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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
6 October 2011 (06.10.2011)

PCT

(10) International Publication Number
WO 2011/121409 A1

(51) International Patent Classification:
B60W 50/08 (2006.01)

(21) International Application Number:
PCT/IB2011/000595

(22) International Filing Date:
21 March 2011 (21.03.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2010-085280 1 April 2010 (01.04.2010) JP

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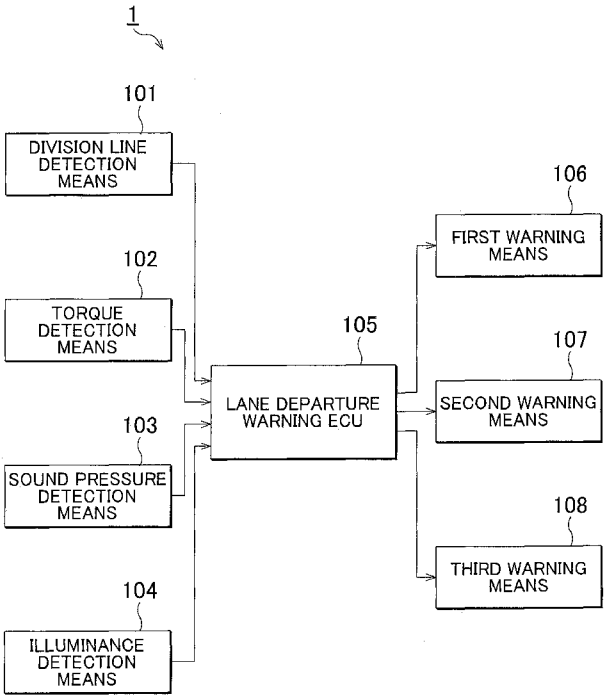
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, 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, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, 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, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: WARNING APPARATUS

FIG. 1



(57) Abstract: A warning apparatus (1) that notifies the driver of a host vehicle that a risk has been detected includes environment recognition means (103, 104), prediction means (105), at least two units of warning means (106, 107, 108), warning selection means (105) and command means (105). The environment recognition means recognizes an environment in which the driver is in. The prediction means predicts the risk. The at least two units of warning means (106, 107, 108) notify prediction of the risk by stimuli that are different in kind from each other (haptic, sound, light). The warning selection means (105) selects from the foregoing warning means the warning means for notifying the driver of the prediction of the risk according to the driver's environment. The command means gives the warning means selected by the warning selection means a command to notify the driver that the risk has been detected by the prediction means.

WO 2011/121409 A1

Published:

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

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

WARNING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The invention relates to a warning apparatus and, more particularly, to a warning apparatus that is mounted in a mobile unit such as a motor vehicle or the like.

2. Description of the Related Art

[0002] In recent years, mobile units, such as motor vehicles and the like, are equipped with warning apparatuses that predict and notify, for example, a risk of colliding with an object such as an on-road stationary object, an oncoming vehicle, a preceding vehicle, etc. An example of such warning apparatuses is an inter-vehicle distance warning apparatus described in Japanese Patent Application Publication No. 2000-36098 (JP-A-2000-36098) (hereinafter, referred to as "related-art technology").

[0003] This related-art technology determines the possibility of collision with an object, and notifies a predicted risk to a driver with a warning light and/or a warning sound commensurate with the level of the determined possibility.

SUMMARY OF THE INVENTION

[0004] The foregoing related-art technology has problems as follows. That is, a vehicle operated by a driver travels in an environment that changes in, for example, the ambient illumination intensity or illuminance, the environmental sound, etc. For example, when the vehicle operated by the driver is in an environment in which there is excessively great environmental sound, it sometimes happens that if the foregoing related-art technology predicts a risk and notifies the risk to the driver with a warning sound, the warning sound is not perceived by the driver. Besides, for example, when the vehicle operated by the driver is in an environment that is illuminated at excessively high illuminance by a strong light source, it also sometimes happens that if the related-art technology predicts a risk and notifies the risk to the driver with a warning light, the warning light is not recognized by the driver.

[0005] That is, since the foregoing related-art technology does not take into account the environment around the vehicle that is operated by a driver, the technology is not able to certainly notify the driver of a predicted risk.

[0006] The invention provides a warning apparatus that is capable of certainly notifying a predicted risk to a driver of a vehicle by taking the environment around the vehicle into account.

[0007] The invention relates to a warning apparatus that notifies a driver of a host vehicle that a risk has been detected. This warning apparatus includes environment recognition means, prediction means, at least two units of warning means, warning selection means, and command means. The environment recognition means is provided for recognizing an environment in which the driver is. The prediction means is provided for predicting the risk. The at least two units of warning means is provided for notifying prediction of the risk by using stimuli that are respectively different in kind from each other. The warning selection means is provided for selecting from the foregoing warning means the warning means for notifying the driver of the prediction of the risk according to the environment. The command means is provided for giving the warning means selected by the warning selection means a command to notify the driver that the risk has been detected by the prediction means.

[0008] In the warning apparatus in the foregoing aspect of the invention, the warning means selected by the warning selection means may notify the prediction of the risk by using a stimulus that is different from stimuli that are being given to the driver from the environment.

[0009] Besides, in the warning apparatus in this aspect, the command means may continue giving the command to the warning means selected by the warning selection means until the risk that has been predicted disappears.

[0010] Besides, in the warning apparatus in this aspect, if the warning means different from the warning means that has already been selected by the warning selection means is selected by the warning selection means according to the environment during a time from selection of the warning means that has already been selected till

disappearance of the risk that has been predicted, the command means may give the command to the warning means that has already been selected and to the different warning means that has just been selected.

[0011] The invention can provide a warning apparatus that is capable of certainly notifying the predicted risk to the driver by taking into account the environment around the vehicle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The features, advantages, and technical and industrial significance of this invention will be described below with reference to the accompanying drawings, in which like numerals denote like elements, and wherein:

FIG. 1 is a diagram showing a general construction of a warning apparatus in accordance with an embodiment of the invention;

FIG. 2 is a flowchart showing processes performed by a lane departure warning ECU in accordance with the embodiment of the invention;

FIG. 3 is a flowchart showing processes performed by the lane departure warning ECU in accordance with the embodiment of the invention;

FIG. 4 is a flowchart showing processes performed by the lane departure warning ECU in accordance with a first modification of the embodiment of the invention; and

FIG. 5 is a flowchart showing processes performed by the lane departure warning ECU in accordance with a second modification of the embodiment of the invention.

DETAILED DESCRIPTION OF EMBODIMENTS

[0013] FIG. 1 is a block diagram showing a general construction of a warning apparatus 1 in accordance with an embodiment of the invention. The warning apparatus 1 in accordance with the embodiment includes division line detection means 101, torque detection means 102, sound pressure detection means 103, illuminance detection means 104, a lane departure warning ECU (Electronic Control Unit) 105, first warning means 106, second warning means 107, and third warning means 108. Incidentally, in the

description of this embodiment, it is assumed that the warning apparatus 1 is mounted in a host vehicle.

[0014] The division line detection means 101 is typically constructed mainly of a camera that takes images by using a CCD (Charge Coupled Device) element, a CMOS (Complementary Metal Oxide Semiconductor) element, etc., and a processing circuit that processes the images taken by the camera. The division line detection means 101 takes images that include the division lines of the current traveling lane in which the host vehicle is traveling, by using the foregoing camera, and then successively detects the right and left-side division lines of the traveling lane of the host vehicle, by performing a well-known process on the images in the foregoing processing circuit. Furthermore, the division line detection means 101 at least successively detects the lane width of the traveling lane of the host vehicle, and the offset of the host vehicle relative to its current traveling lane. The term offset herein means the distance from the center of the width of the traveling lane of the host vehicle to the center of the host vehicle in the width direction. The division line detection means 101 successively generates traveling lane information that shows at least the lane width and the offset detected by the division line detection means 101.

[0015] The torque detection means 102 is typically a torque sensor that successively detects the twist of a steering shaft of the host vehicle by a potentiometer, and that successively converts the detected twist into a torque that occurs on the steering shaft. The torque detection means 102 successively generates torque information that shows the converted torque.

[0016] The sound pressure detection means 103 successively detects the sound pressure in a cabin of the host vehicle, and successively generates sound pressure information that shows the detected sound pressure. The sound pressure detection means 103 used herein may be a sensor that detects the sound pressure by substantially the same principle as a well-known sound pressure meter.

[0017] The illuminance detection means 104 is typically constructed mainly of a photodiode, and successively detects the illuminance (illumination intensity) around the

host vehicle, and successively generates illuminance information that shows the detected illuminance.

[0018] The lane departure warning ECU 105 acquires the torque information, the sound pressure information and the illuminance information, and selects an arbitrary one of the first warning means 106, the second warning means 107 and the third warning means 108 that are described below, on the basis of the acquired information.

[0019] Besides, the lane departure warning ECU 105 acquires the traveling lane information, and predicts the risk of the host vehicle departing from the current traveling lane, on the basis of the acquired traveling lane information. For example, when the offset of the host vehicle shown by the acquired traveling lane information exceeds a predetermined proportion of the width of the lane shown by the traveling lane information, the lane departure warning ECU 105 detects that the host vehicle is about to depart from the current traveling lane.

[0020] Then, upon predicting the risk of the host vehicle departing from the current traveling lane, the lane departure warning ECU 105 commands that the selected warning means notify the prediction of the risk. Details of the process of the lane departure warning ECU 105 in accordance with this embodiment will be described below.

[0021] The first warning means 106, upon receiving from the lane departure warning ECU 105 the command to notify that the risk has been predicted, notifies the prediction of the risk to the driver by giving the driver a stimulus of vibration that is caused by vibrating the steering wheel of the host vehicle.

[0022] The second warning means 107, upon receiving from the lane departure warning ECU 105 the command to notify that the risk has been predicted, notifies the prediction of the risk to the driver by giving the driver a stimulus of sound that is caused by producing a warning sound from a speaker that is provided in the cabin of the host vehicle.

[0023] The third warning means 108, upon receiving from the lane departure warning ECU 105 the command to notify that the risk has been predicted, notifies the prediction of the risk to the driver by giving the driver a stimulus of light that is caused

by producing a display picture that is able to notify the prediction of the risk to the driver in a display screen that is provided at such a location in the cabin of the host vehicle that the displayed picture is visually recognizable by the driver sitting in the driver's seat, or by turning on a warning light that is provided at such a location in the cabin of the host vehicle that the warning light is visually recognizable by the driver sitting in the driver's seat.

[0024] The general construction of the warning apparatus 1 in accordance with this embodiment has been described above. Next, the lane departure warning ECU 105 in accordance with this embodiment will be described in detail.

[0025] After acquiring the torque information generated by the torque detection means 102, the lane departure warning ECU 105 in accordance with this embodiment recognizes the magnitude of the vibration of the host vehicle on the basis of the torque shown by the acquired torque information. Concretely, the lane departure warning ECU 105 calculates the magnitude of a change in torque (hereinafter, termed the amount of change in torque tr) by differentiating the torque shown by the acquired torque information. The lane departure warning ECU 105, after calculating the amount of change in torque tr, compares the calculated amount of change in torque tr with a predetermined threshold amount of change in torque th1. Then, when the lane departure warning ECU 105 has determined that the calculated amount of change in torque tr is greater than or equal to the threshold amount of change in torque th1, the lane departure warning ECU 105 recognizes that the driver of the host vehicle is in an environment in which the driver is being given vibration of the host vehicle as a stimulus.

[0026] Next explained will a reason why the lane departure warning ECU 105 can determine that vibration of the vehicle is being given to the driver as a stimulus when the amount of change in torque tr is greater than or equal to the threshold amount of change in torque th1. For example, when the host vehicle is traveling on a road with great irregularity, and is therefore vibrating, the front wheels also vibrate according to the irregularity, and therefore the vibration of the front wheels propagates to the steering shaft. If the vibration of the front wheels propagates to the steering shaft, this vibration

fluctuates the torque that occurs on the steering shaft, and the torque fluctuation is detected by the aforementioned potentiometer. In this embodiment, the torque that occurs according to the vibration of the front wheels is detected by the torque detection means 102. Therefore, when the magnitude of the change in torque that occurs as described above, that is, the amount of change in torque tr, is greater than or equal to the threshold amount of change in torque th1, it can be considered that a relatively large vibration is occurring on the host vehicle. Therefore, when the amount of change in torque tr is greater than or equal to the threshold amount of change in torque th1, the lane departure warning ECU 105 is able to recognize that the driver of the host vehicle is in an environment in which the driver is being given vibration of the host vehicle as a stimulus.

[0027] Besides, the lane departure warning ECU 105 according to the embodiment, after acquiring the sound pressure information generated by the sound pressure detection means 103, recognizes the magnitude of the sound pressure in the cabin of the host vehicle on the basis of the sound pressure shown by the acquired sound pressure information. Concretely, after acquiring the sound pressure information, the lane departure warning ECU 105 compares the sound pressure shown by the acquired sound pressure information (hereinafter, termed the sound pressure sp) with a predetermined threshold sound pressure value th2. When the lane departure warning ECU 105 has determined that the sound pressure sp is greater than or equal to the threshold sound pressure value th2, the lane departure warning ECU 105 recognizes that the driver of the host vehicle is in an environment in which the driver is being given a stimulus of sound.

[0028] The lane departure warning ECU 105 in accordance with this embodiment, after acquiring illuminance information generated by the illuminance detection means 104, recognizes the illuminance (illumination intensity) on the driver of the host vehicle on the basis of the illuminance shown by the acquired illuminance information. Concretely, after acquiring the illuminance information, the lane departure warning ECU 105 compares the illuminance shown by the acquired illuminance information (hereinafter, termed the illuminance il) with a predetermined threshold

illuminance value th3. When the lane departure warning ECU 105 has determined that the illuminance il is greater than or equal to the threshold illuminance value th3, the lane departure warning ECU 105 recognizes that the driver of the host vehicle is in an environment in which the driver is being given a stimulus of light.

[0029] Incidentally, while the drier is driving the host vehicle, the host vehicle is vibrating even when the host vehicle is traveling on a flat road. Besides, while the driver is driving the host vehicle, sounds, such as road noise, engine sound, etc. propagate into the cabin even when the driver is not in an environment in which a particular noise is occurring, or when the car audio or the like is not being used. Furthermore, while the driver is driving the host vehicle, the driver is illuminated with light such as sun light, street lamps, etc. That is, the driver of the host vehicle is in an environment in which the driver is always given stimuli of vibration, sound, light, etc. that naturally occur. However, if the environment in which the driver is given such naturally occurring stimuli of vibration, sound, light, etc. is recognized by the lane departure warning ECU 105 as an environment in which the driver is in, the lane departure warning ECU 105 will recognize that the driver is being given all kinds of stimuli, and will be unable to select from the first to third warning means 106 to 108 the warning means that is able to notify the driver of the prediction of the risk by a stimulus that is different from the stimuli that are being given to the driver.

[0030] Hence, the threshold amount of change in torque th1, the threshold sound pressure value th2 and the threshold illuminance value th3 that are described above need to be determined beforehand as threshold values whose magnitudes are such as to be able to divide naturally-occurring levels of stimuli of vibration, sound, light, etc. and levels of stimuli thereof that make the stimuli for notifying the prediction of a risk hard for drivers to recognize. The threshold amount of change in torque th1, the threshold sound pressure value th2 and the threshold illuminance value th3 may be determined beforehand, for example, on the basis of results of experiments.

[0031] The lane departure warning ECU 105 in accordance with this embodiment, as described above, compares the amount of change in torque tr, the sound

pressure sp and the illuminance il with the threshold amount of change in torque th1, the threshold sound pressure value th2 and the threshold illuminance value th3, respectively, to recognize the environment in which the driver is in, and determines the stimuli that are being given to the driver from the recognized environment. Upon detecting a risk as described above, the lane departure warning ECU 105 selects from the first to third warning means 106 to 108 the warning means that is able to notify the prediction of the risk to the driver by a stimulus that is different from the stimuli that are being given to the driver.

[0032] Concretely, for example, when the lane departure warning ECU 105 has determined that the driver is being given a stimulus of vibration, the lane departure warning ECU 105 selects from the first to third warning means 106 to 108 at least one of the warning means other than the first warning means 106 for notifying the prediction of the risk by stimulus of vibration. Besides, when the lane departure warning ECU 105 has determined that the driver is being given a stimulus of sound, the lane departure warning ECU 105 selects from the first to third warning means 106 to 108 at least one of the warning means other than the second warning means 107 for notifying the prediction of the risk by the stimulus of sound. When the lane departure warning ECU 105 has determined that the driver is being given stimuli of sound and of light, the lane departure warning ECU 105 selects the first warning means 106 for notifying the driver of the prediction of the risk by giving a stimulus of vibration.

[0033] Thus, by notifying the prediction of the risk to the driver by a stimulus that is different from the stimuli that are being given to the driver, the lane departure warning ECU 105 is able to avoid an incident in which the stimulus for notifying the prediction of the risk is indistinct among the stimuli that are being given to the driver, and therefore cannot be recognized by the driver.

[0034] The lane departure warning ECU 105 in accordance with the embodiment has been described in detail above. Next, a flow of a process performed by the lane departure warning ECU 105 in accordance with the embodiment will be described with reference to a flowchart shown in FIG. 2. Incidentally, it is assumed that

the process shown in the flowchart in FIG. 2 is started, for example, when the ignition switch of the host vehicle or the accessory switch is turned on, and the process is ended when the ignition switch of the host vehicle or the accessory switch is turned off.

[0035] Upon starting the process, the lane departure warning ECU 105 acquires the torque information from the torque detection means 102, and differentiates the torque shown by the acquired torque information to calculate an amount of change in torque tr, and stores the calculated amount of change in torque tr into a storage portion (not shown) (step S101). Next, the lane departure warning ECU 105 acquires the sound pressure information from the sound pressure detection means 103, and stores the sound pressure sp shown by the acquired sound pressure information into a storage (not shown) (step S102). Then, the lane departure warning ECU 105 acquires the illuminance information from the illuminance detection means 104, and stores the illuminance shown by the acquired illuminance information into a storage portion (not shown) (step S103). After storing the amount of change in torque tr, the sound pressure sp and the illuminance il into their respective storage portions, the lane departure warning ECU 105 performs a warning selection process (step S104) of determining the stimuli that are being given from the environment in which the driver is in, on the basis of the stored information, and of selecting from the first to third warning means 106 to 108 the warning means for notifying the prediction of the risk to the driver by a stimulus that is different from the determined stimuli. Details of the warning selection process of the lane departure warning ECU 105 will be described later. After selecting the warning means in the warning selection process, the lane departure warning ECU 105 stores information that shows the selected warning means as selected warning information into a storage portion (not shown) (step S105).

[0036] Next, the lane departure warning ECU 105 acquires the traveling lane information from the division line detection means 101, and predicts whether there is a risk of the host vehicle departing from the current traveling lane, on the basis of the lane width and the offset shown by the acquired traveling lane information (step S106). When the lane departure warning ECU 105 has predicted the risk of the host vehicle

departing from the traveling lane (YES in step S106), the lane departure warning ECU 105 commands the warning means shown by the selected warning information stored in the storage portion (not shown) to notify the prediction of the risk (step S107), and returns to step S101. On the other hand, if the lane departure warning ECU 105 does not predict the risk of the host vehicle departing from the traveling lane (NO in step S106), the lane departure warning ECU 105 does not give the command to notify the prediction of the risk, but deletes all the information stored in the storage portions (not shown) (step S108), and returns to step S101. If the lane departure warning ECU 105 performs a process of step S108 after giving the command to notify the prediction of the risk, the lane departure warning ECU 105 first gives a command to stop the warning to the warning means shown by the selected warning information stored in the storage portion (not shown), and then deletes all the information stored in the storage portions, and returns to step S101.

[0037] Next, with reference to a flowchart shown in FIG. 3, a warning selection process performed by the lane departure warning ECU 105 in accordance with this embodiment will be described in detail.

[0038] Upon starting the warning selection process, the lane departure warning ECU 105 firstly determines whether or not the stimulus of vibration is being given to the driver by determining whether or not the amount of change in torque tr stored in the storage portion (not shown) is greater than or equal to the threshold amount of change in torque th1 (step S201). If it is determined that the amount of change in torque tr is greater than or equal to the threshold amount of change in torque th1, and therefore that the stimulus of vibration is being given to the driver, then the lane departure warning ECU 105 determines whether or not the sound pressure sp stored in the storage portion (not shown) is greater than or equal to the threshold sound pressure value th2 and thereby determines whether or not the stimulus of sound is being given to the driver (step S202).

[0039] If the lane departure warning ECU 105 determines that the sound pressure sp stored in the storage portion (not shown) is greater than or equal to the threshold sound pressure value th2 (YES in step S202) after determining that the stimulus

of vibration is being given to the driver (YES in step S201), then the lane departure warning ECU 105 determines whether or not the illuminance il stored in the storage portion (not shown) is greater than or equal to the threshold illuminance value th3 (step S203). On the other hand, if the lane departure warning ECU 105 determines that the sound pressure sp stored in the storage portion (not shown) is less than the threshold sound pressure value th2 and therefore that the stimulus of sound is not being given to the driver (NO in step S202) after determining that the stimulus of vibration is being given to the driver (YES in step S201), then the lane departure warning ECU 105 determines whether or not the illuminance il stored in the storage portion (not shown) is greater than or equal to the threshold illuminance value th3.

[0040] If the lane departure warning ECU 105 determines that the stimulus of vibration is being given to the driver (YES in step S201), and determines that the stimulus of sound is being given to the driver (YES in step S202), and determines that the illuminance il stored in the storage portion (not shown) is greater than or equal to the threshold illuminance value th3 and therefore that the stimulus of light is being given to the driver (YES in step S203), then the lane departure warning ECU 105 selects all of the first to third warning means 106 to 108 for notifying the prediction (step S204). A reason why the lane departure warning ECU 105 selects all the warning means after determining that all of the stimuli of vibration, sound and light are being given to the driver is that no matter which one of the warning means is selected, it is considered that the stimulus produced from the selected warning means will be indistinct among the stimuli that are naturally given to the driver, and therefore that it is desirable to maximize the possibility of the driver recognizing the notification of the prediction of the risk.

[0041] On the other hand, if the lane departure warning ECU 105 determines that the stimulus of vibration is being given to the driver (YES in step S201), and determines that the stimulus of sound is being given to the driver (YES in step S202), and determines that the illuminance il stored in the storage portion (not shown) is less than the threshold illuminance value th3 and therefore that the stimulus of light is not being given to the driver (NO in step S203), then the lane departure warning ECU 105 selects

the third warning means 108 for notifying the prediction of the risk by the stimulus of light, which is not being given to the driver (step S205).

[0042] Besides, if the lane departure warning ECU 105 determines that the stimulus of vibration is being given to the driver (YES in step S201), and determines that the stimulus of sound is not being given to the driver (NO in step S202), and determines that the illuminance il stored in the storage portion (not shown) is greater than or equal to the threshold illuminance value th3 and therefore that the stimulus of light is being given to the driver (YES in step S206), then the lane departure warning ECU 105 selects the second warning means 107 for notifying the prediction of the risk by the stimulus of sound, which is not being given to the driver (step S207).

[0043] On another hand, if the lane departure warning ECU 105 determines that the stimulus of vibration is being given to the driver (YES in step S201), and determines that the stimulus of sound is not being given to the driver (NO in step S202), and determines that the illuminance il stored in the storage portion (not shown) is less than the threshold illuminance value th3 and therefore the stimulus of light is not being given to the driver (NO in step S206), then the lane departure warning ECU 105 selects one of the second warning means 107 and the third warning means 108 for notifying the prediction of the risk by the stimulus of sound and the stimulus of light, respectively, neither of which is being given to the driver (S208).

[0044] Besides, if the lane departure warning ECU 105 determines that the amount of change in torque tr is less than the threshold amount of change in torque th1 and therefore that the stimulus of vibration is not being given to the driver of the vehicle (NO in step S201), the lane departure warning ECU 105 then determines whether or not the sound pressure sp store din the storage portion (not shown) is greater than or equal to the threshold sound pressure value th2 and thereby determines whether or not the stimulus of sound is being given to the driver (step S209).

[0045] If the lane departure warning ECU 105 determines that the stimulus of vibration is not being given to the driver (NO in step S201), and determines that the sound pressure sp stored in the storage portion (not shown) is greater than or equal to the

threshold sound pressure value th2 and therefore that the stimulus of sound is being given to the driver (YES in step S209), the lane departure warning ECU 105 determines whether or not the illuminance il stored in the storage portion (not shown) is greater than or equal to the threshold illuminance value th3 and thereby determines whether or not the stimulus of light is being given to the driver (step S210).

[0046] If the lane departure warning ECU 105 determines that the stimulus of vibration is not being given to the driver (NO in step S201), and determines that the stimulus of sound is being given to the driver (YES in step S209), and determines that the illuminance il stored in the storage portion (not shown) is greater than or equal to the threshold illuminance value th3 and therefore that the stimulus of light is being given to the driver (YES in step S210), the lane departure warning ECU 105 selects the first warning means 106 for notifying the prediction of the risk to the driver by the stimulus of vibration, which is not being given to the driver (step S211).

[0047] On another hand, if the lane departure warning ECU 105 determines that the stimulus of vibration is not being given to the driver (NO in step S201), and determines that the stimulus of sound is being given to the driver (YES in step S209), and determines that the illuminance il stored in the storage portion (not shown) is less than the threshold illuminance value th3 and therefore that the stimulus of light is not being given to the driver (NO in step S210), the lane departure warning ECU 105 selects at least one of the first warning means 106 and the third warning means 108 for notifying the prediction of the risk by the stimulus of vibration and the stimulus of light, respectively, neither of which is being given to the driver (step S212)..

[0048] Besides, if the lane departure warning ECU 105 determines that the stimulus of vibration is not being given to the driver (NO in step S201), and determines that the sound pressure sp stored in the storage portion (not shown) is less than the threshold sound pressure value th2 and therefore that the stimulus of sound is not being given to the driver (NO in step S209), the lane departure warning ECU 105 determines whether or not the illuminance il stored in the storage portion (not shown) is greater than or equal to the threshold illuminance value th3 and thereby determines whether or not the

stimulus of light is being given to the driver (S213).

[0049] If the lane departure warning ECU 105 determines that the stimulus of vibration is not being given to the driver (NO in step S201), and determines that the stimulus of sound is not being given to the driver (NO in step S209), and determines that the illuminance il stored in the storage portion (not shown) is greater than or equal to the threshold illuminance value th3 and therefore that the stimulus of light is being given to the driver (YES in step S213), the lane departure warning ECU 105 selects at least one of the first warning means 106 and the second warning means 107 for notifying the prediction of the risk by the stimulus of vibration and the stimulus of sound, respectively, neither of which is being given to the driver (step S214).

[0050] On the other hand, if the lane departure warning ECU 105 determines that the stimulus of vibration is not being given to the driver (NO in step S201), and determines that the stimulus of sound is not being given to the driver (NO in step S209), and determines that the illuminance il stored in the storage portion (not shown) is less than the threshold illuminance value th3 and therefore that the stimulus of light is not being given to the driver (NO in step S213), the lane departure warning ECU 105 selects an arbitrary one of the first to third warning means 106 to 108 (step S215). A reason why the lane departure warning ECU 105 selects an arbitrary one of the first to third warning means 106 to 108 upon determining that all of the stimuli of vibration, sound and light are being given to the driver is that it is considered that the prediction of the risk can certainly be recognized by the driver, whichever warning means is used to stimulate the driver.

[0051] The warning apparatus 1 in accordance with this embodiment has been described above. According to the warning apparatus 1 in accordance with this embodiment, since the lane departure warning ECU 105 is able to recognize the environment in which the driver is in, and is able to notify the prediction of the risk by a stimulus that is different from the stimuli that are being given to the driver from the environment, that is, by a stimulus that is not being given to the driver, it is possible to certainly notify the prediction of the risk to the driver.

[0052] Incidentally, with regard to the warning apparatus 1 in accordance with this embodiment, in the case where there are a plurality of warning means that can be selectively used, for example, the case where an arbitrary one of the first to third warning means 106 to 108 is selected (step S215), the case where at least one of the first warning means 106 and the second warning means 107 is selected (step S214), etc., it is permissible to select one warning means in accordance with a predetermined order of priority, or to select all the warning means that can be selected.

[0053] A first modification of the foregoing embodiment of the invention will be described. In the warning apparatus 1 in accordance with the foregoing embodiment, the lane departure warning ECU 105 always selects the warning means for notifying the driver of the prediction of the risk by a stimulus that is not being given to the driver, from the first to third warning means 106 to 108. However, according to the lane departure warning ECU 105 in accordance with the embodiment, if the stimuli that are being given to the driver change, for example, from the stimuli of light and sound to the stimuli of vibration and sound, before the risk that has been predicted disappears, the warning means that is selected also changes from the first warning means 106 for giving a stimulus by vibration to the sound pressure detection means 103 for giving a stimulus by light. However, if the lane departure warning ECU 105 changes the stimulus that the ECU 105 gives to the driver before a risk that the ECU 105 has predicted disappears, the driver may sometimes be discomforted or may sometimes misunderstand that a risk different from the one that has already been notified has been predicted.

[0054] Therefore, a warning apparatus 1 in accordance with a first modification of the embodiment, after having caused the selected warning means to notify prediction of a risk, does not change the selected warning means until the predicted risk disappears. Hereinafter, the warning apparatus 1 in accordance with this modification will be described. Incidentally, the general construction of the warning apparatus 1 in accordance with this modification is the same as that of the warning apparatus 1 in accordance with the foregoing embodiment. Therefore, the same portions and the like of the warning apparatus 1 of the modification as those of the warning apparatus 1 of the

foregoing embodiment are denoted by the same reference characters, and descriptions thereof are omitted below.

[0055] FIG. 4 is a flowchart showing a flow of processes performed by the lane departure warning ECU 105 in accordance with this modification. The flow of the processes performed by the lane departure warning ECU 105 of this embodiment shown in FIG. 4 is different from the flow of the processes performed by the lane departure warning ECU 105 in accordance with the first embodiment, as is apparent from FIG. 4, in that when the lane departure warning ECU 105 has detected a risk of the host vehicle departing from the current traveling lane (YES in step S106), the lane departure warning ECU 105 commands the selected warning means to notify the prediction of the risk (step S107), and then predicts again whether or not there is a risk of the host vehicle departing from the current traveling lane (step S106). Then, when the lane departure warning ECU 105 in accordance with the modification no longer predicts the risk of the host vehicle departing from the current traveling lane, that is, when the risk that the lane departure warning ECU 105 has predicted disappears (NO in step S106), the lane departure warning ECU 105 commands the selected warning means to stop the warning, and deletes all the information stored in the storage portion (not shown) (step S108), and then returns the process to the step S101. After that, the lane departure warning ECU 105 performs the warning selection process in step S104 again.

[0056] The warning apparatus 1 in accordance with the modification has been described above. In the warning apparatus 1 in accordance with this modification, once the lane departure warning ECU 105 detects a risk, the lane departure warning ECU 105 does not change the warning means that the lane departure warning ECU 105 selects, until the risk disappears. Therefore, the warning apparatus 1 in accordance with this modification is able to prevent the driver from being discomforted and from misunderstanding that a risk different from the risk that has already been notified has been predicted.

[0057] A second modification of the embodiment of the invention will be described below. In the foregoing first modification of the embodiment of the invention,

a construction in which once a risk is predicted, the warning means that is selected is not changed until the predicted risk disappears is adopted in order to prevent the driver from misunderstanding that a risk different from the risk that has already been notified has been predicted. However, another construction may also be adopted in order to prevent the driver from misunderstanding that a risk different from the one that has already been notified has been predicted. That is, it is also permissible to adopt a construction in which if after a risk is predicted, a change occurs in the stimuli that are being given to the driver from the environment so that the warning selection process selects different warning means, both the warning means selected prior to the change and the warning means selected subsequently to the change are caused to notify the prediction of the risk. Due to this construction, it is possible to cause the warning means selected prior to a change in the stimuli given to the driver to continue to notify the prediction of the risk to the driver after the change and, at the same time, certainly notify the prediction of the risk by also using a stimulus different from the stimulus used prior to the change. A warning apparatus 1 in accordance with the second modification of the embodiment of the invention will be described below. Incidentally, the general construction of the warning apparatus 1 in accordance with this modification is the same as that of the warning apparatus 1 in accordance with the foregoing embodiment. Therefore, the same portions and the like of the warning apparatus 1 of the modification as those of the warning apparatus 1 of the foregoing embodiment are denoted by the same reference characters, and descriptions thereof are omitted below.

[0058] FIG. 5 is a flowchart showing a flow of processes performed by the lane departure warning ECU 105 in accordance with this modification. Of the processes shown in the flowchart in FIG. 5, the same processes as those in the flowchart showing the flow of processes performed by the lane departure warning ECU 105 in accordance with the first embodiment are denoted by the same reference characters, and descriptions thereof are omitted below.

[0059] After selecting warning means through the warning selection process (step S104), the lane departure warning ECU 105 in accordance with this modification

determines whether or not the presently selected warning means is different from the warning means that has already been selected, with reference to re-selected warning information stored in the storage portion (not shown) as described below (step S301). If the lane departure warning ECU 105 determines that the presently selected warning means is different from the warning means that has already been selected (YES in step S301), the lane departure warning ECU 105 stores information that shows the warning means selected after the change in the stimuli as the foregoing selected warning information into the storage portion (not shown) (step S302), and stores information that shows the warning means selected prior to the change as re-selected warning information into the storage portion (not shown) (step S303). On the other hand, if the lane departure warning ECU 105 determines that the presently selected warning means is not different from the warning means that has already been selected (NO in step S301), the lane departure warning ECU 105 stores the re-selected warning information that shows the warning means selected prior to the change into the storage portion (not shown) without storing selected warning information that shows the warning means selected after the change (step S303).

[0060] After storing the re-selected warning information into the storage portion (not shown) (step S303), the lane departure warning ECU 105 determines whether or not the host vehicle will likely depart from the current traveling lane (step S106). If a risk of the departure is predicted (YES in step S106), the lane departure warning ECU 105 gives the warning means shown by the information stored in the storage portion (not shown) a command to notify the prediction of the risk (step S107), and then returns to step S101. Then, the lane departure warning ECU 105 performs the warning selection process (step S104) again in which it is determined whether or not the warning means selected by the present execution of the process is different from the warning means that has already been selected.

[0061] Incidentally, when the lane departure warning ECU 105 in accordance with this modification performs the process of step S301 for the first time, for example, immediately after the lane departure warning ECU 105 starts the flow of processes shown

by the flowchart in FIG. 5, or the like, only the re-selected warning information is stored into the storage portion (not shown) because the warning selection process of step S104 has been performed only once. Therefore, when the lane departure warning ECU 105 performs the process of step S301 for the first time, the lane departure warning ECU 105 regards the first warning means to be selected as the warning means selected prior to the change, and stores information that shows the first selected warning means as reselected warning information into the storage portion (not shown).

[0062] Besides, if the lane departure warning ECU 105 in accordance with this modification repeats the process shown by the flowchart in FIG. 5 several times, at least one of the selected warning information and the re-selected warning information is stored into the storage portion (not shown). When the lane departure warning ECU 105 is to perform the processes of step S302 and step S303 while at least one of the selected warning information and the re-selected warning information has been selected as described above, the lane departure warning ECU 105 does not re-store the selected warning information or the re-selected warning information that has already been stored in the storage portion (not shown), but updates the stored information with new information.

[0063] Besides, in the process of step S108, after giving the warning means shown by the selected warning information and the re-selected warning information stored in the storage portion (not shown) a command to stop notifying the prediction of the risk, the lane departure warning ECU 105 in accordance with this modification deletes all the information as described above in conjunction with the first embodiment or with the first modification. After that the lane departure warning ECU 105 returns to step S101.

[0064] The warning apparatus 1 in accordance with the second modification of the embodiment of the invention has been described above. According to the warning apparatus 1 in accordance with this modification, by causing the warning means selected prior to a change in the stimuli given to the driver to continue to notify the prediction of the risk, it is possible to prevent the driver from being discomforted and from

misunderstanding that a different risk has been predicted, and, at the same time, certainly notify the prediction of the risk by also using a stimulus different from the stimulus used prior to the change.

[0065] Incidentally, in the first embodiment, the lane departure warning ECU 105 calculates the amount of change in torque tr obtained by differentiating the torque shown by the torque information, in order to determine whether or not the driver of the host vehicle is being given a stimulus of vibration. However, in another embodiment, the lane departure warning ECU 105 may calculate an integral value of the torque shown by the torque information or an absolute value thereof, and may compare the calculated value with the threshold amount of change in torque th1, in order to determine whether or not the driver of the host vehicle is being given a stimulus of vibration.

[0066] Besides, in the warning apparatus 1 in accordance with the foregoing embodiment, whether or not the driver is being given a stimulus of sound is determined on the basis of the sound pressure detected by the sound pressure detection means 103. However, in a warning apparatus 1 in accordance with another embodiment, sound volume detection means may be used instead of the sound pressure detection means 103. The sound volume detection means, for example, when the sound volume of a car audio (not shown) is operated by the driver, detects the sound volume with reference to the storage means for storing the sound volume that has been operated, and generates sound volume information that shows the detected sound volume. In the case where the sound volume detection means is used instead of the sound pressure detection means 103, the lane departure warning ECU 105 is able to acquire sound volume information instead of sound pressure information, and is able to determine that the stimulus of sound is being given to the driver, if the sound volume shown by the acquired sound volume information is greater than a predetermined threshold sound volume value th4.

[0067] Besides, in a warning apparatus 1 in accordance with another embodiment, whether or not the driver is being given a stimulus of sound may be determined by using both the sound pressure detection means 103 and the sound volume detection means. In this case, the lane departure warning ECU 105 may determine that

the driver is being given the stimulus of sound, if it is determined that at least one of the condition that the sound pressure sp is greater than or equal to the threshold sound pressure value th2 and the condition that the sound volume shown by the sound volume information generated by the sound volume detection means is greater than or equal to the threshold sound volume value th4 is satisfied.

[0068] Besides, the warning apparatus 1 in accordance with the embodiment is described above in conjunction with an example in which the lane departure warning ECU 105 notifies the driver by the warning means that a risk of the host vehicle departing from the current traveling lane has been predicted. However, in a warning apparatus 1 in accordance with another embodiment, when an arbitrary risk is predicted, for example, when the host vehicle comes to a point of a predetermined distance from an object in the environment and therefore a risk of collision is predicted, or when the inattentive driving of the driver is detected by an arbitrary technique and therefore a risk of causing an accident or the like is predicted, etc., it is permissible to notify the prediction of the risk by the warning means selected as described above in conjunction with any of the first embodiment and its modifications (the first modification and the second modification).

[0069] Besides, as described above, in the case where the prediction of a risk is notified by the warning means selected as described above by the ECU that predicts a risk of the host vehicle colliding with an object around the host vehicle, the warning apparatus 1 in accordance with the invention may include, for example, posture detection means for detecting the posture of the driver of the host vehicle. The posture detection means herein is, for example, a pressure sensor disposed in a seatback, or the like, and generates pressure information that shows the pressure that the driver's back applies to the seatback from the voltage that changes according to the pressure applied to the seatback. Besides, in this case, the warning apparatus 1 in accordance with the invention includes safety securement means for securing safety by controlling a motor for winding up a seatbelt on the driver of the host vehicle so as to heighten the restraining force of the seatbelt on the driver, upon receiving from the lane departure warning ECU 105 a command to notify the prediction of the risk. This safety securement means can

also be used as fourth warning means for notifying the driver of the prediction of the risk by giving the driver a fastening stimulus by the seatbelt. Then, in the case where the warning apparatus 1 in accordance with the invention includes the posture detection means, the lane departure warning ECU 105 acquires pressure information generated by the posture detection means, and then determines whether or not the driver is being given a fastening force by the seatbelt as a stimulus, on the basis of the pressure shown by the acquired pressure information. Concretely, the lane departure warning ECU 105, after acquiring the pressure information, compares the pressure shown by the acquired pressure information with a predetermined threshold pressure value th5. Then, if it is determined that the pressure is greater than or equal to the threshold pressure value th5, the lane departure warning ECU 105 recognizes that the driver of the host vehicle is in an environment in which the driver is not being given a stimulus of the fastening by the seatbelt. The lane departure warning ECU 105 selects the foregoing fourth warning means when in the warning selection process the ECU 105 has recognized that the driver of the host vehicle is in an environment in which the driver is not being given the stimulus of the fastening by the seatbelt. Then, when the risk of the host vehicle departing from the current traveling lane is predicted while the fourth warning means has been selected, the lane departure warning ECU 105 gives the fourth warning means a command to notify the prediction of the risk.

[0070] Besides, the sound pressure detection means 103 in the above-described embodiment is disposed at an arbitrary position in the cabin of the host vehicle at which it is possible to accurately detect or estimate the sound pressure of the sound that is audible to the driver of the host vehicle.

[0071] Besides, the illuminance detection means 104 in the embodiment described in detail above is disposed at an arbitrary position in the host vehicle at which it is possible to accurately detect the luminance around the host vehicle.

[0072] The lane departure warning ECU 105 in the embodiment described in detail above recognizes the stimuli of vibration, sound and light that are given from the environment in which the driver is in, by using the torque detection means 102, the sound

pressure detection means 103 and the illuminance detection means 104. However, in the other embodiment described above, the lane departure warning ECU 105 may also recognize other arbitrary stimuli of various kinds that are given from the environment in which the driver is in, by using other arbitrary detection means. In this case, the warning apparatus 1 includes various warning means capable of notifying the driver that a risk has been predicted, by a stimulus that is different from the other arbitrary stimuli of various kinds that are recognized by the lane departure warning ECU 105.

[0073] The invention makes it possible to certainly notify a user that a risk has been predicted, and is applicable to, for example, warning apparatuses that are mounted in mobile units such as motor vehicles and the like.

[0074] While some embodiments of the invention have been illustrated above, it is to be understood that the invention is not limited to details of the illustrated embodiments, but may be embodied with various changes, modifications or improvements, which may occur to those skilled in the art, without departing from the scope of the invention.

CLAIMS

1. A warning apparatus that notifies a driver of a host vehicle that a risk has been predicted, characterized by comprising:

environment recognition means for recognizing an environment in which the driver is;

prediction means for detecting the risk;

at least two units of warning means for notifying prediction of the risk by using stimuli that are respectively different in kind from each other;

warning selection means for selecting the warning means for notifying the driver of the prediction of the risk from the at least two units of warning means according to the environment; and

command means for giving the warning means selected by the warning selection means a command to notify the driver that the risk has been detected by the prediction means.

2. The warning apparatus according to claim 1, wherein the warning means selected by the warning selection means notifies the prediction of the risk by using a stimulus that is different from stimuli that are being given to the driver from the environment.

3. The warning apparatus according to claim 1, wherein the command means continues giving the command to the warning means selected by the warning selection means until the risk that has been predicted disappears.

4. The warning apparatus according to claim 1, wherein

if the warning means different from the warning means that has already been selected by the warning selection means is selected by the warning selection means according to the environment during a time from selection of the warning means that has already been selected till disappearance of the risk that has been predicted, the command means gives the command to the warning means that has already been selected and to the different

warning means that has just been selected.

5. A warning apparatus that notifies a driver of a host vehicle that a risk has been detected, comprising:

an environment recognition that recognizes an environment in which the driver is;

a prediction portion that predicts the risk;

at least two warning portions that notify prediction of the risk by using stimuli that are respectively different in kind from each other;

a warning selection portion that selects, from the at least two warning portions, the warning portion that notifies the driver of the prediction of the risk according to the environment; and

a command portion that gives the warning portion selected by the warning selection portion a command to notify the driver that the risk has been detected by the prediction means.

FIG. 1

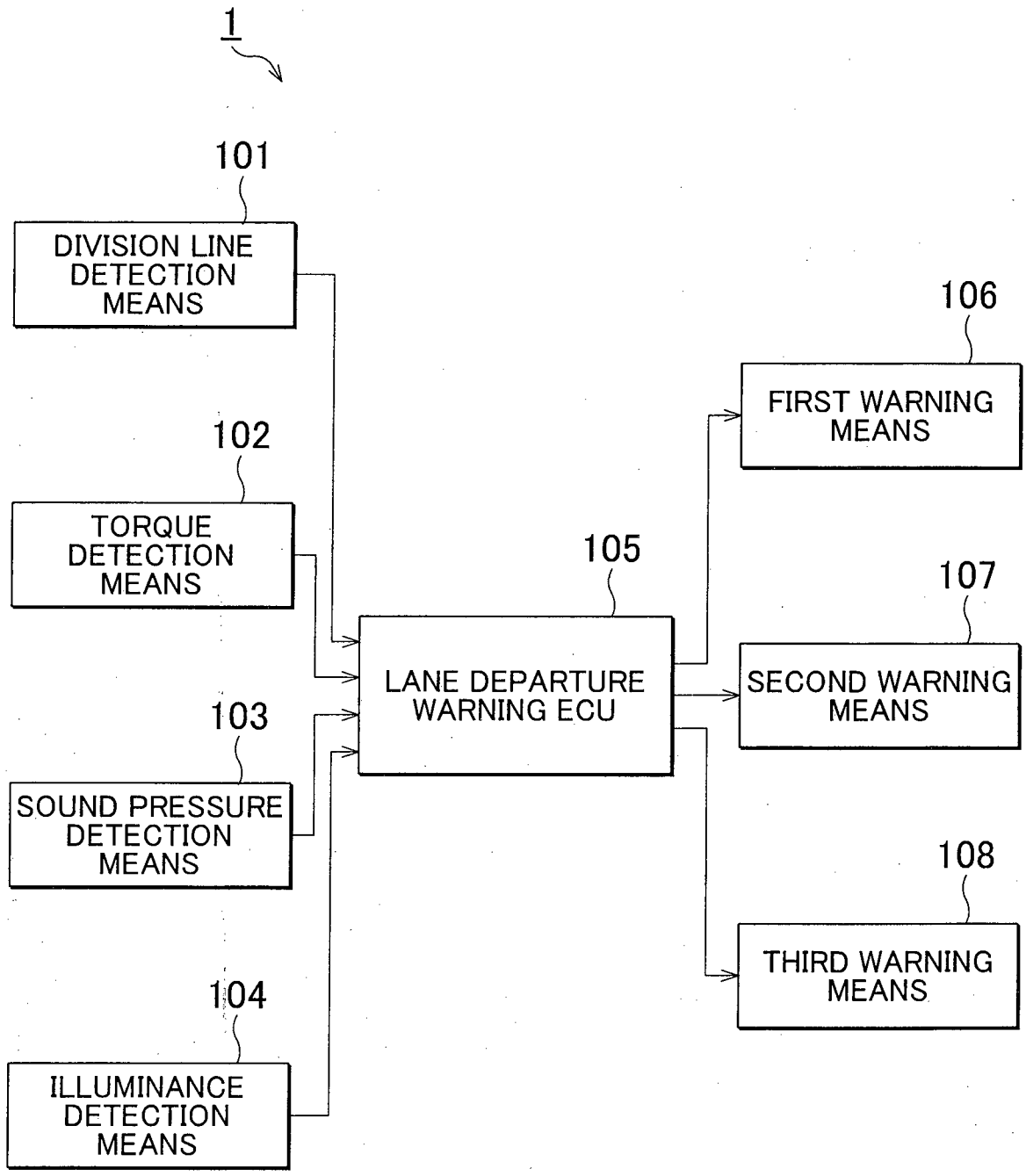

1
101
DIVISION LINE DETECTION MEANS
102
TORQUE DETECTION MEANS
103
SOUND PRESSURE DETECTION MEANS
104
ILLUMINANCE DETECTION MEANS
105
LANE DEPARTURE WARNING ECU
106
FIRST WARNING MEANS
107
SECOND WARNING MEANS
108
THIRD WARNING MEANS

FIG. 2

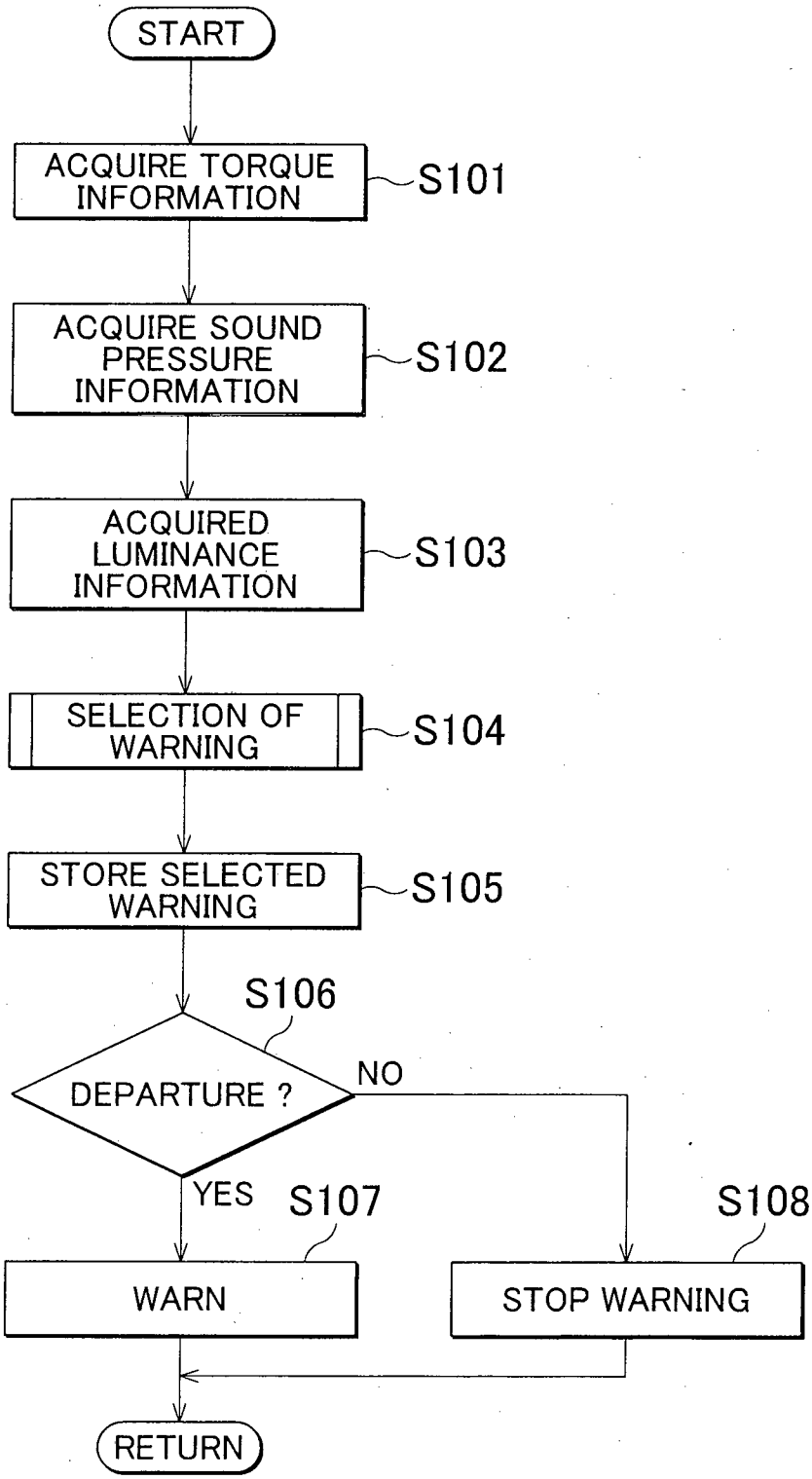

START
ACQUIRE TORQUE INFORMATION
S101
ACQUIRE SOUND PRESSURE INFORMATION
S102
ACQUIRED LUMINANCE INFORMATION
S103
SELECTION OF WARNING
S104
STORE SELECTED WARNING
S105
S106
DEPARTURE ?
NO
YES
S107
S108
WARN
STOP WARNING
RETURN

FIG. 3

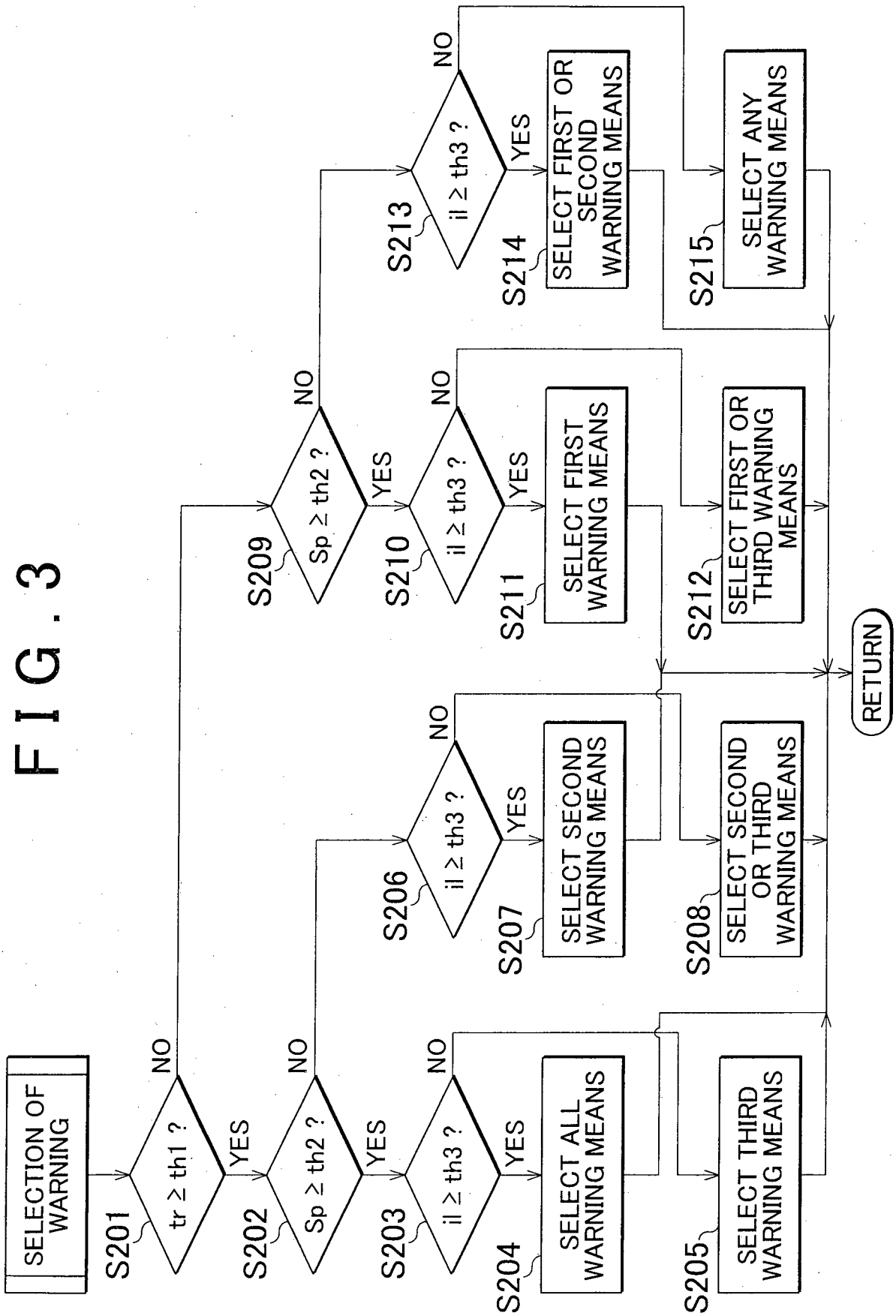

SELECTION OF WARNING
S201
tr ≥ th1 ?
NO
YES
S202
Sp ≥ th2 ?
NO
YES
S203
il ≥ th3 ?
NO
YES
S204
SELECT ALL WARNING MEANS
S205
SELECT THIRD WARNING MEANS
S206
il ≥ th3 ?
NO
YES
S207
SELECT SECOND WARNING MEANS
S208
SELECT SECOND OR THIRD WARNING MEANS
S209
Sp ≥ th2 ?
NO
YES
S210
il ≥ th3 ?
NO
YES
S211
SELECT FIRST WARNING MEANS
S212
SELECT FIRST OR THIRD WARNING MEANS
S213
il ≥ th3 ?
NO
YES
S214
SELECT FIRST OR SECOND WARNING MEANS
S215
SELECT ANY WARNING MEANS
RETURN

FIG. 4

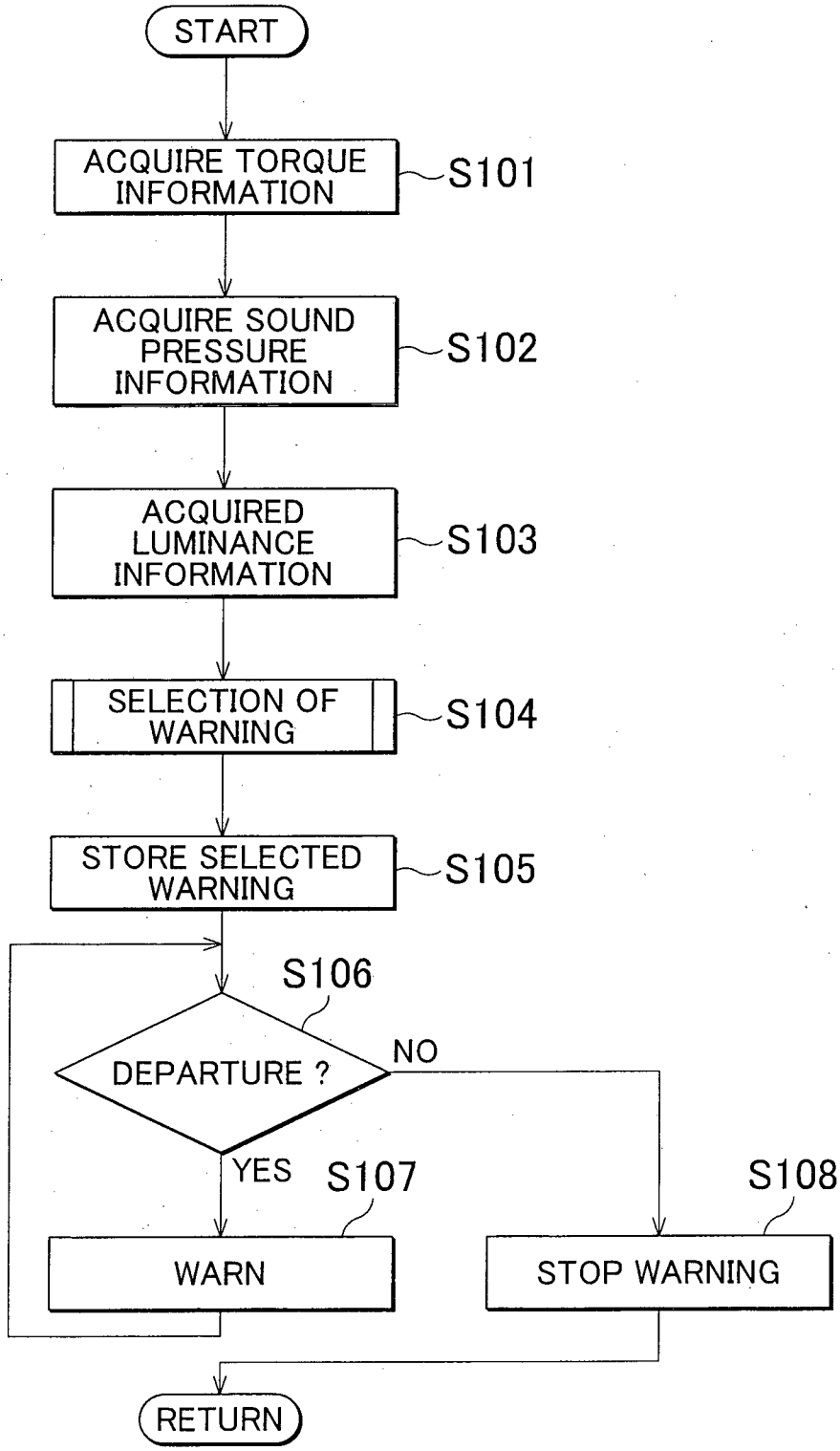
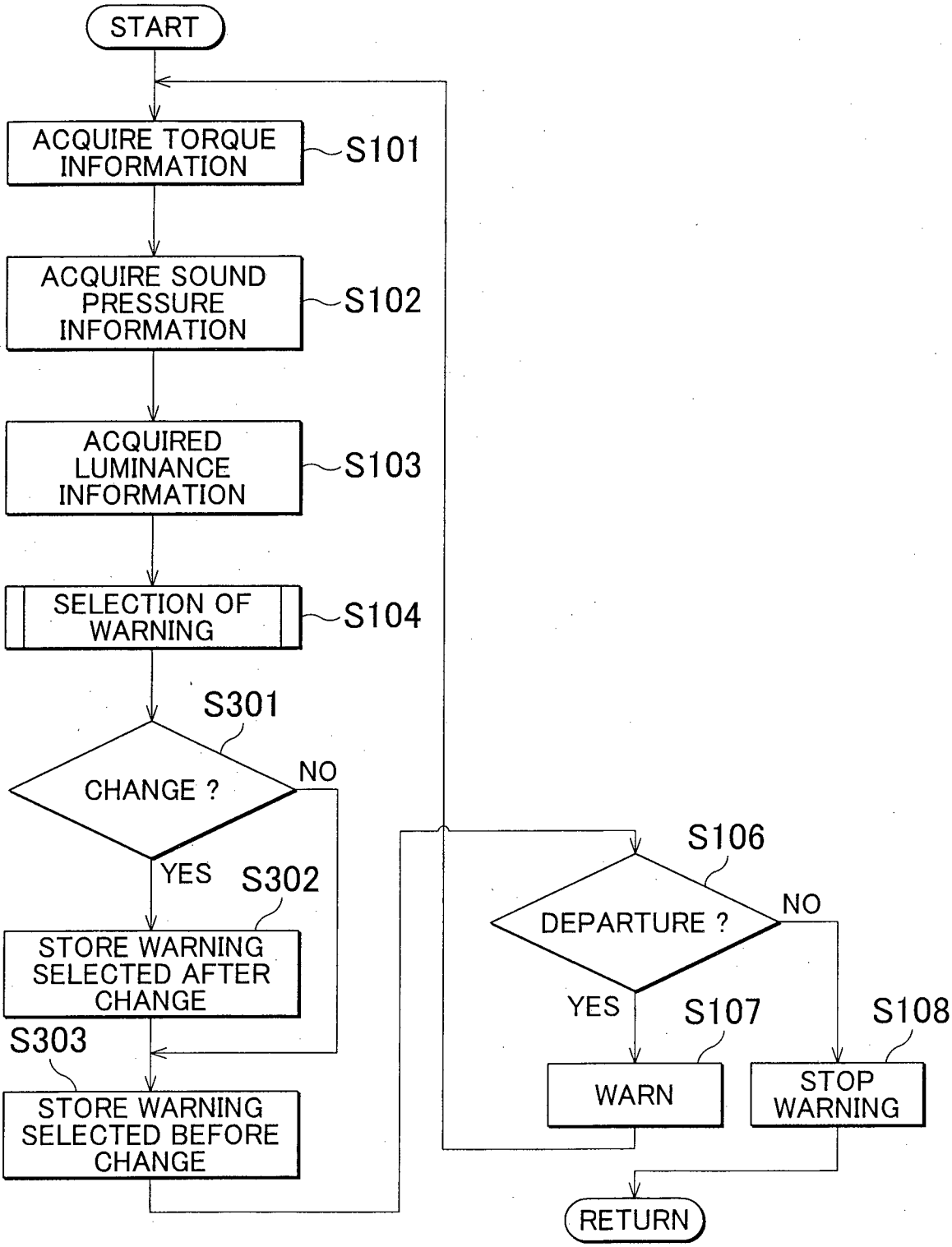

START
ACQUIRE TORQUE INFORMATION
S101
ACQUIRE SOUND PRESSURE INFORMATION
S102
ACQUIRED LUMINANCE INFORMATION
S103
SELECTION OF WARNING
S104
STORE SELECTED WARNING
S105
S106
DEPARTURE ?
NO
YES
S107
S108
WARN
STOP WARNING
RETURN

FIG. 5


START
ACQUIRE TORQUE INFORMATION
S101
ACQUIRE SOUND PRESSURE INFORMATION
S102
ACQUIRED LUMINANCE INFORMATION
S103
SELECTION OF WARNING
S104
S301
CHANGE ?
NO
YES
S302
STORE WARNING SELECTED AFTER CHANGE
S303
STORE WARNING SELECTED BEFORE CHANGE
S106
DEPARTURE ?
NO
YES
S107
WARN
S108
STOP WARNING
RETURN

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2011/000595

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60W50/08
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

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 930 201 A1 (BOSCH GMBH ROBERT [DE]) 11 June 2008 (2008-06-11) paragraphs [0005] - [0007], [0012] the whole document	1-3,5
X	DE 103 43 683 A1 (DAIMLER CHRYSLER AG [DE]) 21 April 2005 (2005-04-21) paragraphs [0057], [0058] the whole document	1-3,5
A	DE 10 2008 010832 A1 (DAIMLER CHRYSLER AG [DE]) 3 September 2009 (2009-09-03) paragraphs [0017], [0032], [0044]	1,5

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

☒ See patent family annex.

* Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 July 2011	04/08/2011

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/IB2011/000595

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1930201 A1	11-06-2008	DE 102006057278 A1	12-06-2008
DE 10343683 A1	21-04-2005	EP 1663728 A1	07-06-2006
		WO 2005035321 A1	21-04-2005
		JP 2007506166 A	15-03-2007
		US 2007124027 A1	31-05-2007
DE 102008010832 A1	03-09-2009	NONE	