(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
30 December 2020 (30.12.2020)

WIPO | PCT

(10) International Publication Number
WO 2020/260745 A1

(51) International Patent Classification:
B60W 10/11 (2012.01) *B60W 20/30* (2016.01)
B60W 10/184 (2012.01) *B60T 8/32* (2006.01)

(21) International Application Number:
PCT/FI2019/050504

(22) International Filing Date:
27 June 2019 (27.06.2019)

(25) Filing Language: English

(26) Publication Language: English

(72) Inventor; and
(71) Applicant: **AUVINEN, Jukka** [FI/FI]; Aisakuja 2, 17200 Vääksy (FI).

(74) Agent: **BERGGREN OY**; Eteläinen Rautatiekatu 10 A, (P.O. Box 16), 00100 Helsinki (FI).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) **Title:** A BRAKING CONTROL ARRANGEMENT FOR A BRAKING SYSTEM OF A VEHICLE

(57) **Abstract:** A braking control arrangement according to the invention is for a braking system of a vehicle (1B). The braking system comprises an anti-lock braking system, ABS, and an electronic stability control, ESC. The braking control arrangement comprises a module (40) that is arranged to operate with the anti-lock braking system and the electric stability control. The arrangement is also arranged to drive a gear arrangement (25A) of the vehicle in such a way that when braking the vehicle, the anti-lock braking system works, and a slippery road is detected, the gear arrangement (25A) of the vehicle (1B) is driven to shift a reverse gear.

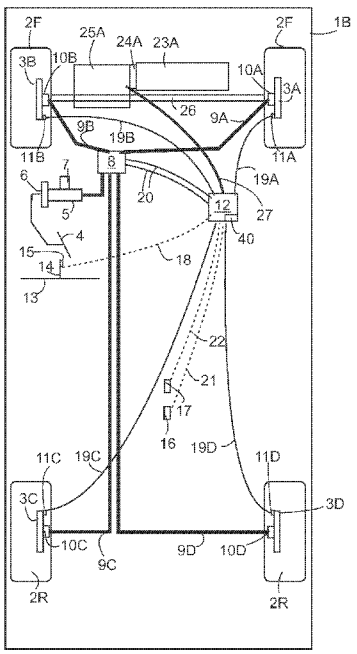


FIG. 2

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A braking control arrangement for a braking system of a vehicle

Field of technology

The invention relates to a braking control arrangement for a braking system of a vehicle. The braking system comprises an anti-lock braking system and an electronic stability control.

Prior art

The brakes of the vehicle area used for decelerating the speed of the vehicle or to stop the vehicle. Nowadays braking systems of vehicles comprises anti-lock braking systems, i.e. ABSs and electronic stability controls, i.e. ESCs. Other abbreviations or names are also used, mostly depending on manufacture specific product names.

In order to prevent skidding of the vehicles wheels while braking the anti-lock braking system, ABS, has been developed. The ABS avoids locking up the wheel during braking. The locking up means that the wheel does not rotate. The ABS reduces and increases the brake pressure repeatedly, even about 15 – 20 times per second. In this way the wheels do not lock up and the steering control of the vehicle remains. Especially at high speed the ABS provider better stability and control of the vehicle, maintaining traction with a road surface.

In general, the ABS decreases stopping distances on dry surfaces. However on slippery surfaces like loose gravel or snowy surface the ABS may significantly increase braking distances, but still remaining or improving the steering control.

The electronic stability control, ESC, improves the vehicles stability by detecting and reducing skidding i.e. loss of traction. When the skidding and loss of steering control is detected by the ESC, the brakes are automatically utilized in order to help the steering of the vehicle. Braking is wheel specific, for example if the vehicles rear starts to skid when driving in a curve, the ESC brakes the outer front wheel.

Although, the ABS and ESC works generally fine, slippery roads may still cause problems, which may be fatal. For example when driving on loose gravel and a sudden obstacle becomes in front of the vehicle and there is no space to steer pass the obstacle the ABS may actually make the situation worse, because it increases a braking distance.

Short description

The object of the invention is to alleviate or even eliminate the problems said above. The object is achieved in a way described in the independent claims. Dependent claims illustrate different embodiments of the invention.

A braking control arrangement according to the invention is for a braking system of a vehicle, which braking system comprises an anti-lock braking system, ABS, and an electronic stability control, ESC. The braking control arrangement comprises a module that is arranged to operate with the anti-lock braking system and the electric stability control. The arrangement is also arranged to drive a gear arrangement of the vehicle in such a way that when braking the vehicle, the anti-lock braking system works, and a slippery road is detected, the gear arrangement of the vehicle is driven to shift a reverse gear.

and when being in reverse gear during the braking, and an unwanted trace of the vehicle or a turn of the vehicle's steering wheel is detected, the gear arrangement of the vehicle is driven to shift from the reverse gear to a forward gear utilizing speed measurement data of the vehicle.

List of figures

In the following, the invention is described in more detail by reference to the enclosed drawings, where

Figure 1	illustrates an example of a known ABS/ESC system,
Figure 2	illustrates an example of the invention with a front wheel drive car,

Figure 3 illustrates an example of the invention with a rear wheel drive car,

Figure 4 illustrates an example the invention with a four wheel drive car, and

Figure 5 illustrates a flow chart example of the method according to the invention.

Description of the invention

Figure 1 illustrates an example of a known ABS/ESC system. A vehicle 1A has front wheels 2F and rear wheels 2R, which each wheel is equipped with a brake 3A, 3B, 3C, 3D. A brake pedal 4 is used by a driver when braking. The brake pedal is connected to a master cylinder 5 through a power booster 6 like a vacuum power booster. A brake fluid reservoir 7 is also connected with the master cylinder 5. The master cylinder is in turn connected via a brake fluid pipe to a modulator unit 8. The modulator unit 8 comprises valves, conveniently for each brake 3A, 3B, 3C, 3D of the wheel, and a pump in order to restore the fluid pressure to the brakes after the valves have released. The brake fluid is in connection with the brake cylinders 10A, 10B, 10C, 10D through brake lines 9A, 9B, 9C, 9D. Some systems may use valves having three positions. When the valve is open, the fuild pressure from the master cylinder is passed through to the brake. When the valve is closed, the brake is isolated from the master cylinder preventing the pressure rise in the brake cylinder. In third position, the valve releases some of the pressure from the brake. The pump is used to restore the fluid pressure.

The system comprises also a control module 12 that is often an integrated module has the ABS and ESC system control. Each wheel has a speed sensor 11A, 11B, 11C, 11D, in order to measure speed of the wheel. The speed sensors are connected to the control module through lines 19A, 19B, 19C, 19D. The control module is also connected 20 to the modulator unit 8 for controlling the valves and the pump. The speed sensors and the connections 20 to the modulator unit are elements needed for the ABS. It should be noted that figure 1 and the other figures of this description are simplified schematic drawings, so the ABS and the ESC may comprise other sensors and elements not shown in the figures. The dashed lines 18, 21, 22 illustrate

connections to steering wheel angle position sensor 15 connected to a steering rod 14, a yaw rate sensor 16 and a lateral acceleration sensor 17. These sensors are used by the ESC. It is worth noting that the ESC also utilizes the speed sensors and the connections 20 to the modulator unit. As can be seen the steering rod 14 is connected with the steering wheel 13. The elements and functions of the example of figure 1 are known as such.

Figures 2, 3 and 4 shows vehicles 1B, 1C, 1D having front wheel drive, rear wheel drive and four wheel drive. Each figure shows a motor 23A, 23B, 23C that is connected to a gear arrangement 25A, 25B, 25C of the vehicle. The connection is usually through a clutch 24A, 24B, 24C. The gear arrangement can be a transmission, like automatic transmission. If the vehicle 1B, 1C, 1D is an electric vehicle, the gear arrangement is a gear system of the electric vehicle. The electric car may have a simple gear but transmission similar with combustion engines may also be used.

Figure 2 shows the front wheel drive car 1B. For simplicity reasons wheel axles are illustrated as one axle 26. The front differential gear is not illustrated as well. The transmission 25A is connected to drive shaft not shown in figure 2. The drive shaft in turn is connected to the differential gear that is connection with the wheel axles. A skilled person understand that the wheel axles, differential gears and drive shafts are known elements of the vehicle.

So, the inventive braking control arrangement is for a braking system of a vehicle, wherein the braking system comprising an anti-lock braking system, ABS, and an electronic stability control ESC. The braking control arrangement comprises a module 40 that is arranged to operate with the anti-lock braking system and the electric stability control. The arrangement is also arranged to drive a gear arrangement 25A, 25B, 25C of the vehicle 1B, 1C, 1C in such a way that when braking the vehicle and the anti-lock braking system works, and a slippery road is detected, the gear arrangement of the vehicle is driven to shift a reverse gear. Further, when being in reverse gear during braking, and an unwanted trace of the vehicle or a turn of the vehicle's steering wheel is detected, the gear arrangement of the vehicle is driven to shift from the reverse gear to a forward gear utilizing speed measurement data of the vehicle. As can seen in figure

2, the module 40 can be integrated with the control module 12, that is also connected to the transmission 25A, i.e. the gear arrangement, in order to make the gear shifts.

The invention works also with the rear wheel drive vehicle 1C having a rear drive shaft 28 to rear wheel axles 29. Further the invention works also with the four wheel drive vehicle 1D having a rear drive shaft 28 to the rear wheel axles 29, and a front drive shaft 30 to the front wheel axles 26. Figure 4 showing the example of the four wheel drive illustrates also front and rear differential gears 31, 32.

The module can be software or an integrated circuit module. The integrated circuit module can, for example, be an ASIC (Application Specific Integrated Circuit) or SoC (System on a Chip). As said it is convenient and practical in install the module with the control module containing the ABS and ESC systems. However the module may also be installed in a different way if desired.

The slippery road is detected by utilizing temperature measurement data and deceleration data of the vehicle. The vehicle has many sensors like temperature sensor to measure weather temperature, a lateral acceleration sensor and a longitudinal acceleration sensor. The longitudinal acceleration sensor can be used for measuring the deceleration of the vehicle in the direction of the vehicles trace if a separate deceleration sensor is not useable.

So, it is worth to note that module 40 (and the control module also in many embodiments) is in connection with sensor data of a number of different sensors. All possible and useable sensors are not illustrated in this description but it is clear for a skilled person that a vehicle contains many different measurement sensors that the invention can utilize. For example, the braking control arrangement may utilize measurement data from a temperature sensor, speed measurement sensors, a steering wheel angle sensor, a yaw rate sensor, a lateral acceleration sensor and a longitudinal acceleration sensor.

So if the temperature measurement data for weather is below a threshold temperature and the deceleration data of the vehicle reveals that the deceleration of the vehicle, in the direction of the vehicles trace / course, is too low, the slippery road is detected. The evaluation of whether the road surface is slippery or not, can be made

by deducing the road surface from the measurements. For example, if there is warm weather and not raining, an asphalt surface provides a good traction with the wheels in this weather condition. A concrete surface provides even better traction. The traction on a warm dry asphalt is so good that it has been considered unnecessary to improve the actions of the vehicles braking system by the invention. The threshold temperature can be selected to be desired, for example 5 Celsius or another value. If the temperature is below the threshold temperature, the weather is considered to be cold in which case even the dry asphalt (or concrete) can be slippery, and the invention can act to improve the braking. Different road surfaces affect the deceleration of the vehicle. The module 40 can have deceleration data relating to different road surfaces and weather conditions. Therefore, the slippery driving condition can be deduced from the deceleration measurement of the vehicle and from the weather temperature measurements of the vehicle. Cold weather is considered to be more slippery to drive a car than a warm weather. A wet asphalt, for example due to raining, is considered to be slippery. A loose gravel or a snowy road surface are considered to be slippery to drive the vehicle.

Another way to detected the slippery road is to utilize temperature measurement data and a camera data of the roads surface, so that if the temperature measurement data is below a threshold temperature and the camera data provides another data than a dry asphalt surface, the slippery road is detected. Nowadays it is common that the vehicles are equipped with several cameras. At least one camera can film or photograph the road surface from which the roads surface can be detected. In these embodiments the camera/s is connected to the module 40 and/or the control module 12.

The gear arrangement of the vehicle, like an automatic transmission for a combustion engine or a gear system for the electric motor of the electric vehicle or other suitable gear system or transmission, is driven to shift a reverse gear. The transmission/gear system has actuator/s to shift a right gear. Normally as known, the right gear depends on the speed of the vehicle. The actuator/s also shift to reverse gear when controlled by the driver. The invention utilizes known structures and actuators of known transmissions and gear systems in order to shift reverse gear and

away from reverse gear to a forward gear. Shifting back to a right forward gear depends on the current speed of the vehicle.

It has been found that when braking on a slippery road, shifting reverse gear can decrease braking distance significantly. Since vehicles may have a system to block shifting reverse when driving forward, the invention is arranged to override this block. Nowadays transmissions and gear arrangement and drive shafts etc. may carry relatively high torques, so shifting reverse gear has been found possible. So when braking the ABS works, but if the slippery road is detected, the gear arrangement of the vehicle can be driven to shift a reverse gear in order to decrease breaking distance. In this way a collision to an obstacle on a road can be avoided if steering the vehicle pass the obstacle is not possible.

In addition the inventive arrangement is also arranged to drive a gear arrangement of the vehicle in such a way that when the electronic stability control works, ESC in order to correct skidding, the gear arrangement of the vehicle is driven to shift a reverse gear in order to improve the correction of the skidding. As said , a steering wheel angle sensor 15, a yaw rate sensor16, , a lateral acceleration sensor 17 and a longitudinal acceleration sensor (not shown in the figures) may be used.

Figure 5 shows a flow chart example of an inventive braking control method for a braking system of a vehicle. The braking system comprises an anti-lock braking system and an electronic stability control. The method is arranged to operate with the anti-lock braking system and the electric stability control, the method comprising steps: to drive 51 a gear arrangement of the vehicle so that when braking the vehicle and the anti-lock braking system works, and a slippery road is detected, the gear arrangement of the vehicle is driven to shift a reverse gear; and to drive 52 the gear arrangement of the vehicle back from the reverse gear to a forward gear utilizing speed measurement data of the vehicle, when an unwanted trace of the vehicle or a turn of the vehicles steering wheel is detected. So, its possible to steer the vehicle, since when turning the steering wheel the gear arrangement is shift to the correct forward gear as said above and the ABS works again.

The method further comprises a step to drive the gear arrangement of the vehicle so that when the electronic stability control works in order to correct skidding, the gear arrangement of the vehicle is driven to shift a reverse gear in order to improve the correction of the skidding.

A vehicle can be a car, a van, a sport car, a pick-up, or a campervan. So, the invention can be mainly used with relative light vehicles, but heavier vehicles may also be configured to utilize the invention.

It is evident from the above that the invention is not limited to the embodiments described in this text but can be implemented in many other different embodiments within the scope of the independent claims.

Claims

1. A braking control arrangement for a braking system of a vehicle (1B, 1C, 1C), the braking system comprising an anti-lock braking system and an electronic stability control, **characterised** in that the braking control arrangement comprises a module (40) that is arranged to operate with the anti-lock braking system and the electric stability control, which arrangement is also arranged to drive a gear arrangement (25A, 25B, 25C) of the vehicle in such a way that when braking the vehicle and the anti-lock braking system works, and a slippery road is detected, the gear arrangement of the vehicle is driven to shift a reverse gear,

and when being in reverse gear during braking, and an unwanted trace of the vehicle (1B, 1C, 1C), or a turn of the vehicles steering wheel (13) is detected, the gear arrangement (25A, 25B, 25C) of the vehicle is driven to shift from the reverse gear to a forward gear utilizing speed measurement data of the vehicle.

2. A braking control arrangement according to claim 1, **characterised** in that the slippery road is detected by utilizing temperature measurement data and deceleration data of the vehicle, so that if the temperature measurement data is below a threshold temperature and the deceleration data of the vehicle (1B, 1C, 1C) reveals that the deceleration of the vehicle is too low, the slippery road is detected.

3. A braking control arrangement according to claim 1, **characterised** in that the slippery road is detected by utilizing temperature measurement data and a camera data of the roads surface, so that if the temperature measurement data is below a threshold temperature and the camera data provides another data than a dry asphalt surface, the slippery road is detected.

4. A braking control arrangement according to any of claim 1 - 3, **characterised** in that the arrangement is also arranged to drive a gear arrangement (25A, 25B, 25C) of the vehicle (1B, 1C, 1C) in such a way that when the electronic stability control works in order to correct skidding, the gear arrangement of the vehicle is driven to shift a reverse gear in order to improve the correction of the skidding.

5. A braking control arrangement according to claim 4, **characterised** in that the braking control arrangement utilizes measurement data from a temperature sensor,

speed measurement sensors, a steering wheel angle sensor, a yaw rate sensor, a lateral acceleration sensor and a longitudinal acceleration sensor.

6. A braking control arrangement according to any of claims 1 - 5, **characterised** in that the module (40) is software or an integrated circuit module.

7. A braking control arrangement according to claim 6, **characterised** in that the gear arrangement (25A, 25B, 25C) is an automatic transmission of the vehicle (1B, 1C, 1C).

8. A braking control arrangement according to claim 1, **characterised** in that the vehicle (1B, 1C, 1C) is an electric vehicle, and the gear arrangement (25A, 25B, 25C) is a gear system of the electric vehicle.

9. A braking control method for a braking system of a vehicle (1B, 1C, 1C), the braking system comprising an anti-lock braking system and an electronic stability control, **characterised** in that the method is arranged to operate with the anti-lock braking system and the electric stability control, the method comprising steps:

to drive (51) a gear arrangement (25A, 25B, 25C) of the vehicle so that when braking the vehicle and the anti-lock braking system works, and a slippery road is detected, the gear arrangement of the vehicle is driven to shift a reverse gear, and

to drive (52) the gear arrangement of the vehicle back from the reverse gear to a forward gear utilizing speed measurement data of the vehicle, when an unwanted trace of the vehicle or a turn of the vehicles steering wheel is detected.

10. A braking control method according to claim 9, **characterised** in that it further comprises a step to drive the gear arrangement of the vehicle (1B, 1C, 1C) so that when the electronic stability control works in order to correct skidding, the gear arrangement of the vehicle is driven to shift a reverse gear in order to improve the correction of the skidding.

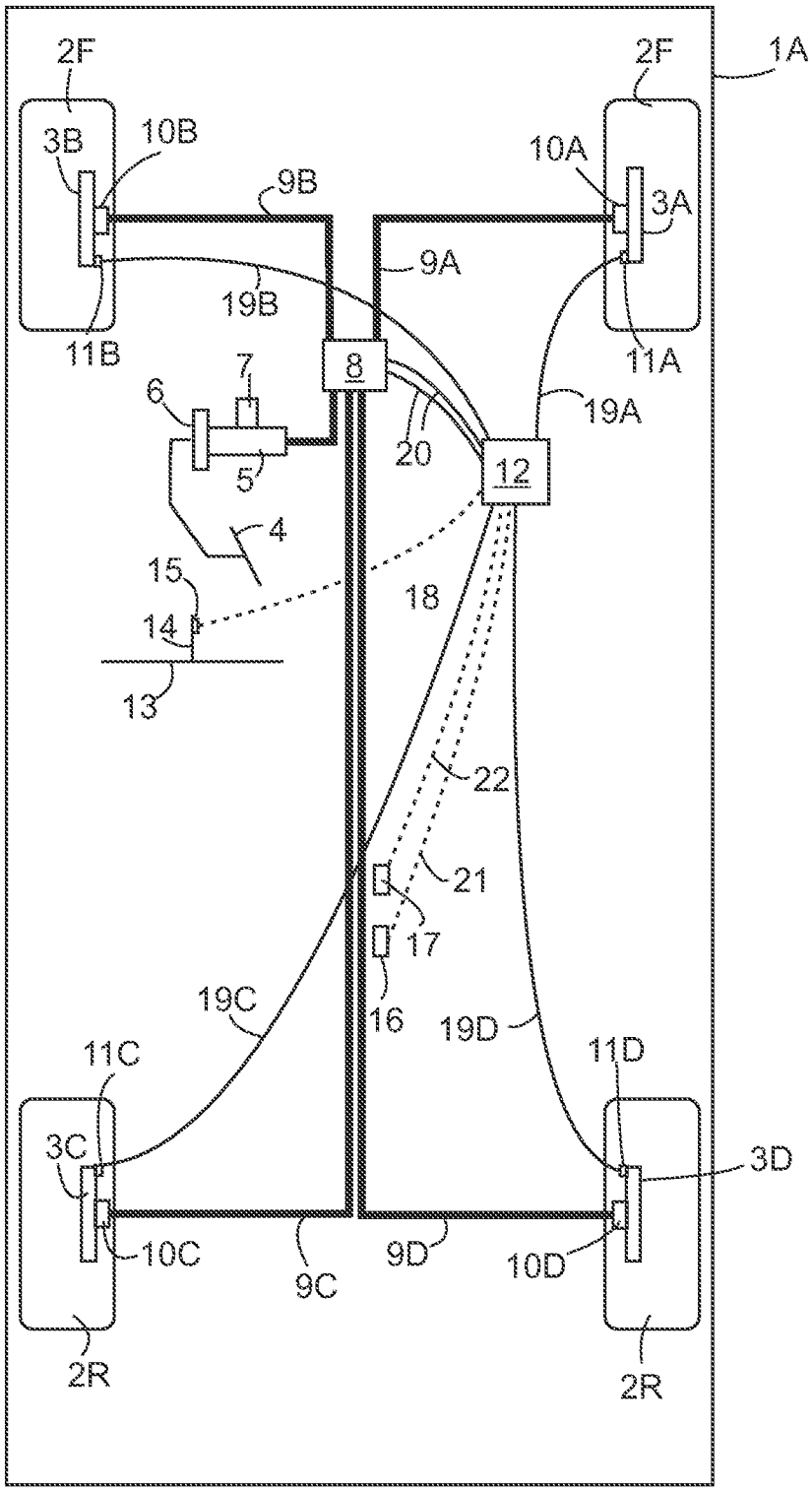

2F
2F
1A
3B
10B
10A
9B
3A
9A
19B
11B
8
11A
7
6
19A
20
5
12
4
15
18
14
13
22
21
17
19C
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3D
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9C
9D
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2R
2R

FIG. 1

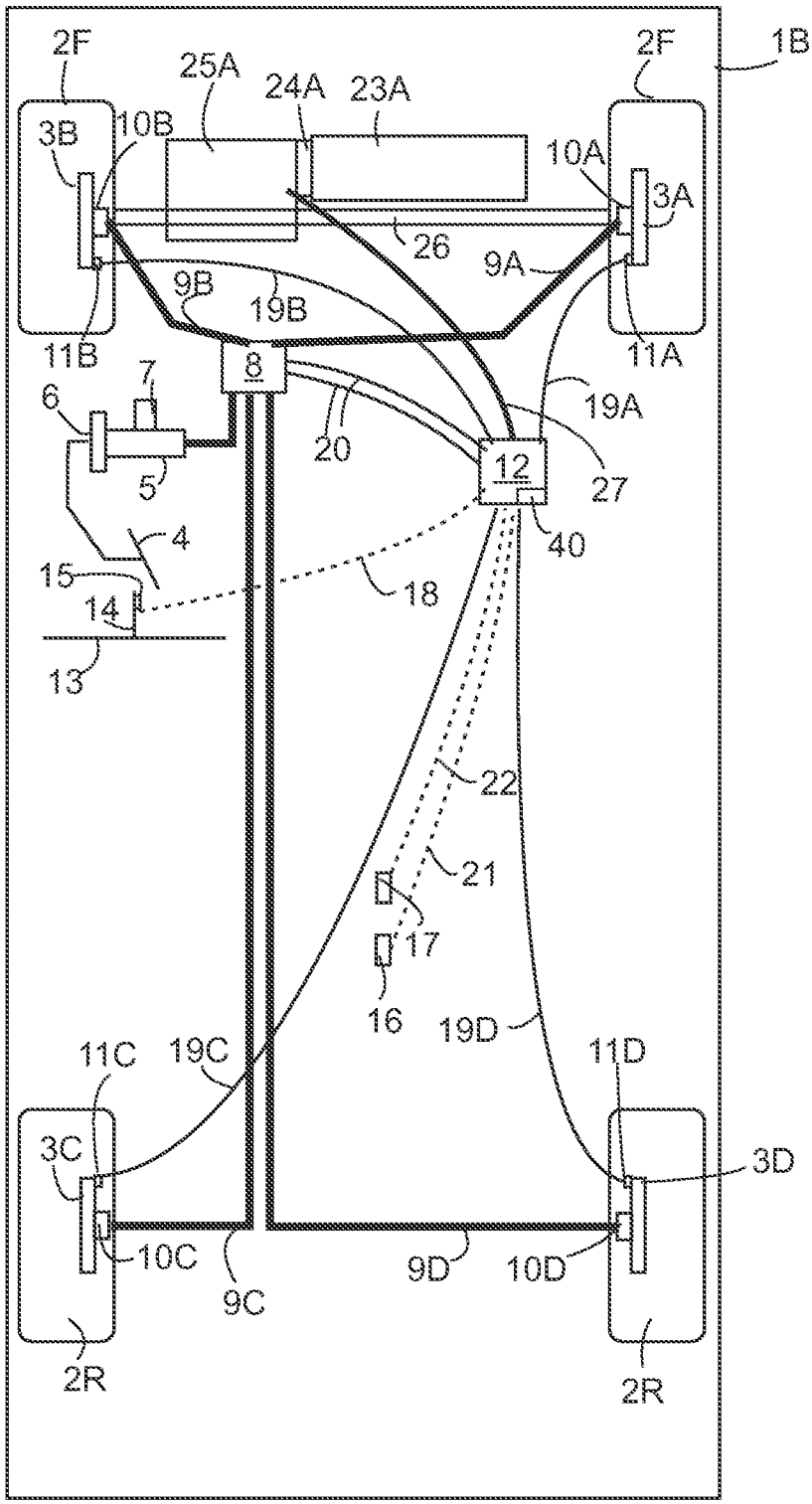

2F
25A
24A
23A
2F
1B
3B
10B
10A
3A
26
9A
9B
19B
11B
11A
8
7
6
19A
20
12
27
5
4
40
15
18
14
13
22
21
17
16
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FIG. 2

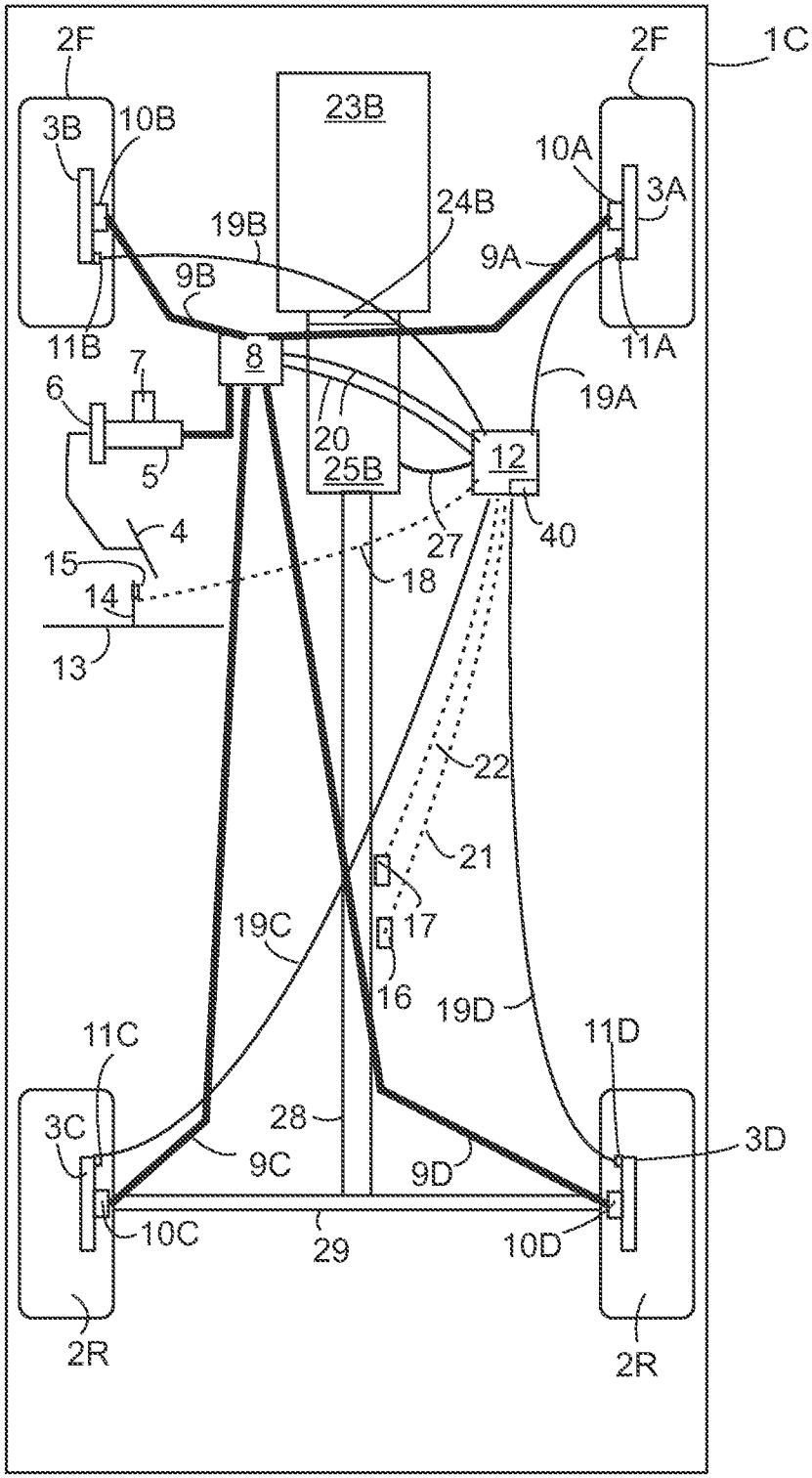

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25B
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27
40
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18
14
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22
21
19C
17
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9D
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29
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2R

FIG. 3

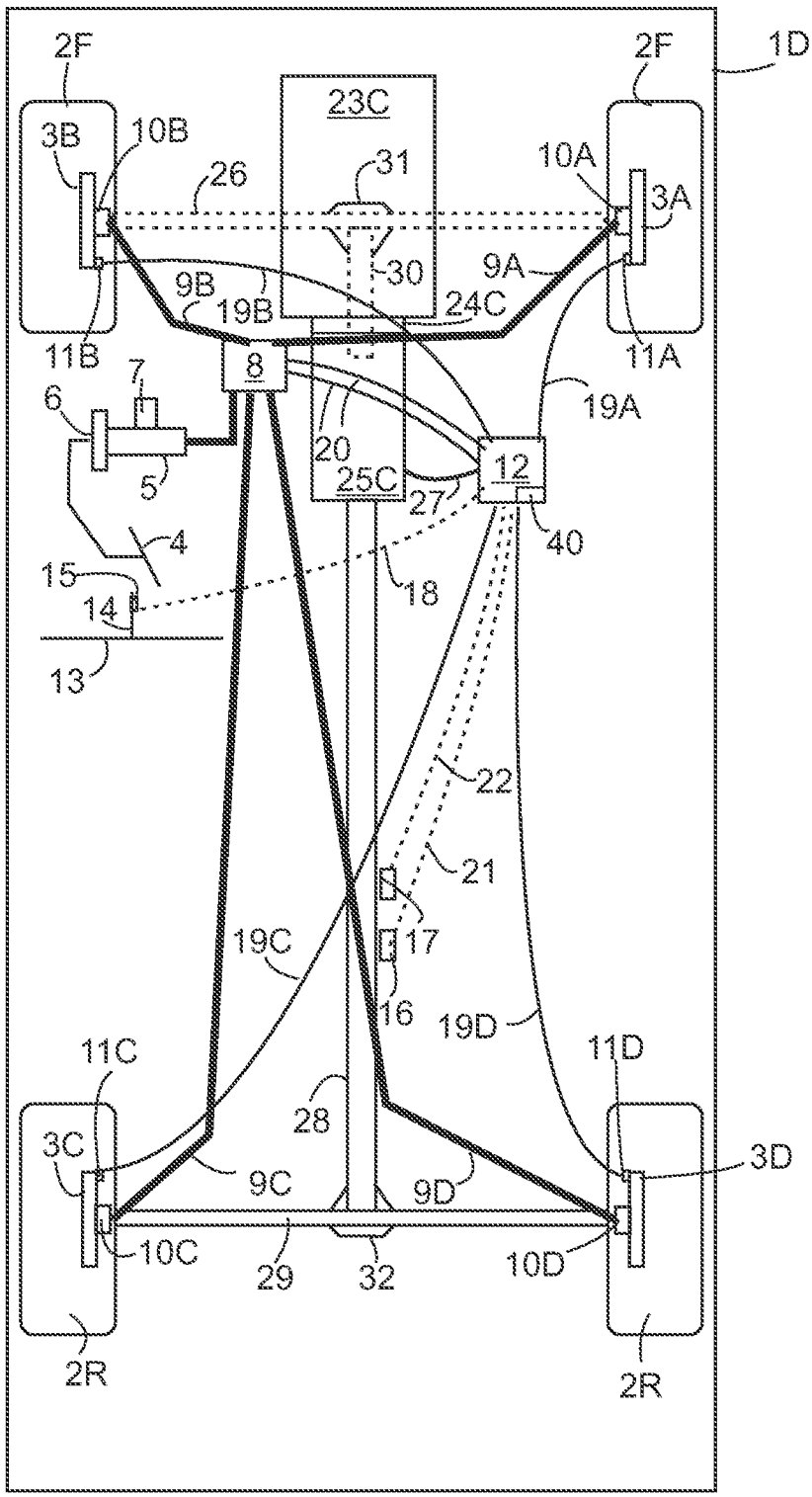

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8
7
6
19A
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25C
12
5
27
4
40
15
18
14
13
22
21
19C
17
16
19D
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9D
3D
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32
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2R

FIG. 4

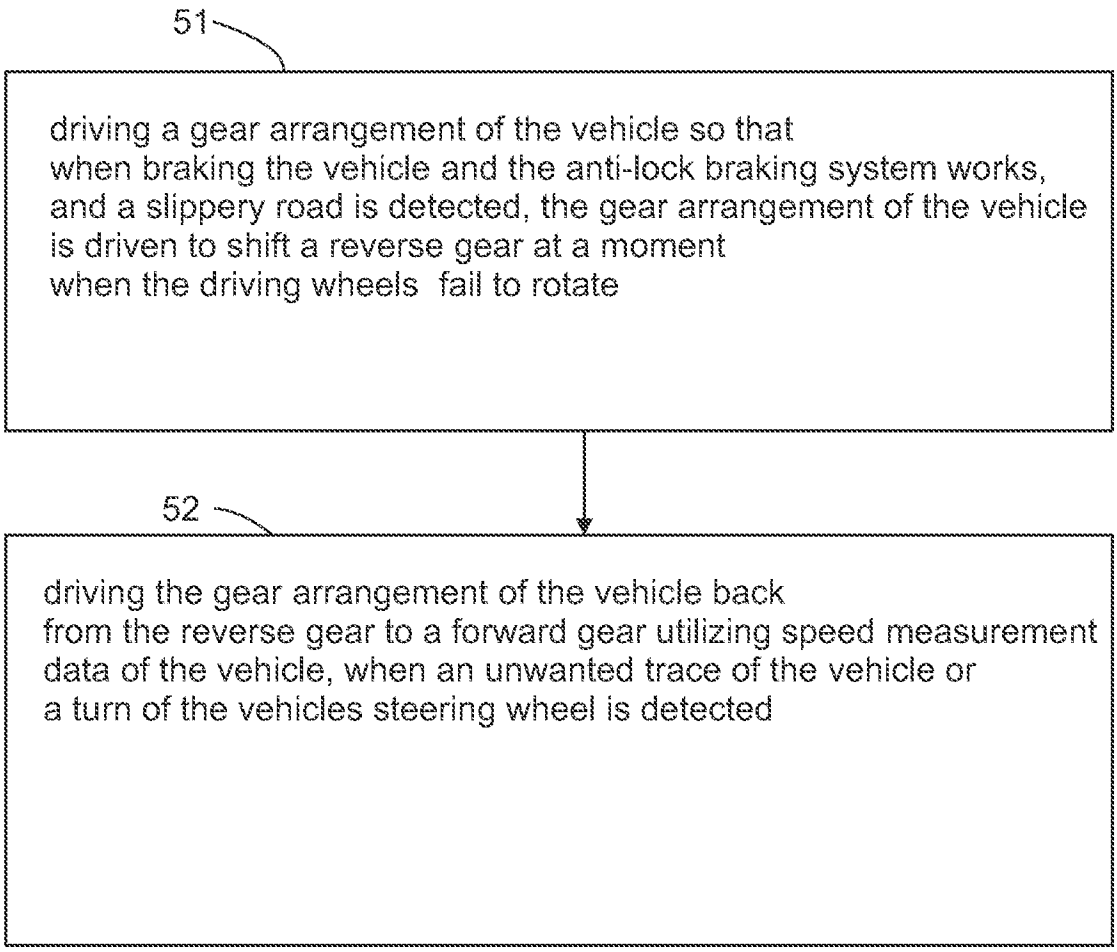

51
driving a gear arrangement of the vehicle so that when braking the vehicle and the anti-lock braking system works, and a slippery road is detected, the gear arrangement of the vehicle is driven to shift a reverse gear at a moment when the driving wheels fail to rotate
52
driving the gear arrangement of the vehicle back from the reverse gear to a forward gear utilizing speed measurement data of the vehicle, when an unwanted trace of the vehicle or a turn of the vehicles steering wheel is detected

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2019/050504

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60W10/11 B60W10/184 B60W20/30 B60T8/32
ADD.

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)
B60W B60T

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 practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 2 321 535 A (SIEMENS AG [DE]) 29 July 1998 (1998-07-29) the whole document	1-10
A	EP 0 795 700 A2 (TOYOTA MOTOR CO LTD [JP]) 17 September 1997 (1997-09-17) the whole document	1-10
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A	US 4 276 972 A (BURNETT STANLEY F ET AL) 7 July 1981 (1981-07-07)	1-10

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
3 March 2020	11/03/2020

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

Information on patent family members

International application No
PCT/FI2019/050504

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