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(71) Applicant
Mercedes-Benz Aktiengesellschaft

(Incorporated in the Federal Republic of Germany)

Stuttgart-Unterturkheim, Federal Republic of Germany

(72) Inventors
Rainer Freitag
Richard Zimmer
Wolfgang Gautsch
Armin Muller

(74) Agent and/or Address for Service
Jensen & Son
70 Paul Street, London, EC2A 4NA, United Kingdom

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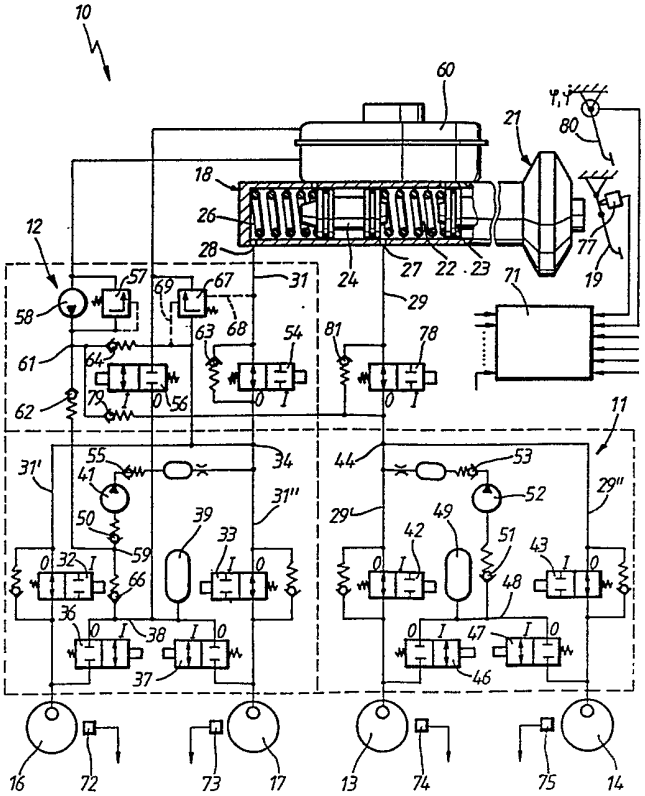
(54) Process for activating the hydraulic service-brake system of a road vehicle

(57) In a vehicle equipped both with an anti-lock system working on the return-flow principle and with a drive-slip control device working on the principle of the differential brake, in which the return pump 41 is utilised as an auxiliary pressure source for applying the brakes 16, 17 of the driven vehicle wheels in drive-slip control, a pump 58 working at a low pressure level is activated, even before the drive slip control responds, and conveys brake fluid both into the brake circuit of the driven vehicle wheels and into the brake circuit of the non-driven vehicle wheels, which are shut off from the brake unit of the brake system by means of an ASR-function control valve 54 on the one hand and by means of an isolating valve 78 on the other hand. The pump 58 is the pre-charge pump of the returns pump of the brake circuits. This pressurisation of the brake circuits with a moderate brake pressure causes a compensation of the lifting play and is utilised both for the drive-slip control and for normal braking.



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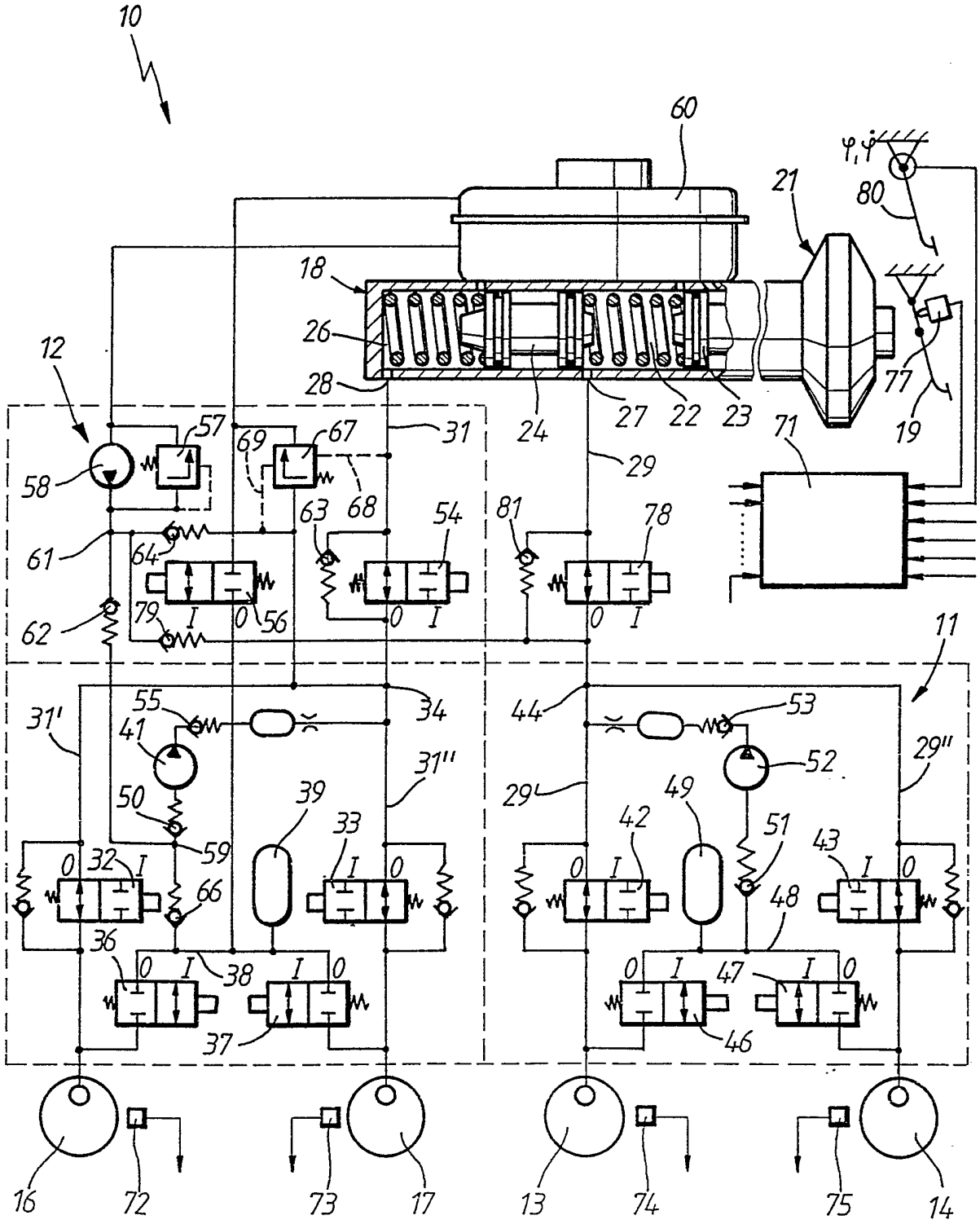
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Process for activating the hydraulic service-brake system of a road vehicle

The invention relates to a process for activating the hydraulic service-brake system of a road vehicle, the vehicle being equipped with an anti-lock system working on the return-flow principle and with a drive-slip control device working on the principle of the differential brake - activation of the wheel brake of a driven vehicle wheel tending to spin. The purpose of the process is to obtain as rapid a situation-related response as possible of the brake of the driven vehicle wheel when the latter is tending to spin. For this, when the drive-slip control commences, the main brake-line of the brake circuit of the driven vehicle wheels is shut off from the static master cylinder of the brake system and for the build-up of brake pressure in the brake circuit of the driven vehicle wheels use is made of the return pump provided for this brake circuit and belonging to the anti-lock system which is designed to work on the return-flow principle. In order to set a specific high pressure level as early as at the commencement of the control, that portion of the main brake-line and its portions branching off towards the wheel brakes via which the ASR-function control valve is connected to the brake-pressure regulating valves which are assigned individually to the driven vehicle wheels and by means of which brake-pressure build-up, holding and reduction phases both of the drive-slip and of the anti-lock control can be controlled even before the ASR-control commences, is charged to specific high pressure, the brake-pressure regulating valves previously being changed to their blocking positions and the return pump simultaneously being activated as a pressure source. This activation of the return pump and changeover of the brake-pressure regulating valves takes place at a moment when the situation requiring control begins to emerge, that is to say an electronic control unit detects, by means of output signals from wheel-speed sensors assigned individually to the vehicle wheels, that the wheel acceleration and/or the drive-slip is beginning to increase and threshold values of the acceleration and/or of the drive-slip are being exceeded, these, although not yet

requiring a cut-in of the control, nevertheless indicating that this will very soon be the case.

A process of this type is known from DE 3,839,178 A1.

This known process, although to a reasonably satisfactory extent serving the purpose of ensuring a rapid response of the control, nevertheless has the disadvantage that those parts of the main brake-line of the brake circuit of the driven vehicle wheels utilised as it were as additional pressure accumulators are pressurised to a very high pressure and, should the control still not commence immediately, but only relatively late, are therefore subjected to very high load. Pressure relief valves which are designed for a high pressure level and which involve a comparatively high outlay and susceptible to faults consequently have to be provided. The brake system has to be protected against damage to the ASR-control valve, by means of which the master cylinder of the brake system is shut off from the main brake-line in the control mode, that is to say central valves provided in the brake master cylinder have to be designed for a high load-bearing capacity, so that they cannot be damaged in the event of a pressure surge which could occur as a result of damage to the ASR-control valve, thus necessitating a construction of the brake unit which involves a high outlay.

In addition, the storage capacity of the brake-line portions connected between the ASR-function control valve and the brake-pressure regulating valves is limited and therefore is not infrequently insufficient to guarantee, with the response of the control, also an immediate effective application of the wheel brake or wheel brakes subjected to the control, this can occur especially when the lifting play of the wheel-brake cylinders has become relatively large, this regularly happening when the brake system has been actuated with only moderate force over a plurality of braking operations and consequently the pistons of the wheel-brake cylinders have been displaced only within the elastic deformability of their sealing rings acting at the same time as return elements, with the result that relatively long displacement travels of the wheel-cylinder pistons are first necessary in order to apply the brakes

effectively. In such instances, a sluggish response behaviour of the drive-slip control then has to be accepted nonetheless, this of course being undesirable.

The present invention seeks, therefore, to provide a process of the type mentioned in the introduction which guarantees a reliable, rapid response of the drive-slip control independently of the particular lifting play of the brake system and a brake system which allows an automatically controlled use of the process on a road vehicle.

According to the present invention there is provided a process for activating the hydraulic service-brake system of a road vehicle which is equipped both with an anti-lock system (ABS) working on the return-flow principle and with a drive-slip control device (ASR) working on the principle of the differential brake, according to which a driven vehicle wheel tending to spin is decelerated again as a result of the activation of its wheel brake, an outlet-pressure space, assigned to braking driven vehicle wheels, of a brake unit provided for generating static brake pressure being shut off in control phases of the drive-slip control by means of an ASR-function control valve from the main brake-line of the brake circuit of the driven vehicle wheels branching off to the brakes of the driven vehicle wheels, and the brake-pressure build-up taking place as a result of the activation of a pump, by means of which, even before brake pressure is fed into the wheel brake of the vehicle wheel subjected to the control, brake-line portions or branches of the brake circuit of the driven vehicle wheels are being brought to an increased pressure, wherein in an operating situation of the vehicle which can be detected by means of output signals from wheel-speed sensors assigned to driven and nondriven vehicle wheels and which requires a drive-slip control, even before the control responds as a result of the activation of one or more brakes of driven vehicle wheels, at least the brake-line branches leading to the wheel brakes and the wheel brakes of the driven vehicle wheels, connected to these via brake-pressure regulating valves provided both for the anti-lock control mode and for the drive-slip control mode, are

loaded by the outlet pressure of a pump working at a low pressure level of between 10 bar and 20 bar, and at the latest at the activation of this pump the brake circuit (II) of the driven vehicle wheels is shut off by means of the ASR-function control valve from the outlet-pressure space, assigned to this brake circuit (II), of the brake unit of the brake system.

The accordingly provided low-pressure loading of the brake circuit of the driven vehicle wheels, even before the drive-slip control, which always commences with a pressure loading of at least one of the wheel brakes of the driven vehicle wheels, has to take effect, ensures that the wheel brake of a vehicle wheel to be subjected to the control at a slightly later moment is already being applied "weakly" when the control commences, so that a pressure build-up by means of the high-pressure pump, initiated thereafter for the purpose of the control, can become effective as it were immediately, with the result that a very rapid and sensitive response of the control becomes possible. At the same time, the metering of pressure to the wheel brakes of the driven vehicle wheels can be appropriately controlled by means of these assigned brake-pressure regulating valves, in such a way that first only the wheel brake of that vehicle wheel for which a response of the control is to be expected first is loaded by the outlet pressure of the low-pressure pump, and this can be achieved in that the wheel brake of the other driven vehicle wheel is shut off by means of the brake-pressure regulating valve or valves assigned to this from the low-pressure pump in the introductory phase of the preliminary pressure build-up and is likewise connected to the low-pressure source only after a short delay time of 100 to 200 ms, after which its wheel brake too is initially applied with a moderate force which still exerts no, at least no appreciable braking effect on this wheel, the control signals, necessary for this, for the brake-pressure regulating valves designed as solenoid valves being generated in control-related sequence and combination by the electronic ASR- and ABS-control unit.

The preferred version, provided according to Claim 2, of the process according to the invention ensures a rapid response of the brakes of the vehicle even during a normal braking, that is to say one which is not subjected to control and which is initiated and controlled by the pedal actuation of the brake unit of the brake system, and, especially when all the wheel brakes of the vehicle are loaded with the assistance of the low-pressure pump, achieves a minimisation of the idle travel of the brake pedal and guarantees that the greatest possible part of the available pedal actuation stroke can be utilised for exerting the brake pressure, this being of considerable advantage in terms of the maximum obtainable braking forces.

In so far as the process according to the invention is used for executing control cycles of the drive-slip control, it is, of course, also possible to achieve an additional response sensitivity of the control if, after a period of time after the expiry of which it can be assumed that the wheels brakes are being applied weakly as a result of the low-pressure loading, their brake-pressure regulating valves are changed over to the blocking position and, in a similar way to the known process explained in the introduction, the brake-line portions and branches connecting the ASR-function control valve to the brake-pressure regulating valves of the brake circuit of the driven vehicle wheels are already being loaded by the high outlet pressure of the return pump, utilised as a brake-pressure source, of this brake circuit, which is then applied to the brake-pressure regulating valves even when these are being switched back into the pressure build-up position for the purpose of activating the wheel brake or wheel brakes.

The object mentioned in the introduction is achieved, in terms of a brake system suitable for carrying out the process according to the invention, by means of the features of Patent Claim 3 and, in further embodiments, by means of those of Claims 4 to 12, as a result of which particularly the below-mentioned functional properties and technical advantages are achieved:

The non-return valve provided according to Claim 4 ensures that braking "into" a drive-slip control operation can be carried out, as it were free of delay, even when the ASR-function control valve, by means of which the brake unit is shut off from the brake circuit of the driven wheels during the drive-slip control phases, is not immediately changed over at the start of braking into its functional position connecting the brake unit to the main brake-line. A slight delay in the changeover of the ASR-function control valve into its basic position suitable for the normal braking mode in relation to the ASR-function position is even beneficial, in order, if, in the AS-control phase, a very high brake pressure was fed into the wheel brake or wheel brakes of the brake circuit of the driven vehicle wheels and the driver would like to select a relatively low pressure by means of the brake unit, to prevent reactions on the brake unit which the driver would detect as a recoil force on the brake pedal and which could even lead to an unnecessarily high stress on gaskets within the brake unit.

In the preferred design of the brake system indicated by the features of Claim 5, even during normal braking this ensures an advantageously rapid response of all the wheel brakes of the vehicle and a minimisation of the lifting play or idle travel of the brake pedal, only after which does the exertion of brake pressure proportional to the actuating force commence.

In combination with this, Claims 6 and 7 indicate designs, which can be used alternately or in combination, of an isolating valve which is suitable for shutting off the brake circuit of the non-driven vehicle wheels from the brake unit at the start of braking and the combined form of which affords additional safety in respect of a function-related changeover of the isolating valve.

If only hydraulic control is provided for such an isolating valve, the design of this valve indicated in Claim 8 can ensure in a simple way that, in the introductory phase of a braking operation, first the brake circuit of the driven vehicle wheels and only thereafter the brake circuit of the non-driven vehicle wheels is activated, this having the advantage, where a

vehicle driven via the rear wheels is concerned, that, in the introductory phase of braking, the wheel brakes of the rear-axle brake circuit are first utilised to a greater extent for exerting the brake force than the front-wheel brakes, with the result that a relatively careful treatment of the front-wheel brakes can be achieved, without a loss of exertion of brake force having to be accepted.

It is advantageous also with regard to the brake circuit of the non-driven vehicle wheels if, as provided according to Claim 9, there is a bypass flow path parallel to the isolating valve and with a non-return valve, via which brake pressure can be fed into the brake circuit in the event of a malfunction of the isolating valve.

As a result of the mode, provided according to Claim 10, of the activation of the low-pressure pump and changeover of the ASR-function control valve and, if appropriate, of the isolating valve into their blocking positions, a preliminary pressure loading of the brake circuits can be initiated even before the driver actuates the brake pedal, use being made, as an indication that braking is to take place, of the logical linkage of a signal characteristic of the basic position of the accelerator pedal with a signal characteristic of a minimum driving speed, since this signal combination occurs with predominant probability only when the driver takes his foot off the accelerator pedal in order subsequently to brake. It is possible in this way to gain up to 200 ms which can be utilised for the preliminary pressure loading of the brake circuits.

In the same situation, an even earlier activation of the low-pressure pump and of the ASR-function control and isolating valves is possible if, instead of a signal characteristic of the end position, a signal indicating a change of position of the accelerator pedal is generated, as provided according to Claim 11.

At all events, it is expedient if, as provided according to Claim 12, an activation of the low-pressure pump and of the ASR-function control valve and, if appropriate, of the isolating valve, which is based in this way on

"indications", is cancelled again after a time period tv, the typical duration of which is between 200 ms and 500 ms.

The invention is described in more detail and explained below by means of an exemplary embodiment of a brake system according to the invention, illustrated in the single drawing figure, the process according to the invention for operating this brake system also becoming clear from the functional description.

In the drawing, a hydraulic dual-circuit brake system, designated as a whole by 10, represents a road vehicle which is equipped both with an anti-lock system (ABS) and with a drive-slip control device (ASR).

The ABS is represented by a hydraulic unit designated as a whole by 11, the ASR likewise being represented by a hydraulic unit designated as a whole by 12, which, in combination with the subunit 11', assigned to the driven vehicle wheels, of the ABS-hydraulic unit 11, also allows the drive-slip control mode on the driven vehicle wheels. In an actual form of construction of these slip control devices, these two hydraulic units 11 and 12 are combined to form a compact constructional unit.

It is further presupposed for the vehicle that it has a rear-axle drive, the wheel brakes 13 and 14 of the non-driven front wheels being combined to form a brake circuit I and the wheel brakes 16 and 17 of the driven rear wheels being combined to form a rear-axle brake circuit II.

The two brake circuits I and II are presupposed to be static brake circuits, for supplying brake pressure to which there is a brake unit, designated as a whole by 18, which is designed as a tandem master cylinder of conventional type and which can be actuated by means of a brake pedal 19 by way of a brake booster 21.

The front-axle brake circuit is connected to the primary outlet-pressure space 22 of the brake unit 18, which is limited by its pressure-rod piston 23 and a floating piston 24 so as to be moveable on both sides in the axial direction; the rear-axle brake circuit II is connected to the secondary outlet-

pressure space 26 of the brake unit 18, which is delimited by the floating piston 24 from the primary outlet-pressure space 22 of the brake unit so as to be moveable on one side in a pressure-tight manner. The main brake-lines of the front-axle brake circuit I and of the rear-axle brake circuit II, which are connected respectively to the delivery outlets 27 and 28, respectively, of the primary outlet-pressure space 22 and of the secondary outlet-pressure space 26, are designated respectively by 29 and 31.

The ABS 11 is produced to work on the return-flow principle, according to which, in brake-pressure reduction phases of the anti-lock control, brake fluid bled from one or more wheel brakes 13 and/or 14 or 16 and/or 17 subjected to the control is pumped back into the respective outlet-pressure space 22 or 26 of the brake unit 18 assigned to the particular brake circuit I or II, respectively.

The ASR works on the principle of the "differential brake" according to which a driven vehicle wheel tending to spin is decelerated again by the activation of its wheel brake 16 or 17 and, if both wheel brakes 16 and 17 tend to spin and therefore have to be braked, the engine torque is reduced, for example by action on the fuel supply, the ignition and/or the supply of combustion air.

The brake-pressure regulating valves, which are utilised in the brake circuit II of the driven vehicle wheels both for the anti-lock control and for the drive-slip control, are inlet valves 32 and 33 which are respectively assigned individually to the rear-wheel brakes 16 and 17 and by way of which are guided the brake-line branches 31′ and 31′′ which start from a branch point 34 of the main brake-line 31 of the rear-axle brake circuit II connected to the secondary outlet-pressure space 26 of the brake unit 18 and via which brake pressure is fed into the rear-wheel brakes 16 and 17, and outlet valves 36 and 37 which are assigned individually to these rear-wheel brakes 16 and 17 and by way of which the wheel brakes 16 and/or 17 of the driven vehicle wheels can be connected individually or jointly to a return line 38 of the rear-axle

brake circuit II. Connected to this return line 38 is a low-pressure buffer accumulator 39 which is designed, for example, as a piston/spring accumulator and which, in brake-pressure reduction phases of the anti-lock control, "rapidly" receives brake fluid which is bled from the rear-wheel brake or brakes 16 and/or 17 subjected to the control and which is then pumped back by means of an electrically driven return pump 41 into the main brake-line 31 of the rear-axle brake circuit II or the associated outlet-pressure space 26 of the brake unit 18.

In the exemplary embodiment illustrated, the inlet valves 32 and 33 are designed as 2/2-way solenoid valves, of which the basic position 0 is their throughflow position connecting the respective rear-wheel brake 16 or 17 to the main brake-line 31 of the rear-axle brake circuit II, and of which the energised position I is a blocking position uncoupling the respective wheel brake 16 or 17 from the main brake-line 31.

The outlet valves 36 and 37 are likewise designed as 2/2-way solenoid valves, of which the basic position 0 is their blocking position, in which the wheel brake or wheel brakes 16 and/or 17 are shut off from the return line 38, and of which the energised position I is in each case a throughflow position, in which the wheel brake or wheel brakes 16 and/or 17 are connected in communication with the return line 38.

The brake-pressure regulating valves of the front-axle brake circuit I, which are used in this solely for the anti-lock control, are inlet valves 42 and 43 which are similar to the brake-pressure regulating valves of the rear-axle brake circuit II in terms of construction and function and by way of which are guided the brake-line branches 29′ and 29′′ starting from a branch point 44 of the main brake-line 29 of the front-axle brake circuit II connected to the primary outlet pressure 22 of the brake unit 18, and outlet valves 46 and 47 which are assigned individually to the front-wheel brakes 13 and 14 and via which the front-wheel brakes 13 and/or 14 can be connected individually or jointly to a return line 48 of the front-axle brake circuit I, to which, on the one hand, a low-pressure buffer accumulator 49 is once again connected and, on the other

hand, is connected via an inlet non-return valve 51 an electrically driven return pump 52 which is itself connected to the main brake-line 29 of the front-axle brake circuit I via an outlet non-return valve 53.

The inlet and outlet non-return valves 50 and 55, corresponding in constructional and functional terms to the inlet and outlet non-return valves 51 and 53 of the return pump 52 of the front-axle brake circuit I, are also provided on the return pump 41 of the rear-axle brake circuit II, these inlet and outlet non-return valves 51 and 53 or 50 and 55 being integrated constructionally into the return pumps 52 and 41 which, as is not specifically shown, are conventionally designed as free-piston pumps with a common eccentric drive.

With the thus far explained hydraulic unit 11 comprising the inlet valves 32, 33, 42 and 43, the outlet valves 36, 37, 46 and 47, the buffer accumulators 39 and 49 and the return pumps 41 and 42 with their inlet and outlet non-return valves, an anti-lock control in the manner of individual wheel control is possible in the two brake circuits I and II, to the effect that brake-pressure reduction, brake-pressure holding and brake-pressure rebuild-up phases can be controlled independently of one another on the individual wheel brakes 13, 14 and 16, 17, that is to say brake-pressure changes in phase opposition are also possible, in such a way that, while brake pressure is being reduced on one of the wheel brakes, the brake pressure is being built up again on another wheel brake.

The hydraulic components which, according to the illustration, are combined in the ASR hydraulic unit and which, in combination with the subunit 11' of the ABS hydraulic unit, perform the drive-slip control function on the driven vehicle wheels, are as follows: an ASR-function control valve 54, an ASR outlet valve 56 and an electrically driven and controllable pre-charge pump 58 which is equipped with a pressure relief valve 57 and by means of which, in the drive-slip control mode, brake fluid can be conveyed out of the reservoir 60 to the inlet of the return pump 41 of the rear-axle brake circuit II which, in the drive-slip control mode, is utilised as a brake-pressure

source. Thus, the delivery outlet 61 of the pre-charge pump 58 is hydraulically connected to the inlet 59 of the return pump 41 of the rear-axle brake circuit II via a first non-return valve 62 which is loaded in the opening direction by a relatively higher pressure at the outlet 61 of the pre-charge pump 58 than in the further pre-charge line 63.

The ASR-function control valve 46 is inserted between the delivery outlet 28 of the brake unit 18 assigned to the rear-axle brake circuit II and the branch point 34 of the main brake-line 31, from which start the brake-line branches 31′ and 31′′ leading further. It is designed as a 2/2-way solenoid valve, of which the basic position 0 is its throughflow position, in which brake pressure can be fed from the brake unit 18 into the main brake-line 31 and, via the inlet valves 32 and 33, into the rear-wheel brakes 16 and 17. Its energised position I, assigned to the ASR control mode, is its blocking position, in which the brake unit 18 is shut off from the rear-axle brake circuit II and there is a brake-pressure loading of one and/or the other rear-wheel brakes 16 and/or 17 with the outlet pressure of the return pump 41 of the rear-axle brake circuit II, which is utilised in the ASR control mode as an auxiliary pressure source and to which brake fluid is fed in this operating state from the reservoir 60 by means of the pre-charge pump 58.

The ASR outlet valve 56 is inserted between the brake-fluid reservoir 60 of the brake unit 18 and the return line 38 or the buffer accumulator 39 connected to this. It is likewise designed as a 2/2-way solenoid valve which has a blocking basic position 0 and, as an energised position I, a throughflow position. The ASR outlet valve 56 is switched into its energised position I only in the drive-slip control mode, appropriately for the entire duration of an ASR control cycle, and otherwise remains held in its basic position 0. Connected in parallel with the ASR-function control valve 54 as a further element of the ASR hydraulic unit 12 is a non-return valve 63 which is loaded in the opening direction by a relatively higher pressure at the delivery outlet 28 of the brake unit 18 assigned to the rear-

axle brake circuit II than in the brake-line branches 31′ and 31′′ of the rear-axle brake circuit II and which otherwise assumes only its blocking position. By means of this non-return valve 63 it is possible as it were to brake "into" a drive-slip control cycle even when at such a moment the ASR-function control valve 54 should still assume its blocking position assigned to the ASR mode.

Via a second non-return valve 64 which is loaded in the opening direction by relatively higher pressure at the delivery outlet 61 of the pre-charge pump 58 than in the brake-line branches 31′ and 31′′ of the rear-axle brake circuit II and which is otherwise blocked, the delivery outlet 61 of the pre-charge pump 58 is connected to the branch point 34 of the main brake-line 31 of the rear-axle brake circuit II.

To prevent the possibility that, in the drive-slip control mode, brake fluid will be conveyed by means of the pre-charge pump 58 into the return line 38 of the rear-axle brake circuit II, there is a further non-return valve 66 which is held in its blocking position by a relatively higher pressure at the inlet 59 of the return pump 41 than in the return line 38.

Furthermore, within the framework of the ASR hydraulic unit, there is a pressure relief valve 67 which is inserted between the branch point 34 of the rear-axle brake circuit II and the brake-fluid reservoir 60 of the brake unit 18 and which limits the maximum value of the brake pressure active in the drive-slip control mode to a value of around 200 bar. This pressure relief valve 67 is pressure-controlled via control lines 68 and 69, represented by broken lines, in such a way that its response threshold is raised by the amount of the brake pressure prevailing at the delivery outlet 28 of the brake unit 18.

During normal braking, that is to say braking not subjected to control, the illustrated basic position 0 of the inlet valves 32, 33 and 42, 43 of the rear-axle brake circuit II and of the front-axle brake circuit I respectively and that of the outlet valves 36, 37 and 46, 47 of the rear-axle brake circuit II and of the front-axle brake circuit I respectively

are utilised both for brake-pressure build-up phases and for brake-pressure reduction phases. During a braking subjected to the anti-lock control, the illustrated basic positions 0 of the inlet and outlet valves are utilised only for brake-pressure build-up phases. Brake-pressure holding phases on the individual wheels of the vehicle are obtained both in the anti-lock and in the drive-slip control by changing over the inlet valve of the particular vehicle wheel tending to lock or spin into its energised blocking position I.

Brake-pressure reduction phases are obtained on a vehicle wheel subjected to the anti-lock control or a driven rear wheel of the vehicle which can be subjected to the drive-slip control, by changing over the outlet valve to its throughflow position I whilst the respective inlet valve is held in the blocking position I or changed over to this.

The control signals, necessary in a control-related sequence and combination for this, for the inlet and outlet valves and for driving the return pumps 51 and 52 of the ABS hydraulic unit 11 and, in the event of a control cycle of the drive-slip control, for the pre-charge pump 58, the ASR-function control valve 54 and the ASR outlet valve 56 of the ASR hydraulic unit are transmitted by a merely diagrammatically indicated electronic control unit 71 which is assigned to the two modes of the slip control and which generates these control signals from a processing, taking place according to known criteria and algorithms, of output signals containing information on the dynamic behaviour of the vehicle wheels in terms of level and/or frequency and from wheel-speed sensors 72 to 75 assigned individually to the vehicle wheels, and of the output signal of the brake-light switch 77, these signals being sent as input signals to this electronic control unit 71.

Furthermore, the electronic control unit 71 is designed to the effect that, over and above the control of the anti-lock and drive-slip control functions, during a braking operation initiated by the driver as a result of the actuation of the brake pedal 19 it also performs the below-explained functions which will also be used to explain the necessary relevant

modifications of the control unit 71, of which the implementation, with the knowledge of the functions mentioned, is possible for a person skilled in the art of electronic circuitry:

It is presupposed that the brake-light switch 77 is designed as a switch of path-dependent response which emits an output signal, occurring as a high-level voltage signal, after the brake pedal 19 has executed only an initial portion of its maximum possible actuating stroke corresponding to a small fraction of this, and this initial portion will also be clearly smaller than the idle stroke of the pedal 19 which is brought about because a pressure build-up in the outlet-pressure spaces 22 and 26 of the brake unit 18 can take place only after the pistons 23 and 24 have been displaced so far that, for example, central valves, which are arranged on the pistons and which, in the basic position of the pistons 23 and 24, make communicating connection between the outlet-pressure spaces 22 and 26, respectively, and the reservoir 60, have had to execute their closing strokes before a brake-pressure build-up in the brake unit 18 itself can take place.

When the brake-light switch output signal occurs, the electronic control unit 71 generates a first output signal, by means of which the pre-charge pump 58 is activated, and simultaneously a second output signal, by means of which the ASR-function control valve 54 is changed over to its blocking position I. The pre-charge pump 58 now conveys brake fluid out of the reservoir 60, on the one hand via the first non-return valve 62 and the preliminary pressure line 65 to the return pump 41 of the brake circuit II of the driven vehicle wheels, and on the other hand via the second outlet non-return valve 64 into the portion of the main brake-line 31 starting from the ASR-function control valve 54 and the brake-line branches 31′ and 31′′ which start from its branch point and in which now builds up a "preliminary brake pressure", the maximum value of which is limited to an amount between 10 and 15 bar by the pressure relief valve 57 connected in parallel to the pre-charge pump 58. This pressure, which is built up, without brake fluid having to

be displaced for this purpose out of the outlet-pressure space 26 of the tandem master cylinder 18, is sufficient to compensate the lifting play of the wheel-cylinder pistons (not shown) and to press the brake jaws and brake linings of the wheel brakes 16 and 17, presupposed to be disc brakes, with moderate force against the brake discs, without an appreciable braking effect initially being exerted.

The activation of the pre-charge pump 58 and the control of the ASR-function control valve 54 into its blocking position I are maintained for a time period ta, the duration of which is calculated to be sufficiently long to ensure that, after this time period has expired, it can be assumed that, if the driver actuates the brake pedal 19 with the force and speed characteristic of conventional braking, the brake pressure at the delivery outlets 27 and 28 of the brake unit 18 corresponds at least to the preliminary pressure achieved by the "preliminary filling" of the rear-axle brake circuit II. After this time period ta, the control of the ASR-function control valve 54 is cancelled again, so that this is once more switched back into its basic position 0, namely its throughflow position, and the delivery outlet 28 of the brake unit 18 assigned to the rear-axle brake circuit II is connected via the ASR-function control valve to the portion, leading further from this, of the main brake-line 31 and to the brake-line branches 31′ and 31′′ of the rear-axle brake circuit II.

If the outlet pressure of the brake unit 18 occurring at the delivery outlet 28 was already higher, before this switching back of the ASR-function control valve 54, than the preliminary pressure fed into the rear-axle brake circuit by means of the pre-charge pump 58, then, while the ASR-function control valve 55 still assumes its blocking position I, the outlet pressure of the brake unit is fed via the non-return valve 63 into the further-leading portion of the main brake-line 31 of the rear-axle brake circuit II and its brake-line branches 31′ and 31′′. By virtue of this "bypass" of the ASR-function control valve 54, this can, in principle, remain held in its blocking position for a relatively long time period ta.

The outlet pressure of the pre-charge pump 58 limited in amount by the pressure relief valve 57 is calculated to be sufficiently high to ensure that the brake linings of the wheels brakes 16 and 17 presupposed to be disc brakes are applied as a result of a displacement of the pistons of the wheel-brake cylinders to the brake discs and pressed with moderate force against these, but without the exertion of an appreciable braking force which, if the driver wanted to increase the brake pressure only very slowly and therefore the outlet pressure of the brake unit would reach the already connected pressure only after a relatively long period of time, could contribute unnecessary wear.

Also in the event of a response of the drive-slip control on the brake circuit II of the driven vehicle wheels, a signal causing the activation of the pre-charge pump 58 and the output signal of the electronic control unit 71 bringing about the changeover of the ASR-function control valve are generated, and consequently the above-mentioned preliminary filling of the rear-axle brake circuit obtained, even before the wheel brake or wheel brakes 16 and/or 17, which are to be activated for the purpose of the drive-slip control, should be "selected" and loaded with the outlet pressure of the return pump 41 by the cut-in of the return pump 41 of the rear-axle brake circuit II and, if appropriate, the changeover of the inlet valve 32 or 33 of that wheel brake 16 or 17 which is not to be activated. For the drive-slip control too, the preliminary filling of the brake circuit II of the driven vehicle wheels is advantageous in order to achieve as rapid a response as possible of the drive-slip control.

In order to achieve on the front-axle brake circuit I too, in the chosen explanatory example the brake circuit of the non-driven vehicle wheels, a preliminary filling, reducing the lifting play of the brake system, of the portion of the main brake-line 29 branching off from the branch point 44 to the wheel brakes 13 and 14 and of the brake-line branches 29′ and 29′′ and the wheel-brake cylinders of the wheel brakes 13 and 14, there is an isolating valve 78 which is similar in

construction and function to the ASR-function control valve 54 of the rear-axle brake circuit II and is designed as a 2/2-way solenoid valve and which can be changed over from its basic position 0, namely the throughflow position, into its energised blocking position I by means of a signal generated by the electronic control unit 71 together with the control signal for the ASR-function control valve, and the delivery outlet 61 of the pre-charge pump 58 is connected, via a third non-return valve 79 functionally similar to the non-return valve 64, to the branch point 44 of the main brake-line 29 of the front-axle brake circuit I, so that this can likewise be loaded with the outlet pressure of the pre-charge pump 58 as a preliminary pressure with the activation of the latter.

The isolating valve 78 too is bridged by means of a bypass formed by a non-return valve 81 similar to the non-return valve 63 of the rear-axle brake circuit I, in so far as, should the isolating valve 78 still be in its blocking position, when the pressure at the outlet 27 of the brake unit 18 is higher than the preliminary pressure previously fed into the front-axle brake circuit, the outlet pressure of the brake unit 18 can be fed into the front-wheel brakes 13 and 14 by way of this bypass.

In order, in the event of a braking operation, to achieve an activation of the pre-charge pump 58 and a changeover of the ASR-function control valve 54 and of the isolating valve 78 which are as early as possible, these functional elements can also be controlled by means of other signals which can be generated as a high-probability indication of the occurrence of a situation requiring braking.

Signals which are suitable for this and from the logical linkage of which a situation requiring braking can be recognised are, for example, as follows:

a) a signal which indicates that the accelerator pedal 80 and/or a control element, for example the throttle flap of the engine, coupled to this in terms of movement is in the basic position, and

b) a signal which indicates that the vehicle speed is relatively high, for example higher than 70 km/h.

An operating situation of a vehicle characterised by these signals indicates with high probability that the driver, after taking his foot off the accelerator pedal at a relatively high vehicle speed, will very soon also brake. A logical AND link of the two signals therefore seems appropriate for generating an activation signal for the pre-charge pump 58 and changeover signals for the ASR-function control valve 54 and isolating valve 78.

The same situation can also be detected if the accelerator pedal 80 is equipped with a position transmitter generating output signals which are characteristic of the particular position of the accelerator pedal and from the change of which in reaction to a rapid removal of the foot from the accelerator pedal at a relatively high speed it can likewise be concluded that the driver intends subsequently to brake, since such a position-change signal occurs even before the accelerator pedal 80 reaches its basic position, and consequently the activation of the pre-charge pump 58 and the changeover of the valves 54 and, if appropriate, 78 can be triggered even earlier. It is expedient, at the same time, if the decrease of a signal triggered by the removal of the foot from the accelerator pedal and controlling the ASR-function control valve 54 and/or the isolating valve 78 into their blocking position or blocking positions is delayed relative to the decrease of the signal activating the low-pressure pump 58 by a time period tv, the typical durations of which are between 200 ms and 500 ms, in order to ensure that the driver has sufficient time to transfer his foot from the accelerator pedal 80 to the brake pedal 19.

c) A signal which indicates that the engine speed and/or the speed of the driven vehicle wheels experiences a reduction of which the amount is greater than a predetermined threshold value.

A situation characterised by these signals is, in particular, one in which the driver would obviously wish to reduce the vehicle speed and it can therefore be expected that the driver, after removing his foot from the accelerator pedal which resumes its basic position, will also actuate the brake.

The same situation can also be detected if the accelerator pedal is equipped with a position transmitter generating output signals which are characteristic of the particular position of the accelerator pedal and from the change of which in reaction to a rapid removal of the foot from the accelerator pedal at a relatively high speed, it can likewise be concluded that braking will subsequently take place.

Claims

1. A process for activating the hydraulic service-brake system of a road vehicle which is equipped both with an anti-lock system (ABS) working on the return-flow principle and with a drive-slip control device (ASR) working on the principle of the differential brake, according to which a driven vehicle wheel tending to spin is decelerated again as a result of the activation of its wheel brake, an outlet-pressure space, assigned to braking driven vehicle wheels, of a brake unit provided for generating static brake pressure being shut off in control phases of the drive-slip control by means of an ASR-function control valve from the main brake-line of the brake circuit of the driven vehicle wheels branching off to the brakes of the driven vehicle wheels, and the brake-pressure build-up taking place as a result of the activation of a pump, by means of which, even before brake pressure is fed into the wheel brake of the vehicle wheel subjected to the control, brake-line portions or branches of the brake circuit of the driven vehicle wheels are being brought to an increased pressure, wherein in an operating situation of the vehicle which can be detected by means of output signals from wheel-speed sensors assigned to driven and nondriven vehicle wheels and which requires a drive-slip control, even before the control responds as a result of the activation of one or more brakes of driven vehicle wheels, at least the brake-line branches leading to the wheel brakes and the wheel brakes of the driven vehicle wheels, connected to these via brake-pressure regulating valves provided both for the anti-lock control mode and for the drive-slip control mode, are loaded by the outlet pressure of a pump working at a low pressure level of between 10 bar and 20 bar, and at the latest at the activation of this pump the brake circuit (II) of the driven vehicle wheels is shut off by means of the ASR-function control valve from the outlet-pressure space, assigned to this brake circuit (II), of the brake unit of the brake system.

2. A process according to Claim 1, wherein, also in an operating phase of the vehicle initiating a braking operation, at least the brake circuit (II) of the driven vehicle wheels is shut off by means of the ASR-function control valve and/or the brake circuit (I) of the non-driven vehicle wheels is/are shut off from the respective associated outlet-pressure space of the brake unit, and the brake-line branches leading to the wheel brakes of this brake circuit (II or I) and the wheel brakes are loaded with the outlet pressure of the low-pressure pump.

3. A brake system for carrying out the process according to Claim 1 or Claim 2 for a road vehicle with an ABS working on the return-flow principle and with a drive-slip control device (ASR) working on the principle of the differential brake, where

a) the wheel brakes of the driven vehicle wheels are combined to form a brake circuit (II) and the wheel brakes of the non-driven vehicle wheels are combined to form a brake circuit (I), and

b) utilised as an auxiliary pressure source for the drive-slip control is the return pump of the ABS (11) which is assigned to the brake circuit (II) of the driven vehicle wheels and for supplying the inlet of which with brake fluid from the reservoir of the brake system there is a pre-charge pump working at a low outlet-pressure level, and also

c) the brake-light switch comprises a position-sensitive switch member which transmits an output signal as soon as the brake pedal of the brake system is shifted out of its basic position,

wherein the occurrence of the brake-light switch output signal and/or the commencement of an operating situation of the vehicle which requires a drive-slip control and the development of which is detected, even before the commencement of the control, by an electronic control unit by means of output signals from wheel-speed sensors assigned to the vehicle wheels, triggers an output signal activating the pre-charge pump and controlling the ASR-function control valve into its blocking position, at least for a limited time period ta sufficient for generating the maximum

outlet pressure of the pre-charge pump and corresponding at least to the period of time after which, in the event of a brake actuation taking place with average pedal force and speed of the pedal adjustment, the wheel brakes are applied.

4. A brake system according to Claim 3, wherein for the ASR control valve there is a bypass flow path leading via a non-return valve which is loaded in the opening direction by a relatively higher pressure at the outlet of the brake unit than in the brake-line portion leading from the ASR control valve to the branch point of the main brake-line of the brake circuit (II) of the driven vehicle wheels.

5. A brake system according to Claim 3 or Claim 4, wherein the portion of the main brake-line of the brake circuit (I) which leads to the branch point of this brake circuit (I) of the non-driven vehicle wheels can be shut off by means of an isolating valve, for at least the limited time period ta, from the delivery outlet of the brake unit assigned to this brake circuit (I), and the delivery outlet of the low-pressure pump is connected to the branch point, by way of the portion of the main brake-line connecting this to the isolating valve, via a non-return valve which is loaded in the opening direction by a relatively higher pressure at the delivery outlet of the low-pressure pump than in this portion of the main brake-line.

6. A brake system according to Claim 5, wherein the isolating valve comprises a 2/2-way solenoid valve, of which the basic position 0 is its throughflow position connecting the delivery outlet of the brake unit to the branch point of the main brake-line of the brake circuit (I) of the non-driven vehicle wheels and which can be controlled, jointly with the ASR-function control valve, into its blocking energised position (I) by means of an output signal from the electronic control unit.

7. A brake system according to Claim 5, wherein the isolating valve of the brake circuit (I) of the non-driven vehicle wheels comprises a hydraulically controlled 2/2-way valve which is controllable out of its blocking basic position (0) into its throughflow position (I) by means of the outlet pressure of the brake unit.

8. A brake system according to Claim 7, wherein the control pressure Ps, at which the isolating valve changes over to its throughflow position (I), satisfies the relation

$$P_{max} < P_s < 1{,}3\ P_{max},$$

Pmax denoting the maximum outlet pressure of the low-pressure pump and Ps preferably being selected from the range

$$1{,}1\ P_{max} < P_s < 1{,}3\ P_{max}.$$

9. A brake system according to any one of Claims 5 to 8, wherein there is a bypass flow path parallel to the isolating valve and leading via a non-return valve which is loaded in the opening direction by a relatively higher pressure at the outlet of the brake unit than in the portion of the main brake-line leading further from the isolating valve to the branch point of the brake circuit (I) of the non-driven vehicle wheels.

10. A brake system according to any one of Claims 3 to 6, wherein a signal of limited duration tp triggering the changeover of the ASR control valve and, if appropriate, of the isolating valve of the brake circuit (I) of the non-driven vehicle wheels into their blocking positions (I) and a signal activating the low-pressure pump are already being generated by the electronic control unit when the accelerator pedal and/or a control element of the engine, for example the throttle flap of an aspirating engine or the control rod of a diesel engine, coupled in terms of movement to the accelerator pedal of the vehicle is in its basic position and at the same time the vehicle speed is higher than a threshold value characteristic of continuous travel ($v > 40$ km/h).

11. A brake system according to any one of Claims 3 to 6, wherein there is a position transmitter which monitors the position of the accelerator pedal and which generates an output signal varying continuously in terms of level and/or frequency with the operating position of the accelerator pedal, there is a differentiation stage which carries out a time differentiation of the position-transmitter output signal and the output signal of which is a measure of the speed at which the accelerator pedal is adjusted, and in that the signal causing the activation of the low-pressure pump and the changeover of the ASR-function control valve and/or of the isolating valve into their blocking position or blocking positions is already being generated when the speed of the adjustment of the accelerator pedal taking place in reaction to a removal of the foot from the latter exceeds a predetermined threshold value and at the same time the vehicle speed v is still higher than a relevant threshold value characteristic of continuous travel.

12. A brake system according to Claim 10 or Claim 11, wherein the decrease of the signal triggered by the removal of the foot from the accelerator pedal and controlling the ASR-function control valve and/or the isolating valve into their basic position or basic positions is delayed relative to the decrease of the signal activating the low-pressure pump by a time period tv, the typical duration of which is between 200 ms and 500 ms.

13. A process for activating the hydraulic service-brake system of a road vehicle which is equipped both with an anti-lock system (ABS) working on the return-flow principle and with a drive-slip control device (ASR) working on the principle of the differential brake, substantially as described herein, with reference to, and as illustrated in, the accompanying drawing.

14. A brake system for carrying out the process according to claim 13.

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Databases (see over)

(i) UK Patent Office

(ii)

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Documents considered relevant following a search in respect of claims 1 TO 14

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
Y	GB 2230068 A (DAIMLER BENZ) Figure 1	1, 3
Y	GB 2217413 A (DAIMLER BENZ) Page 8 line 24 to page 9 line 35	1, 3
Y	GB 2214253 A (DAIMLER BENZ) The Figure (the acknowledged prior art)	1, 3
Y	GB 2182991 A (TEVES) Claims 1 to 4	1, 3
Y	US 4902075 (UNO ET AL) Column 2 lines 52 to 63 and column 3 lines 30 to 40	1, 3

Category	Identity of document and relevant passages	Relevant to claim(s)

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