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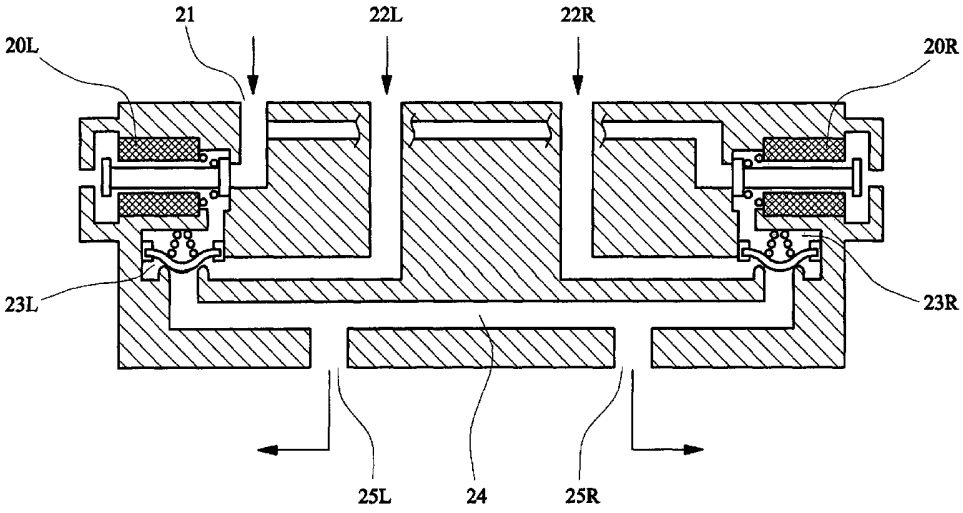
[Continued on next page]

(54) Title: ANTI-LOCK BRAKING FOR A VEHICLE WITH STEERABLE WHEELS



(57) Abstract: In an anti-lock braking system for a commercial road vehicle trailer with compressed air brakes and including a self-steer axle with such brakes, an electronic control unit (ECU) (16) selectively controls respective brake pressures to each side of another braking axle according to differential rolling surface adhesion to reduce skidding by way of respective pressure modulators. The output pressures from these modulators (6L, 6R) are additionally applied directly via an axle control valve (15) to brake actuators of the wheels of the self-steer axle and the axle control valve has means (20L, 20R) electrically controlled by the ECU and which isolates the higher of said modulator outputs from the respective self-steer axle wheel brakes at onset of anti-lock control and thereby tends to provide equal brake pressures to the self-steer wheels corresponding to the modulator pressure at the low adhesion side of the other axle.

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Declarations under Rule 4.17:

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ANTI-LOCK BRAKING FOR A VEHICLE WITH STEERABLE WHEELS

This invention relates to an anti-lock braking system and an axle control valve for a vehicle with self-steerable wheels, especially but not exclusively a trailer vehicle with compressed air braking. The invention is also applicable to a vehicle with force-steered wheels.

In a multi-axle vehicle with self-steerable wheels, wheels of a the vehicle of a steerable axle may be provided with means whereby when the vehicle is passing along a curved roadway, pivotal movement of the wheels of the steerable axle out of parallel with other wheels improves lateral stability and reduces tyre scrub. Such steerable wheels may be on a rigid axle or suspended independently. However, if self-steerable wheels are provided with independent anti-lock control of their brakes the self-steer action, especially when being governed by wheel reaction forces with the roadway, can itself result in tyre wear and vehicle instability whilst an anti-lock mode is operating, due to differential braking forces and reactions at opposite wheels of the self-steerable axle.

With an object to reduce the above shortcoming the specification of European Patent No. 0754609 proposes an anti-skid compressed air braking system for a trailer vehicle with a common brake pressure modulator valve which responds to respective wheel speed sensors at opposite sides of an allotted braked axle having anti-lock control via separate modulators, the common modulator providing the same brake pressure to both wheels of the self-steerable axle.

The present invention seeks to provide an alternative system to the foregoing and having an axle control valve not requiring such a common modulator.

According to the present invention there is provided an anti-lock braking system for a wheeled vehicle having a first axle with speed sensors for braked wheels thereof on opposite sides of the vehicle and an electronic control unit (ECU) which controls fluid pressure modulators to selectively control the respective brake pressures applied to brakes of said wheels in the event of incipient skidding being sensed, the system including means for directly applying output fluid braking pressure from either or both said modulators to brakes of wheels of a further steerable axle of the vehicle and control means whereby at

onset of an anti-lock mode accompanied by differential pressures from said modulators the higher of the braking pressures is isolated from the brakes of the steerable axle.

Preferably said control means is provided by an axle control valve with means to receive the respective output pressures of the brake pressure modulators and communicate them to a delivery port the axle control valve including respective solenoid valves controllable by signals from an anti-lock ECU to isolate the higher said output pressure from the delivery port.

In order that the invention may be more clearly understood, the same will now be further described by way of example with reference to the accompanying drawings of which:-

Fig 1 illustrates in schematic form interconnected components of a compressed air braking system of wheels of a trailer vehicle having three axles, one of which is a self-steered axle;

Fig 2 illustrates diagramatically the example of an axle control valve for the braking system of Fig 1; and

Fig 3 illustrates, in graphical manner, operation of the axle control valve assembly of Fig 2

Referring to Fig 1, fluid pressure communications are shown by solid lines and electronic communications are shown by broken lines. The compressed air braking system of a two line trailer with electronic braking and anti-lock (EBS/ABS) includes control and supply line couplers 1 and 2 respectively and a relay emergency valve 3 (of known form but which may be optional with EBS) via which a compressed air reservoir 4 is charged from a tractor system (not shown). The trailer has first, second and third axles with respective pairs of compressed air operable wheel brake actuators 12L, 12R and 13L, 13R and 14L, 14R. The third axle is self-steerable. Compressed air pressure graduable according to trailer control line pressure from the reservoir 4 is relayed via valve 3, a load control valve 5 (which again may not be a requirement with EBS) and respective left and right hand anti-lock pressure modulators 6L and 6R to the respective left and right hand brake actuators 12, 13. The actuators 14L and 14R are brake actuators of the steerable axle wheels which self-steer according to the reaction between the tyres thereof and the rolling surface to

improve stability and minimise tyre wear. In accordance with the invention, 14L and 14R are normally supplied with substantially equal brake pressure via an axle control valve 15. Valve 15 is supplied directly with pressures from both modulators 6L and 6R. In the present example these modulator pressures are controlled by an electronic ABS control unit (ECU) 16 which operates in known manner in response to wheel speed signals from transducers 17L and 17R adjacent to the middle pair of wheels which thereby sense the road surface adhesion at each side of the vehicle during braking. In normal braking conditions with no ABS operation the modulators 6L and 6R apply equal load dependent brake pressures to actuators 12L, 13L and 12R, 13R, these equal pressures are also fed to the axle control valve 15 normally emerging at the output of valve 15 to actuators 14R and 14L.

However, when the system is operating in ABS mode (and there is a difference of pressures from modulators 6L and 6R,) the axle control valve 15 operates to isolate from actuators 14R and 14L the highest modulator output. These actuators can therefore apply only equal and reduced brake forces to both wheels of the steered axle corresponding to brake pressure at the lowest adhesion side of the first axle.

Referring to Figs 2 and 3, the axle control valve 15, includes valve arrangements with respective two-state solenoid valves 20L and 20R which are identical and are each shown in an unenergised state wherein the areas above the diaphragms of respective open/closed diaphragm valves 23L and 23R are vented, trailer reservoir pressure at a port 21 being prevented from influencing respective diaphragm valves 23L and 23R. In this condition equal pressures at ports 22L and 22R and interconnection 24 from the ABS modulators for the middle axle are normally permitted to reach common output connections 25L and 25R to the brake actuators 13L and 13R of the self-steered axle.

In the graphical representation of Fig 3, solid curves (a) and (b) respectively represent curves of wheel speed against time for right and left hand wheels of the first and second axles (the non—steering axles of the trailer. The broken curve (c) represents brake pressure to the right and the left hand wheel brake actuators of the third axle (the steerable axle) of the trailer and wheel speed is represented by the solid line curve (d) . Controlling electronic

signals to the right hand and left hand solenoid valves 20R and 20L and represented at (e) and (f) on the same time scale.

During the brief period shown preceding point A there is no brake pressure. At point A (curve (c)) brake pressure is applied to decelerate the vehicle in known manner as indicated between points A and B (curves (a) and (b)). Initially, there is no tendency to skid sensed by transducers 17R and 17L and the ECU 16 but at point B, lower adhesion is sensed uniformly across the middle axle with a tendency for the braked wheels to lock and during period BC, the ECU controls modulators 6L and 6R to reduce the braking pressure accordingly. However, no control is imposed by the ECU upon the axle control valve at this time and both braking pressures from the modulators can reach the delivery ports to the brake actuators 14R and 14L of the steered axle. The wheels of the steered and non-steerable axles return to road speed, braking pressure being restored to a level as indicated between C and D of curve (c). At point D reduced adhesion is again encountered but now unequally across the vehicle. Greater wheel deceleration now tends to occur on the left side of the braked wheel axles and the ECU now controls modulators 6L and 6R differentially to produce greater pressure reduction from modulator 6L to correct the tendency to lock the wheels of the first and second axles. At the same time an electronic control signal (e) is applied by the ECU to solenoid valve 20R to close the diaphragm valve 23R to pressure from modulator 6R. The pressure applied directly from only modulator 6L is thereby permitted to be the sole controlling pressure of the actuators 14R and 14L of the wheels of the steerable axle over a period DEF (curve c). Corresponding wheel speeds for the wheels of the steerable axle under braking are indicated diagramatically in curve (d) assuming identity of performance (which may not be so) between the steered wheels but those are simply exemplary. Moreover, in the event of the vehicle encountering a surface which presents lower adhesion at the wheels of its right hand side, electronic energisation of the solenoid valve 20R is interrupted and energisation of the solenoid valve 20L commences, to maintain the requirement of isolating the higher braking pressure from the brakes of the steerable axle.

Various operating conditions of the axle control valve 15 under control of the ECU 16 may now be summarised. With the system charged and the solenoids unenergised trailer reservoir pressure is isolated from the diaphragm 23L and 23R and the upper areas thereof

are subject to atmospheric pressure. Accordingly, as described above, the substantially equal input pressures at ports 22L and 22R merge as a common output pressure to the steered axle brakes. Similarly, such brake application releases via the diaphragm valves, ports 22L and 22R and the two modulators, In the case of brake force reduction being initiated by the ECU in anti-lock mode the solenoid valve corresponding to highest adhesion wheel of the second axle is energised thereby isolating the output of the respective modulator valve from the delivery of the axle control valve and permitting the pressure to the brake actuators of the self-steered axle to be reduced to the extent of control from the low adhesion side. In the case of reversal of the detected adhesion conditions the formerly energised solenoid valve is de-energised and the formerly unenergised solenoid is energised but without overlap to maintain control from the non lowest adhesion wheel of the middle axle.

In order to enhance the rate of reduction of the common brake pressure from the actuators of the self-steer axle the actuators may be provided with actuator pressure through a common delivery port and via a common quick release valve. Indeed, such quick-release valve may be integrated with an axle control valve unit according to the invention if so required.

When installing an axle control valve arrangement such as described in the foregoing for a self-steer axle of a vehicle it is to be appreciated that the air ways are to be sufficiently large and hysteresis is not to be such as to result in unintended depletion of brake pressure through unsynchronised cycling in ABS mode.

Whilst the axle control valve described in the foregoing with reference to Fig 2 and Fig 3 of the accompanying drawings is described more especially in relation to anti-lock control of brakes of self-steerable axle during anti-lock braking of a vehicle, such an axle control valve may be employed in force-steerable axle arrangements. Moreover, such an axle control valve may be provided to afford simplified anti-lock control of brake pressure of wheels of a lifting axle the tyres of wheels of which contact the rolling surface only when the vehicle is heavy-laden. By such means the size of actuators to one or more other axles may be less than otherwise required, whilst providing extended distribution of braking of the vehicle.

CLAIMS

1. An anti-lock braking system for a wheeled vehicle having braked wheels of a first axle with speed sensors (17L,17R) for braked wheels thereof on opposite sides of the vehicle and an electronic control unit (ECU) (16) which controls fluid pressure modulators (6L,6R) to selectively control respective brake pressures applied to brakes of said wheels in the event of incipient skidding being sensed,
characterised in that the system includes brake pressure application means adapted to directly apply output fluid braking pressure from either or both said modulators to brakes of the wheels of a further steerable axle of the vehicle and control means (15) whereby at onset of an anti-lock mode accompanied by differential pressures from said modulators (6L,6R) the higher of the braking pressures is isolated from the brakes of the steerable axle.

2. An anti-lock braking system as claimed in Claim 1, wherein said control means comprises an axle control valve (15) with input ports to receive the respective output pressures of the brake pressure modulators (6L,6R) and with means to communicate these pressures to a delivery port, the control means including respective solenoid valve arrangements controllable by signals from an ECU (16) to isolate the higher said output pressure from the delivery port.

3. An anti-lock braking system as claimed in Claim 2, each said solenoid valve arrangement comprising an open/closed diaphragm valve (23L,R) in the communication path between a respective input port and the delivery port and a respective solenoid valve operable to selectively apply a closing pressure from a pressure source to the diaphragm valve.

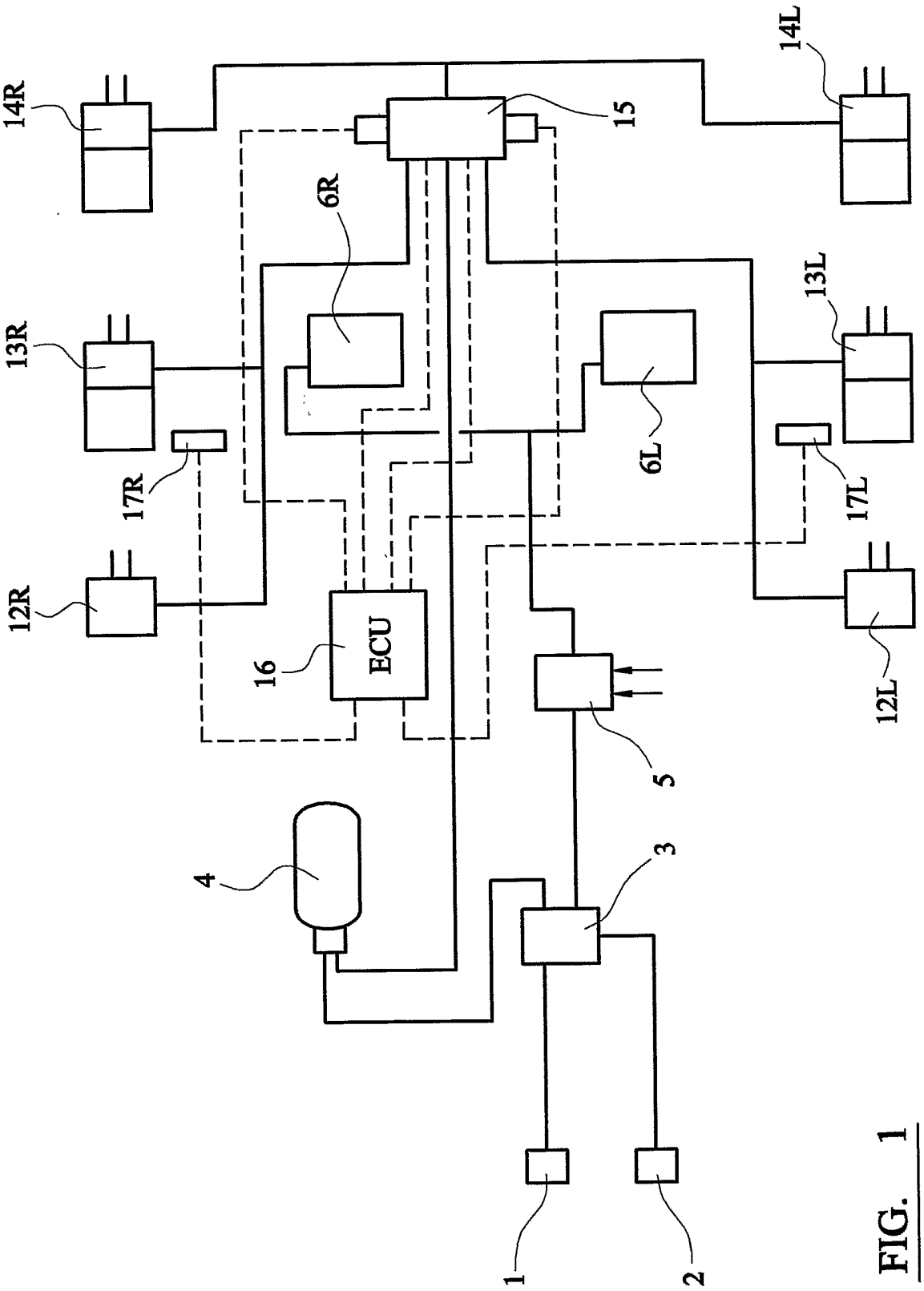

FIG. 1

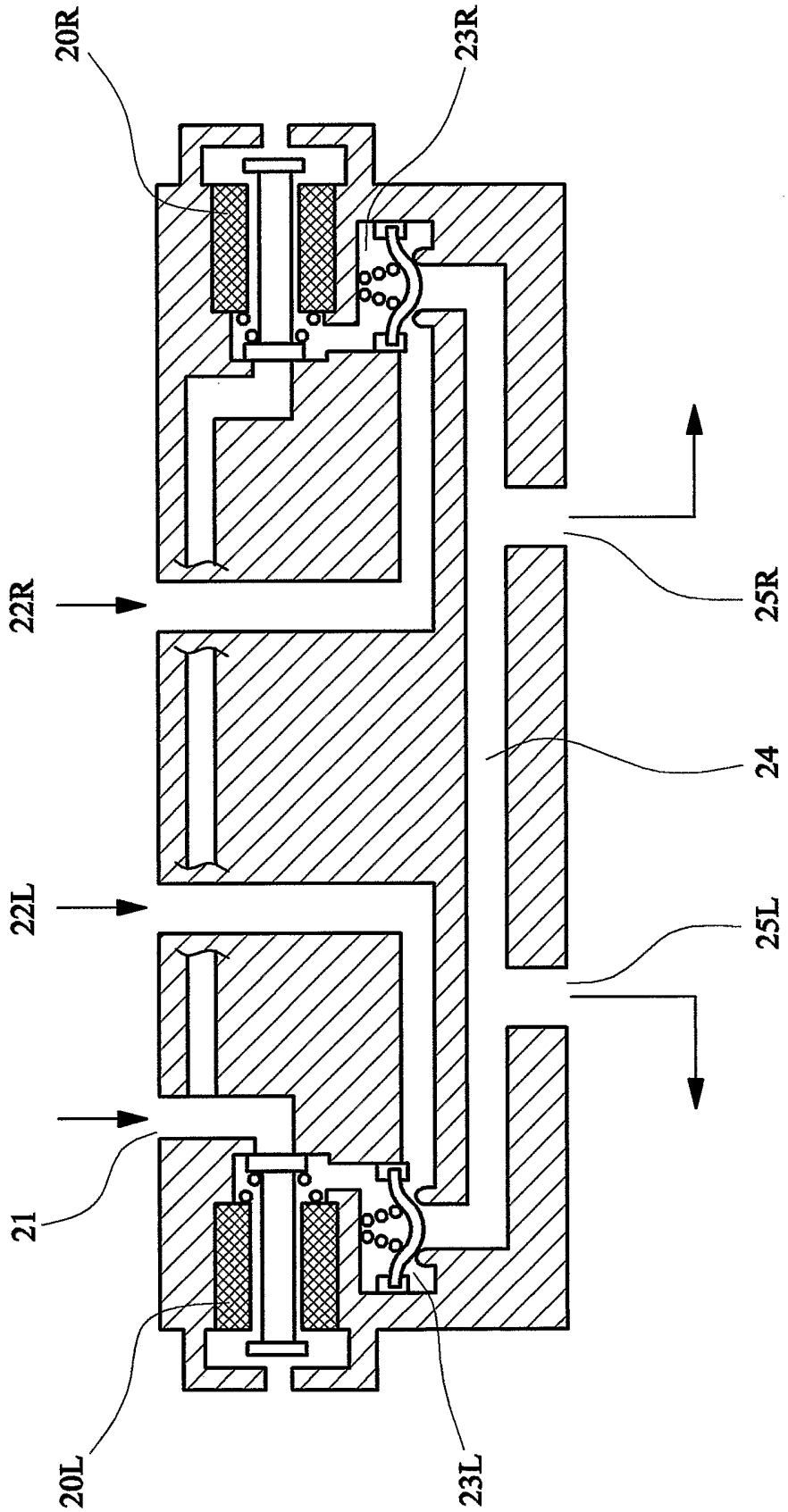

FIG. 2

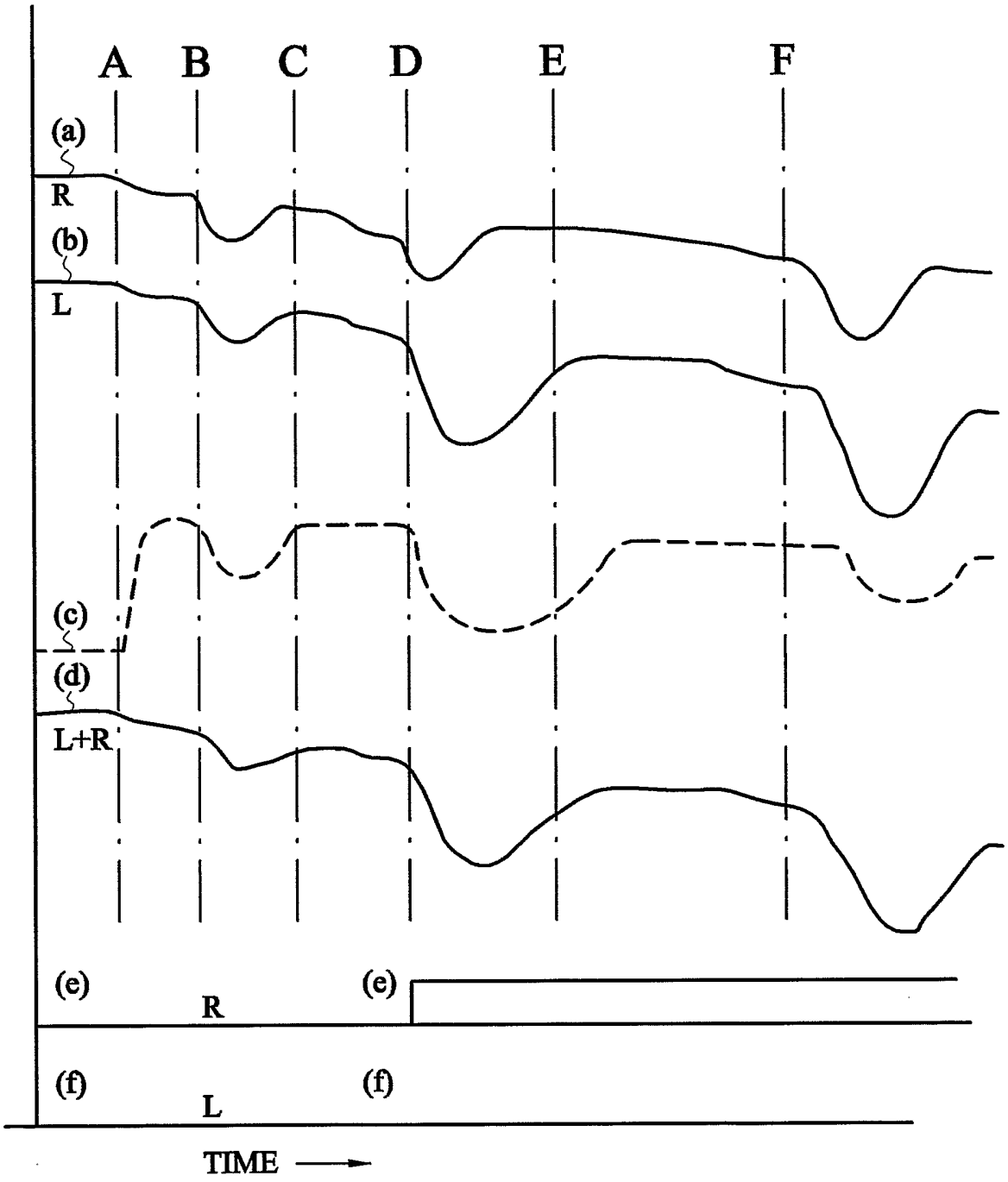

FIG. 3

INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/GB 03/00426

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B60T8/34

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B60T B62D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
12 May 2003	23/05/2003

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Intel ional Application No
PCT/GB 03/00426

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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