(12) UK Patent Application (19) GB (11) 2 207 721 (13) A

(43) Application published 8 Feb 1989

(21) Application No 8818255

(22) Date of filing 1 Aug 1988

(30) Priority data
(31) 3725594 (32) 1 Aug 1987 (33) DE

(71) Applicant
Daimler-Benz AG
(Incorporated in FR Germany)
Stuttgart-Unterturkheim, Federal Republic of Germany

(72) Inventor
Reinhard Resch

(74) Agent and/or Address for Service
Jensen & Son
8 Fulwood Place, High Holborn, London, WC1V 6HG

(51) INT CL⁴
B60T 8/48 // 8/42

(52) Domestic classification (Edition J):
F2F FE

(56) Documents cited
None

(58) Field of search
F2F
Selected US specifications from IPC sub-class B60T

(54) Anti-lock system and propulsion control system for a road vehicle

(57) An anti-lock and propulsion-control system for a road vehicle, has, as a brake-pressure regulating member used both for anti-lock and for propulsion control, a hydraulic cylinder 47 which can be driven under valve 79 control and which has an ABS control space 46 increasing and an ASR outlet-pressure space 48 decreasing when a drive-pressure space 53 of the hydraulic cylinder is subjected to pressure, which space, in normal braking not subjected to control, are both connected to the brake circuit I of the driven vehicle wheels 17, 18. The control system is activated respectively as a result of the valve-control connection of an auxiliary pressure source 56 to the drive-pressure space of the hydraulic cylinder. The control mode is selected by means of a function-control valve arrangement which, in the event of anti-lock control, connects only the ABS control space and, in the event of propulsion control, only the AST outlet-pressure space to the portion 72 branching off to the wheel brakes of the driven wheels of the main brake line of the brake circuit of the latter. The valves 73, 74 stay as shown during ABS control, but are switched for ASR control. In the latter case space 48 is connected to the brake line 72, and the pressure in the space is controlled by application of pressure from the auxiliary pressure source 56 to space 53.

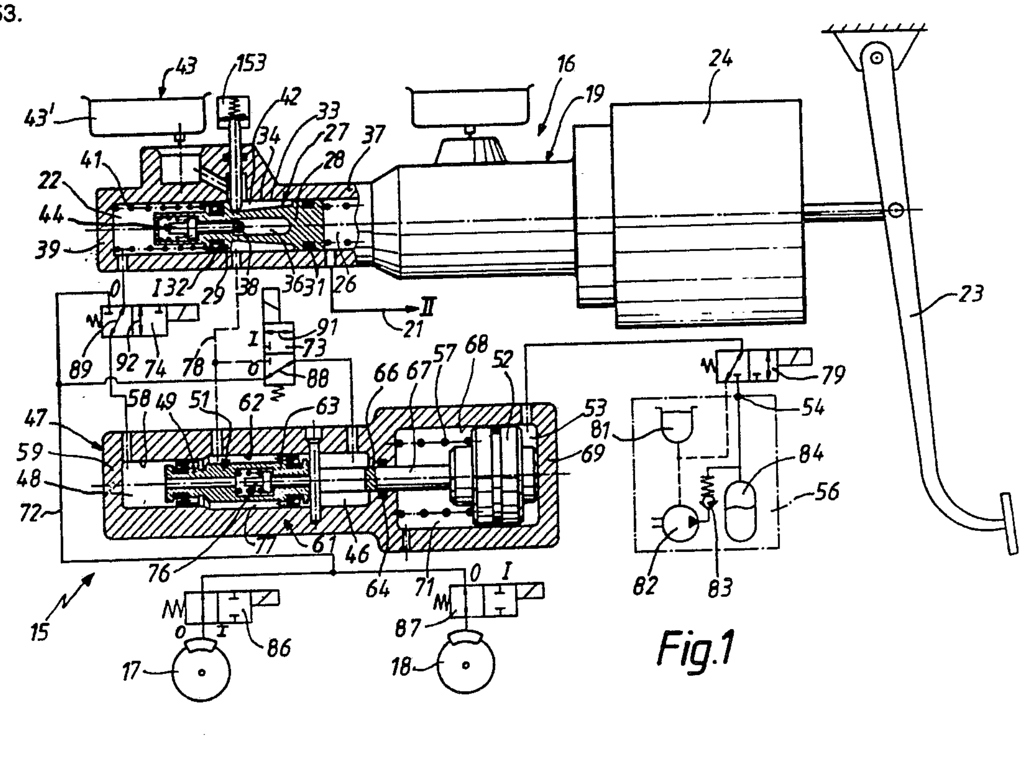

Fig.1

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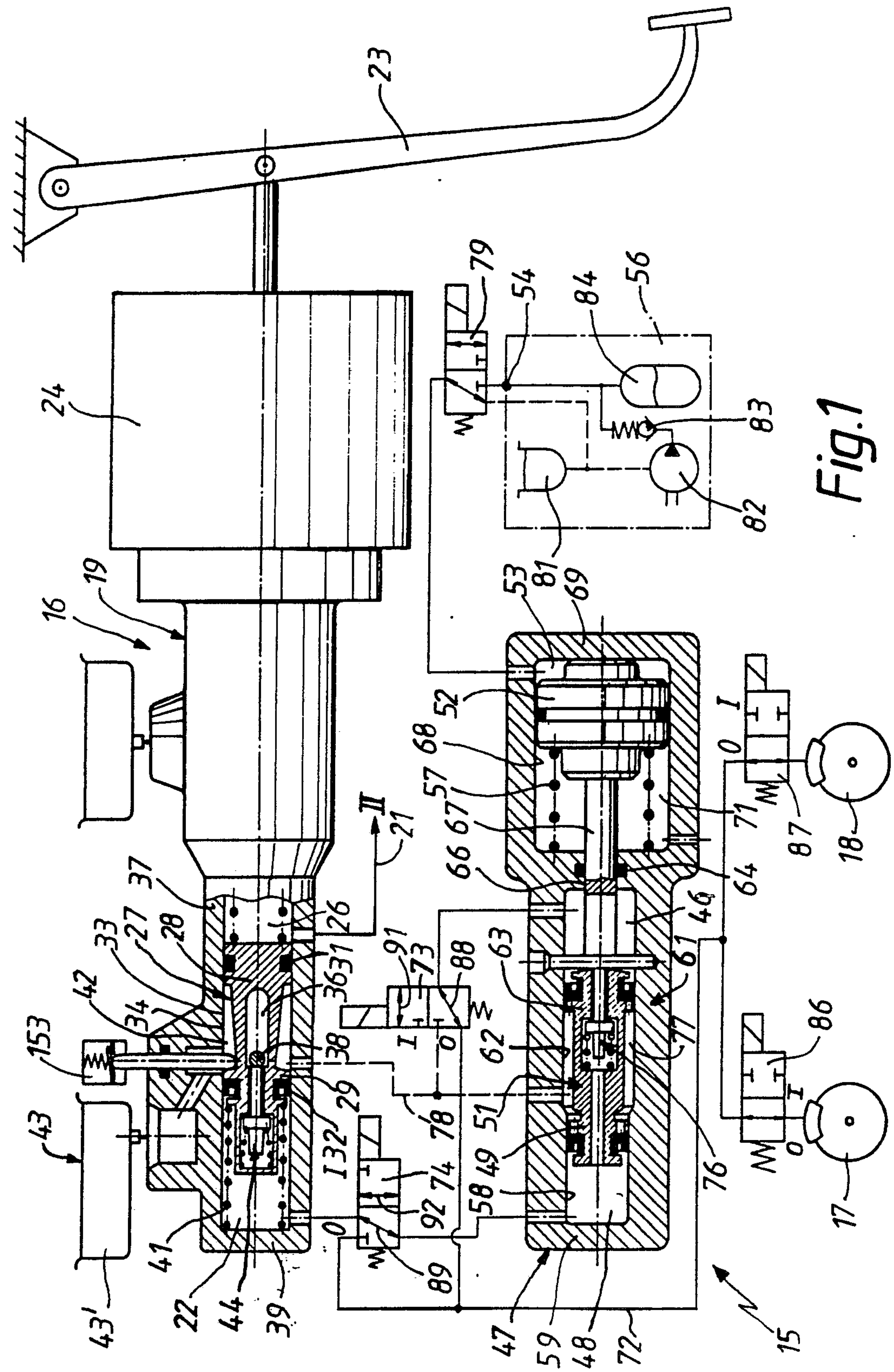

Fig.1

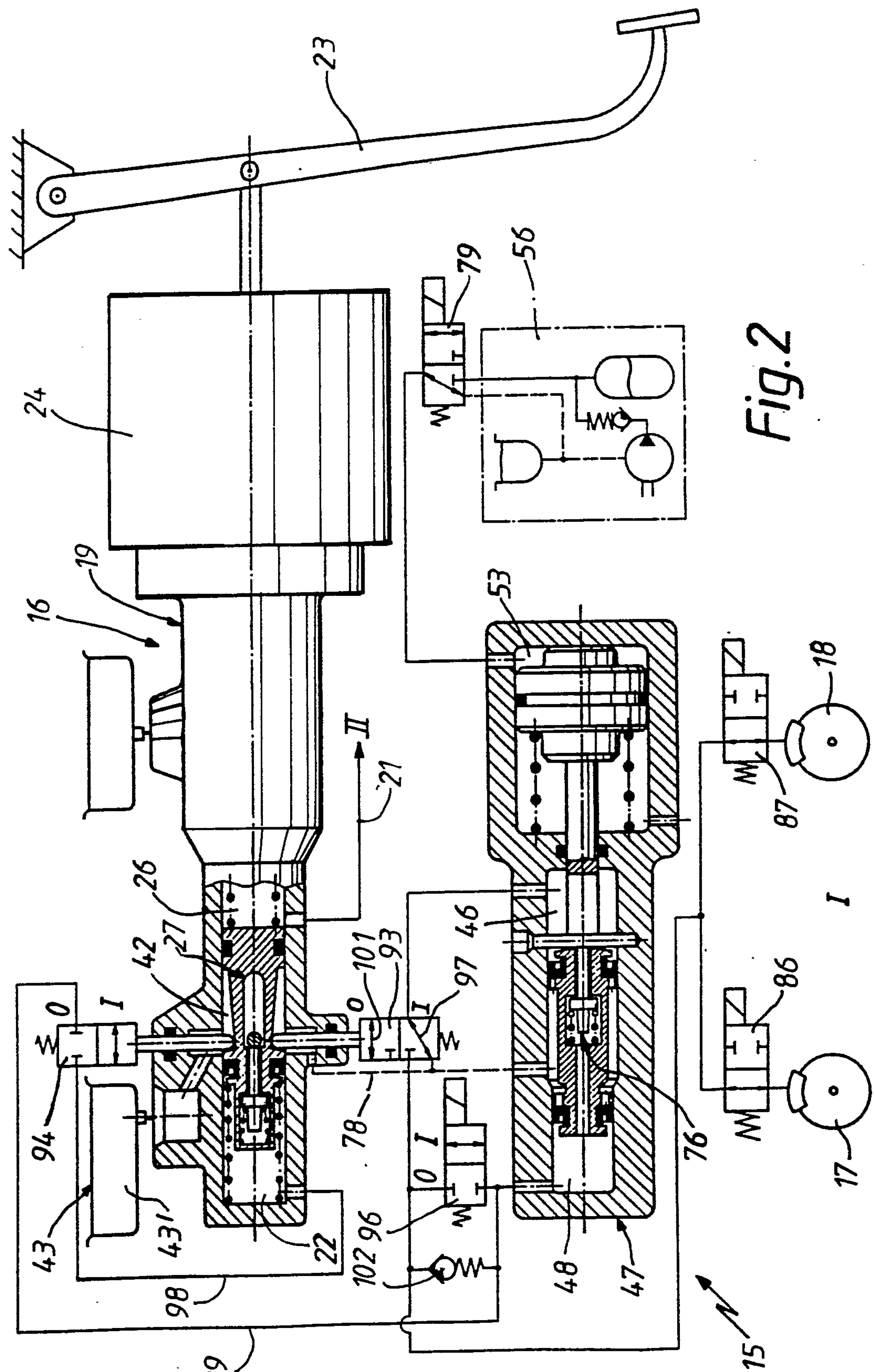
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Fig.2

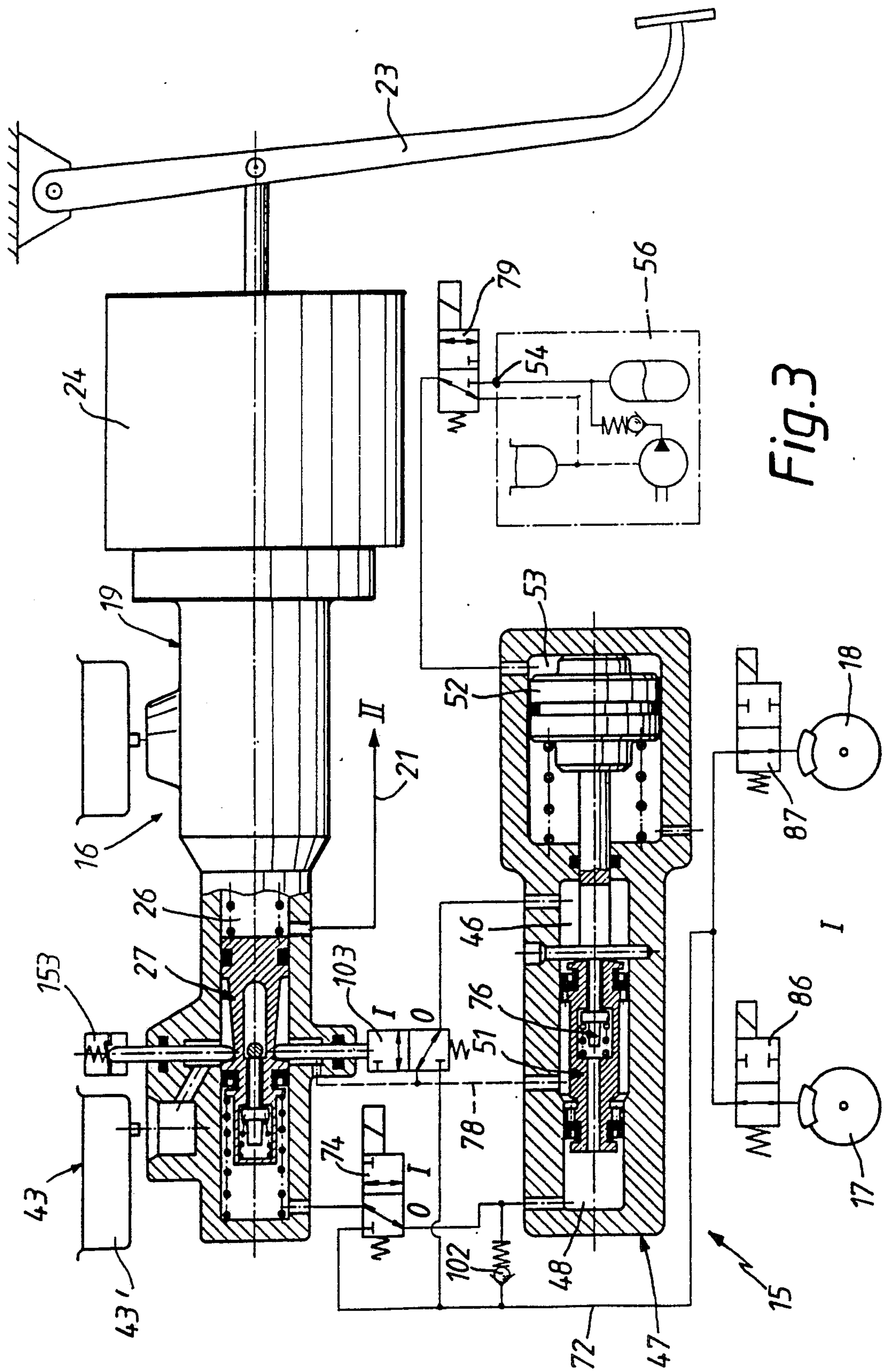
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Fig.3

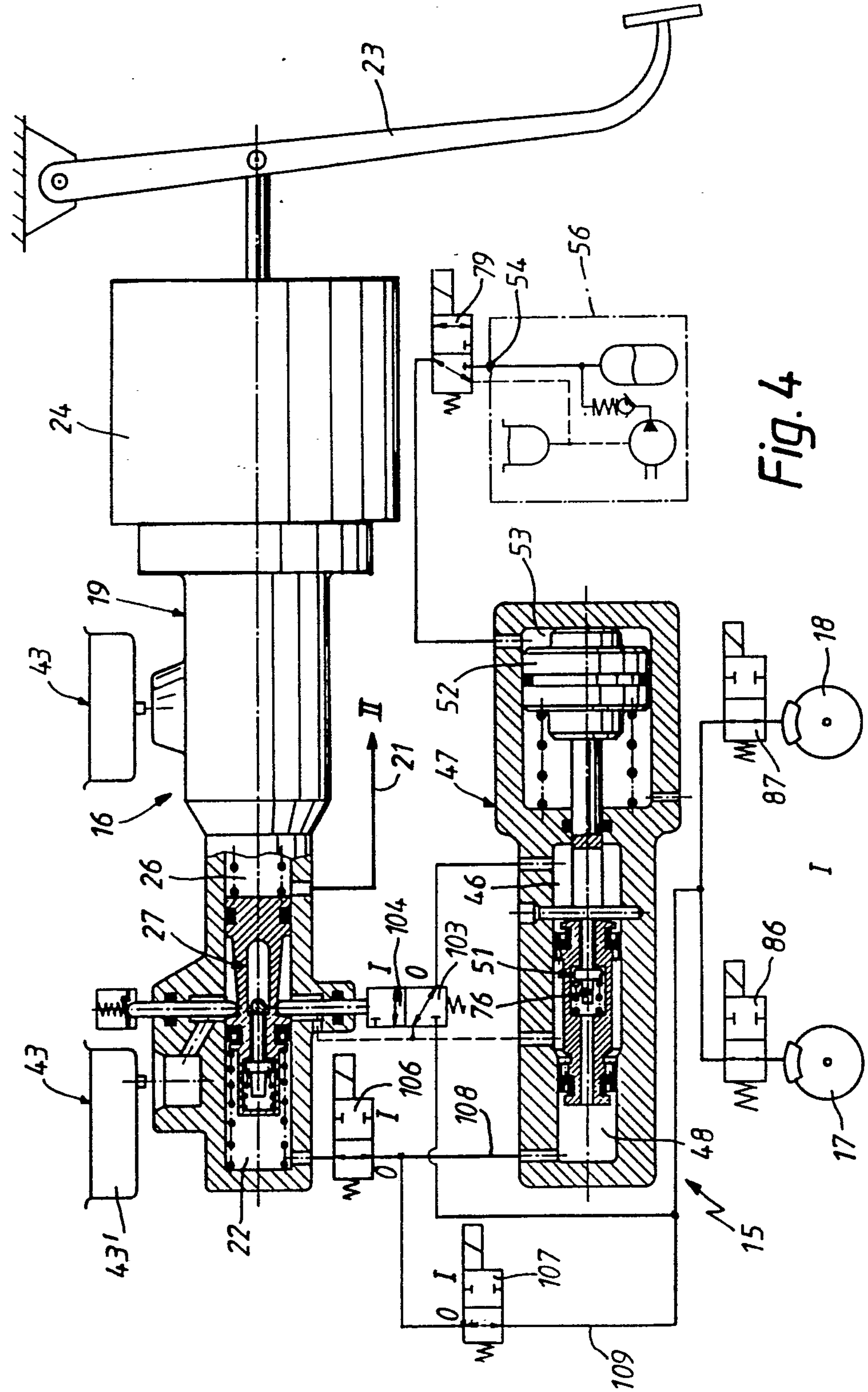
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Fig. 4

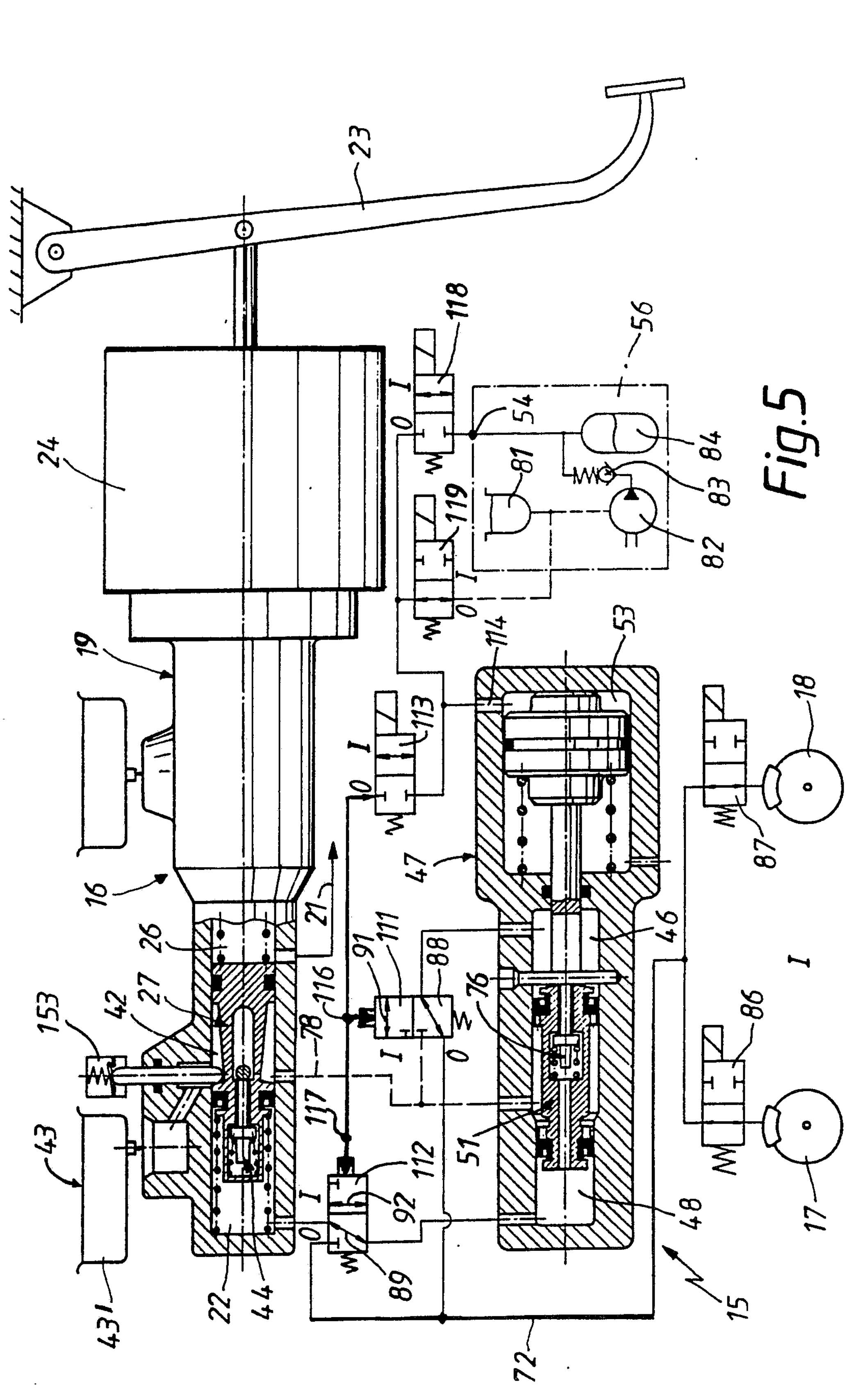
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Fig.5

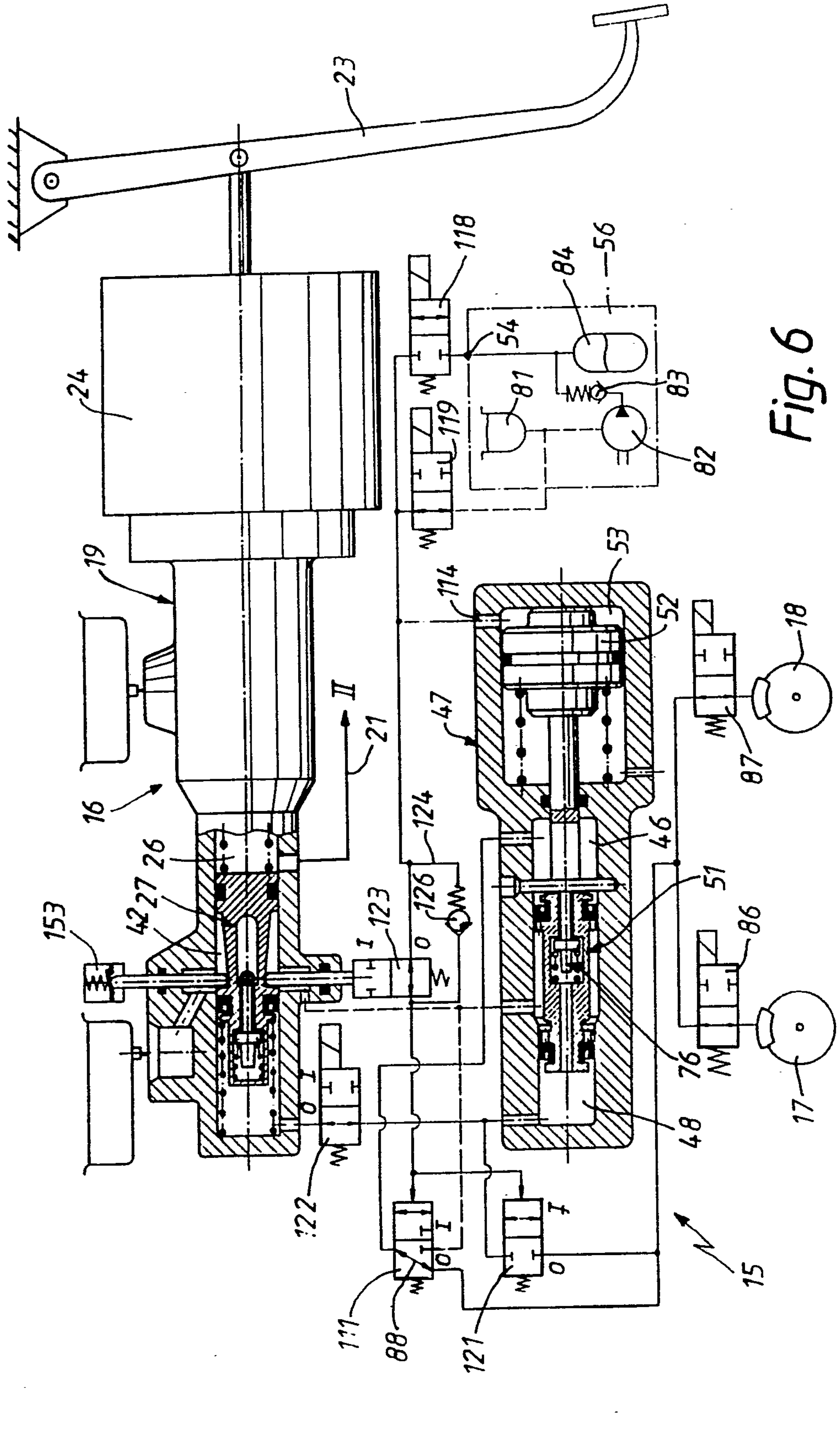

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Fig. 6

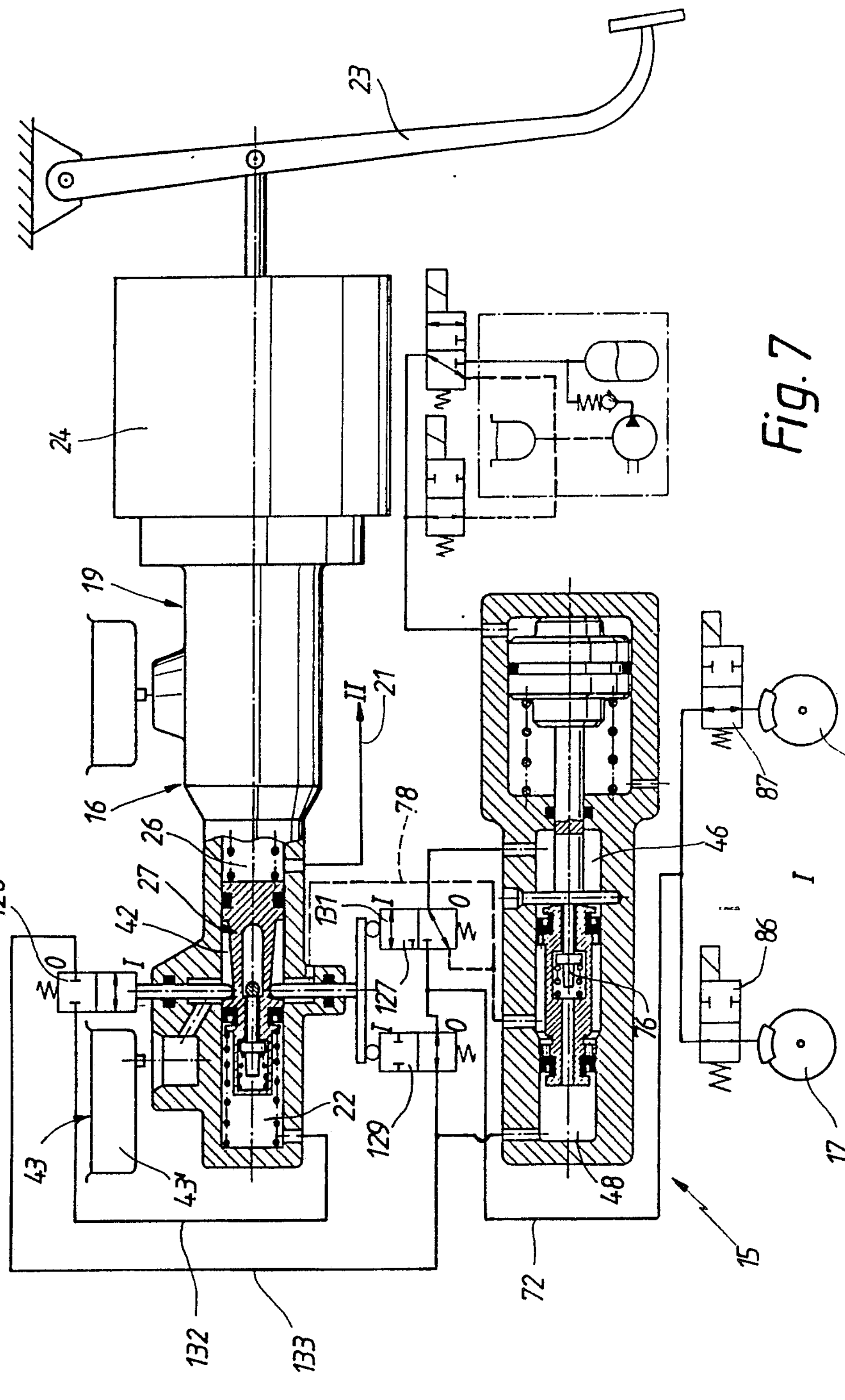
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Fig. 7

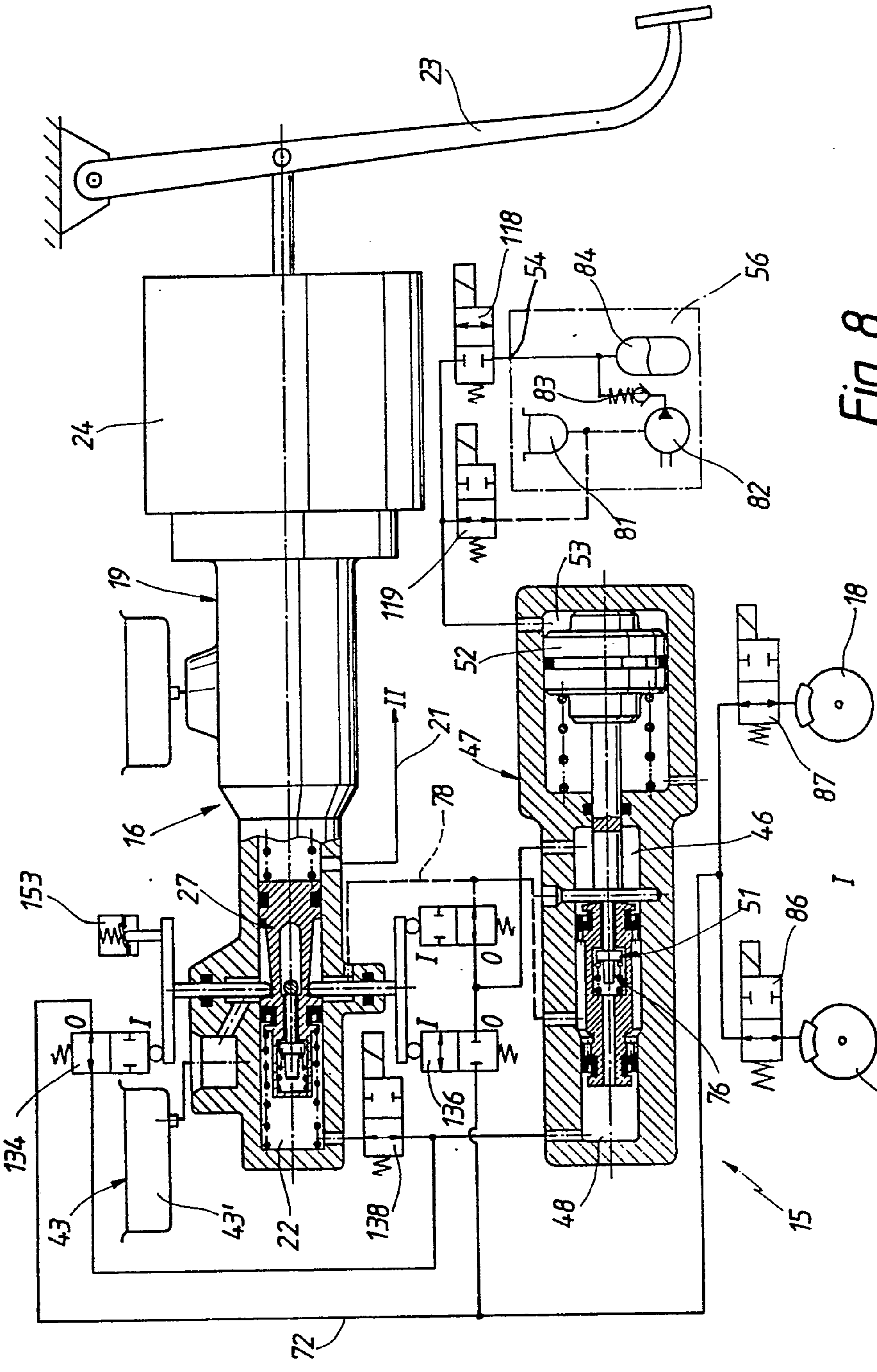
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Fig. 8

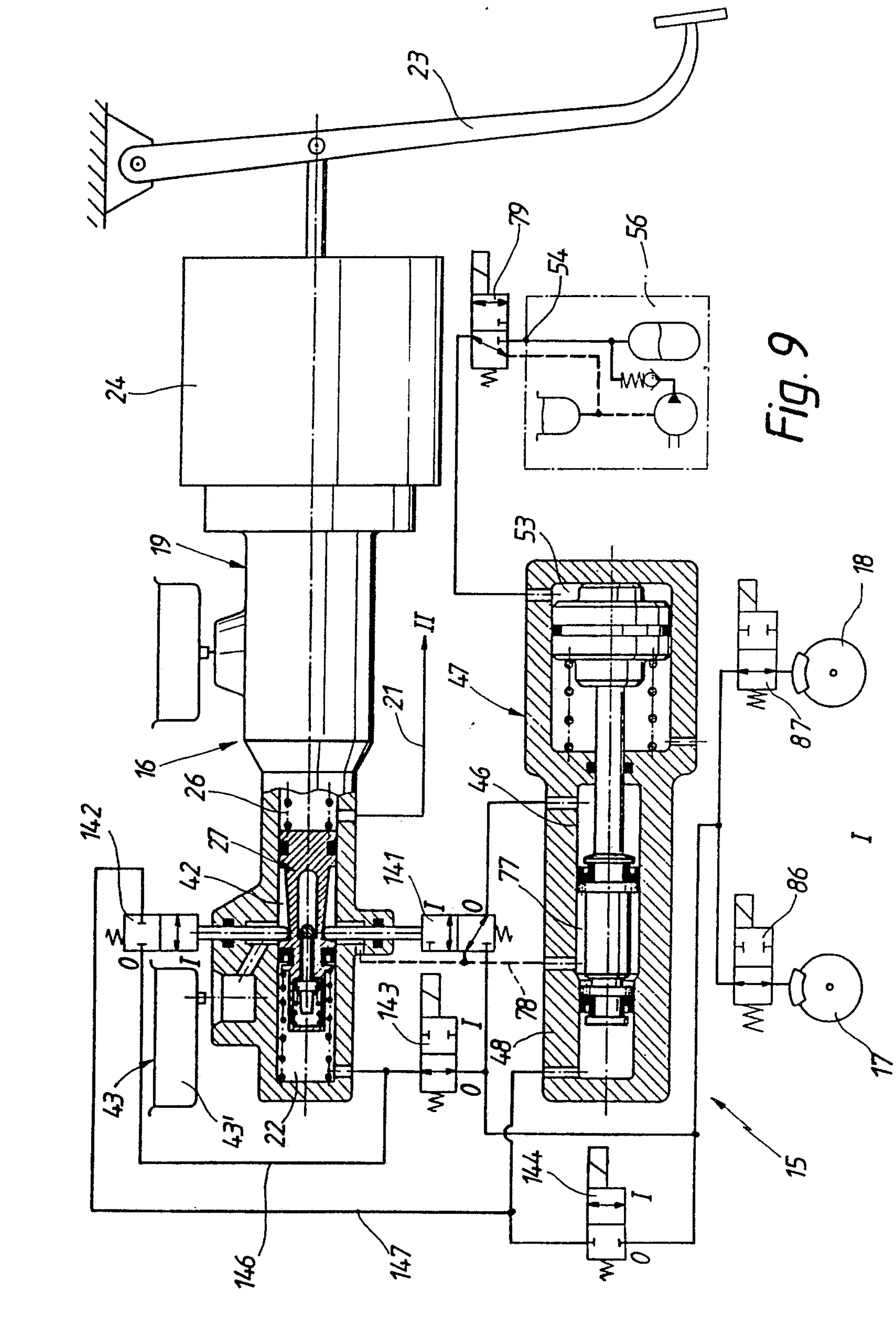
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Fig. 9

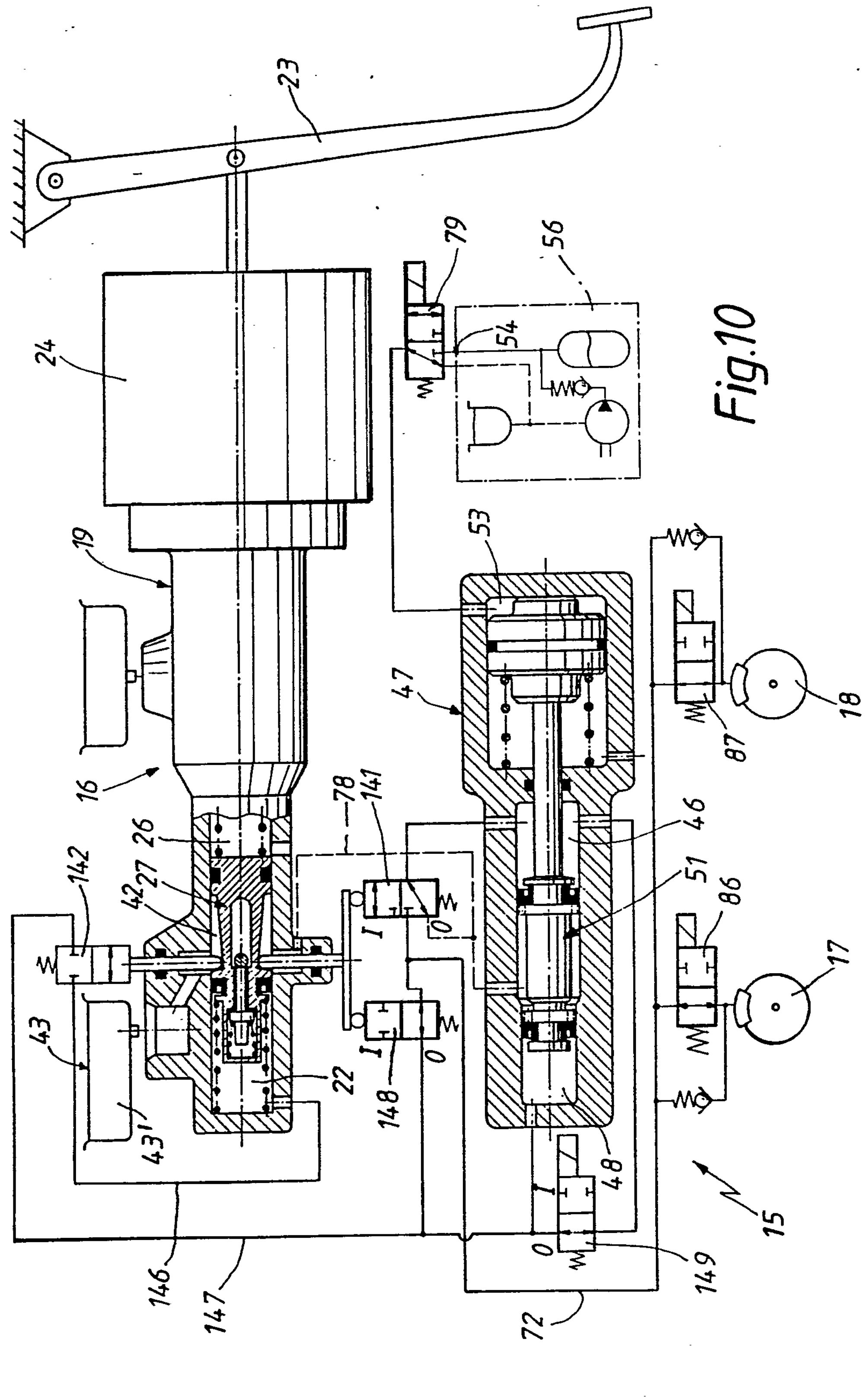
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Fig.10

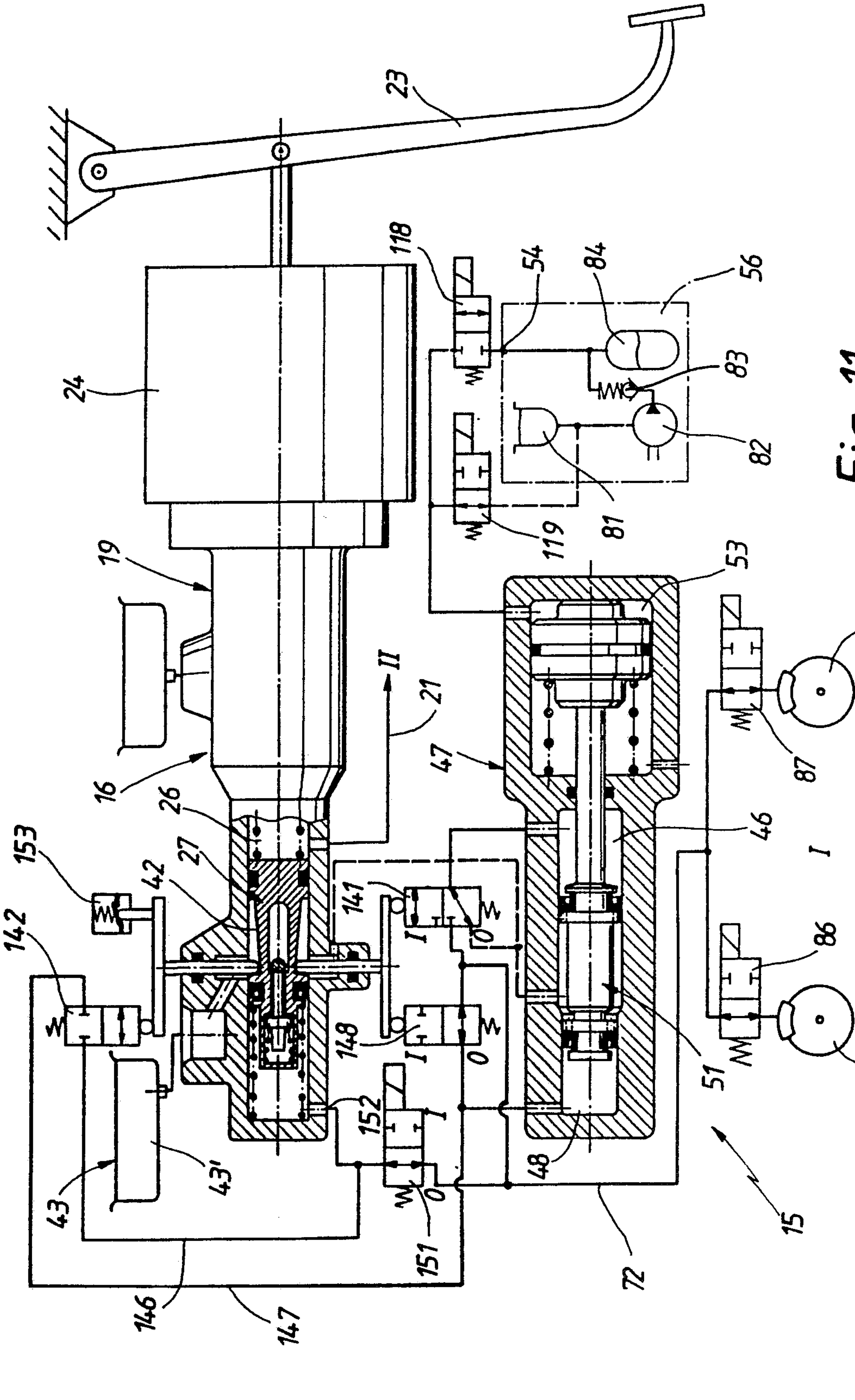
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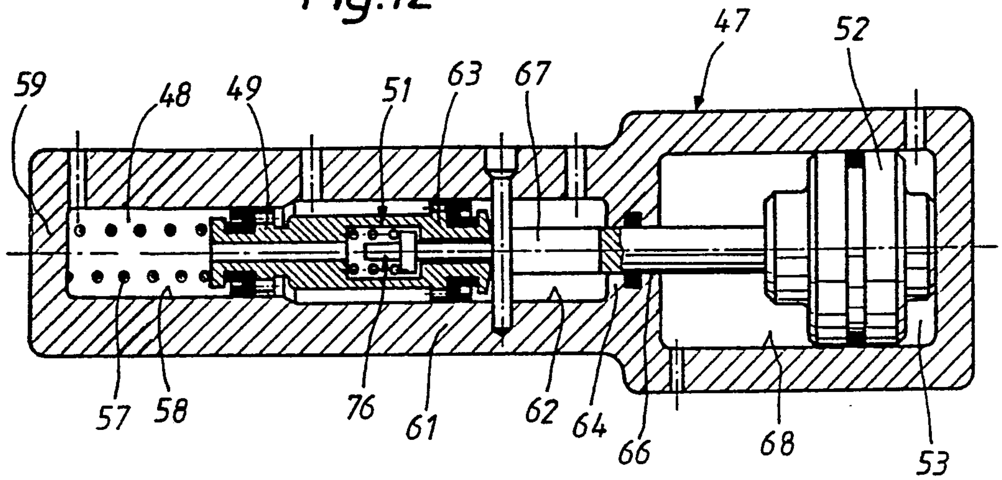
Fig. 11

Fig.12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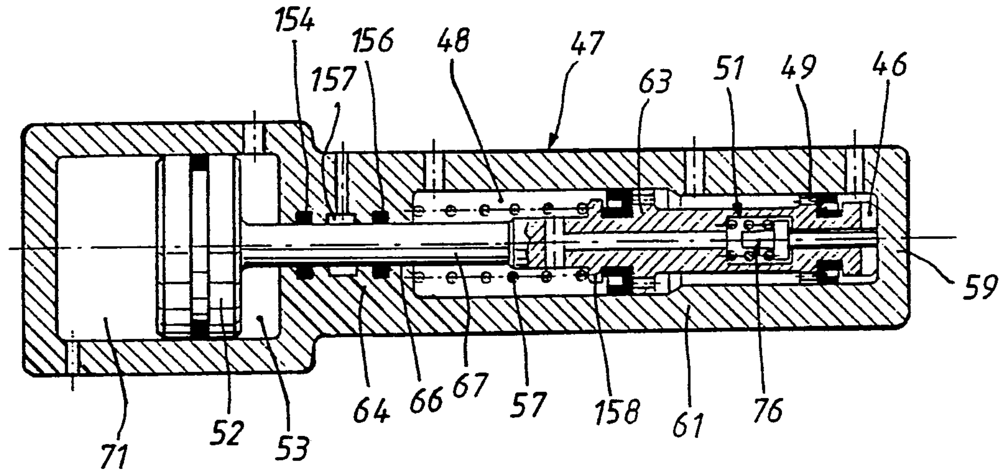
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Fig.13

Anti-lock system (ABS) and propulsion-control system (ASR) for a road vehicle

The invention relates to an anti-lock system (ABS) and a propulsion-control system (ASR) for a road vehicle with a hydraulic multi-circuit brake system, in which the brakes of the driven vehicle wheels form a static brake circuit connected to an outlet-pressure space of a brake unit actuable by means of a pedal, the ABS working on the principle of controlling brake-pressure reduction and brake-pressure build-up phases of the anti-lock control by respectively increasing and decreasing the volume of an ABS control space connected to the wheel brakes, and the propulsion control working on the principle of decelerating a vehicle wheel tending to spin by activating its wheel brake until its drive slip remains within a range of values compatible both with good propulsion acceleration and good driving stability.

Such a combination of an anti-lock system and of a propulsion-control system is the subject of the applicant's own older German patent application P 37 06 662.5 not previously published.

In the subject of this older patent application, each wheel brake which can be subjected to the anti-lock control has assigned to it a hydraulic cylinder which acts as a buffer accumulator and within which the accumulator space connected to the wheel brake and at the same time forming a portion of the brake-line branch leading to the particular wheel brake is delimited in a pressure-type manner by means of the cylinder piston from a control-pressure space which, under valve control, can be connected to the high-pressure outlet of an auxiliary pressure source or alternatively to its pressureless tank or can be shut off from both. Inserted between the brake-pressure outlet, assigned to the respective brake circuit, of the brake unit and the accumulator space of the hydraulic cylinder assigned to the respective wheel brake is an electrically activatable pressure-inlet control valve, the basic position of which is the open position, in which brake pressure can be fed into the connected wheel brake, whether, as with normal braking, that is to say braking not subjected to an anti-lock control, as a result of actuation of the brake unit or, as with activation of the proportion control on a driven vehicle wheel, as a result of valve-controlled connection of the pressure outlet of an auxiliary pressure source to the brake circuit of the driven vehicle wheels. From time to time, for example during the starting of the vehicle, after the end of a braking operation and/or at regular time intervals during motoring, the control-pressure spaces of the buffer accumulators are connected briefly, via function-control valves assigned individually to the hydraulic cylinders, to the pressure outlet of the auxiliary pressure source provided for propulsion control, after which the function-control valves are switched back into their basic position, namely the blocking position, once again.

As a result, at all events as long as the anti-lock control does not respond, the pistons of the hydraulic cylinders are maintained in their end position linked to a minimum volume of the accumulator spaces and are as it were "locked" hydraulically in these. To obtain a pressure reduction phase on a wheel brake subjected to the anti-lock control, its pressure-inlet control valves are moved into the blocking position and the control-pressure space of the buffer accumulator assigned to this wheel brake is connected to the pressureless tank of the auxiliary pressure source by changing over its function-control valve to its pressure-reduction position, with the result that the piston of the buffer accumulator can move with the effect of increasing in the accumulator space connected to the wheel brake and the desired pressure drop is obtained.

By switching the function-control valve back into its neutral blocking position, namely the basic position, the brake pressure can subsequently be maintained at a lowered value appropriate for control purposes. A brake-pressure rebuild-up phase of the anti-lock control, necessary at a later stage, can be obtained if the control-pressure space of the hydraulic cylinder is connected to the high-pressure outlet of the auxiliary pressure source by changing over the associated function-control valve to its pressure build-up position, with the result that the piston of the hydraulic cylinder again experiences a displacement with the effect of decreasing the volume of its accumulator space and brake fluid previously discharged into this is forced back into the wheel brake once more, a precondition being that the outlet-pressure level of the auxiliary pressure source is higher than the highest possible brake pressure which can be built up in the wheel brakes as a result of the actuation of the brake unit.

Within the framework of the propulsion-control device, connected to the brake circuit of the driven vehicle wheels is a further hydraulic cylinder which acts as a pressure reducer and as a result of the connection of which, controllable by means of an ASR function-control valve, to the high-pressure outlet of the auxiliary pressure source or its tank or as a result of its shut off from both brake pressure build-up, brake pressure reduction and brake pressure holding phases of the propulsion control can be selected, the latter also as a result of the alternate or joint shut-off of the inlet control valves used both for the anti-lock and for the propulsion control.

The brake unit is shut off from the brake circuits of the vehicle for the duration of a propulsion control cycle.

Regardless of favourable properties of the control devices according to the older patent application P 37 06 662.5, which are to be seen especially in that, during normal braking, the pistons of the hydraulic cylinders provided for the anti-lock control and for the propulsion control do not have to be displaced, and therefore their piston seals cause no frictional losses, although this would be a disadvantage if, in the event of a failure of the brake booster, braking had to be carried out by means of pedal force alone, this control-system combination is also afflicted with some disadvantages:

Since, when the anti-lock control responds, the buffer accumulator of the wheel brake subjected to the control is shut off from the brake unit as a result of the closing of the pressure-inlet control valve, the driver obtains a reaction, detectable on the brake pedal, to the response of the anti-lock control only when the control has responded on all the wheel brakes combined in the brake circuit, and even then only in the form of an "arresting" of the brake pedal. However, this "brake-pedal reaction" is unfavourable in as much as it can be misunderstood by the driver, for example as meaning that the brake system has failed completely, which in many cases will lead to a panic reaction from the driver.

Even if restoring springs, which force the buffer accumulator pistons into their basic positions linked to a minimum volume of the accumulator spaces, are made "weak", so that the minimum pre-stress and the maximum pre-stress of these springs are equivalent to a pressure of only a few bars, this still has the unfavourable consequence, when the anti-lock control responds at low absolute values of the brake pressure, that the residual pressure which is caused by the pre-stress of the restoring springs and below which the brake pressure cannot be lowered by means of a pressure -reduction phase of the anti-lock control corresponds to a still appreciable proportion of the brake pressure previously fed into the wheel brakes, and therefore, under unfavourable circumstances, the control does not result in a sufficient lowering of the brake pressure.

In addition, the construction of the combined antilock and propulsion-control system according to the older patent application also involves a considerable technical outlay; although the two buffer accumulators of the brake circuit, conventionally comprising two wheel brakes, of the driven vehicle wheels, for example the rear wheels of the vehicle, are combined in constructional terms to form a compact constructional unit, nevertheless integration of the pressure converter required for the propulsion control into this hydraulic unit, owing to the necessary insertion of the inlet control valves between the pressure converter and buffer accumulators, is scarcely feasible in technical terms because it involves an extremely high outlay in terms of construction.

It is true that, in relation to a vehicle with all wheel drive, German Offenlegungsschrift 3,531,137 makes known a combined anti-lock and propulsion-control system which does not have the disadvantages mentioned above as regards the response of the anti-lock control at low brake pressures and no or unclear notification of the response of the anti-lock control. In this combined anti-lock and propulsion-control system, there are pressure modulators which are assigned individually to the wheel brakes and which each perform the function of a single-circuit master cylinder, for the drive of which there is a double-acting hydraulic cylinder having, in addition to a drive-pressure space into which the outlet pressure of the pedal-actuable brake circuit is fed during normal braking, a counter-pressure space, as a result of the valve-controlled connection of which to an auxiliary pressure source the piston of the pressure modulator is displaceable, counter to the effect of the drive pressure fed in, in the direction of a pressure reduction in the outlet-pressure space of the modulator connected to the particular wheel brake. Propulsion-control phases can be controlled by coupling the auxiliary pressure source to the drive-pressure space of the pressure modulator and shutting off the latter from the outlet-pressure space of the brake unit of the brake system.

However, the known anti-lock and propulsion-control system, as compared with the subject of the aforesaid older patent application, is afflicted with a series of major disadvantages:

Because of the large number of axially successive functional spaces of the pressure modulators, they have a very large constructional length.

The multiplicity of piston seals necessary for sealing off the various functional spaces from one another causes high frictional losses, the result of which can be that, in the event of a failure of the brake booster, the brake system requires disproportionately high actuating forces, so that even this malfunction can deceive the driver into thinking that the entire brake system has failed. Because of the numerous piston seals of the pressure modulators, the pistons of which are displaced even during normal braking, the susceptibility to wear of the brake system as a whole is also increased.

Starting from a propulsion-control device, combined with an anti-lock system, of the type mentioned in the introduction, the object of the invention is, therefore, to improve such a control system in such a way that, whilst nevertheless ensuring a simple design and a low susceptibility to faults of the said control system, a more sensitive response of the anti-lock control at low brake pressures and a reliable notification of the response of the anti-lock control are achieved, and also a space-saving constructional integration of the hydraulic anti-lock and propulsion-control regulating elements becomes possible in a constructively simple way.

According to the invention, there is provided an anti-lock system (ABS) and propulsion-control system (ASR) for a road vehicle with a hydraulic multi-circuit brake system, in which the brakes of the driven vehicle wheels form a static brake circuit which is connected to an outlet-pressure space of a brake unit actuable by means of a pedal, the ABS working on the principle of the control of brake-pressure reduction and brake pressure build-up phases of the anti-lock control by respectively increasing or decreasing the volume of an ABS control space connected to the wheel brakes, and the propulsion control working on the principle of decelerating a vehicle wheel tending to spin by activating its wheel brake until its drive slip remains within a range of values compatible both with good propulsion acceleration and with good driving stability, wherein:

a) for controlling pressure-reduction, pressure build-up and pressure-holding phases of both the anti-lock control and the propulsion control, there are electrically activatable brake-pressure regulating valves which can be moved out of a throughflow position, assigned to the pressure-reduction and pressure build-up phases of the particular control and to normal braking not subjected to anti-lock control, into a blocking position which is assigned to brake pressure holding phases on the respective wheel brake;

b) as a pressure build-up and pressure-reduction regulating element of the anti-lock control, there is a hydraulic cylinder having a piston which is displaceable as a result of the alternate connection of a drive pressure space to the pressure outlet of an auxiliary pressure source or to its pressureless tank between end positions corresponding to a minimum and a maximum volume of an ABS control space and which, during normal braking and in the pressure-reduction and pressure build-up phases of the anti-lock control, is in communicating connection with the wheel brake or wheel brakes of the static brake circuit;

c) as a pressure build-up and pressure-reduction regulating member of the propulsion control, there is a hydraulic cylinder having an ASR outlet-pressure space which is connectable, alternatively to the outlet-pressure space of the brake unit, to the brake circuit of the driven vehicle wheels and which is limited movably by a piston of this hydraulic cylinder displacable in the direction of a brake-pressure build-up or reduction because a drive-pressure space is subjected under valve control to the outlet pressure of the auxiliary pressure source or is relieved respectively, and

d) there is an ABS and ASR function-control valve arrangement which, in the sequence in combination corresponding to the respective control purpose, makes the connection between the drive-pressure space and the tank or the pressure outlet of the auxiliary pressure source and opens or blocks the brake-fluid flow paths, via which, in the respective control phases of the anti-lock and propulsion control, the brake pressure is reduced or built up on the wheel brakes used for the control, having the following features:

a) for the brake circuit (I) which can be subjected both to the anti-lock control and to the propulsion control, there is at least one hydraulic cylinder which is designed as a step cylinder of differing diameter, one of which constitutes the moveable limitation of an ASR outlet-pressure space, as a result of the decrease in volume of which the brake pressure in a connected wheel brake can be built up, and the other of which constitutes the movable limitation of an ABS control space, as a result of the increase in volume of which the brake pressure in a connected wheel brake can be reduced, the regulating piston being coupled in terms of movement, via a piston rod passing displacably in a pressure-tight manner through an intermediate wall of the cylinder housing, to a drive piston which movably limits the drive-pressure space and as a result of the valve-controlled pressure subjection and pressure relief of which the drive piston is displaceable respectively in the direction of an increase of the ABS control space and a decrease of the ASR outlet-pressure space and in the direction of a decrease of the ABS control space and an increase of the ASR outlet-pressure space, and the composite piston structure comprising the regulating piston and the drive piston being forced by a restoring spring into its basic position corresponding to the minimum volume of the ABS control space;

b) the function-control valve arrangement performs the following functions:

b1) in normal braking, that is to say braking not subjected to the anti-lock control, both the outlet pressure space of the brake unit assigned to the controllable brake circuit (I) and the ASR outlet pressure space and the ABS control space of the hydraulic cylinder are connected to the portion branching off to the wheel brakes of the main brake line of the brake circuit which can be subjected to the control;

b2) in braking subjected to the anti-lock control, the ABS control space only is connected to the brake circuit (I) which can be subjected to the control and the ASR outlet-pressure space only is connected to the outlet-pressure space of the brake unit;

b3) when the control system responds in the propulsion-control mode, the outlet pressure space of the brake unit is shut off from the wheel brakes, the ABS control space is connected to the pressureless brake-fluid storage tank of the brake system, and the ASR outlet-pressure space is connected to the brake line leading to the wheel brakes.

Accordingly, there is, for the brake circuit which can be subjected both to the propulsion-control and to the anti-lock control, at least one hydraulic cylinder designed as a step cylinder and having a working piston with two piston flanges of differing diameters, one of which forms the movable limitation of an ASR outlet-pressure space, as a result of the decreases in volume of which brake pressure can be built up in the connected wheel brakes, and the other of which forms a movable limitation of an ABS control space, as a result of the increase in volume of which brake pressure can be reduced in the connected wheel brakes. This working piston is coupled in terms of movement, via piston rod passing displaceably in a pressure tight manner through an intermediate wall of the cylinder housing, to a drive piston movably limiting the drive pressure space, as a result of the valve-controlled pressure subjection and relief of which the drive piston and with this the working piston are displacable respectively in the direction of an increase of the ABS control space and a decrease of the ASR outlet-pressure space and a decrease of the ABS control space and an increase of the ASR outlet pressure space. The composite piston structure comprising the working piston and the drive piston is forced by a restoring spring respectively into its basic position corresponding to a minimum volume of the ABS control space and maximum volume of the ASR outlet-pressure space. There is a control valve arrangement which performs the following functions:

a) in normal braking, that is to say braking not subjected to the anti-lock control, both the outlet-pressure space of the brake unit and the ASR outlet-pressure space and ABS control space are connected to the wheel brakes;

b) in braking subjected to the anti-lock control, the ABS control space alone is connected to the brake line or brake lines of the controllable brake circuit and the ASR outlet-pressure space alone is connected to the outlet pressure space of the brake unit;

c) when the propulsion control responds, the outlet pressure space of the brake unit is shut off from the wheel brakes, the ABS control space is connected to the pressureless brake-fluid storage tank of the brake system, and the ASR outlet-pressure space is connected to the brake line or brake lines leading to the wheel brakes.

The anti-lock and propulsion-control system according to the invention has at least the following advantages:

Since the composite piston structure of a hydraulic cylinder is displaced in the same direction both when the anti-lock control responds and when the propulsion control responds, the drive control of this hydraulic cylinder becomes particularly simple. The constructional design of the hydraulic cylinder provided for controlling the anti-lock and propulsion-control functions becomes correspondingly simple, since it requires only a single drive pressure space. Since the brake-pressure reduction and brake-pressure build-up phases of the respective control which initiate an anti-lock or a propulsion controlled cycle are controlled by subjecting the drive pressure space of the hydraulic cylinder pressure, a rapid response of the particular control is also guaranteed under all circumstances, with the obvious precondition that the hydraulic drive circuit of the hydraulic cylinder be made sufficiently "powerful".

In one embodiment, the housing space limited by the intermediate wall of the cylinder housing and by the regulating piston is used as a drive-pressures space of the hydraulic cylinder, in that the ASR outlet-pressure space is limited movably by the diametrically larger piston step of the regulating piston and fixedly relative to the housing by the intermediate wall, and in that the space limited movably by the smaller piston step of the regulating piston and fixedly relative to the housing in the axial direction by the end wall of the cylinder housing, the regulating piston and the drive piston being connected firmly to one another, is used as the ABS control space. In another embodiment, the ASR outlet-pressure space is limited movably by the diametrically smaller piston flange of the regulating piston of the hydraulic cylinder and fixedly relative to the housing in the axial direction by the end wall of the cylinder housing, in that the ABS control space is limited moveably by the externally diametrically larger piston flange of the regulating piston and fixedly relative to the housing by the intermediate wall, through which passes the piston rod making the coupling with the drive piston in terms of movement, and in that the cylinder space limited fixedly relative to the housing in the axial direction by an end wall of the cylinder housing and movably by the drive piston is used as a drive-pressure space.

This latter embodiment has the advantage that the space limited fixedly relative to the housing by the intermediate wall and movably by the drive piston can be utilised for separating the conventionally different pressure medium in the drive circuit and in the control circuits connected hydraulically to the wheel brakes, this being beneficial for a short design of the hydraulic cylinder.

Preferably,the drive piston and the regulating piston of the hydraulic cylinder are designed as separate piston elements, the regulating piston being supported axially on the drive piston by means of a rod-shaped extension guided displaceably in a pressure-tight manner through the central bore in the intermediate wall of the cylinder housing, and the restoring spring forcing the regulating piston and the drive piston into their basic position being arranged so as to engage on the regulating piston.

Preferably, the effective amount of that flange surface of the regulating piston movably limiting the ABS control space and the effective area of its surface limiting the ASR outlet-pressure space of the hydraulic cylinder are approximately equal and preferably of equal size within a range of variation of +/- 15%.These dimensions for the effective surfaces of the working piston of the hydraulic cylinder which limit the ASR outlet-pressure space and ABS control-pressure space of the latter ensure that, in control phases the anti-lock control, the quantity of brake fluid conveyed back into the outlet-pressure space of the brake unit corresponds approximately to that which flows back into the ABS control space from the wheel brakes, thus on the one hand preventing the possibility that the outlet-pressure space of the brake unit will be "controlled empty" and on the other hand ensuring that the driver receives an appropriate notification of the activation of the anti-lock control.

Preferably, in the non-activated state of the control system, the function-control valve arrangement makes a hydraulic series connection between the outlet-pressure space of the brake unit, the ASR outlet-pressure space of the hydraulic cylinder and its ABS control space and the brake line or brake lines leading on to the wheel brakes and belonging to the brake circuit which can be subjected to the control, and in that there is a control valve which, when the respective control (ABS or ASR) is initiated, is changed over from a throughflow position making the communicating connection between the ASR outlet-pressure space and the ABS control space to its blocking position (Figures 1 to 8).

It goes without saying, of course, that, instead of a central valve integrated in the piston of the hydraulic cylinder, it would be also be possible to provide a laterally arranged valve which is accommodated in the housing of the hydraulic cylinder and designed, for example, as a seat valve and the valve body of which is forced by a valve spring into the blocking position of the valve and is maintained in its open position by means of a stop arm interacting, for example with the piston of the hydraulic cylinder, in the basic position of the hydraulic-cylinder piston, and as a result of such a lateral arrangement of a mechanically actuable valve constructional length can be saved once again.

A position indicator which responds to the position of the piston limiting the outlet-pressure space of the brake unit and which, in a simplest case, can be designed as a limit switch provides, in a simple way, a safeguard in order, during brake pressure reduction phases of the anti-lock control, to prevent too much brake fluid from flowing back into the brake unit and finally into the brake-fluid storage tank, as a result of which, when it is necessary for the propulsion control to respond immediately after an anti-lock control cycle, its functioning capacity could be impaired.

In a preferred embodiment, the drive control-valve arrangement comprises two control valves which are designed as 2/2-way solenoid valves and of which one, in its basic position shuts off the pressure outlet of the auxiliary pressure source from the drive-pressure space of the hydraulic cylinder and in its excited position connects this to the pressure outlet of the auxiliary pressure source, and of which the other, namely the valve, in its basic position connects the drive-pressure space of the hydraulic cylinder to the pressureless tank of the auxiliary pressure source and in its excited position shuts it off from this, these two valves being movable into their excited positions by means of a signal linked to the activation of the control system (Figures 5 to 8 and 11).

The advantage of this design of the control valve arrangement provided for the drive control of the hydraulic cylinder used as a regulating member for the two control modes is that, in the event of a leak of the valve provided for connecting the drive pressure space of the hydraulic cylinder to the auxiliary pressure source, there cannot be an undesirable pressure build-up in the drive-pressure space of the hydraulic cylinder, since pressure medium an flow off to the storage tank of the auxiliary pressure source via the through flow path of the other valve intended for relieving the drive-pressure space of the hydraulic cylinder.

Further details and features of the invention emerge from the following description of exemplary embodiments with reference to the drawing:

Figure 1 shows, in a simplified block-diagram representation, a first exemplary embodiment of an anti lock and propulsion control system according to the invention for a road vehicle with rear-axle drive, with a hydraulic cylinder used as a brake-pressure regulating member for both control modes and with a control valve arrangement for function control composed solely of solenoid valves,

Figures 2 to 8 show respectively, in a representation corresponding to that of Figure 1, further exemplary embodiments, corresponding in functional terms to the exemplary embodiment according to Figure 1, of the anti-lock and propulsion-control system according to the invention, in which solenoid valves, displacement-control valves and/or hydraulically activated valves are used alternatively or in combination for producing the function-control valve arrangement,

Figures 9 to 11 show, in a representation corresponding to that of Figure 1, further exemplary embodiments of the anti-lock and propulsion-control system according to the invention, with a design, alternative to the exemplary embodiments according to Figures 1 to 8, of a hydraulic cylinder used as a brake-pressure regulating member and of the function-control valve arrangement,

Figure 12 shows, in longitudinal section, a hydraulic cylinder which can be used in the exemplary embodiments according to Figures 1 to 8 instead of the hydraulic cylinder provided in these as a brake-pressure regulating member, and

Figure 13 shows a further design of a hydraulic cylinder which can be used within the framework of the exemplary embodiments according to Figures 1 to 8, otherwise in a longitudinal-sectional representation corresponding to that of Figure 12.

Figure 1, to the particulars of which express reference will be made, shows the functionally essential details of an anti-lock and propulsion-control system designated as a whole by 15, for a road vehicle represented, moreover, by its brake system 16 which, without any restriction of generality, that is to say, merely for the purpose of the explanation, will be presupposed to be a hydraulic dual circuit brake system in which the rear-wheel brakes 17 and 18 are combined to form a rear-axle brake circuit I and the front-wheel brakes (not shown) are combined to form a front-axle brake circuit II which, moreover, for the sake of simplicity of representation, is symbolized merely by a portion of its main brake line 21 extending from the brake unit 19 of the brake system 16.

It will also be presupposed, where the vehicle is concerned, that it has a rear-axle drive, that is to say the propulsion control has to take effect only on the rear axle.

The rear-axle brake circuit is designed as a static brake circuit connected to the secondary outlet-pressure space 22 of a cylinder designed, in the exemplary embodiment illustrated, as a tandem master cylinder of a type conventional per se and connected to the brake unit 19 which can be actuated by means of a brake pedal 23 via a pneumatic or hydraulic brake booster 24. In this case, the front-axle brake circuit II is likewise designed as a static brake circuit which is connected to the primary outlet-pressure space 26 of the tandem master cylinder 19. The secondary piston 27 delimiting the primary outlet-pressure space 26 of the tandem master cylinder 19 from its secondary outlet-pressure space 22 has two piston flanges 28 and 29 which are arranged at an axial distance from one another corresponding to the maximum stroke of the secondary piston 27 and which are sealed off respectively by means of an annular gasket 31 and 32 from the master-cylinder bore 33 forming the radial limitation of the primary outlet-pressure space 26 and the radial limitation of the secondary outlet-pressure space 22.

The two piston flanges 28 and 29 are connected to one another by means of an intermediate piece 34 of the secondary piston 27 equipped with a longitudinal slot 36 which is extended in the axial direction and through which passes radially a stop pin 38 connected firmly to the housing 37 of the brake unit 19 and extending perpendicularly relative to the drawing plane in the representation of Figure 1. The basic position of the secondary piston

27 of the brake unit 19 corresponding to the non-actuated state of the brake system 16 is marked by contact of that edge of the longitudinal slot 36 of the secondary piston 27 located on the same side as the outlet-pressure space against the stop pin 38 fixed to the housing, the secondary piston 27 being forced into its basic position by a restoring spring 41 supported on the one hand on the latter and on the other hand on the end wall 39 of the master-cylinder housing 37 limiting the secondary outlet-pressure space in the axial direction fixedly relative to the housing.

The two piston flanges 28 and 29 of the secondary piston 27 form the axial limitation of a follow-up space 42 in the form of an annular gap, which is in constant communicating connection with that part 43' of the brake-fluid storage tank 43 of the brake system 16 which is assigned to the rear-axle brake circuit I.

Integrated in the secondary piston 27 of the brake unit 19 as a compensating valve is a central valve 44 of a design known per se which, in its basic position shown, linked to the non-activated state of the brake system 16, is open and which, in this open position, puts the secondary outlet-pressure space 22 of the brake unit 19 in communicating connection with its follow-up space 42 and, via this, also with the brake-fluid storage tank 43, 43'. This central valve 44 is designed so that when the brake system 16 is actuated, as soon as the secondary piston 27 of the brake unit 19 has executed a small initial portion of its movement stroke, the central valve 44 assumes its blocking position, after which, during a further displacement of the secondary piston 27, the pressure build-up starts in the secondary outlet-pressure space 22 and consequently in the wheel brakes 17 and 18.

In the special exemplary embodiment illustrated, the central valve 44 is designed as a disc-type seat valve, of which the valve body in the form of a circular disc is forced by a valve spring supported fixedly relative to the piston up against the valve seat formed by the edge, on the same side as the outlet-pressure spare, of a central piston channel which opens into the longitudinal slot 36 of the secondary piston 27 and through which passes a rear stop tappet of the valve body of the central valve 44 which, as soon as the stop tappet comes up against the stop pin 38 fixed to the housing, is lifted off from its valve seat when the secondary piston 27 approaches its basic position.

The design of the brake system 16, which has been explained so far and which, for the sake of simplicity in the explanation, is also presupposed to apply to the exemplary embodiments to be explained later, is known per se.

The anti-lock and propulsion-control system 15, also referred to below more briefly as "control system", works, in control phases of the anti-lock control, on the principle of controlling the brake pressure by varying the volume of an ABS control space 46, in communicating connection with the wheel-brake cylinders, of a brake-pressure regulating member, designated as a whole by 47, which is also used in this function for propulsion control which works on the principle known per se of decelerating a vehicle wheel tending to spin by activating its wheel brakes 17 and/or 18, until its drive slip always remains within a range of values compatible both with sufficient driving stability and with good propulsion acceleration of the vehicle.

In the event that the ASR control is activated in terms of the rear-axle brake circuit I, this brake-pressure regulating member 47 performs the function of a master cylinder which is connected to the rear-axle brake circuit instead of the brake unit 19 and which has a ASR outlet-pressure space 48 used for the propulsion-control (ASR) function and limited movably in a pressure-tight manner by a flange 49 of a regulating piston, designated as a whole by 51, of the brake-pressure regulating member 47, the regulating piston 51 being displacable in the direction of a brake-pressure build-up in the ASR outlet-pressure space 48 of the brake-pressure regulating member 47 as a result of valve-controlled connection of a drive-pressure space 53, limited movably in a pressure-tight manner by a drive piston 52, of the brake-pressure regulating member 47 to the high-pressure outlet 54 of an auxiliary pressure source, designated as a whole by 56, and, when the drive-pressure space 53 is relieved of pressure, being forced back towards its basic position by a restoring spring 57 in the direction of a brake-pressure reduction in the outlet-pressure space 48 and in the wheel brake or wheel brakes 17 and/or 18 connected to this.

In all the exemplary embodiments, the brake-pressure regulating member 47 of the control system 15 is designed to the effect that a displacement of the regulating piston 51 resulting from the subjection of it's drive-pressure space 53 to the outlet pressure of the auxiliary pressure source 56 leads, on the one hand, to an increase in volume of the ABS control space 46 and, on the other hand, to a decrease in volume of the ASR outlet-pressure space 48, so that alternative brake-pressure reduction phases of the anti-lock control and brake-pressure build-up phases of the propulsion control can be controlled as a result of a corresponding alternative connection of the wheel brake or wheel brakes 17 and/or 18 used respectively for the control to the particular functional space 46 or 48 of the brake-pressure regulating member 47, whilst the initiating activation of the control system 15 in its two control modes is obtained respectively by subjecting the drive-pressure space 53 of a brake-pressure regulating member 47 to pressure under valve control.

Before several alternative design versions of a function-control valve arrangement suitable for "selecting" the particular control mode required are discussed below, the construction of a brake-pressure regulating member which forms the central functional element of the control system 15 and which can be used in conjunction with a multiplicity of such design versions of the function-control valve arrangement will be explained first.

In the design of this brake-pressure regulating member 47 provided in the exemplary embodiments according to Figures 1 to 8, the latter is designed as a single-acting hydraulic cylinder, the drive piston 52 of which is connected firmly to the regulating piston 51 forming the movable limitation of both the ASR outlet-pressure space 48 and the ABS control space 46.

The hydraulic cylinder 47, in its functional part limiting the ASR outlet-pressure space 48 and the ABS control space 46 fixed relative to the housing, is designed as a step cylinder, of which the spatially narrower bore step 58, closed off by the end wall 59 of the cylinder housing 61, forms the limitation, fixed relative to the housing, of the ASR outlet-pressure space 48 limited movably by the piston flange 49 of the regulating piston 51. Guided displacably in a pressure-tight manner in the bore step 62 adjoining this narrower bore step 58 and of somewhat larger diameter is a second dimetrically correspondingly larger flange 63 of the regulating piston 51 forming, within this larger bore step 62, the movable limitation of the ABS control space 46, of which the axial limitation fixed relative to the housing is formed by an intermediate wall 64 of the cylinder housing 61 equipped with a central bore 66, in which is guided displacably in a pressure-tight manner a piston rod 67 connecting the regulating piston 51 of the hydraulic cylinder 47 to its drive piston 52 fixedly in the exemplary embodiment shown. At the same time, the drive piston 52 is arranged in a diametrically even larger bore step 68 of the cylinder housing 61 and within this forms the movable limitation of the drive-pressure space 53, connectable to the auxiliary pressure source 56 and axially limited fixedly relative to the housing by an end wall 69 of the cylinder housing, relative to a separating space 71 which is kept pressureless and of which the axial limitation fixed relative to the housing is formed by the intermediate wall 64.

Arranged in this separating space 71 is the restoring spring 57 which is supported axially on the intermediate wall 64 on the one hand and on the drive piston

52 on the other hand and which forces the composite piston structure comprising the regulating piston 51 and the drive piston 52 of the hydraulic cylinder 47 into its basic position linked to a minimum volume of the ABS control space 46 and a maximum volume of the ASR outlet-pressure space 48.

By means of the separating space 71 which, as seen in the axial direction, is arranged "between" the drive-pressure space 53 of the hydraulic cylinder 47 and the ABS control space 46 of the latter, the necessary media separation between the drive circuit and the ABS and ASR function control circuits is obtained in a simple way.

The regulating piston 51 is designed so that the effective cross-sectional area of its flange 49 limiting the ASR outlet-pressure space 48, which is equal to the cross-sectional area of the smaller bore step 58, and the effective area of the flange 63 limiting the ABS control space 46, the amount of which is determined by the difference between the cross-sectional area of the larger bore step 62 and the cross-sectional area of the central bore 66 of the intermediate wall 64, are approximately equal, that is to say equal within a margin of ± 15%, and preferably have exactly the same amount.

This ensures, in a pressure-reduction control phase of the anti-lock control, in which the portion 72 branching off to the wheel brakes of the main brake line of the rear-axle brake circuit I is connected to the ABS control space 46 via a first control valve 73 and the ASR outlet-pressure space 48 of the hydraulic cylinder 47 is connected to the secondary outlet-pressure space 22 of the brake unit 19 via a second control valve 74 of a control valve arrangement 73, 74 obtaining the anti-lock or the propulsion-control mode, depending on the switching state, that the quantity of brake fluid received by the ABS control space 46 from the wheel brake or wheel brakes 17 and/or 18 subjected to the control is virtually the same as that quantity of brake fluid which, in such a pressure-reduction phase, is forced out of the ASR outlet-pressure space 48 of the hydraulic cylinder 47 into the secondary outlet-pressure space 22 of the brake unit 19, as a result of which, on the one hand, a reaction appropriate for the activation of the anti-lock control becomes detectable on the brake pedal 23 because of the associated retreat of the secondary piston 27 of the brake unit 19 and consequently also of its primary piston (not shown) and, on the other hand, the possibility that the secondary outlet-pressure space 22 of the brake unit 19 will be "controlled empty" as a result of several successive pressure-reduction phases of the anti-lock control is prevented.

Integrated in the regulating piston 51 of the hydraulic cylinder 47 is a central valve, designated as a whole by 76, the design of which is identical to that of the central valve 44 of the secondary piston 27 of the brake unit 19. The central valve 76 is designed and arranged to the effect that, in the basic position of the regulating piston 51 which is illustrated and which the latter assumes as long as the control system 15 is not activated or after a control cycle has been terminated or is immediately before its conclusion, the central valve 76 is in its open position, in which the ASR outlet-pressure space 48 and the ABS control space 46 of the hydraulic cylinder 47 are in communicating connection with one another and, when the control system 15 is activated after the composite piston structure 51, 52 of the hydraulic cylinder 47 has executed a small initial portion of its possible working stroke, assumes its blocking position, in which this connection between the ASR outlet-pressure space 48 and the ABS control space 46 of the hydraulic cylinder 47 is then broken.

A compensating space 77 of the hydraulic cylinder 47, in the form of an annular gap and, in all the exemplary embodiments illustrated, extending between the flanges 49 and 63 of the regulating piston 51, is connected respectively via a compensating line 78 to the follow-up space 42 of the brake unit 19, limited in the axial direction by the piston flanges 28 and 29 of the secondary piston 27 of the brake unit 19, and via this follow-up space 42 to the brake-fluid storage tank 43, 43' of the brake system 16.

In the exemplary embodiment according to Figure 1, a solenoid valve 79 designed as a 3/2-way valve is provided for controlling the activation of the control system 15. In the basic position of this solenoid valve 79 corresponding to the non-activated state of the control system 15, the drive-pressure space 53 of the hydraulic cylinder 47 is connected to the tank 81 of the auxiliary pressure source 56 and is shut off from the high-pressure outlet 54 of the latter. The auxiliary pressure source 56 comprises, in a conventional design, a pressure accumulator 84 which can be charged by means of a charging pump 82 via an accumulator charging valve 83 and the outlet pressure of which is maintained at a minimum level. In order to activate the control system, the 3/2-way solenoid valve 79 is changed over to its excited position I, in which the outlet pressure of the auxiliary pressure source 56 is fed into the drive-pressure space 53 of the hydraulic cylinder 47.

Within the control system 15, brake-pressure regulating valves 86 and 87 are assigned respectively to the rear-wheel brakes 17 and 18 and, here, are designed specially as 2/2-way solenoid valves, the basic position 0 of which is the throughflow position, in which brake pressure can be built up or reduced in the wheel brake 17 or 18 connected to the portion 72 of the main brake line respectively via the brake-pressure regulating valve 86 or 87, and of which the excited position I assumed when they are activated by means of a control-system control signal is the blocking position, in which the brake pressure on the particular connected wheel brakes 17 or 18 is kept constant at the value previously activated or a brake-pressure build-up is prevented.

The activation signals necessary for the appropriate activation of the control system 15 according to the situation and intended for the pressure-supply control valve 79 and the brake-pressure regulating valves 86 and 87 and, if necessary, for function-control valves 73 and 74 designed as electrically activatable valves are transmitted in a stipulated sequence and in combination by an electronic control unit, not shown for the sake of simplicity, which generates these control signals as a result of a processing, carried out according to known criteria, of electrical output signals proportional to wheel speeds, coming from wheel-speed sensors, likewise not shown for the sake of simplicity, by means of which the movement behaviour of the vehicle wheels is monitored continuously. It is assumed that there is no need to describe these functional elements (not shown) of the control system 15, since they are known in many versions for the purpose mentioned, but at the very least can be produced by a person skilled in the art, knowing the control purpose, by common means in electronic circuitry.

In the exemplary embodiment according to Figure 1, the first function-control valves 73 and the second function-control valve 74 are designed as 3/2-way solenoid valves which assume their respective basic position 0 shown both during normal braking, that is to say braking not subjected to the anti-lock control, and in braking subjected to the anti-lock control.

In the basic position of the first solenoid valve 73, the ABS control space is connected, via the throughflow path 88 open in this basic position 0, to the portion 72 of its main brake line branching off to the rear-wheel brakes 17 and 18 of the rear-axle brake circuit I.

In the basic position 0 of the second solenoid valve 74 of the function-control valve arrangement, the secondary out-let-pressure space 22 is connected, via the throughflow path 89 open in the basic position 0 of the second solenoid valve 74, to the ASR outlet-pressure space 48 of the hydraulic cylinder 47 provided as a brake-pressure regulating member of the control system 15.

In the basic position of the composite piston structure 51, 52 of the hydraulic cylinder 47 which corresponds to the non-activated state of the control system 15 and in which its central valve 76 assumes its open position, the ASR outlet-pressure space 48 is also in communicating connection with the ABS control space 46 of the hydraulic cylinder 47. During normal braking, the outlet pressure generated in the secondary outlet-pressure space 22 of the brake unit 19 as a result of the actuation of the latter is thus fed, via the second function-control valve 74, into the ASR outlet-pressure space 48 of the hydraulic cylinder 47, from this via the open central valve 76 into the ABS control space 46 and from this, via the throughflow path 88 of the first solenoid valve 73 open in the basic position 0 of the latter, into portion 72, leading onto the wheel brakes, of the main brakeline of the rear-axle brake circuit I.

When the control system 15 is activated in its anti-lock control mode by coupling the drive-pressure space 53 of the hydraulic cylinder 47 to the high-pressure outlet 54 of the auxiliary pressure source 56, the regulating piston 51 experiences a displacement in the direction of an increase of the ABS control space 46 and a decrease of the volume of the ASR outlet-pressure space 48 of the hydraulic cylinder 47, the central valve 76 of the regulating piston 51, after a small initial portion of the regulating stroke of the regulating piston 51, assuming its blocking position, in which there is no longer a communicating connection between the ASR outlet-pressure space 48 and the ABS control space 46. The ASR outlet-pressure space 48 is now connected only to the outlet-pressure space 22 of the brake unit 19 via the throughflow path 89 of the second control valve 74, whilst the ABS control space 46 is connected, via the throughflow path 88 of the first control valve 73, only to the portion 72 branching off to the wheel brakes 17 and 18 of the main brake line of the rear-axle brake circuit I.

Brake fluid can overflow into the ABS control space 46 from the wheel brake or wheel brakes 17 and/or 18 subjected to the anti-lock control, with the result that a corresponding quantity of brake fluid is forced back into the secondary outlet-pressure space 22 of the brake unit 19

... necessary in terms of anti-lock control ... brake pressure outlet-pressure space 48 of the hydraulic cylinder 47.

Brake-pressure rebuild-up phases are controlled by switching the pressure-supply control valve 79 back into its basic position 0 again for the duration of such phases, whilst brake-pressure holding phases on the particular wheel brakes 17 and/or 18 can be controlled by changing its brake-pressure regulating valve 86 and/or 87 over into the blocking position I.

When the control system 15 is activated with the effect of propulsion control, in addition to the pressure-supply control valve 79 the two solenoid valves 73 and 74 of the function-control valve arrangement are also moved into their excited positions I. With regard to propulsion control too, the connection between the ASR outlet-pressure space 48 and the ABS control space 46 of the hydraulic cylinder 47 is shut off as a result of the closing of the central valve 76. In the excited position I of the first solenoid valves 73 of the function-control valve arrangement, the ABS control space 46 of the hydraulic cylinder 47 is now connected to the compensating line 78 via the alternative throughflow path 91 open in this position. Furthermore, in the excited position I of the second solenoid valve 74 of the function-control valve arrangement, the ASR outlet-pressure space 48 of the hydraulic cylinder 47 is connected, via the throughflow path 92 opening in this position of the valve 74, to the portion 72 branching off to the rear-wheel brakes 17 and 18 of the main brake line of the rear-axle brake circuit I, but the latter is shut off from the secondary outlet-pressure space 22 of the brake unit 19. In control phases of the propulsion control, the hydraulic cylinder 47 acts as it were as a master cylinder for the rear-axle brake circuit, and in this case brake-pressure reduction phases of the propulsion control can be controlled by changing over the drive control valve 79 to its basic position 0. In propulsion control too, of course, brake-pressure holding phases on the wheel brakes 17 and/or 18 ar controlled by moving the respective brake-pressure regulating valves 16 and/or 18 into its excited position I.

By means of the function-control valve arrangement 73, 74, 76 which has been explained with reference to Figure 1 and which must also include the central valve 76 of the regulating piston 51 of the hydraulic cylinder 47, the following functions are therefore performed:

a) in normal braking not subjected to the anti-lock control, both the outlet-pressure space 22 of the brake unit 19 assigned to the controllable brake circuit and the ASR outlet-pressure space 48 and the ABS control space 46 of the hydraulic cylinder 47 are connected to the wheel brakes 17 and 18 via the brake-pressure regulating valves 86 and 87;

b) during braking subjected to the anti-lock control, the ABS control space 46 alone is connected to the brake line 72 of the controllable brake circuit I and the ASR outlet-pressure space 48 of the hydraulic cylinder alone is connected to the outlet-pressure space 22 of the brake unit 19;

c) when the propulsion control responds, the outlet-pressure space 22 of the brake unit 19 is shut off from the wheel brakes 17 and 18, the ABS control space 46 is connected to the pressureless brake-fluid storage tank 43, 43' of the brake system 16, and the ASR outlet-pressure space 48 of the hydraulic cylinder 47 is connected to the main brake line 72 leading to the wheel brakes 17 and 18.

The exemplary embodiments to be explained below with reference to Figures 2 to 11, to the details of which your attention is drawn in advance, differ essentially in the form taken by the function-control valve arrangements effecting these functions and modifications possibly resulting herefrom in the hydraulic cylinder which can be used in each case as brake-pressure regulating member.

Wherever the same reference numerals are used in further drawing figures as in Figure 1 or another figure previously described, this is intended to indicate that elements thus denoted are identical to those previously described or that they are analogous in design and function and that you are referred to the parts of the description associated with these figures in order to avoid repetitions.

In the exemplary embodiment according to Figure 2, to the details of which you are now expressly referred, the function-control valve arrangement - in addition to the central valve 76 of the hydraulic cylinder 47 - comprises two displacement-controlled change-over valves 93 and 94, which assume their basic positions 0 in the basic position of the secondary piston 27 of the brake unit 19 associated with the not actuated state of the brake system 16 and, after the secondary piston 27 of the brake unit 19 has executed a small initial portion of its brake pressure build-up stroke, transfer from these basic positions into their through-flow positions I, as well as an electrically actuable valve, which is designed as a 2/2-way solenoid valve 96. The one of these two displacement controlled valves is designed as a 3/2-way valve 93, in the basic position 0 of which the ABS control space 46 is connected via a throughflow flow path 97, open in this position of the valve 93, to the compensating line 78 and the follow-up space 42 of the brake unit 19 to the brake-fluid storage tank 43, 43'.

The other of the two displacement-controlled change-over valves is designed as a 2/2-way valve 94, the basic position 0 of which is the blocking position, in which an initial portion 98 of the main brake line of the rear axle brake circuit I, starting from the secondary outlet-pressure space 22 of the brake unit, is blocked off from an intermediate portion 99 of the main brake line of the rear axle brake circuit I leading to the ASR control-pressure space 48 of the hydraulic cylinder 47.

In the throughflow position, alternative to the basic position 0, of displacement-controlled 3/2-way valve 93, the ABS control space 46 of the hydraulic cylinder 47 is connected via the throughflow flow path 101, open in the changed-over position I, of this 3/2-way valve 93 to the portion 72 of the main brake line of the rear axle brake circuit I branching off to the wheel brakes 12 and 18.

In the throughflow position of the displacement-controlled valve 94 designed as 2/2-way valve, the secondary outlet-pressure space 22 is connected via the main brake line portions 98 and 99 to the ASR outlet-pressure space 48 of the hydraulic cylinder 47.

In the basic position 0 of the 2/2-way solenoid valve 96, the ASR outlet-pressure space 48 of the hydraulic cylinder 47 is blocked off from the portion 72 of the main brake line of the rear axle brake circuit I branching off to the wheel brakes. In the excited position I, the ASR outlet-pressure space 48 of the hydraulic cylinder 47 is connected to the portion 72 of the main brake line branching off to the wheel brake.

In normal brake operation, the pressure supply control valve 79 on the one hand and the 2/2-way solenoid valve 96 of the function-control valve arrangement are not activated and only the displacement-controlled valves 93 and 94 are changed over into their throughflow positions I.

The activation of the anti-lock control mode of the control system 15 takes place by change-over of the 3/2-way solenoid valve 79 in its position affecting the coupling of the auxiliary pressure source 56 to the drive-pressure space 53 of the hydraulic cylinder 47.

The control system 15 operates in the propulsion-control mode when - corresponding to the non-actuated state of the brake system 16 - the two displacement-controlled change-over valves 93 and 94 are in their basic positions 0, the pressure supply control valves 79 have switched into its excited position I and likewise also the 2/2-way solenoid valve 96 of the function-controlled valve arrangement has switched into its excited position I, its throughflow position.

In the exemplary embodiment according to Figure 2, there is connected in parallel to the 2/2-way solenoid valve 96 of the function-control valve arrangement, that is to say, in the circuit arrangement which can be seen in Figure 2, "between" the ASR outlet-pressure space 48 and the portion 72 of the main brake line of the rear axle brake circuit II branching to the wheel brakes 17 and 18, a non-return valve 102, which is subjected to higher pressure in opening direction in this main brake line portion 72 than in the ASR outlet-pressure space 48 of the hydraulic cylinder 47. This non-return valve 102 has the effect that brake fluid can flow out of the wheel brakes 17 and 18 back into the ASR outlet-pressure space 48 of the hydraulic cylinder 47 even in the blocking position of the 2/2-way solenoid valve 96 and thus - in the basic position of the regulating piston 51 of this hydraulic cylinder - a compensating flow can take place towards the brake-fluid storage tank 43, 43' if the brake fluid expands thermally in the wheel brakes 17 and 18.

The exemplary embodiment according to Figure 3 differs from that according to Figure 1 merely in that, instead of the first function-control valve 73 designed there as a solenoid valve, a displacement-controlled 3/2-way valve 103 is provided, the basic position 0 of which corresponds functionally to the excited position I of the 3/2-way solenoid valve 73 of Figure 1 and, after a small initial portion of the brake-pressure build-up stoke of the secondary piston 27 of the brake unit 19, the assumed functional position I (sic), corresponds functionally to the basic position 0 of the 3/2-way solenoid valve 73 of the function-control valve arrangement according to Figure 1.

A non-return valve 102, functionally analogous to the non-return valve according to Figure 2, is also provided in the exemplary embodiment according to Figure 3. Otherwise, there is design identity and functional analogy with the exemplary embodiment according to Figure 1.

Also in the exemplary embodiment according to Figure 4, to the details of which reference will now be made, which differs from the exemplary embodiments according to figures 1 to 3 merely in the configuration of the function-control valve arrangement, the latter comprises a valve 103, designed as a 3/2-way valve, controlled as a function of the operational stroke of the secondary piston 27 of the brake unit 19 and, after a small fraction of the pressure build-up stroke of this secondary piston 27, is changed over from its basic position 0, in which the ABS control space 46 of the hydraulic cylinder 47 is connected via the compensating line 78 - in the final event - to the brake fluid storage tanks 43, 43' of the brake system 16, but is blocked off from the rear axle brake circuit I, into its alternative function position I, in which the ABS control space 46 is connected via the throughflow flow path 104, open in the function position I of this displacement-controlled valve 103, to the portion 72 of the main brake line of the rear axle brake circuit branching to the wheel brakes 17 and 18 of the rear axle brake circuit I, but is, on the other hand, blocked off from the brake-fluid storage tank.

Moreover, the function-control valve arrangement comprises a first solenoid valve 106, which is designed as a 2/2-way valve and the basic position 0 of which is its throughflow position and the excited position I of which is its blocking position, as well as a second solenoid valve 107, which is designed as a 2/2-way valve and the basic position 0 of which is likewise its throughflow position and the excited position I of which is its blocking position.

The first 2/2-way solenoid valve 106 releases, in its basic position 0, a pressure medium flow path 108, which leads from the secondary outlet-pressure space 22 of the brake unit 19 to the ASR outlet-pressure space 48 of the hydraulic cylinder 47. It is controlled into its blocking position I by a signal associated with an activation of the control system 15 in its propulsion-control mode.

The second 2/2-way solenoid valve 107 releases in its basic position 0 a pressure medium flow path 109, which leads from the ASR outlet-pressure space 48 of the hydraulic cylinder 47 directly to the portion 72 of the main brake line of the rear axle brake circuit I branching off to the wheel brakes 17 and 18. This second 2/2-way solenoid valve 107 is controlled by a signal associated with an activation of the control system 15 in its anti-lock control mode into its blocking position. In the exemplary embodiment according to Figure 4 as well, the activation of the control system 15 in the one or other control mode is achieved by changing over the pressure supply control valve 79 into its excited position I.

In the exemplary embodiment according to Figure 5, to the details of which reference will now expressly be made, the function-control valve arrangement comprises a first hydraulically actuable 3/2-way valve 111 and a second hydraulically actuable 3/2-way valve 112, which are jointly hydraulically actuable. For the joint actuation of these two 3/2-way valves 111 and 112, a 2/2-way solenoid valve 113 is provided as further function-control valve, which is switched between the supply-pressure inlet 114 of the propulsion-pressure space 53 of the hydraulic cylinder 47 and the hydraulic control connections 116 and 117 of the two 3/2-way valves 111 and 112. The basic position 0 of this further function-control valve 113 is the blocking position, its excited position I is the throughflow position. The hydraulic cylinder 47 is, from the exemplary embodiment according to Figure 5, identical with regard to design and function to the hydraulic cylinder shown in each of figures 1 to 4.

The exemplary embodiment according to Figure 5 is also functionally identical to the exemplary embodiment according to Figure 1 to the extent that the two 3/2-way valves 111 and 112 effect the same hydraulic switching connections in their basic positions 0, which are assigned to normal braking and to braking subject to an anti-lock control, and in their excited positions I, which they assume when the further function-control valve 113 is changed into its throughflow position I, if at the same time the control system 15 is activated, that is to say the drive-pressure space 53 of the hydraulic cylinder 47 is subjected to the outlet pressure of the auxiliary pressure source 56, as the, likewise jointly actuable - two 3/2-way solenoid valves 73 and 74 of the function-control valve arrangement according to Figure 1. Accordingly, the throughflow flow path 88 and 91 and 89 and 92, respectively, released in the alternative function positions 0 and I of the two hydraulically activated 3/2-way valves 111 and 112 are given the same reference numerals as the corresponding throughflow flow paths of the two 3/2-way solenoid valves 73 and 74 of the function-control valve arrangement according to Figure 1.

To this extent, the only difference in these two exemplary embodiments is the form taken by the activation of the 3/2-way valves 111 and 112.

As a further structural difference from the exemplary embodiment according to Figure 1, in the exemplary embodiment according to Figure 5, the control-valve arrangement utilized for activation of the control system 15 comprises a first change-over valve 118, designed as a 2/2-way solenoid valve, and a second change-over valve 119, likewise designed as a 2/2-way solenoid valve, one of which - the change-over valve 118 - blocks in its basic position 0 and is switched to throughflow in its excited position and the second of which - the change-over valve 119 - is switched to throughflow in its basic position and is blocked in its excited position. In the basic position of the first change-over valve 118, the auxiliary pressure source 56 is blocked off from the drive-pressure space 53 of the hydraulic cylinder 47. In the basic position of the second change-over valve 119, the drive-control space 53 of the hydraulic cylinder 47 is, on the other hand, connected to the pressureless storage tank 81 of the auxiliary pressure source 56. By excitation of the second change-over valve 119 and simultaneous or slightly delayed excitation also of the first change-over valve 118, the drive-pressure space 53 of the hydraulic cylinder 47 is blocked off from the storage tank 81 of the auxiliary pressure source 56 and instead connected to its high-pressure outlet 54. With a little activation of the two change-over valves 118 and 119, the anti-lock control mode of the control system 15 is activated. The activation of the control system 15 in the propulsion-control mode is achieved by additional changing over of the further control valve 113 into its excited position I, as a result of which the two 3/2-way solenoid valves are also changed - hydraulically - into their "excited" positions I.

During a brake pressure reduction phase of the propulsion control, which requires a switching-back of the two control valves 118 and 119 into their respective basic position, the further change-over valve 113 is likewise switched back into its basic position 0 - the blocking position - expediently before the two change-over valves 118 and 119 are changed over, in order that control pressure in the control spaces of the 3/2-way valves is maintained and these function positions necessary for the propulsion control remain. In order to ensure, on the other hand, that the two hydraulically actuated 3/2-way valves 111 and 112 again return to their basic positions 0 intended for normal braking after completion of a propulsion-control cycle, the 2/2-way solenoid valve 113 provided as further function-control valve is controlled into its throughflow position for a short period of time after termination of such a control phase, so that the control pressure of the 3/2-way valves 111 and 112 can expand into the pressureless storage tank 81 of the auxiliary pressure source 56. Thereafter, the further function-control valve 113 can remain in its basic position 0 - the blocking position. It is then adequately ensured by the second change-over valve 119, held in its basic position 0 after completion of a control phase, that an undesired pressure build-up in the drive-pressure space 53 of the hydraulic cylinder 47 and/or in the control pressure spaces of the hydraulically controlled 3/2-way valves 111 and 112, due for example to a leakage of the first change-over valve 118, cannot occur. This gain in functional reliability can also be utilized in conjunction with the other exemplary embodiments of the control system 15 according to the invention if, instead of a single 3/2-way solenoid valve 79, as shown in Figures 1 to 4 as well as 9 and 10, two change-over valves 118 and 119, designed as 2/2-way solenoid valves, are used.

The exemplary embodiment in Figure 6, to the details of which reference will now be made, is very similar, structurally and in terms of circuitry, to that explained with reference to Figure 5, and therefore is explained below essentially by a comparative consideration of these two exemplary embodiments.

In the exemplary embodiment according to Figure 6 as well, there are provided as part of the function-control valve arrangement, two hydraulically activatable valves 111 and 121, which are switched into their "excited" positions I only when the control system 15 operates in its propulsion-control mode, otherwise, i.e. in normal braking or to braking subjected to the antilock control, remain in their basic positions 0 shown. If one of these two valves is designed as a 3/2-way valve 111, which corresponds structurally and functionally to the valve 111 of the function-control valve arrangement according to Figure 5 and, in its basic position 0, connects via the throughflow flow path 88, open in this position, the ABS control space 46 of the hydraulic cylinder 47 to the portion 72 of the main brake line of the rear axle brake circuit I branching off to the wheel brakes 17 and 18, while, in its excited position I, it connects the ABS control space 46 via its throughflow flow path 91, open in this position I, to the compensating line 78 or the brake-fluid storage tank 43, 43' of the brake system 16.

The second hydraulically activatable valve 121 is designed as a 2/2-way valve which, in its basic position 0, blocks the ASR outlet-pressure space 48 of the hydraulic cylinder 47 from the portion 72 of the main brake line of the rear axle brake circuit I branching off to the wheel brakes 17 and 18 and, in its excited position I, assumed in propulsion-control operation, connects the ASR outlet-pressure space 48 of the hydraulic cylinder 47 to the portion 72 of the main pressure line of the rear axle brake circuit I branching off to the wheel brakes 17 and 18.

The function-control valve arrangement further comprises a control valve 122, which is designed as a 2/2-way solenoid valve and in the basic position of which, assigned to normal brake operation and a brake operation subject to the anti-lock control, the secondary outlet-pressure space 22 of the brake unit 19 is connected to the ASR outlet-pressure space 48 of the hydraulic cylinder, and in its excited position I, which is assigned to the propulsion-control mode of the control system 15, this connection is interrupted. The activation of the control system 15 again takes place by a feeding of the outlet pressure of the auxiliary pressure source 56 into the drive pressure space 53 of the hydraulic cylinder 47 which can be controlled by means of the two change-over valves 118 and 119.

As pilot control valve for the two hydraulically activatable valves 111 and 121, a 2/2-way change-over valve 123 corresponding functionally to the control valve 113 of Figure 5 is provided, but here is designed as a valve which is mechanically displacement-controlled as a function of the working stroke of the secondary piston 27 of the brake unit 19 and which, once the secondary piston 27 of the brake unit 19 has not executed a small initial portion of its brake-pressure build-up stroke when actuated, transfers from its basic position 0 shown, in which the drive-pressure supply connection 114 of the hydraulic cylinder 47 is connected to the control-pressure connections of the two hydraulically activatable valves 111 and 121, into its blocking position I, in which, if subsequently the anti-lock control comes into action, the outlet pressure of the auxiliary pressure source 56 can no longer act on the hydraulic control elements of the two hydraulically controllable valves 111 and 121. Connected into a bypass flow path 124, bypassing as it were the pilot control valve 123, a non-return valve 126 is connected, which is subjected to relatively higher pressure in opening direction in the control pressure spaces of the two hydraulically activatable valves 111 and 121 than in the drive-pressure space 53 of the hydraulic cylinder 47 or in the - pressureless - storage tank 81 of the auxiliary pressure source 56.

The purpose of this non-return valve 126 is to make it possible to reduce the control pressure in the control-pressure spaces of the hydraulically activatable valves 111 and 121, if the driver actuates the brake system 16 during a propulsion-control phase and the pilot valve 123 thereby assumes is blocking position I, in which it would otherwise be impossible to reduce the pressure in the control-pressure spaces of the hydraulically activatable valves 111 and 121, with the result that the braking function of this brake circuit would be impaired.

In the exemplary embodiment according to Figure 7, to the details of which reference will now be made, the function-control valve arrangement is formed solely by displacement-controlled valves, one of which is the central valve 76 of the hydraulic cylinder 47 and accordingly assumes its open position or its blocking position, depending on the position of its piston, whilst the other function-control valves 127, 128 and 129 are designed as valves which respond to the position of the secondary piston 27 of the brake unit 19 and which, as soon as the secondary piston 27 has executed a small initial portion of its brake-pressure build-up stroke when the brake system has been actuated, change from their basic positions 0 shown into their functional positions I alternative to these.

The "selection" of the control mode, in which the control system 15, when activated, works as a result of coupling of the drive-pressure space 53 of the hydraulic cylinder 47 to the high-pressure outlet 54 of the auxiliary pressure source 56, is therefore made purely "mechanically", that is to say as a result of the actuation or non-actuation of the brake pedal 23.

A first of the function-control valves controlled in this way by (pedal) displacement is designed as a 3/2-way valve 127, in the illustrated basic position 0 of which the ABS control space 46 is connected to the compensating line 78 and, via the latter, finally to the brake-fluid storage tank 43, 43' of the brake system 16, and in the functional position I of which, alternative to this and assumed when the brake system 19 is actuated, the ABS control space 46 of the hydraulic cylinder 47 is connected, via the throughflow path 131 open in this valve position, to the portion 72 branching off to the wheel brakes 17 and 18 of the main brake line of the rear-axle brake circuit I. A second of these displacement-controlled function-control valves is designed as a 2/2-way change-over valve 128, of which the basic position 0 is its blocking position and the functional position I alternative to this is its throughflow position, in which the initial portion 132, starting from the secondary outlet-pressure space 22 of the brake unit 19, of the main brake line of the rear-axle brake circuit I is connected to a leading-on portion 133 of the main brake line, which is itself connected to the ASR outlet-pressure space 48 of the hydraulic cylinder 47.

The third correspondingly displacement-controlled function-control valve 129 is likewise designed as a 2/2-way valve, the basic position 0 of which is its throughflow position, in which the leading-on portion 133 of the main brake line of the rear-axle brake circuit I or the ASR outlet-pressure space 48 of the hydraulic cylinder 47 is likewise connected to the portion 72 branching off to the wheel brakes of the main brake line of the rear-axle brake circuit, and in the functional position I of which, alternative to this, this above-mentioned connection is broken.

Also in the exemplary embodiment according to Figure 8, to the details of which reference will now be made, the function-control valve arrangement comprises, in addition to the central valve 76 of the hydraulic cylinder 47, three further displacement-controlled change-over valves 134, 136 and 137 which, as long as the brake system 16 is not actuated, assume their basic positions 0 shown and, as soon as the secondary piston 27 of the brake unit 19 has executed a small initial portion of its brake-pressure build-up stroke in response to an actuation of the brake system, are changed over to their functional positions I which are alternative to the basic positions 0 and which are linked to normal braking or to braking subjected to the anti-lock control.

Moreover, the function-control valve arrangement comprises a fourth change-over valve 138 which is designed as a 2/2-way solenoid valve and the basic position 0 of which is assigned to normal braking and to braking subjected to the anti-lock control and the excited position I of which is the blocking position which is assigned to the ASR control mode of the control system 15.

The displacement-controlled change-over valves 134, 136 and 137 are also designed as 2/2-way valves. The first displacement-controlled change-over valve 134, in its basic position, connects the ASR outlet-pressure space of the hydraulic cylinder 47 to the portion 72 branching off to the wheel brakes 17 and 18 of the main brake line of the rear-axle brake circuit I, when this first displacement-controlled change-over valve 134 is in the functional position alternative to this and assumed when the brake system is actuated, this connection is blocked.

In the basic position of the second displacement-controlled change-over valve 136, the ABS control space 46 is shut off from this portion 72 of the main brake line of the rear-axle brake circuit, but in the alternative functional position I of this second change-over valve 136, assumed when the brake system 16 is actuated, is connected to the portion 72 of the main brake line branching off to the wheel brakes 17 and 18.

The th'rd displacement-controlled change-over valve

137, in its basic position, makes the connection between the ABS control space 46 and the compensating line 78 of the pressureless brake-fluid storage tank 43, 43' of the brake system 16 and blocks this connection when it is changed over to its functional position 1 as a result of an actuation of the brake system 16.

In the basic position of the fourth electrically activatable change-over valve 138, the secondary outlet-pressure space 22 of the brake unit 19 is connected to the ASR outlet-pressure space 48 of the hydraulic cylinder 47, but in the excited position of this change-over valve 138 is shut off from it.

Instead of the two displacement-controlled change-over valves 136 and 137 designed as 2/2-way valves, there can also be, though not shown particularly, a change-over valve designed as a 3/2-way valve, in the basic position of which the ABS control space 46 is connected to the brake-fluid storage tank 43, 43' of the brake system 16 and in the functional position of which, alternative to this and assumed when the brake unit 19 is actuated, the ABS control space 46 is shut off from the brake-fluid storage tank, but instead is connected to the portion 72 branching off to the wheel brakes 17 and 18 of the main brake line of the static rear-axle brake circuit I.

Whereas, in each of the exemplary embodiments explained with reference to Figures 1 to 8, one valve element of the function-control valve arrangement is designed each as a central valve 76 integrated in the hydraulic cylinder 47 provided as a brake-pressure regulating member, each of the exemplary embodiments of the control system 15 according to the invention which are to be explained below with reference to Figures 9 to 11 the function-control valve arrangement take the form of a circuit "peripheral" of the hydraulic cylinder 47, and reference will now first be made to the relevant details of Figure 9 in order to explain appropriately suitable designs of the function-control valve arrangement:

The function-control valve arrangement provided there within the framework of the control system 15 shown complete for the brake circuit I of the driven vehicle wheels is composed, in a similar way to those explained above, of mechanically and displacement-controlled valves 141 and 142 and electrically activatable solenoid valves 143 and 144 which, in response to an activation of the control system 15, is taking place as it were "non-specifically" as a result of the connection, controlled by solenoid valve, of the drive-pressure space 53 of the hydraulic cylinder 47 to the high-pressure outlet 54 of the auxiliary pressure source 56, and make the appropriate "selection" of the control mode, namely anti-lock or propulsion control.

The two mechanically controlled valves 141 and 142 are, once again, designed so that they assume their basic positions 0 when and as long as the brake system 16 is not actuated by the driver, and are changed over to their functional positions I alternative to the basic positions when the brake system 16 is actuated by the driver and the secondary piston 27 of the brake unit 19 has accordingly executed a small initial portion of its brake-pressure build-up stroke, the basic positions 0 of these two mechanically and displacement-controlled valves 141 and 142 being linked to the propulsion-control mode of the control system 15 and their functional positions I, alternative to these, being linked to normal braking or to braking in which the control system 15 is activated in its anti-lock control mode.

In the special exemplary embodiment illustrated, one of these two displacement-controlled valves is designed as a 3/2-way valve 141, in the basic position 0 of which the ABS control space 46 of the hydraulic cylinder 47 is connected to the compensating line 78, connecting the compensating space 77 of this hydraulic cylinder 47 to the follow-up space 42 of the brake unit 19, and consequently to the brake-fluid storage tank 43, 43' of the brake system 16, and in the alternative functional position I of which the ABS control space 46 is connected to the portion 72 branching off to the wheel brakes 17 and 18 of the main brake line of the rear-axle brake circuit I.

The second displacement-controlled change-over valve 142 of the function-control valve arrangement 141, 142, 143, 144 is designed as a 2/2-way valve, the basic position 0 of which is its blocking position, in which an initial portion 146, starting from the secondary outlet-pressure space 22 of the brake unit 19, of the main brake line of the rear-axle brake circuit I is shut off from a portion 147, leading on from this valve 142, of the main brake line of the rear-axle brake circuit I. This intermediate portion 147 of the main brake line is connected permanently to the ASR outlet-pressure space 48 of the hydraulic cylinder 47. Thus, in the functional position I of the second mechanically and displacement-controlled valve 142 assumed when the brake system 16 is actuated, the secondary outlet-pressure space 22 of the brake unit 19 is connected to the ASR outlet-pressure space 48 of the hydraulic cylinder 47.

The first solenoid valve 143, in its basic position 0, connects the secondary outlet-pressure space 22 of the brake unit to the portion 72 branching off to the wheel brakes 17 and 18 of the main brake line of the rear-axle brake circuit I and is changed over to its blocking position I in the event that the control system 15 is activated either in its anti-lock control mode or in its propulsion-control mode.

The second 2/2-way solenoid valve 144 of the function-control valve arrangement 141, 142, 143, 144 is inserted "between" the intermediate portion 147 and the portion 72 branching off to the wheel brakes 17 and 18 of the main brake line 146, 147, 72 of the rear-axle brake circuit I. Its basic position 0 is the blocking position, in which these two brake-line portions 147 and 72 are shut off from one another. In normal braking and in braking subjected to the anti-lock control, it is maintained in its basic position 0, and only when the control system 15 is activated in its propulsion-control mode is it changed over to its excited position I, namely the throughflow position, in which then only the ASR outlet-pressure space 48 is connected to the portion 72 branching off to the wheel brakes 17 and 18 of the main brake line of the rear-axle brake circuit I.

Instead of the solenoid valve 143 which is inserted between the secondary outlet-pressure space 22 and the portion 72 of the main brake line branching off to the wheel brakes 17 and 18 and which is moved into its excited position I whenever the control system 15 is activated, there can also be a hydraulically activated valve of corresponding function, which, together with the drive-pressure space 53 of the hydraulic cylinder 47, is subjected to control pressure.

Also in the exemplary embodiment according to Figure 10, to the details of which reference will now be made, the function-control valve arrangement comprises two mechanically and displacement-controlled valves 141 and 142 which correspond in constructional and functional terms to the valves bearing the same functional symbols in the exemplary embodiment according to Figure 9.

Furthermore, the function-control valve arrangement comprising a third mechanically and displacement-controlled valve 148 which, together with the other two, can be moved out of its basic position 0 shown, namely its open position, in which the intermediate portion 147 of the main brake line of the rear-axle brake circuit 1 is connected to its portion 72 branching off to the wheel brakes 17 and 18, into its blocking position I, in which the connection between these portions 147 and 72 of the main brake line is broken.

As a fourth function-control valve 149 there is a 2/2-way solenoid valve, in the basic position 0 of which the intermediate portion 147 of the main brake line and, with this, also the ASR outlet-pressure space 48 of the hydraulic cylinder 47 are connected to the ABS control space 46 of the latter, and in the excited position I of which this connection is broken. This 2/2-way solenoid valve assumes its basic position 0 during normal braking only and is changed over to its excited position I, namely the blocking position, both for the anti-lock mode and for the propulsion-control mode of the control system 15.

Here too, instead of the electrically activated valve 149 there could be a hydraulically activated valve which can be activated by means of the outlet pressure of the auxiliary pressure source 56.

During normal braking, the pressure built up in the secondary outlet-pressure space 22 of the brake unit 19 is also fed, via the intermediate portion 147 of the main brake line of the rear-axle brake circuit I, into the ASR outlet-pressure space 48 and, via the solenoid valve 149 which, in this operation state of the brake system 16, is in its basic position 0, namely the throughflow position, also into the ABS control space 46 of the hydraulic cylinder 47, and in this operating state of the brake system 16, in which the displacement-controlled valve 141 designed as a 3/2-way valve assumes its functional position I, the ABS control space 46 is connected to the portion 72 branching off to the wheel brakes of the main brake line of the rear-axle brake circuit I.

Thus, the solenoid valve 149 provided in the exemplary embodiment according to Figure 10 and belonging to the function-control valve arrangement, in terms of its function, insofar as during normal braking it makes the series connection of the ASR outlet-pressure space and the ABS control space 46 of the hydraulic cylinder 47, is similar to the central valves 76 provided in the exemplary embodiments according to Figures 1 to 8.

When the control system 15 works in the anti-lock control mode, that is to say the drive-pressure space 53 of the hydraulic cylinder 47 is connected to the high-pressure outlet 54 of the auxiliary pressure souce 56 via the pressure-supply control valve 79, the 2/2-way solenoid valve 149 is blocked and the displacement-controlled valves 141, 142 and 148 ar moved into their functional positions I, the ABS control space 46 of the hydraulic cylinder 47 is connected only via the 3/2-way valve 141 to the portion

72 branching off to the wheel brakes 17 and 18 of the main brake line of the rear-axle brake circuit I, whilst the ASR outlet-pressure space 48 is connected to the secondary outlet-pressure space 22 of the brake unit 19 via the displacement-controlled 2/2-way valve 142 which is in its open position. During the time when, during a pressure-reduction regulating movement of the regulating piston 51 of the hydraulic cylinder 47 taking place in the direction of an increase of the ABS control space 46, brake fluid overflows from the wheel brake or wheel brakes 17 and/or 18 subjected to a pressure-reduction phase into the ABS control space, a corresponding quantity of brake fluid is forced out of the ASR outlet-pressure space 48 of the hydraulic cylinder 47 back into the secondary outlet-pressure space 22 of the brake unit 19. As a result, the secondary piston 27 of the latter is pushed back towards its basic position, this being expressed by a corresponding "backward movement" of the brake pedal 23 and giving the driver appropriate notification of the activation of the anti-lock control.

When the control system 15 is activated in the propulsion-control mode, that is to say the drive-pressure space 53 is once again connected to the high-pressure outlet 54 of the auxiliary pressure source 56 and the 2/2-way solenoid valve 149 of the function-control valve arrangement is moved into its blocking position I, but the displacement-controlled valves 141, 142 and 148 of the latter assume their basic positions, then only the ASR outlet-pressure space 48 of the hydraulic cylinder 47 is connected, via the displacement-controlled 2/2-way valve 148 located in its basic position, to the portion 72 branching off to the wheel brakes 17 and 18 of the main brake line of the rear-axle brake circuit I. The ASR outlet-pressure space 48 is shut off from the ABS control space 46 which itself is connected to the compensating line 78, via the displacement-controlled 3/2-way valve 141 located in its basic position, and consequently is finally relieved towards the brake-fluid storage tank 43, 43' of the brake system 16. The secondary outlet-pressure space 22 of the brake unit 19 is shut off from the wheel brakes 17 and 18 because the displacement-controlled valve 142 is in its blocking position.

The brake-pressure build-up and brake-pressure reduction phases of the propulsion control are controlled by coupling and uncoupling the drive-pressure space 53 of the hydraulic cylinder 47 respectively to and from the auxiliary pressure source 56. Brake-pressure holding phases are controlled by changing over the respective brake-pressure regulating valve 86 and/or 87 from its blocking position I.

Also in the alternative embodiment illustrated in Figure 11, to the details of which express reference will now be made, the function-control valve arrangement comprises three mechanically and displacement-controlled change-over valves 141, 142 and 148 and a fourth change-over valve 151 designed as a 2/2-way solenoid valve.

The mechanically and displacement-controlled valves 141, 142 and 148 correspond in constructional and functional terms to the valves bearing the same reference symbols in Figure 10, so that to that extent reference can be made to the description of Figure 10. The only difference from the exemplary embodiment according to Figure 10 is the insertion of the 2/2-way solenoid valve 151 into the hydraulic circuit arrangement.

In the alternative embodiment according to Figure 11, the 2/2-way solenoid valve 151 is inserted between the pressure outlet 152 of the secondary outlet-pressure space 22 of the brake unit 19 and the portion 72 branching off to the wheel brakes 17 and 18 of the main brake line of the rear-axle brake circuit I.

When the 2/2-way solenoid valve 151 is in the basic position 0 assigned to normal braking, the secondary outlet-pressure space 22 of the brake unit 19 is thus connected directly to this portion 72 of the main brake line.

The 2/2-way solenoid valve 151 is also moved into its blocking position I both when the control system 15 works in the anti-lock control mode and when it is activated in the propulsion-control mode.

Instead of the solenoid valve 151, therefore, there could also be a hydraulically activated 2/2-way valve which is moved out of its open position into the blocking position when the control system 15 is activated by subjecting the drive-pressure space 53 of the hydraulic cylinder 47 to pressure.

In the exemplary embodiments of the control system 15 according to the invention which are illustrated in figures 1 and 3 to 6 and 8, the brake unit 19 is equipped with a position indicator 153 generating an electrical output signal which differs characteristically, depending on whether the secondary piston 27 of the brake unit is in its particular basic position shown or in the immediate vicinity of this or is shifted out of this position by more than a small initial portion of its possible working stroke.

In these exemplary embodiments, the output signal, characteristic of the basic position or a position near this of the secondary piston 27 of the brake unit 19 and coming from the position indicator 153 generating this signal after a response of the anti-lock control, is used to terminate the subjection of the drive-pressure space 53 of the hydraulic cylinder 47 to pressure by changing over the pressure-supply/control-valve arrangements 79 and 118, 119 to their basic positions, in order thereby to prevent more brake fluid from being forced out of the ASR outlet-pressure space 48 of the hydraulic cylinder 47 towards the brake unit 19 or from being conveyed back into its brake-fluid storage tank 43, 43' than required by the anti-lock control.

Without the position indicator 153, a "malfunction" of this kind would be possible if the anti-lock control were to respond in the part-braking range, that is to say in a braking situation in which the secondary piston 27 of the brake unit 19 has been displaced by the amount of only part of its possible pressure build-up stroke, but as a result of the anti-lock control the regulating piston 51 of the hydraulic cylinder 47 reaches its end position linked to a minimum volume of the ASR outlet-pressure space 48 and therefore much more brake fluid than would be necessary for the anti-lock control is conveyed out of the ASR outlet-pressure space 48 back into the secondary outlet-pressure space 22 of the brake unit 19 and, as soon as the secondary piston 27 of the latter has assumed its basic position, back into the brake-fluid storage tank 43, 43' via the central valve 44 then open.

If, in this case, a response of the control system 15 in its propulsion-control mode were to become necessary immediately after the end of the anti-lock control cycle, that is to say even before the regulating piston 51 of the hydraulic cylinder 47 could assume its basic position, the propulsion control could take effect at most only to a restricted degree, if at all, since in this case the volume of brake fluid which can be forced of the ASR outlet pressure space 48 into the wheel brake or wheel brakes 17 and/or 18 to be subjected to the control would, under unfavourable circumstances, no longer be sufficient to build up the necessary brake pressure.

This malfunction can be prevented effectively in a simple way by means of the position-indicator output signal.

Figure 12, to the details of which reference will now be made, shows an alternative version of the hydraulic cylinder 47 which can be used within the control system 15 according to the invention and which, in the exemplary embodiments according to Figures 1 to 8, can take the place of hydraulic cylinder 47 shown in each of these. It differs from this only in that the regulating piston 51 and the drive piston 52 are designed as separate piston elements, and the restoring spring 57 forcing the regulating piston 51 and, with this, also the drive piston 52 into the basic position shown is now arranged within the ASR outlet-pressure space 48 of the hydraulic cylinder 47 according to Figure 12, is supported on the end wall 59 of the cylinder housing 61 axially limiting the latter fixed relative to the housing and engages on the diametrically smaller flange 49 of the regulating piston 51 movably limiting the ASR outlet-pressure space 48. The regulating piston 51 is supported, by means of an extension 67 in the form of a piston rod, which is guided displaceably in a pressure-tight manner through the central bore 66 of the intermediate wall 64 of the cylinder housing 61, on the side of the drive piston 52 facing the intermediate wall 64, but is not connected firmly to the drive piston 52.

In this design of the hydraulic cylinder 47, an exact centring of the bore steps 58 and 62, in which the flanges 49 and 63 of the regulating piston 51 are guided displaceable in a pressure-tight manner, and relative to the housing bore 68, in which the drive piston 52 is guided displaceably in a pressure-tight manner, is not necessary, and this can be of considerable advantage in terms of production.

Also the alternative version, illustrated in Figure 13 to the details of which reference will finally be made, of a hydraulic cylinder 47 which can be used as a brake-pressure regulating member within the control system according to the invention can, in the exemplary embodiments explained with reference to Figures 1 to 8, take the place of the hydraulic cylinder 47 shown there, with the same circuit peripherals being used, that is to say the same design and layout of the function-control valve arrangement and the drive-pressure supply, if there is used as a drive-pressure space 53 of the hydraulic cylinder 47 according to Figure 13 the annular space limited fixedly relative to the housing by the intermediate wall 64 of its housing 61 and movably by the drive piston 52, furthermore the annular space is limited fixedly relative to the housing by the intermediate wall 64 of the housing 61 and movably in the axial direction by the larger piston step 53 of the regulating piston is used as the ASR outlet-pressure space 48, and the functional space limited movably in the axial direction by the smaller piston step 49 of the regulating piston and fixedly relative to the housing by the end wall 59 of the cylinder housing 61 is used as an ABS control space 46.

In the hydraulic cylinder 47 according to Figure 13, the drive piston 52 is once again connected firmly via a piston rod 67 sealed off from the housing 61, within the axial bore 66 through which the intermediate wall 64 extends, by means of two annular gaskets 154 and 156, between which is arranged a pressureless leakage-oil space 157 provided for media separation between the drive circuit and the control circuit.

Here, the restoring spring 57 forcing the composite piston structure 51, 52 into its illustrated basic position linked to a minimum volume of the ABS control space 46 and a maximum volume of the ASR outlet-pressure space 48 is arranged within the ASR outlet-pressure space of the hydraulic cylinder 47, and it is supported fixedly relative to the housing on the intermediate wall 64 and on the piston side engages on a supporting flange 158 of the latter.

Here, the central valve 76 making the communicating connection between the ABS control space 46 and the ASR outlet-pressure space 48 in the basic position of the composite piston structure 51, 52 is maintained in its open position as a result of the support of its valve tappet against the end wall 59 of the cylinder housing.

CLAIMS

1. Anti-lock system (ABS) and propulsion-control system (ASR) for a road vehicle with a hydraulic multi-circuit brake system, in which the brakes of the driven vehicle wheels form a static brake circuit which is connected to an outlet-pressure space of a brake unit actuable by means of a pedal, the ABS working on the principle of the control of brake-pressure reduction and brake pressure build-up phases of the anti-lock control by respectively increasing or decreasing the volume of an ABS control space connected to the wheel brakes, and the propulsion control working on the principle of decelerating a vehicle wheel tending to spin by activating its wheel brake until its drive slip remains within a range of values compatible both with good propulsion acceleration and with good driving stability, wherein:

a) for controlling pressure-reduction, pressure build-up and pressure-holding phases of both the anti-lock control and the propulsion control, there are electrically activatable brake-pressure regulating valves which can be moved out of a throughflow position, assigned to the pressure-reduction and pressure build-up phases of the particular control and to normal braking not subjected to anti-lock control, into a blocking position which is assigned to brake pressure holding phases on the respective wheel brake;

b) as a pressure build-up and pressure-reduction regulating element of the anti-lock control, there is a hydraulic cylinder having a piston which is displaceable as a result of the alternate connection of a drive pressure space to the pressure outlet of an auxiliary pressure source or to its pressureless tank between end positions corresponding to a minimum and a maximum volume of an ABS control space and which, during normal braking and in the pressure-reduction and pressure build-up phases of the anti-lock control, is in communicating connection with the wheel brake or wheel brakes of the static brake circuit;

c) as a pressure build-up and pressure-reduction regulating member of the propulsion control, there is a hydraulic cylinder having an ASR outlet-pressure space which is connectable, alternatively to the outlet-pressure space of the brake unit, to the brake circuit of the driven vehicle wheels and which is limited movably by a piston of this hydraulic cylinder displacable in the direction of a brake-pressure build-up or reduction because a drive-pressure space is subjected under valve control to the outlet pressure of the auxiliary pressure source or is relieved respectively, and

d) there is an ABS and ASR function-control valve arrangement which, in the sequence in combination corresponding to the respective control purpose, makes the connection between the drive-pressure space and the tank or the pressure outlet of the auxiliary pressure source and opens or blocks the brake-fluid flow paths, via which, in the respective control phases of the anti-lock and propulsion control, the brake pressure is reduced or built up on the wheel brakes used for the control, having the following features:

a) for the brake circuit (I) which can be subjected both to the anti-lock control and to the propulsion control, there is at least one hydraulic cylinder which is designed as a step cylinder of differing diameter, one of which constitutes the moveable limitation of an ASR outlet-pressure space, as a result of the decrease in volume of which the brake pressure in a connected wheel brake can be built up, and the other of which constitutes the movable limitation of an ABS control space, as a result of the increase in volume of which the brake pressure in a connected wheel brake can be reduced, the regulating piston being coupled in terms of movement, via a piston rod passing displacably in a pressure-tight manner through an intermediate wall of the cylinder housing, to a drive piston which movably limits the drive-pressure space and as a result of the valve-controlled pressure subjection and pressure relief of which the drive piston is displaceable respectively in the direction of an increase of the ABS control space and a decrease of the ASR outlet-pressure space and in the direction of a decrease of the ABS control space and an increase of the ASR outlet-pressure space, and the composite piston structure comprising the regulating piston and the drive piston being forced by a restoring spring into its basic position corresponding to the minimum volume of the ABS control space;

b) the function-control valve arrangement performs the following functions:

b1) in normal braking, that is to say braking not subjected to the anti-lock control, both the outlet pressure space of the brake unit assigned to the controllable brake circuit (I) and the ASR outlet pressure space and the ABS control space of the hydraulic cylinder are connected to the portion branching off to the wheel brakes of the main brake line of the brake circuit which can be subjected to the control;

b2) in braking subjected to the anti-lock control, the ABS control space only is connected to the brake circuit (I) which can be subjected to the control and the ASR outlet-pressure space only is connected to the outlet-pressure space of the brake unit;

b3) when the control system responds in the propulsion-control mode, the outlet pressure space of the brake unit is shut off from the wheel brakes, the ABS control space is connected to the pressureless brake-fluid storage tank of the brake system, and the ASR outlet-pressure space is connected to the brake line leading to the wheel brakes.

2. Control system according to claim 1, wherein the housing space limited by the intermediate wall of the cylinder housing and by the regulating piston is used as a drive-pressures space of the hydraulic cylinder, in that the ASR outl t-pressure space is limited movably by

the diametrically larger piston step of the regulating piston and fixedly relative to the housing by the intermediate wall, and in that the space limited movably by the smaller piston step of the regulating piston and fixedly relative to the housing in the axial direction by the end wall of the cylinder housing, the regulating piston and the drive piston being connected firmly to one another, is used as the ABS control space.

3. Control system according to claim 1, wherein the ASR outlet-pressure space is limited movably by the diametrically smaller piston flange of the regulating piston of the hydraulic cylinder and fixedly relative to the housing in the axial direction by the end wall of the cylinder housing, in that the ABS control space is limited moveably by the externally diametrically larger piston flange of the regulating piston and fixedly relative to the housing by the intermediate wall, through which passes the piston rod making the coupling with the drive piston in terms of movement, and in that the cylinder space limited fixedly relative to the housing in the axial direction by an end wall of the cylinder housing and movably by the drive piston is used as a drive-pressure space.

4. Control system according to claim 3, wherein the drive piston and the regulating piston of the hydraulic cylinder are designed as separate piston elements, the regulating piston being supported axially on the drive piston by means of a rod-shaped extension guided displaceably in a pressure-tight manner through the central bore in the intermediate wall of the cylinder housing, and the restoring spring forcing the regulating piston and the drive piston into their basic position being arranged so as to engage on the regulating piston (Figure 12).

5. Control space according to one of the preceding claims 1 to 4, wherein the effective amount of that flange surface of the regulating piston movably limiting the ABS control space and the effective area of its surface limiting the ASR outlet-pressure space of the hydraulic cylinder are approximately equal and preferably of equal size within a range of variation of +/- 15%.

6. Control system according to one of the preceding claims 1 to 5, wherein, in the non-activated state of the control system, the function-control valve arrangement makes a hydraulic series connection between the outlet-pressure space of the brake unit, the ASR outlet-pressure space of the hydraulic cylinder and its ABS control space and the brake line or brake lines leading on to the wheel brakes and belonging to the brake circuit which can be subjected to the control, and in that there is a control valve which, when the respective control (ABS or ASR) is initiated, is changed over from a throughflow position making the communicating connection between the ASR outlet-pressure space and the ABS control space to its blocking position (Figures 1 to 8).

7. Control system according to claim 6, wherein the control valve is designed as a valve actuable mechanically as a result of the displacement of the regulating piston of the hydraulic cylinder.

8. Control system according to claim 7, wherein the mechanically actuable control valve is designed as a central valve which is integrated in the regulating piston of the hydraulic cylinder and which, in the basic position of the regulating piston corresponding to the non-activated state of the control system, is maintained in is open position as a result of a stop effect and, as soon as the piston has executed a small initial portion of its functional stroke, assumes its blocking position (Figures 1 to 8, 12 and 13).

basic positions into the functional positions respectively alternative to these, and in the basic position of one valve designed as a 2/2-way valve a flow path leading from the outlet of the ASR outlet-pressure space of the hydraulic cylinder to the brake-circuit connection of the outlet-pressure space of the brake unit is blocked and in the alternative functional position of this valve is opened, in that the other displacement-controlled valve is designed as a 3/2-way valve, in the basic position of which the ABS control space is shut off from the brake circuit, but instead is connected to the brake-fluid storage tank, and in the alternative functional position of which the ABS control space is connected to the brake circuit of the controllable wheel brakes, but is shut off from the brake-fluid storage tank, and in that the function-control valve arrangement comprises, as a third control valve, a 2/2-way solenoid valve, in the basic position of which the outlet of the ASR outlet pressure space is shut off from the portion branching off to the wheel brakes of the main brake line of the brake circuit which can be subjected to the control, and in the alternative position of which, assumed when it is excited by means of an ASR function-control signal, the ASR outlet-pressure space of the hydraulic cylinder is connected to the portion branching off to the wheel brakes of the main brake line.

11. Control system according to any one of the preceding claims 6 to 8, wherein the function-control valve arrangement comprises a displacement-control valve which is designed as a 3/2-way valve and which, after a small fraction of the pressure build-up stroke of the piston limiting the outlet-pressure space of the brake unit, is moved out of its basic position, in which the ABS control space of the hydraulic cylinder is connected to the brake-fluid storage tank of the brake system, but is shut off from the brake circuit of the vehicle wheels which can be subjected to the particular control mode, irto its

9. Control system according to any one of the preceding claims 6 to 8, wherein the function-control valve arrangement comprises a control valve which can be moved out of a basic position, which is assigned to normal braking and to the anti-lock control mode and in which it connects the outlet-pressure space of the brake unit to the ASR outlet-pressure space of the hydraulic cylinder, into a throughflow position alternative to this, in which the ASR outlet-pressure space of the hydraulic cylinder, via the brake pressure regulating valve or regulating valves, is connected to the wheel brake of wheel brakes which can be subjected to the control and which belong to the static brake circuit, whereas the outlet pressure space of the brake unit is shut off from this, and a second function-control valve which can be moved from a basic position, which corresponds to normal braking and to the anti-lock control mode and in which the ABS control space is connected, via the brake-pressure regulating valves, to the wheel brakes of the brake circuit which can be subjected to the control, to a functional position alternative to this, which is provided for the ASR control mode and in which the ABS control space is in communicating connection with the brake-fluid storage tank of the brake system, but is shut off from the brake circuit, these two function-control valves being designed as 3/2-way solenoid valves which, by means of output signals from an electronic control unit of the control system, are moved into the functional position combinations necessary for the particular control mode (Figure 1).

10. Control system according to any one of the preceding claims 6 to 8, wherein the function-control valve arrangement comprises two mechanically and displacement-controlled valves which, after a small fraction of the brake-pressure build-up stroke of the piston limiting the outlet-pressure space of the brake unit, come out of their

functional position alternative to this, in which the ABS control space is connected to the brake line or brake lines of the controllable brake circuit, but is shut off from the brake-fluid storage tank, and in that the control valve arrangement comprises a control valve which is designed as 3/2-way solenoid valve and which, by means of an output signal linked to the activation of the control system in its propulsion control mode and coming from the electronic control unit of the control system, is moved out of its basic position, which is assumed in normal braking or in braking subjected to the anti-lock control and in which the outlet-pressure space of the brake unit and the ASR outlet-pressure space of the hydraulic cylinder are connected to one another, into its excited position, in which only the ASR outlet-pressure space of the hydraulic cylinder is connected to the brake circuit of the controllable vehicle wheels and the outlet-pressure space of the brake unit is shut off from this brake circuit (Figure 3).

12. Control system according to claim 10 or claim 11, wherein inserted between the ASR outlet-pressure space of the hydraulic cylinder and the main brake line of the brake circuit which can be subjected to the particular control, in parallel with the valve connecting the outlet-pressure space of the brake unit to the ASR outlet-pressure space in its basic position, is a non-return valve which is stressed in the opening direction as a result of a higher pressure in the main brake line than in the ASR outlet-pressure space of the hydraulic cylinder and which is otherwise blocked (Figures 2 and 3).

13. Control system according to any one of the preceding claims 6 to 8, wherein the function-control valve arrangement comprises a displacement-controlled valve which is designed as 3/2-way valve and which, after a small fraction of the pressure build-up stroke of the piston limiting the outlet-pressure space of the brake

unit, is moved out of its basic position, in which the ABS control space of the hydraulic cylinder is connected to the brake-fluid storage tank of the brake system, but is shut off from the brake circuit of the vehicle wheels which can be subjected to the particular control, into its functional position alternative to this, in which the ABS control space is connected to the brake line of the controllable brake circuit, but is shut off from the brake-fluid storage tank, and a first control valve which is designed as 2/2-way solenoid valve and which, by means of a control signal linked to an activation of the control system in the propulsion control mode, is moved out of its basic position, which is linked to normal braking or braking subjected to the anti-lock control and in which the outlet-pressure space of the brake unit is connected to the ASR outlet-pressure space of the hydraulic cylinder, into its excited position braking this connection, and comprises furthermore a second control valve which is designed as a 2/2-way solenoid valve and which, by means of a control signal linked to an activation of the control system in its anti-lock control mode, is moved out of its basic position, which is linked to normal braking or to activation of the propulsion control and in which the pressure outlet of the ASR outlet-pressure space of the hydraulic cylinder is connected directly to the brake line of the brake circuit which can be subjected to the control, into its relevant blocking position (Figure 4).

14. Control system according to any one of the preceding claims 6 to 8, wherein the control valve arrangement comprises two jointly hydraulically activatable valves which, in their basic positions, make the hydraulic connections, necessary for normal braking and for braking subjected to the anti-lock control, between the outlet-pressure space of the brake unit and the ASR outlet-pressure space of the hydraulic cylinder, on the one hand, and the connection between the ABS control space of the

hydraulic cylinder and the brake circuit of the vehicle wheels which can be subjected to the control, on the other hand, and, in their functional positions assumed when activated by the outlet pressure of the auxiliary pressure source, make the connection, necessary for the propulsion-control mode of the control system between the ASR outlet-pressure space and the brake circuit, on the one hand, and the connection of the ABS control space of the hydraulic cylinder to the brake fluid storage tank on the other hand, and in that there is an electrically activable function-control valve which, by means of a control signal linked to an activation of the propulsion control, can be moved into its excited position, in which control pressure is fed into the control spaces of the hydraulically activatable valve, and in that there is a relief flow path which is open in the basic position of these valves or which can be opened at least temporarily by means of a further control valve and via which the control-pressure spaces of the two hydraulically controlled valves can be relieved (Figure 5).

15. Control system according to any one of the preceding claims 6 to 8, characterised by the following features:
a) there is a control valve which is designed as a 2/2-way solenoid valve and which, by means of a control signal linked to an activation of the propulsion control, is moved out of its basic position, in which the outlet-pressure space of the brake unit is connected to the ASR outlet-pressure space ofthe hydraulic cylinder, into its blocking position;
b) there are two hydraulically activatable control valves, of which the basic positions corresponding to the pressureless state of their control spaces are linked to normal braking and to braking subjected to the anti-lock control, and of which the alternative functional positions assumed under hydraulic activation are linked to the propulsion-control mode, one hydraulically controlled valve being designed as a 3/2-way valve which, in its

basic position connects the ABS control space of the hydraulic cylinder to the brake circuit of the controllable vehicle wheels and, in its functional position alternative to this, connects the ABS control space to the pressureless brake-fluid storage tank, and the other hydraulically controllable valve being designed as a 2/2-way valve, in the basic position of which the ASR outlet-pressure space of the hydraulic cylinder is shut off from the brake circuit of the driven vehicle wheels and in the alternative functional position of which the ASR outlet-pressure space is connected to the brake circuit of the driven vehicle wheels;

c) there is a displacement-controlled 2/2-way valve which, after a small fraction of the brake-pressure build-up stroke of the piston movably limiting the outlet-pressure space of the brake unit, can be moved out of its basic position, in which the control-pressure spaces of the pressure-controlled valves are connected to the drive-pressure space of the hydraulic cylinder, into a functional position alternative to this, in which this connection is broken;

d) inserted between the common control connection of the hydraulically activatable valves and the drive-pressure space of the hydraulic cylinder is a non-return valve which is stressed in the opening direction as a result of a relatively higher pressure in the control-pressure space of the valves than in the drive-pressure space of the hydraulic cylinder and which is otherwise blocked (Figure 6).

16. Control system according to any one of the preceding claims 6 to 8. wherein the control valve arrangement comprises altogether three displacement-controlled valves which, after a small fraction of a brake-pressure build-up stroke of the piston movably limiting the outlet-pressure space of the brake unit, move from their basic positions, linked to the non-actuated state of the brake system or to the propulsion-control mode into the alternative

functional positions linked to normal braking or to braking subjected to the anti-lock control, and in that, furthermore, the particular control mode can be selected by connecting the drive-pressure space of the hydraulic cylinder to the high-pressure outlet of the auxiliary pressure source (Figure 7).

17. Control system according to claim 16, wherein a first of the mechanically activated valves is designed as a 2/2-way valve which, in its basic position, blocks the initial portion, starting from the outlet-pressure space of the brake unit, of the main brake line of the brake circuit which can be subjected to the control relative to its portion leading on, which is also connected to the ASR outlet pressure space of the hydraulic cylinder, and, in its alternative functional position assumed when the brake system is actuated, is open, in that a second of the displacement-controlled valves is likewise designed as a 2/2-way valve which, in its basic position, connects the portion, leading on from the first valve, of the main brake line to the portion branching off to the wheel brakes of the main brake line and otherwise shuts off the latter from the intermediate portion of the main brake line, and in that the third displacement-controlled valve is designed as 3/2-way valve, in the basic position of which the ABS control space of the hydraulic cylinder is connected to the brake fluid storage tank and in the alternative functional position of which, assumed when the brake system is actuated, the ABS control space is connected to the portion branching off to the wheel brakes of the main brake line of the brake circuit which can be subjected to the control (Figure 7).

18. Control system according to any one of the preceding claims 6 to 8, wherein there is a mechanically and displacement-controlled valve arrangement, in the basic position of which, correponding to the non-actuated state of the brake system, the ASR outlet-pressure space of the

hydraulic cylinder is connected to the brake-line portion branching off to the wheel brakes of the controllable brake circuit and the ABS control space is shut off from this portion of the main brake line, but is connected to the brake-fluid storage tank of the brake system, and in the functional position of which, assumed when the brake system is actuated, the ABS control space is connected to the portion branching off to the wheel brakes of the main brakeline, the ABS control space is shut off from the brake-fluid storage tank and the connection between the ASR outlet-pressure space and the ABS control space is broken, and in that there is an electrically activable function-control valve which, by means of a control signal linked to the activation of the propulsion control, is changed over from a basic position, in which the outlet-pressure space of the brake unit is connected to the ASR outlet-pressure space of the hydraulic cylinder, to its blocking position braking this connection (Figure 8).

19. Control system according to claim 18, wherein the mechanically and displacement-controlled valve arrangement comprises altogether three change-over valves which are designed as 2/2-way valves and the first of which, in its basic position, connects the ASR outlet-pressure space of the hydraulic cylinder to the portion branching off to the wheel brakes of the main brake line of the static brake circuit, and the second of which, in its basic position, blocks the ABS control space relative to the portion leading to the wheel brakes of the main brake line, and the third of which, in its basic position, connects the ABS control space to the brake-fluid storage tank (Figure 8).

20. Control system according to claim 18, wherein the mechanically and displacement-controlled valve arrangement comprises a valve which is designed as a 2/2-way valve and can be changed over between a through-flow position as

a basic position and a blocking position and in the basic position of which the ASR outlet-pressure space of the hydraulic cylinder is connected to the portion branching off to the wheel brakes of the main brake line of the static brake circuit, and a valve which is designed as 3/2-way valve and in the basic position of which the ABS control space is connected to the brake-fluid storage tank and in the functional position of which, alternative to this and assumed when the brake unit is actuated, the ABS control space is shut off from the brake-fluid storage tank, but instead is connected to the portion branching off to the wheel brakes of the main brake line of the static brake circuit .

21. Control system according to any one of the preceding claims 1 to 5, wherein the function-control valve arrangement comprises a displacement-controlled valve unit which, in its basic position corresponding to the non-actuated state of the brake system, causes the pressure relief of the ABS control space of the hydraulic cylinder and the shut-off of the initial portion, starting from the outlet-pressure space of the brake unit, of the main brake line of the static brake circuit from a portion thereof leading on to the ASR outlet-pressure space of the hydraulic cylinder and, in its functional position assumed when the brake system is actuated, connects the ABS control space of the hydraulic cylinder to the portion branching off to the wheel brakes of the main brake line of the static brake circuit and connects the outlet-pressure space of the brake unit to the ASR outlet-pressure space of the hydraulic cylinder, and in that there is a first electrically activatable function-control valve which, during normal braking, assumes its basic position connecting the outlet-pressure space of the brake unit to the portion branching off to the wheel brakes of the main brake line and which is moved into its blocking position for the duration of both an anti-lock cycle and a propulsion-control cycle, and a second

electrical activatable function-control valve which, in its basic position, blocks a flow path leading from the ASR outlet-pressure space of the hydraulic cylinder to the portion branching off to the wheel brakes of the main brake line and which, by means of an output signal linked to the activation of the propulsion control, can be moved into its excited position, in which the ASR outlet-pressure space is connected to the portion branching off to the wheel brakes of the main brake line of the static brake circuit (Figure 9).

22. Control system according to claim 21, wherein the first function-control valve is designed as a hydraulically activatable 2/2-way valve which, when subjected to the outlet pressure of the auxiliary pressure source via the drive-control valve arrangement of the latter also making the connection between the drive-pressure space of the hydraulic cylinder and the auxiliary pressure source, is moved into its blocking position .

23. Control system according to any one of the preceding claims 1 to 5, wherein the function-control valve arrangement comprises a displacement-controlled valve arrangement, in the basic position of which, corresponding to the non-actuated state of the brake system,

a) the ABS control space of the hydraulic cylinder is relieved of pressure,

b) the initial portion, starting from the outlet pressure space of the brake unit, of the main brake line of the static brake circuit is shut off from a leading-on portion thereof, but the latter is connected, via a valve element of the mechanically actuable valve arrangement, to the portion branching off to the wheel brakes of the main brake line, and the ASR outlet-pressure space of the hydraulic cylinder is likewise connected, via this valve element, to the portion branching off to the wheel brakes of the main brake line, and, when the brake system is actuated, after a small fraction of the pressure build-up stroke of the piston limiting the outlet-pressure space of the brake unit, moves into its functional position which is alternative to the basic position and in which

a) the ABS control space is connected to the portion branching off to the wheel brakes of the main brake line of the static brake circuit,

b) although the shut-off of the portion of the main brake line starting from the outlet-pressure space of the brake unit from the portion leading on is cancelled, the latter is nevertheless itself shut off from the portion branching off to the wheel brakes of the main brake line of the static brake circuit, and

c) the ASR outlet-pressure space of the hydraulic cylinder is likewise shut off from the portion branching off to the wheel brakes of the main brake line.

24. Control system according to claim 23, wherein there is a change-over valve which, in its basic position, namely a throughflow position, connects the ASR outlet-pressure space of the hydraulic cylinder to its ABS control space and is moved into its blocking position alternative to this, when and as long as the anti-lock control or the propulsion control is activated (Figure 10).

25. Control system according to any one of the preceding claims 21 to 24, wherein the change-over valve is designed as a 2/2-way solenoid valve which is moved into its blocking position by means of an electrical signal appearing for the duration of activation of the control system, or as a hydraulically controlled valve which is moved into its blocking position when and as long as the auxiliary pressure source is coupled to the drive-pressure space of the hydraulic cylinder or to the drive-pressure space of the valve via the drive/control valve arrangement.

26. Control system according to claim 23, wherein there

is a change-over valve which, in its basic position namely a throughflow position, connects the outlet-pressure space of the brake unit to the portion branching off to the wheel brakes of the main brake line of the static brake circuit and is moved into its blocking position alternative to this, when and as long as the control system is activated (Figure 11).

27. Control system according to any one of the preceding claims, wherein there is a position indicator which monitors the position of the piston of the brake unit limiting outlet-pressure space of the latter and which generates an output signal causing the auxiliary pressure source to be disconnected from the drive-pressure space of the hydraulic cylinder, when, during the course of an anti-lock control phase, the piston of the brake unit reaches its basic position or a position immediately adjacent to this.

28. Control system according to one of the preceding claims, wherein the drive control-valve arrangement comprises two control valves which are designed as 2/2-way solenoid valves and of which one, in its basic position shuts off the pressure outlet of the auxiliary pressure source from the drive-pressure space of the hydraulic cylinder and in its excited position connects this to the pressure outlet of the auxiliary pressure source, and of which the other, namely the valve, in its basic position connects the drive-pressure space of the hydraulic cylinder to the pressureless tank of the auxiliary pressure source and in its excited position shuts it off from this, these two valves being movable into their excited positions by means of a signal linked to the activation of the control system (Figures 5 to 8 and 11).

29. Anti-lock system (ABS) and propulsion-control system (ASR) for a road vehicle with a hydraulic multi-circuit brake system, substanti.lly as described herein, with

reference to and as illustrated in, the accompanying drawings.

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