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674345

Patents Act 1990

Australian Patent Application No. 49830/93

NOTICE OF ENTITLEMENT

I, Tetsuya KATADA,

of Kabushiki Kaisha Komatsu Seisakusho, 3-6, Akasaka 2-chome, Minato-ku, Tokyo 107 Japan

being authorised by the Applicant(s)/Nominated Person(s) in respect of an application entitled:

Vehicle Slip Detection Device

state the following:-

1. The Applicant(s)/Nominated Person(s) has/have, for the following reasons, gained entitlement from the actual inventor(s):-

The Applicant is the assignee of the actual inventor.

2a.* The Applicant(s)/Nominated Person(s) is/are the applicant(s) of the of the basic applicati[illegible] listed* ~~on the Patent Request/~~ *in the Declaration under Article 8 of the PCT.

2b * ~~The Applicant(s)/Nominated Person(s) is/are entitled to rely on the basic application(s) listed* on the Patent Request/ *in the Declaration under Article 8 of the PCT as follows:~~

3.* The basic application(s) listed *~~on the Patent Request/~~ *in the Declaration under Article 8 of the PCT is/are the application(s) first made in a Convention Country in respect of the invention.

~~4a.* The Applicant(s)/Nominated Person(s) is/are the depositor(s) of the deposit(s) listed in the Schedule hereto.~~

~~4b.* The Applicant(s)/Nominated Person(s) has/have the consent of _____, of~~

~~the depositor(s) of the deposit(s) listed in the Schedule hereto, to rely on that/those deposit(s).~~

DATED this thirteenth day of February 1995

Tetsuya Katada

(Signature)

Tetsuya KATADA, President

(Name & Title)

* Delete if not applicable.

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APPARATUS FOR DETECTING SLIP OF VEHICLE

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(56) Prior Art Documents
JP 60-161256
JP 61-247832
WO 93/11959

(57) Claim

1. A vehicle slip detection device comprising:

a vehicle speed sensor provided in a vehicle, for detecting a speed of the vehicle;

a steering angle sensor provided in the vehicle, for detecting a steering angle of the vehicle;

a heading angle sensor provided in the vehicle, for detecting a heading angle of the vehicle;

theoretical turning angular velocity computing means for computing a theoretical turning angular velocity of the vehicle based on a vehicle geometry factor and outputs of the vehicle speed sensor and the steering angle sensor;

correcting means for correcting the theoretical turning angular velocity based on the theoretical turning angular velocity computed by the theoretical turning angular velocity computing means and on a lag time from operation of steering of the vehicle to a start of turning of the vehicle resulting from the operation;

current turning angular velocity computing means for computing a current turning angular velocity of the vehicle based on an output of the heading angle sensor; and

detection means for detecting a slip of the vehicle based on a difference between the computed current turning angular velocity and the corrected theoretical turning angular velocity.

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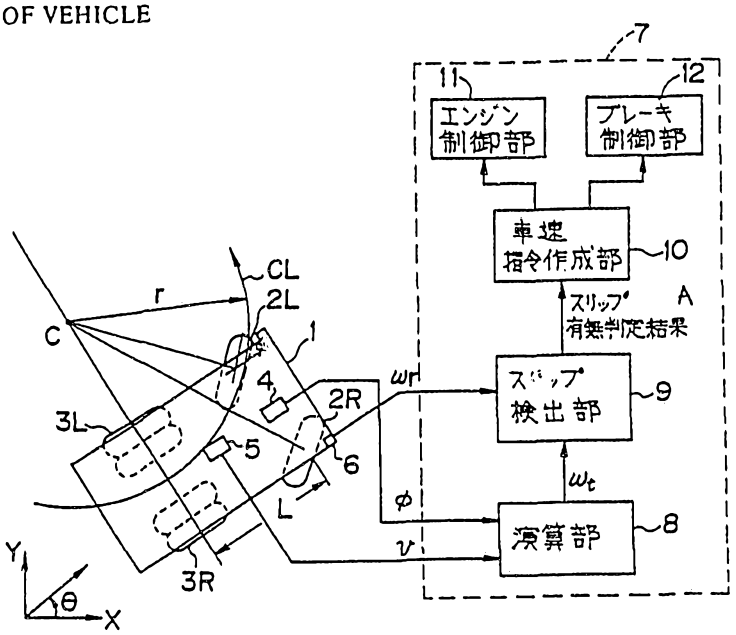
674345

(54) Title : APPARATUS FOR DETECTING SLIP OF VEHICLE

(54) 発明の名称 車両のスリップ検出装置

8 ... computing element
9 ... slip detecting element
10 ... vehicle speed command generation element
11 ... engine controller
12 ... brake controller
A ... result of judgement as to whether vehicle is slipping or not.



(57) Abstract

An apparatus for automatically detecting a slip of a vehicle. A theoretical turning speed ωt of a vehicle (1) the wheels or roller belts of which do not slip at all on the road surface on which the vehicle travels is computed on the basis of the outputs v, Φ from a vehicle speed sensor (5) and a steering angle sensor (4). An actual turning angular speed ωr of the vehicle (1) is computed on the basis of the output of a posture angle sensor (6). Slip of the vehicle is detected on the basis of the difference between these two turning angular speeds ωt, ωr. This prevents deviation from the course of a vehicle, and the safety is significantly improved.

(57) 要約

車両のスリップを自動的に検出する装置である。車速センサ５と操舵角センサ４の各出力ｖ、φに基づき車両１の車輪または履帯が走行路面に対して全く滑っていないときの理論的な旋回速度ωｔが検出される。そして、姿勢角センサ６の出力に基づき車両１の現在の旋回角速度ωｒが演算される。そして、これら両旋回角速度ωｔ、ωｒの偏差に基づき車両１がスリップしていることが検出される。この結果、コースアウト等を未然に防止することができ、車両の安全性が飛躍的に向上する。

情報としての用途のみ
PCTに基づいて公開される国際出願のパンフレット第1頁にPCT加盟国を同定するために使用されるコード

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AU オーストラリア
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BE ベルギー
BF ブルキナ・ファソ
BG ブルガリア
BJ ベナン
BR ブラジル
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CA カナダ
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CM カメルーン
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TG トーゴ
UA ウクライナ
US 米国
UZ ウズベキスタン共和国
VN ヴェトナム

DESCRIPTION

VEHICLE SLIP DETECTION DEVICE

TECHNICAL FIELD

The present invention relates to a device for detecting a lateral slip of the front or rear wheels (hereafter referred to simply as slip) of a vehicle.

BACKGROUND ART

With dump trucks or other such vehicles, if an operator is on board and at the controls, it is possible to ensure that the vehicle does not deviate from its desired course through proper manipulation of the steering wheel, accelerator and brakes, for the operator feeling the slip of the vehicle when travelling through a curve.

However, there have been attempts in recent years at the unmanned operation of dump trucks, in which case [the vehicle] has gone off-course when it has slipped during travelling and no suitable countermeasure has been taken. Therefore, the realization of an unmanned system will require slip to be detected automatically and suitable countermeasures to be taken based on the detection results.

The present invention was devised in light of this situation, and its object is the automatic detection of vehicle slip.

DISCLOSURE OF THE INVENTION

In this invention, ~~a vehicle is provided with a~~

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there is provided a vehicle slip detection device comprising:

a vehicle speed sensor provided in a vehicle, for detecting a speed of the vehicle;

a steering angle sensor provided in the vehicle, for detecting a steering angle of the vehicle;

a heading angle sensor provided in the vehicle, for detecting a heading angle of the vehicle;

theoretical turning angular velocity computing means for computing a theoretical turning angular velocity of the vehicle based on a vehicle geometry factor and outputs of the vehicle speed sensor and the steering angle sensor;

correcting means for correcting the theoretical turning angular velocity based on the theoretical turning angular velocity computed by the theoretical turning angular velocity computing means and on a lag time from operation of steering of the vehicle to a start of turning of the vehicle resulting from the operation;

current turning angular velocity computing means for computing a current turning angular velocity of the vehicle based on an output of the heading angle sensor; and

detection means for detecting a slip of the vehicle based on a difference between the computed current turning angular velocity and the corrected theoretical turning angular velocity.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred form of the present invention will now be described by way of example with reference to the accompanying drawings, wherein:

Figure 1 is a block diagram which depicts the structure of an embodiment of a vehicle slip detection device which pertains to the present invention, and Figure 2 is a flow chart which illustrates the order of the steps implemented by the control device shown in Figure 1.

BEST MODE FOR CARRYING OUT THE INVENTION

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An embodiment of a vehicle slip detection device which pertains to the present invention is described below with reference to the figures.

Figure 1 is a block diagram depicting the structure of the device of the embodiment; a vehicle 1 is, for example, a dump truck, and has front wheels 2L (left) and 2R (right) and rear wheels 3L (left) and 3R (right). The steering angle ϕ of the front wheels 2L and 2R is changed by steering input. The vehicle 1 therefore travels over the locus CL having a turning center C and a turning radius r in accordance with the steering angle ϕ. The vehicle 1 is an unmanned vehicle, and is steered automatically. The vehicle 1 is furnished with a steering angle sensor 4, a vehicle speed sensor 5, and a gyro 6.

The steering angle sensor 4 is provided at the lower side of the vehicle body in the vicinity of the front wheels 2L and 2R, and detects the steering angle ϕ of the vehicle 1. The vehicle speed sensor 5 detects the vehicle speed v by detecting the speed of rotation of the output shaft of the engine. The gyro 6 is a so-called rate gyro which detects the current turning angular velocity ωr of the vehicle 1 by ascertaining the change over time of the heading angle θ of the vehicle with respect to the X axis direction of the road surface on which the vehicle travels. This turning angular velocity ωr moreover includes a component in which the angular velocity is changed by the slip of the vehicle 1. The output ϕ of the steering angle

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sensor 4 and the output v of the vehicle speed sensor 5 are

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supplied to a computing unit 8 of a control device 7 mounted in the vehicle 1, and the output ωr of the gyro 6 is supplied to a slip detector 9 of the same control device 7.

In the computing unit 8, the theoretical turning angular velocity ωt is computed based on formula (1) below based on the supplied sensor outputs ϕ and v assuming that the vehicle 1 is not slipping.

$$\omega t = v \cdot \tan\phi / L \quad \ldots (1)$$

where L is the wheel base of the vehicle 1.

This computed result ωt is then supplied to the slip detector 9. The slip detector 9 computes the error evaluation amount e shown in formula (2) below based on the ωt supplied from the computing unit 8 and the current turning angular velocity ωr supplied from the gyro 6.

$$e = \int SQ(\omega r - \omega t')dt \quad \ldots (2)$$

where SQ(ωr - ωt') indicates the square of (ωr - ωt').

Here, the integral time is a predetermined time. Further, ωt' is the value obtained by correcting ωt by adding a time lag component, since there is a time lag from the steering change until the vehicle 1 actually changes direction. The corrected value ωt' is determined using a differential equation such as that given below, with s being the time lag time constant.

$$\tau \cdot d\omega t'/dt + \omega t' = \omega t \quad \ldots (3)$$

The reason that the integral of the square of the

turning angular velocity difference ωr - ωt' is taken as the evaluation amount e in formula (2) is that there may be a case where an accurate evaluation is not possible when the difference ωr - ωt' is used directly, because of the influence of noise or the like. The larger the evaluation amount e, the larger the current slip of the vehicle 1.

Whether the vehicle 1 is currently slipping or not is determined based on a determination of whether or not this evaluation amount e is at or above the threshold value e0.

As a result, when it has been determined that the vehicle 1 is slipping, a signal indicating this result is sent to the vehicle velocity command generator 10.

When the determination result has been given, the vehicle velocity command generator 10 issues, based on this, a deceleration command for decelerating the vehicle 1 to a specified velocity, and this is output to the engine controller 11 and the braking controller 12. Here, the specified speed is a predetermined speed at which the vehicle 1 does not readily go off-course even when it travels at this speed. The engine controller 11 controls the amount of fuel injected so that the target speed of the engine becomes the set speed when the deceleration command has not been given, and the brake controller 12 activates the brake in response to brake application when the deceleration command has not been given. When the deceleration command has been given, however, the engine controller 11 controls the amount of fuel injection so that

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the vehicle 1 is decelerated to the specified speed, and the brake controller 12 activates the brakes independently of the brake application so that the vehicle speed is reduced to the specified speed.

The brake control effected by the brake controller 12 is carried out only when the difference between the current speed of the vehicle 1 and the specified speed is at or above a specified value, and the duration of deceleration is thus shortened. Figure 2 is a flow chart illustrating the order in which the steps are carried out by the control device 7. Specifically, during the travelling of the vehicle 1, the vehicle speed v is input from the vehicle speed sensor 5, and the steering angle ϕ is input from the steering angle sensor 4 (step 101). Next, the theoretical turning angular velocity ωt on the assumption that the wheels of the vehicle 1 are not slipping is computed based on the input vehicle speed v and steering angle ϕ using formula (1) above (step 102).

Next, the current turning angular velocity ωr is input from the gyro 6 (step 103). Next, the error evaluation amount e is computed from formula (2) above based on the turning angular velocities ωt and ωr obtained in steps 102 and 103, respectively (step 104). A determination is then made as to whether this evaluation amount e that has been computed in step 104 exceeds the threshold value e0 (step 105). When the evaluation amount e does not exceed the threshold value e0, not enough slip

is generated to constitute a problem, and there is consequently no danger of course deviation at this vehicle speed, and the process shifts to step 101 again without decelerating the vehicle 1.

On the other hand, when the evaluation amount e exceeds the threshold value e0, it is determined that slip is generated and that there is a danger of course deviation at this speed; the next step 106 is then proceeded to for reducing vehicle speed for the sake of safety.

A determination result of "slip" is consequently output to the vehicle speed command generator 10, and a command for reducing the speed of the vehicle 1 is output to the engine controller 11 and the brake controller 12. As a result, the speed of the vehicle 1 is reduced to the specified speed, and the turn is safely accomplished without course deviation (step 106).

Although the speed of the vehicle 1 is reduced to a specified speed in the embodiment, it is also possible to vary the rate of deceleration depending on the error evaluation amount.

In the embodiment, moreover, although deceleration is effected when vehicle slip has been detected, the present invention is not limited to this, and if slip has been detected the vehicle may also be stopped for the sake of safety. In short, as long as a specific countermeasure against abnormal slippage is taken based on a detection result of "slip," the particulars of the process are optional.

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In the embodiment, although the current turning angular velocity ωr of the vehicle 1 is directly detected by the rate gyro, it may also be determined through the differentiation of the gyro compass output. It is also possible to determine the turning angular velocity based on the output of a magnetic sensor. In short, any means may be applied as long as the actual turning angular velocity can be computed based on the output of a specified heading angle sensor.

Although the evaluation amount e is computed in the embodiment based on formula (2) above, so long as the presence or absence of slip can be accurately determined based on the difference between the turning angular velocities, the particulars of the computation are optional.

Although it is assumed in the embodiment that a dump truck having wheels serves as the vehicle, the present invention is not limited to this, and can also apply to crawler vehicles; any type of vehicle is acceptable. The present invention is not limited to front wheel-steering vehicles, and can also of course apply to rear wheel-steering vehicles.

Although an unmanned vehicle is considered in the embodiment, the present invention can apply to manned vehicles operated by a driver.

INDUSTRIAL APPLICABILITY

As described above, since the present invention

allows the slip of a vehicle during travelling to be automatically detected, it is possible to take suitable steps based on this detection result to prevent problems such as course deviation. It is consequently possible to significantly improve the vehicle safety.

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1. A vehicle slip detection device comprising:

a vehicle speed sensor provided in a vehicle, for detecting a speed of the vehicle;

a steering angle sensor provided in the vehicle, for detecting a steering angle of the vehicle;

a heading angle sensor provided in the vehicle, for detecting a heading angle of the vehicle;

theoretical turning angular velocity computing means for computing a theoretical turning angular velocity of the vehicle based on a vehicle geometry factor and outputs of the vehicle speed sensor and the steering angle sensor;

correcting means for correcting the theoretical turning angular velocity based on the theoretical turning angular velocity computed by the theoretical turning angular velocity computing means and on a lag time from operation of steering of the vehicle to a start of turning of the vehicle resulting from the operation;

current turning angular velocity computing means for computing a current turning angular velocity of the vehicle based on an output of the heading angle sensor; and

detection means for detecting a slip of the vehicle based on a difference between the computed current turning angular velocity and the corrected theoretical turning angular velocity.

2. A vehicle slip detection device as defined in Claim 1, further comprising control means for controlling the vehicle speed so as to effect deceleration of the vehicle when slippage of the vehicle has been detected.

3. A vehicle slip detection device as defined in Claim 1, wherein the theoretical turning angular velocity computing means computes the theoretical turning angular velocity based on a wheel base of the vehicle, the steering angle output from the steering angle sensor, and the vehicle speed output from the vehicle speed sensor.

4. A vehicle slip detection device as defined in Claim 1, wherein the detection means computes a mean square error of the difference between the corrected theoretical turning angular velocity and the computed current turning angular velocity, and determines that the vehicle is slipping when the computed mean square error value is at or above a specified value.

5. A vehicle slip detection device substantially as hereinbefore described with reference to the accompanying drawings.

Dated 10 October, 1996
Kabushiki Kaisha Komatsu Seisakusho
Patent Attorneys for the Applicant/Nominated Person
SPRUSON & FERGUSON

[N:\LIBLL]00603:JCC

ABSTRACT

A device for automatically detecting vehicle slip. A theoretical turning velocity ωt is detected when wheels or crawlers of a vehicle 1 do not slip at all with respect to the road surface on which the vehicle travels based on outputs v and ϕ of a vehicle speed sensor 5 and a steering angle sensor 4. A current turning angular velocity ωr of the vehicle 1 is then computed based on the output of a heading angle sensor 6. The slip of the vehicle 1 is then detected based on a difference between these two turning angular velocities ωt and ωr. It is therefore possible to prevent course deviation and the like, and thus possible to dramatically improve vehicle safety.

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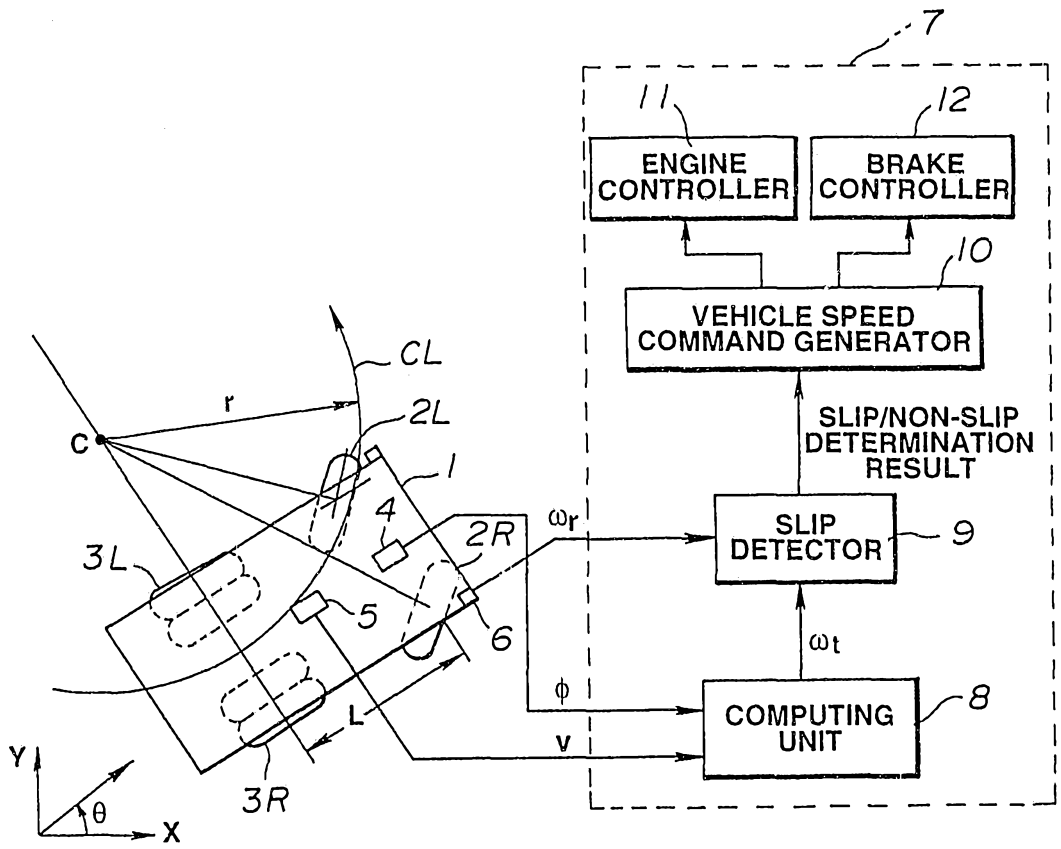
7
11
12
ENGINE CONTROLLER
BRAKE CONTROLLER
10
VEHICLE SPEED COMMAND GENERATOR
SLIP/NON-SLIP DETERMINATION RESULT
SLIP DETECTOR
9
COMPUTING UNIT
8
CL
r
C
2L
1
4
2R
3L
5
6
3R
L
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ωr
ωt
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v

FIG.1

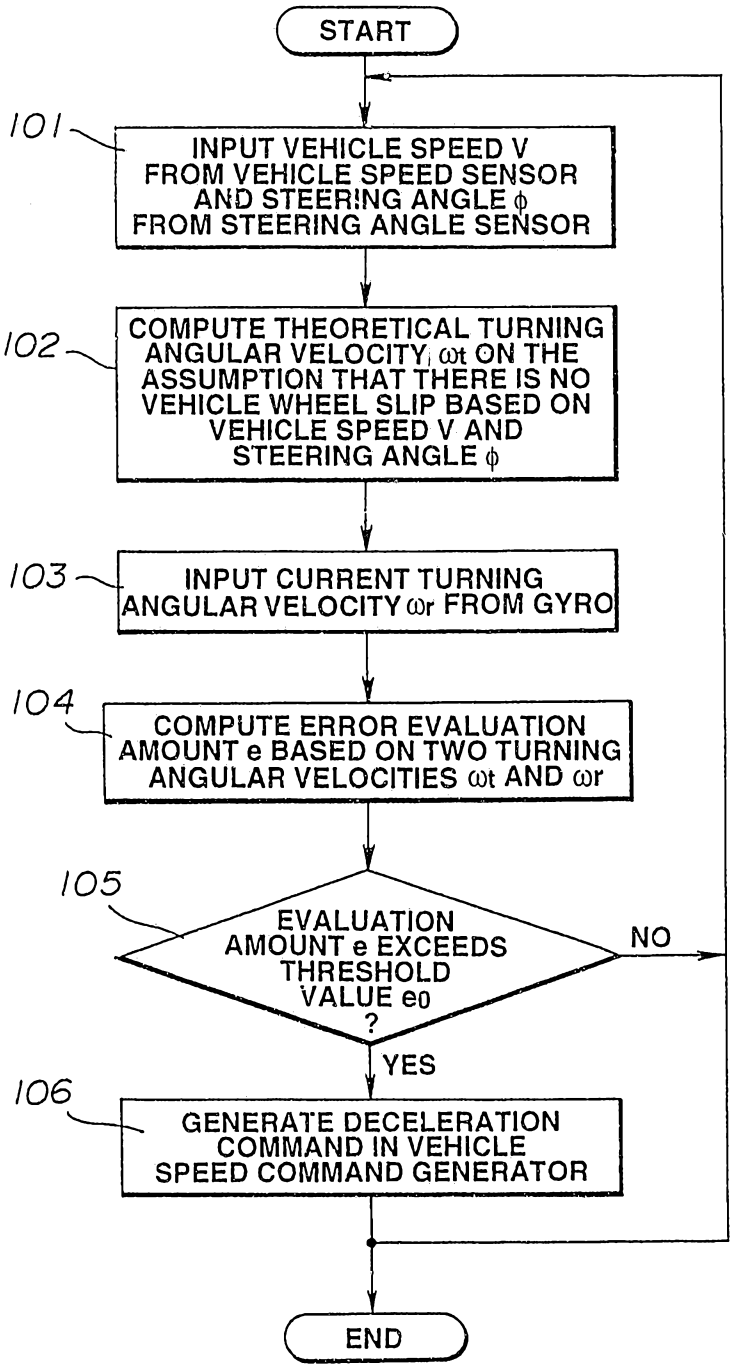
START
101
INPUT VEHICLE SPEED V FROM VEHICLE SPEED SENSOR AND STEERING ANGLE ϕ FROM STEERING ANGLE SENSOR
102
COMPUTE THEORETICAL TURNING ANGULAR VELOCITY ωt ON THE ASSUMPTION THAT THERE IS NO VEHICLE WHEEL SLIP BASED ON VEHICLE SPEED V AND STEERING ANGLE ϕ
103
INPUT CURRENT TURNING ANGULAR VELOCITY ωr FROM GYRO
104
COMPUTE ERROR EVALUATION AMOUNT e BASED ON TWO TURNING ANGULAR VELOCITIES ωt AND ωr
105
EVALUATION AMOUNT e EXCEEDS THRESHOLD VALUE e0 ?
NO
YES
106
GENERATE DECELERATION COMMAND IN VEHICLE SPEED COMMAND GENERATOR
END

FIG.2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP93/01267

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl^5 B60K28/16

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)
Int. Cl^5 B60K28/16, B62D7/14, B62D6/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1926 - 1992
Kokai Jitsuyo Shinan Koho 1971 - 1992

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP, A, 60-161256 (Nissan Motor Co., Ltd.), August 22, 1985 (22. 08. 85), (Family: none)	1
Y	JP, A, 61-247832 (Mazda Motor Corp.), November 5, 1986 (05. 11. 86), (Family: none)	1

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
November 29, 1993 (29. 11. 93)	December 21, 1993 (21. 12. 93)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)