stabilise and the control device 21 therefore reactivates the automatic level regulation immediately after time t2.

According to an alternative embodiment, the control device 21 is adapted to inactivating the automatic level regulation when the control device finds that the following conditions are simultaneously fulfilled:

- the value of the first parameter P1 is increasing,
- the value of the second parameter P2 is decreasing, and
- the speed of the vehicle is lower than or equal to a given lower limit value, e.g. of the order of 0-10 km/h.

In the embodiment illustrated in Fig. 4, the control device 21 is adapted to also inactivating the automatic axle pressure regulation when it inactivates the automatic level regulation.

A process for unloading the load carrier 50 from the vehicle 1 by means of the load changer 10 takes place in the opposite manner to the loading process described above, i.e. in accordance with the steps according to Figs. 1a-f in reverse order. During this unloading process, the distance between the forward wheelshaft 4 and the chassis 2 and the distance between the rear wheelshaft 6a and the chassis 2 change in the manner illustrated in Fig. 6. In Fig. 6, the continuous curve K3 represents the distance between the forward wheelshaft 4 and the chassis 2 as a function of time during the unloading process, while the broken curve K4 represents the distance between the rear wheelshaft 6a and the chassis 2 as a function of time during the unloading process. When the load carrier 50 starts moving rearward along the vehicle 1 at time t3, the distance between the forward wheelshaft 4 and the chassis 2 increases, and the distance between the rear wheelshaft 6a and the chassis decreases somewhat. At the same time, the air pressure in the forward air bellows 30 decreases, and the air pressure in the rear air bellows 40 increases. Consequently the aforesaid first parameter P1 increases and the aforesaid second parameter P2 decreases and the control device 21 therefore inactivates the automatic level regulation immediately after time t3. During the remainder of the unloading process, the control device 21 effects no regulation of the height position of the chassis 2. When the load carrier 50 reaches its final position on the ground behind the vehicle at time t4, the distance between the respective wheelshafts 4, 6a and the chassis 2 will stabilise. At the same time, the air pressure in the forward and rear air bellows 30, 40 stabilises. Consequently the aforesaid first and second parameters P1, P2 stabilise and the control device 21 therefore reactivates the automatic level regulation immediately after time t4.

Fig. 8 is a flowchart illustrating an embodiment of a method according to the present invention for regulating the chassis height of a vehicle provided with a load changer. At a first step S1 the electronic control device 21 of an air suspension system 20 of the type described above determines or receives values pertaining to a first parameter P1 which represents the distance in the height direction between the forward wheelshaft 4 and the chassis 2 of the vehicle or the air pressure in the rear air bellows 40, and values pertaining to a second parameter P2 which represents the distance in the height direction between the rear wheelshaft 6a and the chassis 2 of the vehicle or the air pressure in the forward air bellows 30. At the next step S2, the control device 21 determines whether the value of said first parameter P1 is increasing and whether the value of said second parameter P2 is decreasing. If it is found at step S2 that the value of the first parameter P1 is increasing while at the same time the value of the second parameter P2 is decreasing, the control device 21 inactivates an ongoing automatic level regulation at a third step S3. If such is found not to be the case, steps S1 and S2 are repeated. After an ongoing automatic level regulation has been inactivated at step S3, the control device 21 determines at a fourth step S4 whether a condition for reactivation of the automatic level regulation is fulfilled. If at step S4 it is found that a condition for reactivation of the automatic level regulation is fulfilled, the control device 21 activates the automatic level regulation at a fifth step S5, followed by repeating of steps S1 and S2. If at step S4 it is found that a condition for reactivation of the automatic level regulation is not fulfilled, step S4 is repeated.

Computer programme code for implementing a method according to the invention is with advantage included in a computer programme which can be read into the internal memory of a computer, e.g. the internal memory of an electronic control unit of a vehicle provided with a load carrier. Such a computer programme is with advantage provided via a computer programme product comprising a data storage medium which is readable by an electronic control unit and which has the computer programme stored on it. Said data storage medium is for example an optical data storage medium in the form of a CD ROM disc, a DVD disc etc, a magnetic data storage medium in the form of a hard disc, a diskette, a cassette tape etc, or a flash memory or a memory of the ROM, PROM, EPROM or EEPROM type.

A computer programme according to an embodiment of the invention comprises computer programme code for causing an electronic control device 21 of the air suspension system in a vehicle with an air suspension system 20 of the type described above to

- receive from the aforesaid detection means 31, 41 measured values representing the distance between a forward wheelshaft 4 and the chassis 2 and the distance between a rear wheelshaft 6a and the chassis 2,
- effect automatic level regulation and thereby regulate the air pressure in the air bellows 30 at the forward wheelshaft 4 and in the air bellows 40 at the rear wheelshaft 6a in such a way that the vehicle's chassis 2 is caused to assume a preset height position $h_{ref}$ relative to the wheelshafts 4, 6a,
- determine or receive values pertaining to a first parameter P1 and values pertaining to a second parameter P2, such that the first parameter P1 represents the distance in the height direction

between the forward wheelshaft 4 and the chassis 2 or the air pressure in the air bellows 40 at the rear wheelshaft 6a, and the second parameter P2 represents the distance in the height direction between the rear wheelshaft 6a and the chassis 2 or the air pressure in the air bellows 30 at the forward wheelshaft 4, and

- inactivate the automatic level regulation when the control device finds that the following conditions, possibly in combination with one or more further conditions, are simultaneously fulfilled:

- the value of said first parameter P1 is increasing, and
- the value of said second parameter P2 is decreasing.

Fig. 7 illustrates very schematically an electronic control unit 60 comprising an execution means 61, e.g. a central processor unit (CPU), for execution of computer software. The execution means 61 communicates with a memory 63, e.g. of the RAM type, via a data bus 62. The control unit 60 comprises also a data storage medium 64, e.g. in the form of a flash memory or a memory of the ROM, PROM, EPROM or EEPROM type. The execution means 61 communicates with the data storage means 64 via the data bus 62. A computer programme comprising computer programme code for implementing a method according to the invention, e.g. in accordance with the embodiment illustrated in Fig. 8, is stored on the data storage medium 64.

The invention is of course in no way limited to the embodiments described above, since a multiplicity of possibilities for modifications thereof are likely to be obvious to a specialist in the field without having for that purpose to deviate from the basic concept of the invention such as defined in the attached claims. The invention may for example be applied to a vehicle provided with the load changer of some other type than the load changer illustrated in Figs. 1a-f, e.g. a load changer with hook arm of the type described in WO 03/074323 A1 or WO 2006/093458 A1 or a load changer with draw wire of the type described in GB 1 474 322 A.

CLAIMS

1. An air suspension system for a vehicle which is provided with a load changer, which air suspension system comprises:
- two or more forward air bellows (30) by means of which the distance in the height direction between a forward wheelshaft and the chassis of the vehicle is adjustable,
- first detection means (31) for detecting the distance in the height direction between said forward wheelshaft and the chassis of the vehicle,
- two or more rear air bellows (40) by means of which the distance in the height direction between a rear wheelshaft and the chassis of the vehicle is adjustable,
- second detection means (41) for detecting the distance in the height direction between said rear wheelshaft and the chassis of the vehicle, and
- an electronic control device (21) for controlling the air pressure in the respective air bellows (30, 40) and hence the distance in the height direction between the respective wheelshafts and the chassis of the vehicle, such that this control device (21) is connected to said first and second detection means (31, 41) in order to receive from them measured values representing said distance and can be set to effect automatic level regulation and hence regulate the air pressure in said air bellows (30, 40) in such a way that the vehicle's chassis is caused to assume a preset height position ($h_{ref}$) relative to the wheelshafts,
**characterised** in that:
- the control device (21) is adapted to determining or receiving values pertaining to a first parameter (P1) and values pertaining to a second parameter (P2), such that the first parameter (P1) represents the distance in the height direction between said forward wheelshaft and the chassis of the vehicle or the air pressure in the rear air bellows (40), and the second parameter (P2) represents the distance in the height direction between said rear wheelshaft and the chassis

of the vehicle or the air pressure in the forward air bellows (30), and

- the control device (21) is adapted to inactivating the automatic level regulation when the control device finds that the following conditions, possibly in combination with one or more further conditions, are simultaneously fulfilled:
  - the value of said first parameter (P1) is increasing, and
  - the value of said second parameter (P2) is decreasing.

2. An air suspension system according to claim 1, **characterised** in that the control device (21) is adapted to inactivating the automatic level regulation when the control device finds that the following conditions are simultaneously fulfilled:
   - the value of the first parameter (P1) is increasing,
   - the value of the second parameter (P2) is decreasing, and
   - the speed of the vehicle is lower than or equal to a given limit value.

3. An air suspension system according to claim 1 or 2, **characterised** in that, after inactivation of the automatic level regulation, the control device (21) is adapted to activating the automatic level regulation when the control device finds that the following conditions are simultaneous fulfilled:
   - said first parameter (P1) has stabilised, and,
   - said second parameter (P2) has stabilised.

4. An air suspension system according to any one of claims 1-3, **characterised** in that, after inactivation of the automatic level regulation, the control device (21) is adapted to activating the automatic level regulation when the control device finds that the speed of the vehicle exceeds a given limit value.

5. An air suspension system according to any one of claims 1-4, **characterised** in that, after inactivation of the automatic level regulation, the control device (21) is adapted to activating the

automatic level regulation when the control device finds that a given amount of time has passed since the time when the automatic level regulation was inactivated.

6. An air suspension system according to any one of claims 1-5, **characterised** in that:
- said rear air bellows (40) take the form of a first set of rear air bellows fitted close to a first rear wheelshaft of the vehicle,
- the air suspension system (20) also comprises:
  - a second set of rear air bellows (40b) fitted close to a second rear wheelshaft of the vehicle,
  - a first pressure sensor (46) for detecting the air pressure in the air bellows (40) of said first set of rear air bellows, and
  - a second pressure sensor (46b) for detecting the air pressure in the air bellows (40b) of said second set of rear air bellows,

- the control device (21) is connected to said first and second pressure sensors (46, 46b) in order to receive from them measured values representing said air pressure, such that the control device can be set to effect automatic regulation of the axle pressure of said rear wheelshafts by regulating the air pressure in the air bellows (40, 40b) of said sets of rear air bellows in such a way that the axle pressure of the first rear wheelshaft and the axle pressure of the second rear wheelshaft are caused to assume a preset relationship to one another, and
- the control device (21) is adapted to also inactivating the automatic axle pressure regulation when it inactivates the automatic level regulation.

7. An air suspension system according to claim 6, **characterised** in that the control device (21) is adapted to activating the automatic axle pressure regulation when it activates the automatic level regulation.

8. A method for regulating the air pressure in the air bellows of an air suspension system of a vehicle which is provided with a load changer, which air suspension system comprises:
- two or more forward air bellows (30) by means of which the distance in the height direction between a forward wheelshaft (4) and the chassis (2) of the vehicle is adjustable,
- first detection means (31) for detecting the distance in the height direction between said forward wheelshaft (4) and the chassis (2) of the vehicle,
- two or more rear air bellows (40) by means of which the distance in the height direction between a rear wheelshaft (6a) and the chassis (2) of the vehicle is adjustable,
- second detection means (41) for detecting the distance in the height direction between said rear wheelshaft (6a) and the chassis (2) of the vehicle, and
- an electronic control device (21) for controlling the air pressure in the respective air bellows (30, 40) and hence the distance in the height direction between the respective wheelshafts (4, 6a) and the chassis (2) of the vehicle, such that this control device (21) is connected to said first and second detection means (31, 41) in order to receive from them measured values representing said distance and can be set to effect automatic level regulation and hence regulate the air pressure in said air bellows (30, 40) in such a way that the vehicle's chassis is caused to assume a preset height position ($h_{ref}$) relative to the wheelshafts,
**characterised** in that:
- the control device (21) determines or receives values pertaining to a first parameter (P1) and values pertaining to a second parameter (P2), such that the first parameter (P1) represents the distance in the height direction between said forward wheelshaft (4) and the chassis (2) of the vehicle or the air pressure in the rear air bellows (40), and the second parameter (P2) represents the distance in the height direction between said rear wheelshaft (6a) and the chassis (2) of the vehicle or the air pressure in the forward air bellows (30), and

- the control device (21) inactivates the automatic level regulation when the control device finds that the following conditions, possibly in combination with one or more further conditions, are simultaneously fulfilled:
    - the value of said first parameter (P1) is increasing, and
    - the value of said second parameter (P2) is decreasing.

9. A method according to claim 8, **characterised** in that the control device (21) inactivates the automatic level regulation when the control device finds that the following conditions are simultaneously fulfilled:
    - the value of the first parameter (P1) is increasing,
    - the value of the second parameter (P2) is decreasing, and
    - the speed of the vehicle is lower than or equal to a given limit value.

10. A method according to claim 8 or 9, **characterised** in that, after inactivation of the automatic level regulation, the control device (21) activates the automatic level regulation when the control device finds that the following conditions are simultaneous fulfilled:
    - said first parameter (P1) has stabilised, and,
    - said second parameter (P2) has stabilised.

11. A method according to any one of claims 8-10, **characterised** in that, after inactivation of the automatic level regulation, the control device (21) activates the automatic level regulation when the control device finds that the speed of the vehicle exceeds a given limit value.

12. A method according to any one of claims 8-11, **characterised** in that, after inactivation of the automatic level regulation, the control device (21) activates the automatic level regulation when the control device finds that a given amount of time has passed since the time when the automatic level regulation was inactivated.

13. A computer programme product comprising computer programme code in order, in a vehicle which is provided with
    - a load changer,
    - two or more forward air bellows by means of which the distance in the height direction between a forward wheelshaft and the chassis of the vehicle is adjustable,
    - first detection means for detecting the distance in the height direction between said forward wheelshaft and the chassis of the vehicle,
    - two or more rear air bellows by means of which the distance in the height direction between a rear wheelshaft and the chassis of the vehicle is adjustable,
    - second detection means for detecting the distance in the height direction between said rear wheelshaft and the chassis of the vehicle,

    to cause an electronic control device of the vehicle to:

    - receive from said first and second detection means measured values representing said distance,

    - effect automatic level regulation and thereby regulate the air pressure in said air bellows in such a way that vehicle's chassis is caused to assume a preset height position ($h_{ref}$) relative to the wheelshafts,

    - determine or receive values pertaining to a first parameter (P1) and values pertaining to a second parameter (P2), such that the first parameter (P1) represents the distance in the height direction between said forward wheelshaft and the chassis of the vehicle or the air pressure in the rear air bellows, and the second parameter (P2) represents the distance in the height direction between said rear wheelshaft and the chassis of the vehicle or the air pressure in the forward air bellows, and

    - inactivate the automatic level regulation when the control device finds that the following conditions, possibly in combination with one or more further conditions, are simultaneously fulfilled:
    - the value of said first parameter (P1) is increasing, and

- the value of said second parameter (P2) is decreasing.

14. A computer programme product according to claim 13, **characterised** in that the computer programme product comprises a data storage medium which is readable by an electronic control device, said computer programme code being stored on the data storage medium.

15. An electronic control device of a vehicle provided with a load changer, comprising an execution means (61), a memory (63) connected to the execution means, and a data storage medium (64) connected to the execution means, the computer programme code of a computer programme product according to claim 13 being stored on said data storage medium (64).

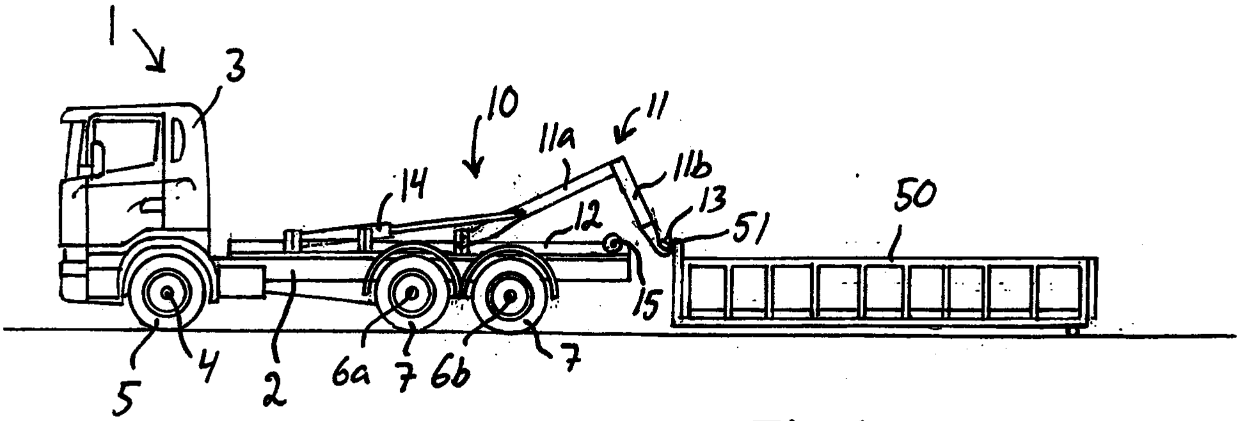


Fig 1a

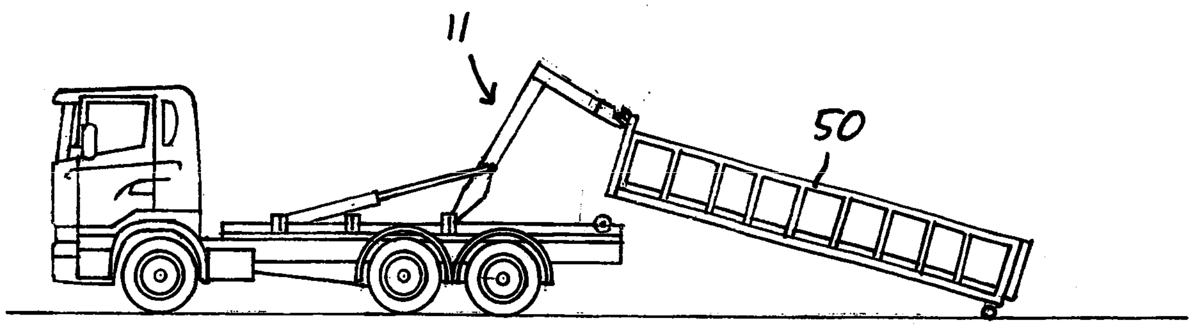


Fig 1b

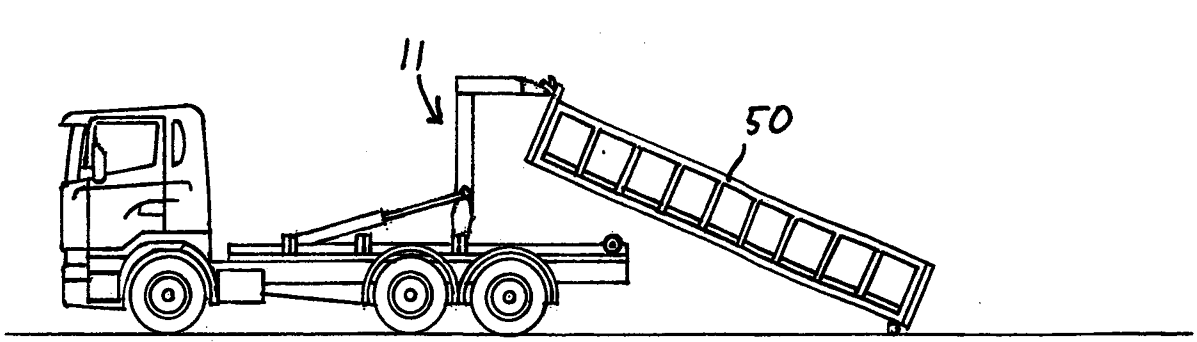


Fig 1c

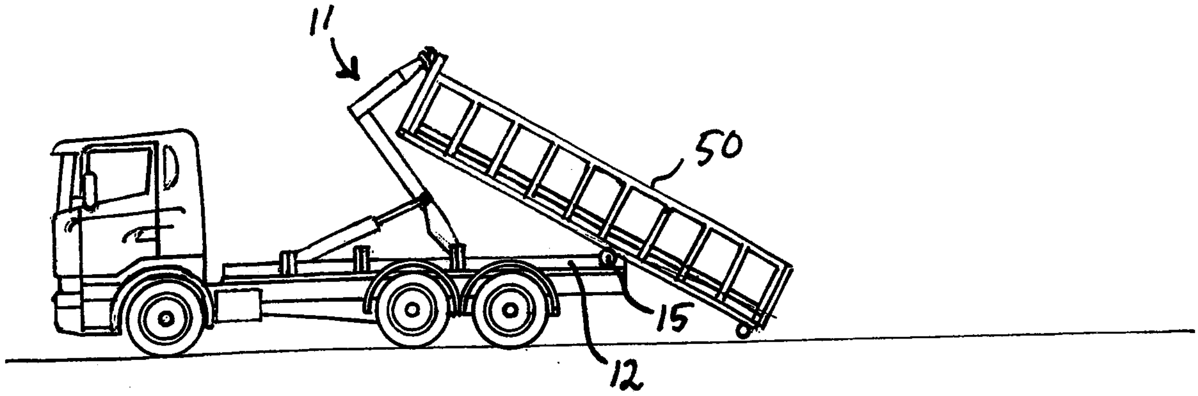


Fig 1d

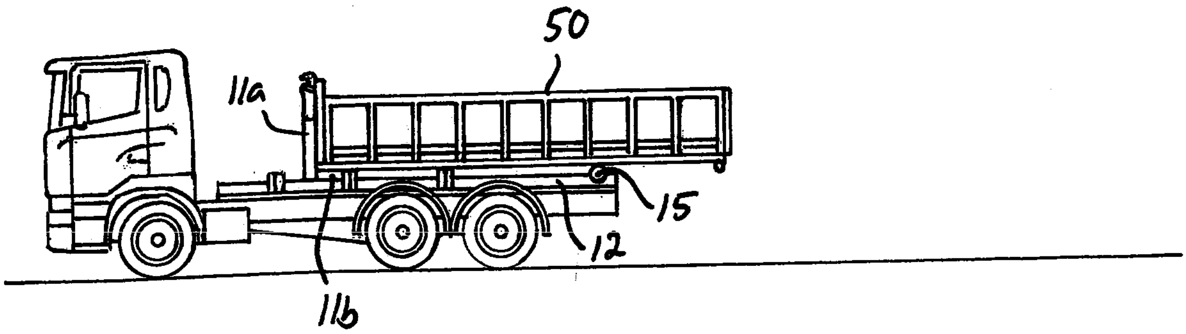


Fig 1e

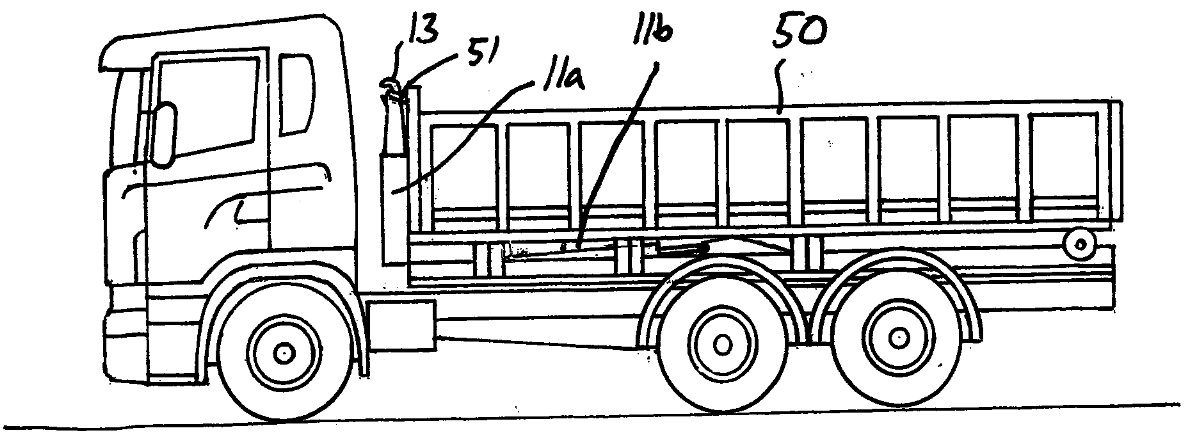


Fig 1f

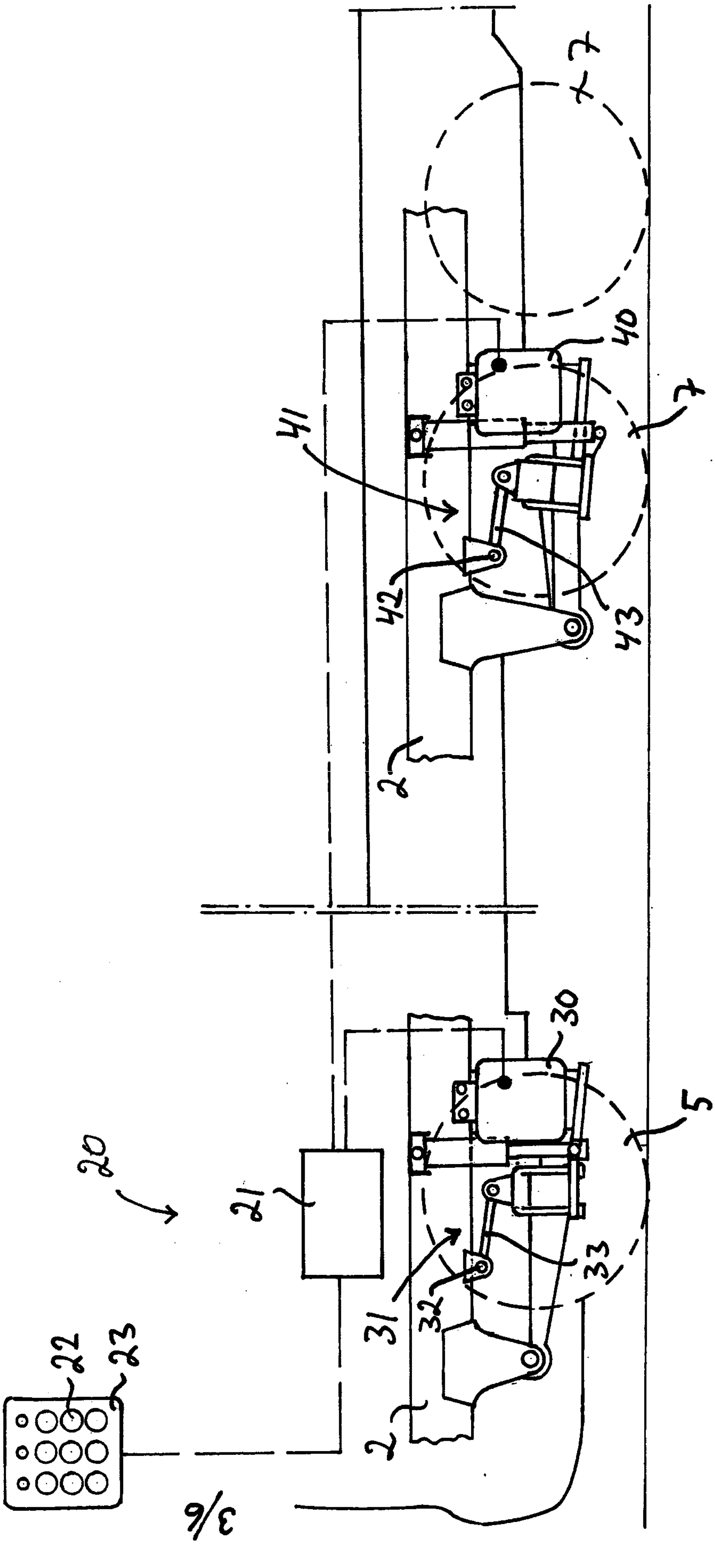


Fig 2

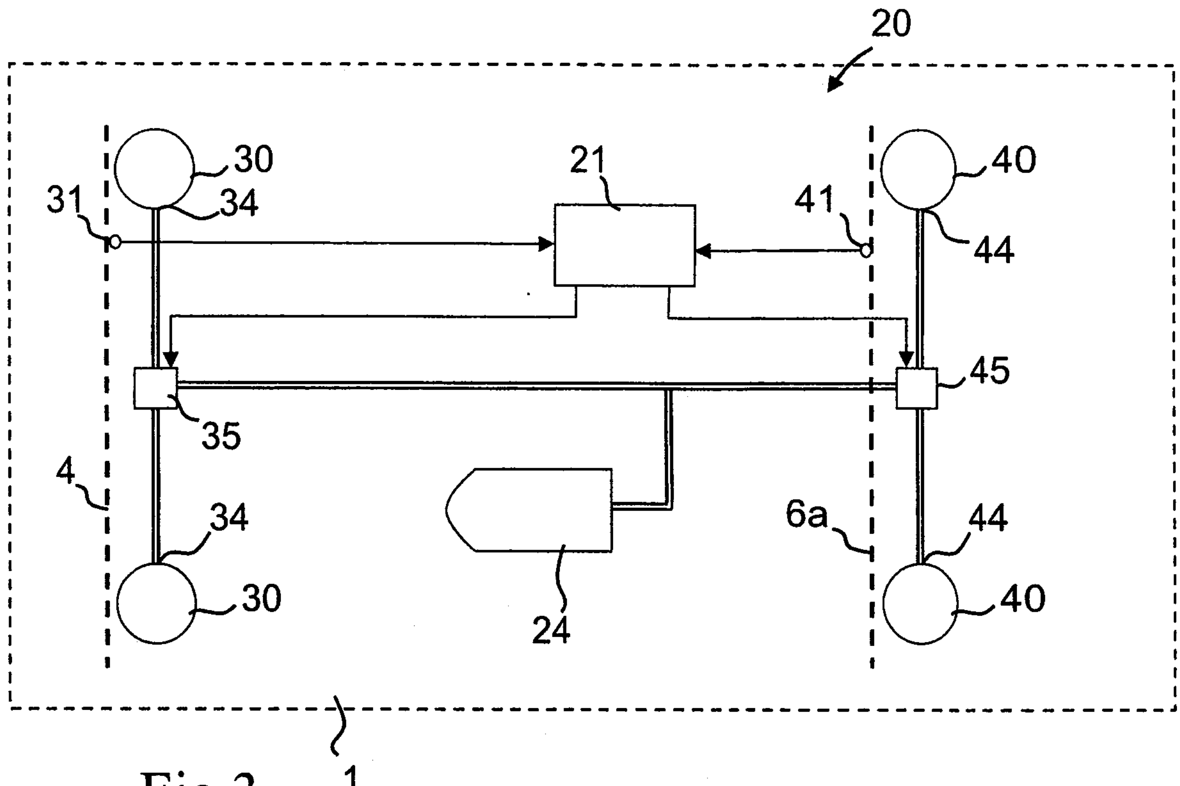
20
30
31
34
21
41
40
44
45
35
4
34
24
6a
44
30
40
1

Fig 3

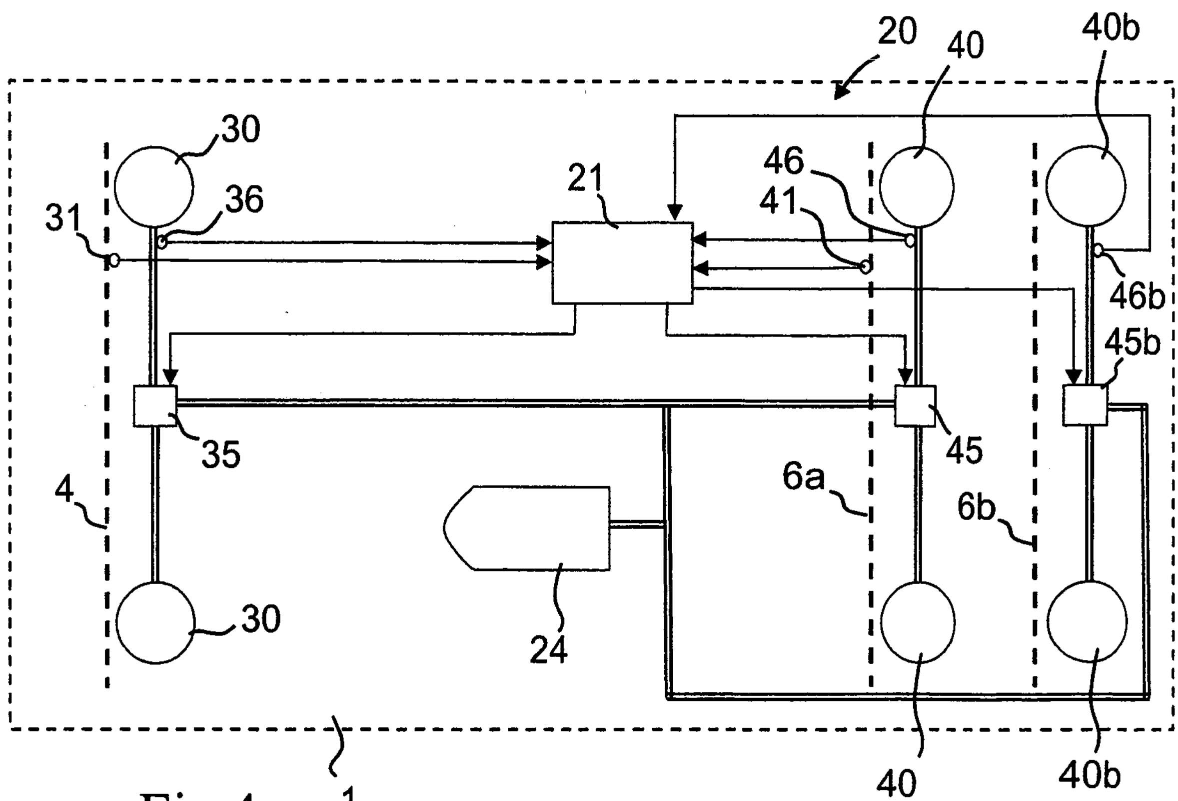
20
40
40b
30
46
36
21
41
31
46b
45b
35
45
6a
4
6b
24
30
40
40b
1

Fig 4

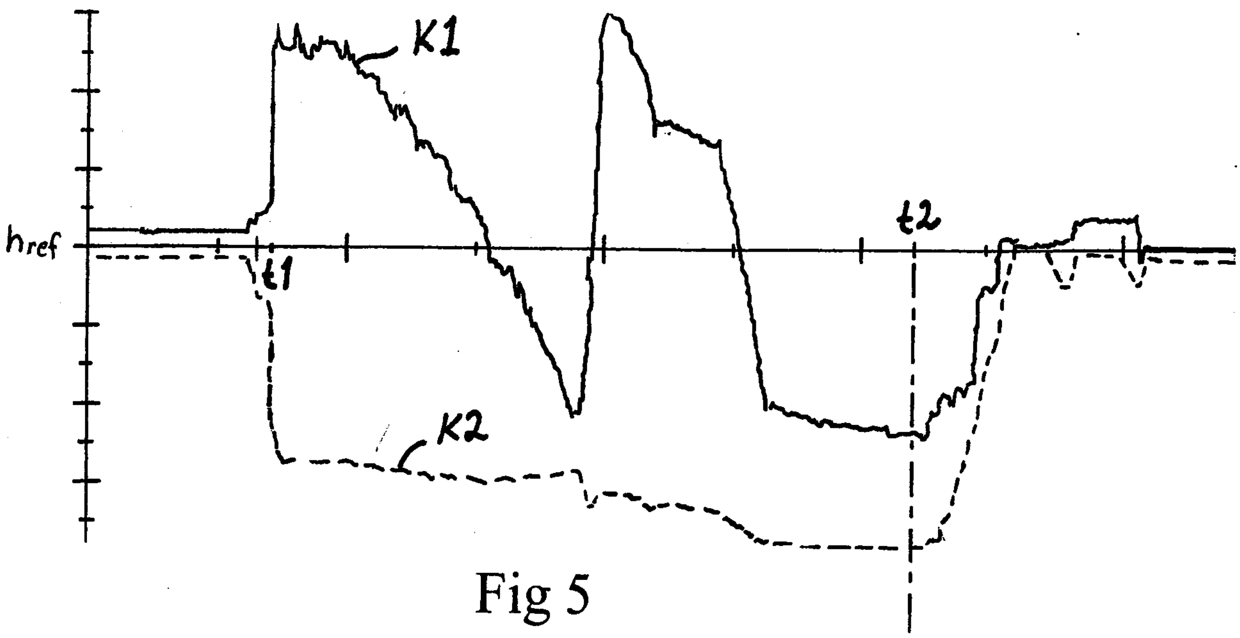


Fig 5

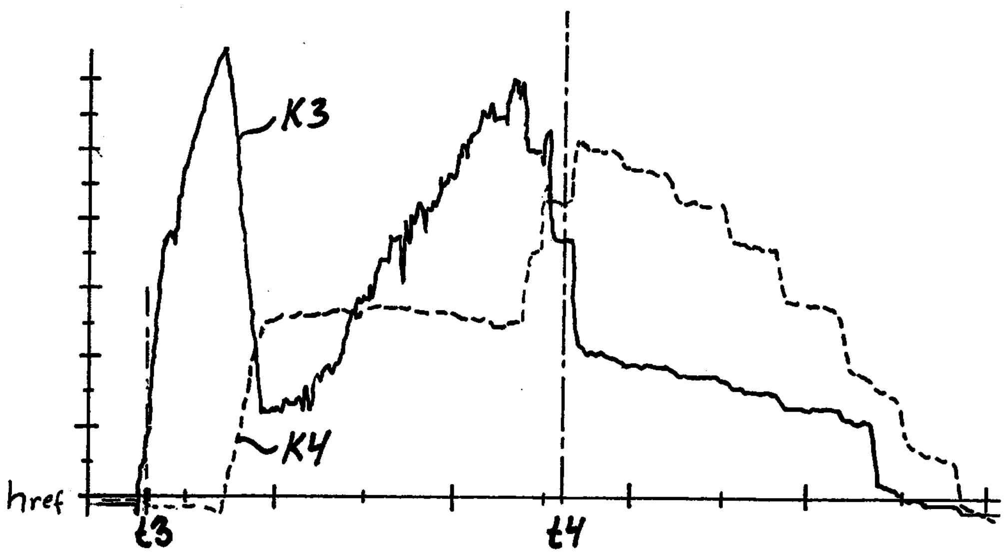


Fig 6

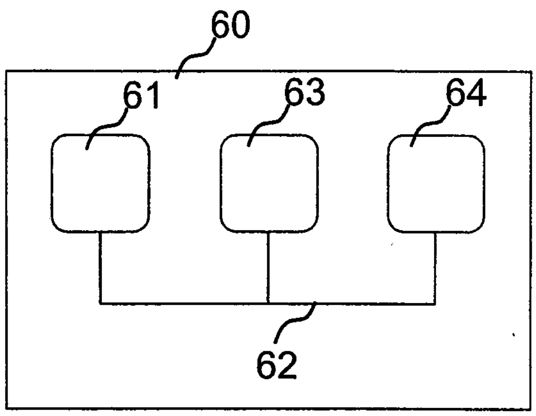
60
61
63
64
62

Fig 7

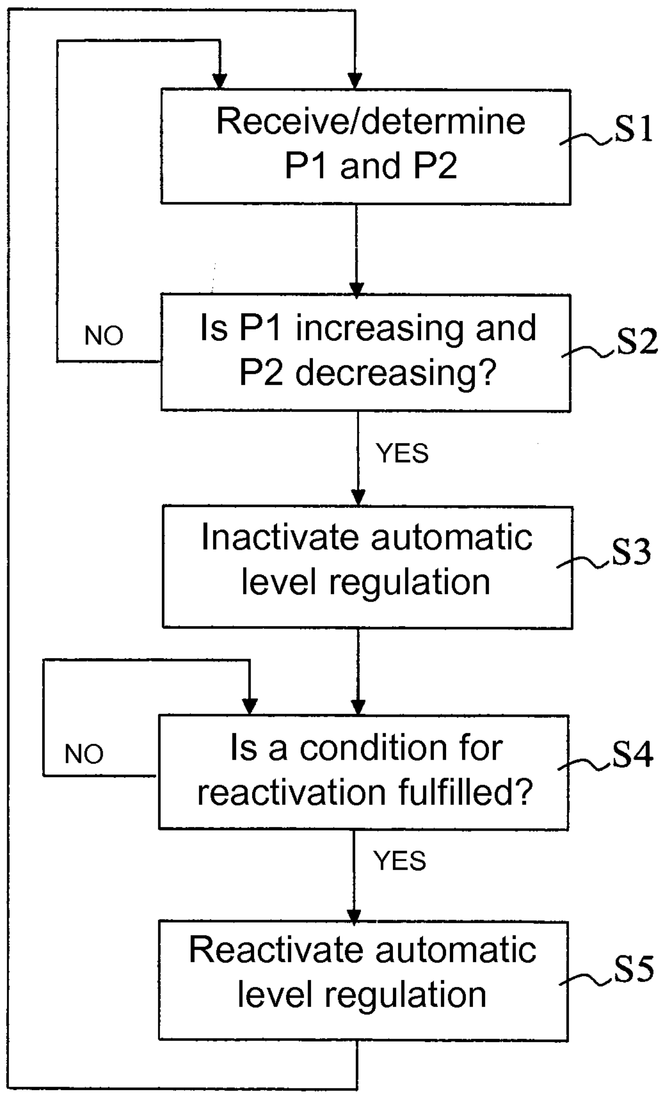
Receive/determine P1 and P2
S1
Is P1 increasing and P2 decreasing?
S2
NO
YES
Inactivate automatic level regulation
S3
Is a condition for reactivation fulfilled?
S4
NO
YES
Reactivate automatic level regulation
S5

Fig 8