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(54) ANTI-LOCK BRAKE CONTROL SYSTEM FOR VEHICLES

(71) We, TELDIX G.m.b.H., of Grenzhofer Weg 36, 6900 Heidelberg, Federal Republic of Germany, a German body corporate, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to an anti-lock brake control system for vehicles. In one such system, sensors are provided for monitoring the wheel acceleration behaviour and an evaluation circuit is provided, to which circuit the signals of the sensors are supplied and which produces control signals from these signals. This system also comprises a brake pressure control unit, to which the control signals of the evaluation circuit are supplied and which has positions for reducing the brake pressure (outlet valve open) as well as a position for allowing build up of the brake pressure (inlet valve open) and for maintaining the brake pressure at least approximately constant (both inlet and outlet valves closed). The evaluation circuit has switching means which, when there is a tendency to lock, produce an control signal for reducing the brake pressure. When the wheel is accelerated to a certain extent, the switching means may produce a control signal for maintaining the brake pressure constant, as in the transition period between the end of the deceleration signal (U_{-b}) produced in order to reduce the brake pressure and the beginning of the acceleration signal (U_{+b}) produced when there is an acceleration of the wheel; these usually also produce an control signal for maintaining the brake pressure constant.

Such an anti-lock control system is, for example, known from German Patent Specification No. 1,655,380. There, two deceleration thresholds are provided, the second and lower deceleration threshold being used to provide for the brake pressure to be maintained constant.

This is not however, essential here. In this prior specification the brake pressure is reduced once a large deceleration threshold has been exceeded and continues until the deceleration is below this threshold. When an acceleration signal occurs, the pressure is maintained constant and a storage chamber is provided which is filled when the outlet valve is controlled. The storage chamber may be discharged after control of the outlet valve has ended through an inlet valve. As a result of this discharge, the inlet valve remains energized after the deceleration signal has come to an end, i.e. there is no immediate build-up in pressure, but the pressure is held constant. The time constant of a timing element is selected such that the period between the end of the deceleration signal and the beginning of the acceleration signal is bridged, i.e. during this period the pressure is held constant.

In contrast, the present invention seeks not only to prevent the immediate build-up in brake pressure after the end of the signal indicating a tendency to lock, but to prolong the reduction of the brake pressure in certain road conditions so as to cause only slow reacceleration of the wheels.

According to the invention, there is provided an anti-lock brake control system for vehicles comprising sensors for sensing the rotary behaviour of the wheels, an evaluation circuit for producing control signals from signals fed to it by at least one said sensor and a brake pressure control unit responsive to the control signals for allowing a pressure build-up, maintaining pressure constant or causing a pressure reduction, the evaluation circuit comprising switch means producing a first control signal to cause pressure reduction when a tendency to lock is sensed and a second control signal to hold the pressure constant when there is a wheel acceleration of a predetermined value, the evaluation circuit further comprising a first monitoring circuit for detecting whether a wheel acceleration signal after the end of the pressure reducing

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signal occurs within a first predetermined period and for changing over the control system from normal operation in which the pressure is held constant in the transition period between the end of the pressure reducing signal and the start of a wheel acceleration signal, to a special operation in which pressure reduction is only terminated by an acceleration signal, in the absence of the wheel acceleration signal occurring within the said first predetermined time period and a second monitoring circuit for changing back the control system to normal operation when said acceleration signal appears within a second predetermined period which is less than the first predetermined period.

In the system in accordance with the invention, use is made, therefore of two operating states, i.e. the known normal operation and a special operation which is made effective under certain road conditions and then remains effective until certain criteria are present so that normal operation may be resumed. The special road conditions are present if the wheel was not accelerated or accelerated again only slowly, i.e. if, after a certain time after the end of pressure reduction, adequate acceleration of the wheel has still not been established. In these road conditions—meant here are road conditions with a low μ , and also braking along curves—the reduction of pressure was not sufficient and as a result reduction of pressure takes place in the present control cycle, after establishing this state until the acceleration signal occurs and, in the cycle sequence basically from when the signal indicating the tendency to lock occurs until the wheel acceleration signal occurs. This state remains operative until a relatively early occurrence of the acceleration signal in the pressure reduction extension phase, i.e. an improvement in the road conditions, which brings about a switch back to normal operation.

The second predetermined time period may suitably be half the first predetermined period.

The first monitoring circuit may comprise a bistable member which is set by the pressure reducing signal and is resettable by the acceleration signal and its set output signal, available after the expiry of the first predetermined period, serves to change over a second bistable member, the output signal of which, then appearing, causes a reduction in pressure after the end of the deceleration signal when an acceleration signal is not present, the first bistable member being reset at the end of the first predetermined period if the second bistable member is in its reset condition. The second bistable member may also form part of the second monitoring circuit and may be reset by an acceleration signal which appears before the end of the second time period.

The evaluation circuit may include second switching means which, when a slip signal is still present at the end of the acceleration signal switch over to special control operation. The evaluation circuit may also include third switching means which discontinue the special control operation if there is a large wheel acceleration.

The invention will now be described in greater detail, by way of example, with reference to the drawings, in which:—

Figure 1 shows diagrammatically one embodiment of the invention,

Figure 2 shows a related diagram for description of changeover, and

Figure 3 shows a diagram for description of the change-back.

In a preferred embodiment of the invention, an anti-lock brake control system basically comprises sensors for sensing the rotary behaviour of the wheels, an evaluation circuit for producing control signals from signals fed to it by at least one said sensor and a brake pressure control unit EV, AV responsive to the control signals for allowing a pressure build up, maintaining pressure constant or causing a pressure reduction. The evaluation circuit, only part of which is shown comprises switch means producing a deceleration signal U_{-b} used to cause a pressure reduction when a tendency to lock is sensed and an acceleration signal U_{+b} used to cause the pressure to be held constant when the wheel acceleration is of a predetermined value. The evaluation circuit also comprises a first monitoring circuit 1 to 6, 9, 10 and 18 for detecting whether an acceleration signal U_{+b} after the end of a deceleration signal U_{-b} occurs within a first predetermined time period T_1 and for changing over the control system from normal operation in which the pressure is held constant in the transition period between the end of the deceleration signal U_{-b} and the start of a wheel acceleration signal U_{+b} to a special operation in which pressure reduction is only terminated by an acceleration signal U_{+b} in the absence of the acceleration signal U_{+b} in the period T_1 . A second monitoring circuit 1 to 3, 10, 19 and 20 is provided for changing back the control system to normal operation when the acceleration signal U_{+b} appears within a second predetermined period T_2 which is less than the period T_1 .

In the part of the evaluation circuit shown in figure 1, an L-signal appears at terminal 1 (AV decel) if the anti-lock control is in operation. A wheel deceleration signal U_{-b} (produced in the evaluation circuit by switch means which are not shown) supplied

to terminal 2 may then be applied to a timing element 4 via and AND-gate 3. At the same time this signal brings a bistable element 5 into the set position.

5 As a result, gate 6 is prepared. Because of the inverter 9, the AND-gate 6 becomes open after expiry of the time constant of the timing element 4, which extends the deceleration signal U_{-b} by T_1 , and thus a
10 bistable element 10 is set. The bistable element 5 is later reset via OR-gate 12, AND-gate 11 and OR-gate 13. This bistable element 10 is not set if, before expiry of T_1 , a wheel acceleration signal U_{+b} (also
15 produced by the switch means which are not shown) is produced, which, when the bistable element 10 is not set, resets the bistable member 5 via OR-gate 12, AND-gate 11 and OR-gate 13, whereby the
20 subsequent output signal of the inverter 9 is not able to reach the bistable member 10. The operation of the setting of the bistable element 10 may be seen from the diagram of Figure 2. There the signal U_{-b} is applied, which is fed to the timing element 4. At the
25 output of the timing element 4, the signal path U_T is obtained corresponding to the signal U_{-b} extended by the time T_1 . Since, in the time period T_1 , no U_{+b} signal is produced, then at t_2 the element 10 is set, its
30 output signal U_{10} causing a brake pressure reduction to be effected immediately and causing the pressure reduction to be extended from the end of the U_{-b} signal until occurrence of the U_{+b} signal. This
35 means that from the point in time t_2 to the point in time t_3 , the outlet valve AV (which together with the inlet valve EV forms the brake pressure control unit), is additionally energized. In terms of circuit technology
40 this is carried out in Figure 1 so that a wheel deceleration signal U_{-b} and a slip signal U_{-s} energize the inlet valve EV and the outlet valve AV via the OR-gates 14 and 15 and that furthermore the acceleration signal U_{+b}
45 energizes the inlet valve. In order to ensure that the pressure remains constant in normal operation between the end of the U_{-b} or U_{-s} signal and the beginning of the U_{+b} signal, the timing element 16 is provided
50 which extends the control signal of the outlet valve AV by a predetermined time to hold the inlet valve EV shut.

The AND-gate 17 is closed and thus the U_{-s} signal is shut off when an acceleration signal U_{+b} occurs.

The output signal of the bistable element 10 reaches the outlet valve via the AND-gate 18 and causes lowering of the pressure
60 if the outlet valve AV responds, the time constant of the element 16 is still in operation and as long as there is no U_{+b} signal; i.e. after the element 10 has been successfully set, brake pressure is reduced
65 until the acceleration signal occurs and the

brake pressure reduction is undertaken in the cycle sequence from the end of U_{-b} until the beginning of U_{+b} .

The element 10 is reset if, within a time T_2 smaller than T_1 , for example

$$T_2 \approx \frac{T_1}{2}$$

from the end of the deceleration signal, a U_{-b} signal occurs. By means of the timing element 20, the deceleration signal U_{-b} extended by T_2 , reaches the AND-gate 19.
75 Resetting of the element 10 takes place as for element 5, if the AV_{decel} signal at terminal 1 has disappeared at the end of the control.

The resetting process is shown in the diagram in Figure 3. Within the signal U_{T_3} there is a signal U_{+b} which resets the member 10. Thus the brake pressure is no longer reduced by U_{-b} .

The determination as to whether an acceleration signal occurs within a predetermined time after termination of the signal for lowering pressure, may also find use in an anti-lock brake control system according to British Patent No. 1371 776, in which the wheel speed signal is compared
90 alternatively with two different reference values, at least approaching the curve of the vehicle speed, wherein, usually, the smaller reference value serves as a comparison value. When a deceleration signal occurs, there is a switch over to the larger reference value as a comparison value (smaller slip valve), wherein, if the wheel speed drops
95 below the connected reference value, a lowering of the brake pressure is effected. When the deceleration signal disappears and the associated return of the comparison arrangement to the smaller reference value takes place, the pressure is no longer reduced if the wheel speed is not also below the small reference value (large slip value).

The present invention comes into use in this mentioned design of an anti-lock controller in such a manner that, after
110 establishing the absence of the wheel acceleration signal within the time T_1 from the end of the brake pressure reduction, the large comparison value is connected from the end of the deceleration signal and the first monitoring circuit changes the system over to special operation so that lowering of the pressure again takes place. Only when the acceleration signal occurs or when also the large reference value is exceeded is this interrupted. In the following cycles, after
120 switching over to special control operation, the pressure reduction after the end of the deceleration signal is retained when the wheel speed is below the large reference value until the acceleration signal occurs.
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Only when an early acceleration signal before T_2 indicates other road conditions, will there be a change back to normal operation, i.e. the additional control signal for switching in the large comparison value disappears. This control signal may, for example, be the signal at the output of the bistable member 10 of figure 1.

It has become evident that it is favourable generally, i.e. without waiting for the test mentioned, to make the special control operation effective when building up the pressure because there is only a slip signal (without a deceleration signal being present). For this, a special bistable member may be used which is set when there is a slip signal reducing the pressure and causes special operation and which is reset with an early recurrence of the acceleration signal. The second bistable member 10 may be used for this.

In a further embodiment (not shown) a further switching means may be provided which makes use of the slip signal U_{-A} to cause switch over to special control operation. Thus, if the slip signal U_{-A} is still present at the end of the acceleration signal, these switch means switch over to special control operation. The control may then be reset by yet a further switch means when there is a large wheel acceleration.

WHAT WE CLAIM IS:—

1. An anti-lock brake control system for vehicles comprising sensors for sensing the rotary behaviour of the wheels, an evaluation circuit for producing control signals from signals fed to it by at least one said sensor and a brake pressure control unit responsive to the control signals for allowing a pressure build-up, maintaining pressure constant or causing a pressure reduction, the evaluation circuit comprising switch means producing a first control signal to cause pressure reduction when a tendency to lock is sensed and a second control signal to hold the pressure constant when there is a wheel acceleration of a predetermined value, the evaluation circuit further comprising a first monitoring circuit for detecting whether a wheel acceleration signal after the end of the pressure reducing signal occurs within a first predetermined period and for changing over the control system from normal operation in which the pressure is held constant in the transition period between the end of the pressure reducing signal and the start of a wheel acceleration signal, to a special operation in which pressure reduction is only terminated by an acceleration signal, in the absence of the wheel acceleration signal occurring within the said first predetermined time period and a second monitoring circuit for changing back the control system to normal

operation when said acceleration signal appears within a second predetermined period which is less than the first predetermined period.

2. A system as claimed in claim 1, wherein the second predetermined period is half the first predetermined period.

3. A system as claimed in claim 1 or 2, wherein the first monitoring circuit comprises a bistable member which is set by the pressure reducing signal and is resettable by the acceleration signal and its set output signal, available after expiry of the first predetermined period, serves to change over a second bistable member, the output signal of which, then appearing, causes a reduction in pressure, and wherein the first bistable member, is reset at the end of the first predetermined period if the second bistable member is in its reset condition.

4. A system as claimed in claim 3, wherein the second bistable member also forms part of the second monitoring circuit and may be reset by an acceleration signal which appears before the end of the second predetermined period.

5. A system as claimed in any one of claims 1 to 4, wherein the evaluation circuit includes second switching means which, when a slip signal is still present at the end of the acceleration signal, switch over to special control operation.

6. A system as claimed in any one of claims 1 to 5, wherein the evaluation circuit includes third switching means which discontinue the special control operation if there is a large wheel acceleration.

7. A system as claimed in any one of claims 1 to 6 wherein the evaluation circuit includes comparison means for alternating comparison of a wheel speed signal with one of two different reference values, whereby a pressure reduction signal is produced when the wheel speed falls below one reference value the lower reference value being normally used as the comparison value until a wheel deceleration signal is present, this wheel deceleration signal causing change over to the larger reference value and wherein the pressure reduction signals are suppressed by an acceleration signal, the first monitoring circuit changing over the control system to special control operation when to the larger reference value becomes effective, the larger reference value remaining effective until an acceleration signal occurs before expiry of the second predetermined period.

8. A system as claimed in any one of claims 3 or any claim appendent directly or indirectly thereto, wherein a further bistable member is provided in the evaluation circuit which bistable member is set when there is a slip signal reducing the pressure and causes

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special operation and which is reset with an early occurrence of the acceleration signal.

5 9. A system as claimed in claim 8 when appendant to claim 5, wherein second bistable member is used as the further bistable member.

10. An anti-lock brake control system for

vehicles substantially as described herein with reference to the drawings.

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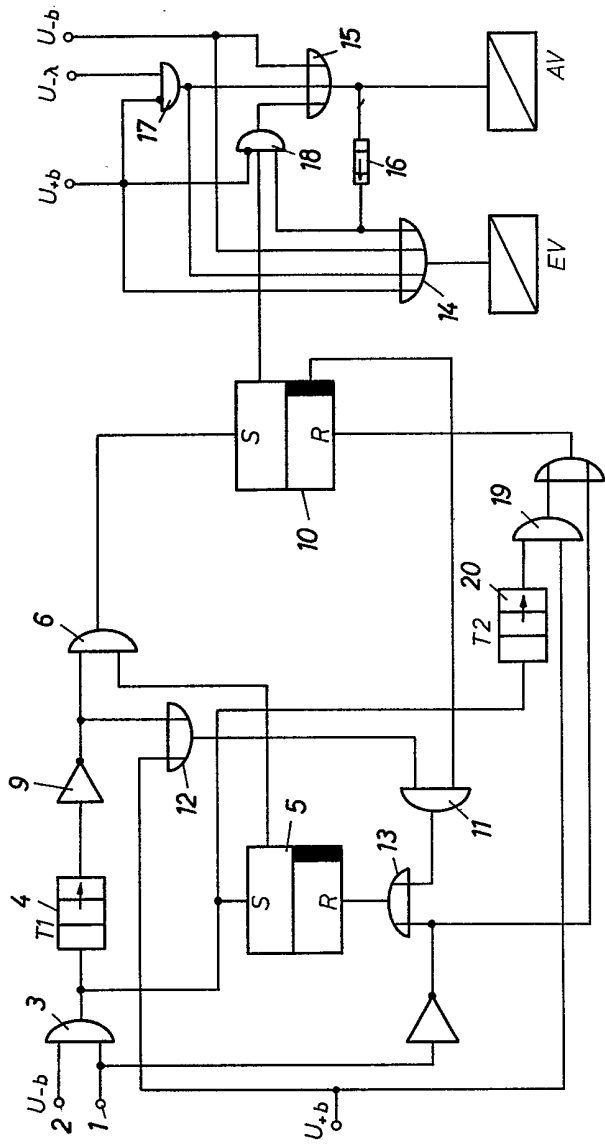


FIG. 1

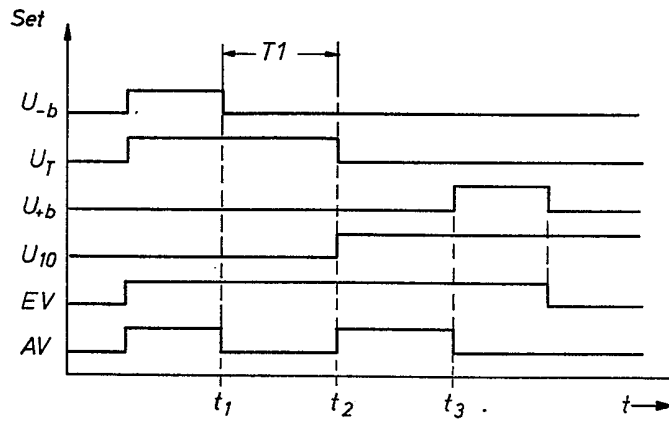


FIG.2

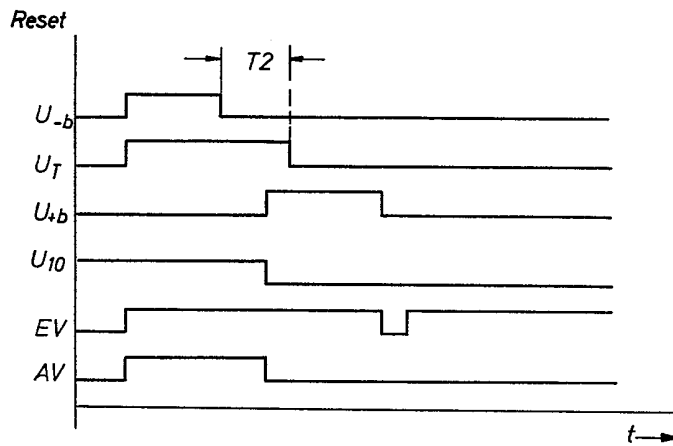


FIG.3