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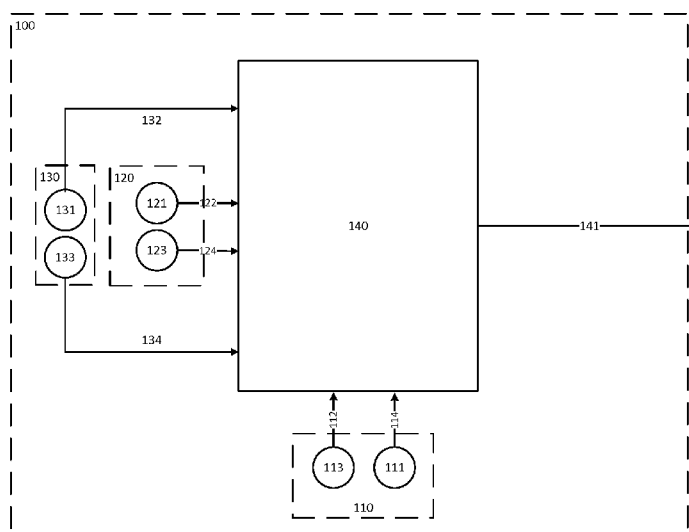


Fig. 1

(57) Abstract: Embodiments of the present invention provide a system (100) for a vehicle, the system comprising noise input means (110) for generating a noise signal (112, 114) indicative of noise, error sensing means (120) for generating an error signal (122, 124) indicative of a noise cancellation error at a location in the vehicle, proximity sensing means (130) for generating a signal indicative of an obstruction proximal to the error sensing means (120) and outputting a proximity signal (132, 134) in dependence thereon, and noise cancellation means (140) arranged to determine a noise cancellation signal (141) in dependence on the noise signal (112, 114), the error signal (122, 124) and the proximity signal, and to output the noise cancellation signal (141) to an audio output means for reducing noise in the vehicle.



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SYSTEM AND METHOD FOR NOISE CANCELLATION

TECHNICAL FIELD

Aspects of the invention relate to a system and method and particularly, but not exclusively, to a system and method for noise cancellation. Aspects of the invention relate to a system, to a method, to a vehicle, to a controller and to computer software.

BACKGROUND

Noise, especially within a vehicle, can be troublesome for occupants in the vehicle. Noise may distract a driver of the vehicle and may be tiring for the occupants of the vehicle, for example. Mechanical measures have been used to reduce noise within vehicles. However such measures are bulky and heavy. The use of active noise cancellation has been suggested. Active noise cancellation involves the generation of a cancellation sound wave to at least partly cancel a noise sound wave thus making environment quieter for a listener.

In a noise cancellation system, it is known to measure an error between the cancellation sound wave and the noise sound wave to provide feedback. However vehicles may be loaded with a wide variety of objects such as luggage, clothes etc., in a wide variety of configurations or arrangements, thereby making the determination of the error problematic.

It is an object of embodiments of the invention to at least mitigate one or more of the problems of the prior art.

SUMMARY OF THE INVENTION

Aspects and embodiments of the invention provide a system, a method, a vehicle, a controller, and computer software as claimed in the appended claims.

According to an aspect of the invention, there is provided a noise cancellation system, comprising noise input means, error sensing means for generating an error signal, proximity sensing means for generating a signal indicative of an obstruction proximal to the error sensing means wherein a noise cancellation signal is determined in dependence thereon.

According to an aspect of the invention, there is provided a noise cancellation system, comprising noise input means for generating a noise signal, error sensing means for generating an error signal, and proximity sensing means for generating a signal indicative of an obstruction proximal to the error sensing means and outputting a proximity signal in dependence thereon. A noise cancellation means is arranged for receiving the noise signal and the error signal and determining a noise cancellation signal in dependence thereon.

According to an aspect of the invention, there is provided a system for a vehicle, the system comprising: noise input means for generating a noise signal indicative of noise; error sensing means for generating an error signal indicative of a noise cancellation error at a location in the vehicle; proximity sensing means for generating a signal indicative of an obstruction proximal to the error sensing means and outputting a proximity signal in dependence thereon; and noise cancellation means arranged to determine a noise cancellation signal in dependence on the noise signal, the error signal and the proximity signal, and to output the noise cancellation signal to an audio output means for reducing noise in the vehicle.

A system as described above, wherein:

the noise input means is one or more noise input devices, such as vibro-acoustic devices;

the error sensing means is one or more error sensing devices, such as microphones;

the proximity sensing means is a proximity sensing device or sensor; and

the noise cancellation means is a noise cancellation controller comprising inputs for receiving the noise signal, the error signal and the proximity signal, and an electronic processor having an associated memory, and wherein the processor is programmed to access the memory to carry out instructions saved therein so as to, in dependence on the noise signal, the error signal and the proximity signal, determine the noise cancellation signal.

The noise cancellation means may be arranged to control a weight value associated with the error signal in the determination of the noise cancellation signal in dependence on the proximity signal. Advantageously, an obstruction of the error sensing means may be accounted for in the determination of the noise cancellation signal.

The weight value associated with the error signal may be reduced in the determination of the noise cancellation signal in dependence on the proximity signal. Advantageously less emphasis is given to the error signal in the presence of an obstruction to the error sensing means. The weight value associated with the error signal in the determination of the noise cancellation signal may be reduced to substantially zero in dependence on the proximity signal. Advantageously, the error signal may have no influence on the determination of the noise cancellation signal when the error sensing means is obstructed.

It may be that the weight value is set to an intermediate value between zero and one in dependence on the proximity signal. It may be that the noise cancellation means is arranged to set the weight value associated with the error signal in the determination of the noise cancellation signal to an intermediate value between zero and one in dependence on the proximity signal. It may be that the noise cancellation means is arranged to set, in dependence on the proximity signal, the weight value associated with the error signal in the determination of the noise cancellation signal such that the noise cancellation means uses the error signal to an intermediate extent between no usage of the error signal and full usage of the error signal in the determination of the noise cancellation signal. By allowing the error signal to be used to an intermediate extent between no usage and full usage in the determination of the noise cancellation signal, a more granular use of the error signal is facilitated in the determination of the noise cancellation than a binary choice of no usage or full usage. Advantageously, this enables more accurate noise cancellation signals to be determined under some circumstances (e.g. if the error sensing means is only partially obstructed) than if the error signal could only either be fully used or not used at all in the determination of the noise cancellation signal.

The noise cancellation means may be arranged to assign a predetermined value to the error signal in dependence on the proximity signal. Advantageously the error signal may be given a known value when the error sensing means is obstructed. The noise cancellation means may be arranged to assign a value to the error signal equivalent to the value prior to the obstruction proximal to the error sensing means being determined by the proximity sensing means. Advantageously, a previously-valid value of the error signal may be used in the presence of an obstruction.

The proximity sensing means optionally comprises a proximity sensing device such as an optical detector for determining an optical parameter. Advantageously the

obstruction may be optically detected. It may be that the proximity sensing means comprises an optical detector arranged to determine an optical parameter from which the presence of an obstruction proximal to the error sensing means can be determined. It may be that the proximity sensing means is arranged to generate the proximity signal in dependence on the optical parameter. The optical parameter may be an ambient light level at the optical detector. The proximity signal may be indicative of a reduction in the ambient light level. Advantageously, obstruction may be detected in dependence on the ambient light level, which may consume little power.

The proximity sensing means may comprise a light emitter. The optical detector may be arranged to detect the light from the light emitter. The obstruction may be beneficially detected with more sensitivity by means of the light emitter. The optical detector may be arranged to output the proximity signal indicative of the intensity of the reflected light. Advantageously, the detection of obstructions may be improved.

Optionally, the proximity sensing means may comprise a capacitive sensor. Advantageously the presence of the obstruction proximal to the capacitive sensor may be determined.

In an embodiment of the system, the proximity sensing means comprises an ultrasonic transceiver arranged to output the proximity signal in dependence on reflected ultrasonic signals. Advantageously, the location and/or proximity of the obstruction may be accurately detected. Advantageously, transparent obstructions may be determined.

Optionally, the noise input means may be arranged to measure a sound pressure level, SPL. The noise cancellation means may be arranged to control a weight value of the error signal when a difference in SPL is above a predetermined threshold. Advantageously, the presence of an obstruction may be inferred by the difference in SPL.

The noise input means may comprise one or more vibro-acoustic devices, for example microphones. The noise input means may advantageously detect acoustic waves in air or vibrations in solid materials.

According to another aspect of the invention, there is provided a method of noise cancellation for a vehicle, comprising generating a noise signal, generating an error signal, generating a proximity signal indicative of an obstruction, determining a noise cancellation signal in dependence on the noise signal, the proximity signal, and the error signal for reducing noise in the vehicle, and outputting the noise cancellation signal to an audio output means to reduce noise in the vehicle.

According to another aspect of the invention, there is provided a method of noise cancellation for a vehicle, the method comprising: generating a noise signal indicative of noise; generating an error signal indicative of a noise cancellation error at a location in the vehicle; generating a proximity signal indicative of an obstruction proximal to the location of the generation of the error signal; determining a noise cancellation signal in dependence on the noise signal, the proximity signal, and the error signal for reducing noise in the vehicle; and outputting the noise cancellation signal to an audio output means for reducing noise in the vehicle.

In an embodiment of the method, when determining the noise cancellation signal a weight value associated with the error signal is controlled in dependence on the received proximity signal. The weight value associated with the error signal may be reduced in dependence on the proximity signal. The weight value associated with the error signal may be reduced substantially to zero in dependence with the proximity signal.

It may be that the weight value associated with the error signal is set to an intermediate value between zero and one in dependence on the proximity signal. It may be that the weight value associated with the error signal is set, in dependence on the proximity signal, such that the noise cancellation means uses the error signal to an intermediate extent between no usage of the error signal and full usage of the error signal in the determination of the noise cancellation signal.

Optionally, a predetermined value may be assigned to the error signal in dependence on the received proximity signal. The value assigned to the error signal may be equivalent to the value prior to the obstruction proximal to the error sensing means being determined.

The determining of the noise signal may comprise determining a sound pressure level, SPL. The weight value of the received error signal may be reduced when a difference in determined SPL is above a predetermined threshold.

- 5 According to a further aspect of the invention, there is provided a controller for a noise cancellation system, comprising an input for receiving a noise signal indicative of noise, an input for receiving an error signal indicative of a noise cancellation error at a location in a vehicle, an input for receiving a proximity signal indicative of an obstruction proximal to the error input means, and processing means for determining
10 a noise cancellation signal in dependence on the noise signal, the error signal and the proximity signal, and for outputting the noise cancellation signal to an audio output means for reducing the noise in the vehicle.

A controller as described above, wherein:

- 15 the input for receiving a noise signal is an electrical input for receiving a signal from one or more noise input devices, such as vibro-acoustic devices;
the input for receiving an error signal is an electrical input for receiving a signal from one or more error sensing devices, such as microphones; and
the input for receiving a proximity signal is an electrical input for receiving a
20 signal from a proximity sensing device.

- In an embodiment of the controller, the processing means is arranged to determine the noise cancellation signal by controlling a weight value associated with the error signal in the determination of the noise cancellation signal in dependence on the
25 proximity signal.

The processing means may be arranged to reduce the weight value of the error signal based on the received proximity signal.

- 30 It may be that the processing means is arranged to set the said weight value associated with the error signal in the determination of the noise cancellation signal to an intermediate value between zero and one in dependence on the proximity signal. It may be that the processing means is arranged to set, in dependence on the proximity signal, the weight value associated with the error signal in the
35 determination of the noise cancellation signal such that the processing means uses the error signal to an intermediate extent between no usage of the error signal and full usage of the error signal in the determination of the noise cancellation signal.

According to a still further aspect of the invention, there is provided a vehicle arranged to perform a method, comprising an apparatus or comprising a system according to an aspect of the invention.

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According to yet another aspect of the invention, there is provided computer software which, when executed by a computer, is arranged to perform a method according to an aspect of the invention. This computer software may be stored on a computer readable medium. The computer software may be tangibly stored on the computer readable medium. The computer readable medium may be non-transitory.

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Within the scope of this application it is expressly intended that the various aspects, embodiments, examples, and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features thereof, may be taken independently or in any combination. That is, all embodiments and/or features of any embodiment can be combined in any way and/or combination, unless such features are incompatible. The applicant reserves the right to change any originally filed claim or file any new claim accordingly, including the right to amend any originally filed claim to depend from and/or incorporate any feature of any other claim although not originally claimed in that manner.

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BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described by way of example only, with reference to the accompanying figures, in which:

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Figure 1 shows a noise cancellation system according to an embodiment of the invention;

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Figure 2 shows a system according to an embodiment of the invention;

Figure 3 shows a method according to an embodiment of the invention; and

Figure 4 shows a vehicle according to an embodiment of the invention.

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DETAILED DESCRIPTION

Figure 1 illustrates a noise cancellation system 100 according to an embodiment of the invention. The system 100 comprises noise input means 110, error sensing means 120, proximity sensing means 130, and noise cancellation means 140.

5 As noted above, noise is a significant issue within a vehicle. A noisy environment can affect the enjoyment and comfort of occupants of the vehicle. For example, the occupant(s) of the vehicle may become tired through exposure to the noise in the vehicle. Furthermore, a characteristic of a premium vehicle is that an environment in the vehicle is relatively quiet. Noise cancellation may be used to reduce the noise
10 experienced by one or more occupants in the vehicle. Noise cancellation operates by producing an acoustic signal or sound wave arranged to destructively interfere with the noise signal or sound wave, such that both signals are substantially cancelled out.

15 The noise input means 110 may be arranged to generate one or more noise signals 112, 114 indicative of the noise in the vehicle. In an embodiment of the invention, the noise input means 110 may comprise one or more noise input devices 111, 113. The noise cancellation means 140 may be arranged to determine the noise within one or more noise zones associated with the vehicle. Each noise zone may be associated
20 with a seating position of one or more occupants within the vehicle. The noise input means 110 may be used to generate at least one specific noise signal 112, 114 within the respective noise zone. That is, each noise input means 110 may be used to generate a different noise signal 112, 114 corresponding to the respective noise zone. In some embodiments, the noise input devices 111, 113 may be associated
25 with the suspension of the vehicle, the engine, or any other location that produces or transmits noise to within the vehicle.

In an embodiment of the invention, the noise input devices 111, 113 may comprise at least one vibro-acoustic device, such as a microphone. In an embodiment of the
30 invention, the noise input means 110 may be arranged to determine a Sound Pressure Level (SPL) at a location of the respective noise input device 111, 113. In another embodiment at least some of the noise input devices 111, 113 may be one or more accelerometers, or other movement-sensing devices, which are arranged to determine movement or vibration at a respective location of each device 111, 113.

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The error sensing means 120 is arranged to generate one or more error signals 122, 124. In some embodiments, the error sensing means 120 comprises at least one

error sensing device 121, 123, such as a vibro-acoustic device. The vibro-acoustic device may be a device for measuring a Sound Pressure Level (SPL), for example, a microphone, and outputting the error signal indicative thereof. Each error signal 122, 124 is indicative of a noise cancellation error at a location in the vehicle. In operation, the error sensing means 120 measures the error as the remaining noise at the location in the vehicle, typically in the occupant compartment or cabin given the noise cancellation means 100. The error signal 122, 124 is thus indicative of the residual signal after a noise cancellation signal 141 produced by the system 100 has been output to reduce the noise in the vehicle. In an ideal scenario where the noise cancellation means 100 operatively cancels out all noise within the vehicle and the error signal will be zero. However in reality this is not always the case. The one or more error signals 122, 124 may be used in a feedback loop provided to the noise cancellation means 140 in order to modify one or more noise cancellation parameters, such that a more accurate noise cancellation signal 141 is produced. The error signals 122, 124 may comprise a difference in value between the noise signal 112, 114 and a predetermined threshold. The error sensing means 120 is arranged in some embodiments to generate the error signal at one or more locations within the one or more noise zones in the vehicle.

The proximity sensing means 130 is arranged to output one or more proximity signals 132, 134 indicative of an obstruction proximal or proximate to the error sensing means 120. In other words, to output the proximity signal when the obstruction is in proximity to the error sensing means 120 such that an ability of the error sensing means to accurately generate the error is affected.

The proximity sensing means 130 may comprise at least one proximity sensing device 131, 133, such as a proximity sensor. For example, the proximity sensing means 130 may be arranged to output at least one proximity signal 132, 134 when a portion of an occupant of the vehicle is near to the proximity sensing device 131, 133. Similarly, the proximity sensing means 130 may be arranged to output a proximity signal 132, 134 when a physical object is near to the proximity sensing device 131, 133. In an embodiment of the invention, the proximity sensing device 131, 133 may be provided in an arrangement corresponding to the error sensing means 120, such that each error sensing device 121, 123 may be associated with a respective proximity sensing device 131, 133. Thus in some embodiments a proximity sensing device 131, 133 may be co-located with a respective error sensing device 121, 123.

In an embodiment of the invention, the proximity sensing means 130 comprises at least one optical detector 130 for determining a light level and outputting a signal indicative thereof. For example, the proximity sensing means 130 may comprise an ambient light sensor. In an embodiment of the invention, the light level may comprise an ambient light level at the optical detector 130, and the proximity signal 132, 134 may thus be indicative of a reduction in the ambient light level at the optical detector 130. In this way, when the optical detector is co-located with the error sensing device, 121, 123 the signal output by the optical detector is indicative of an obstruction which may affect the error sensing device 121, 123.

In an embodiment of the invention, the proximity sensing means 130 comprises at least one light emitter in combination with the optical detector 130. The light emitter may be arranged to output non-visible light, such as infra-red although other embodiments may be envisaged. The optical detector may be arranged to detect reflected light from the light emitter, wherein the proximity signal is indicative of a value in dependence thereon.

In an embodiment of the invention, the proximity sensing means 130 comprises at least one capacitive sensor. A capacitance value of the capacitive sensor may vary in dependence on proximity of an object, such that a signal output by the capacitive sensor is indicative of the presence of the object.

In an embodiment of the invention, the proximity sensing means 130 comprises an ultrasonic transceiver. The ultrasonic transceiver may be arranged to output an ultrasonic signal such as a plurality of ultrasonic pulses. The proximity sensing means 130 is arranged to output the proximity signal 134 in dependence on a reflected ultrasonic signal indicative of the presence of an object.

It will be appreciated that the proximity sensing means 130 described herein may be used individually or one or more of the identified proximity sensing means may be used in combination. Such a combination allows for the accuracy of an obstruction detected by one sensing means to be corroborated by another sensing means.

The noise cancellation means 140 may comprise a noise cancellation controller. The noise cancellation controller may comprise one or more processing devices, such as electronic processors, arranged to operatively execute computer instructions which may be stored in a memory of the controller. As used herein the term "processor"

should be interpreted to mean a single processor or a plurality of processors acting together or independently to provide the required electronic processing.

5 The noise cancellation means 140 is arranged to receive the one or more noise signals 112, 114 and one or more error signals 122, 124 and to determine a noise cancellation signal 141 in dependence on the one or more noise signals 112, 114 and the one or more error signals 122, 124. The noise cancellation means 140 is arranged to output the noise cancellation signal 141 to at least one audio output means for reducing noise in the vehicle. In some embodiments, the audio output
10 means comprises one or more speakers or other suitable vibro-acoustic devices. The one or more speakers may be arranged to output audio in the form of sound waves into an interior of the vehicle.

In an embodiment of the invention, the noise cancellation means 140 is operative
15 based on a plurality of filter coefficients to determine the noise cancellation signal 141. The filter coefficients may be coefficients associated with one or more transfer functions. Each filter coefficient may further correspond to a respective reference acoustic pattern. The filter coefficients may be determined by processing the received noise and error signals 112, 114, 122, 124 by a predetermined algorithm.
20 The filter coefficients may be stored in the memory of the noise cancellation means 140.

In an embodiment of the invention, the noise cancellation means 140 may comprise a feedback loop, wherein the noise cancellation means 140 is arranged to output a
25 noise cancellation signal 141 in response to the received noise signals 112, 114 and error signals 122, 124 such that subsequent error signals 122, 124, i.e. at a later time, are minimised. In an embodiment of the invention, the noise cancellation means 140 may assign a weight value to the one or more received error signals 122, 124 wherein the weight value may define an amount of influence of the respective error
30 signal 122, 124 when determining the noise cancellation signal 141. For example, a weight value of 0 indicates that the respective error signal 122, 124 is not used in generating the filter coefficients to determine the noise cancellation signal 141, whereas, another value such as a value of 1, indicates that the respective error signal 122, 124 is fully utilised. Intermediate weight values are indicative of
35 intermediate levels of usage. Intermediate weight values between 0 and 1 facilitate intermediate levels of usage of the error signal in the determination of the noise cancellation signal which can lead to more accurate noise cancellation signals being

generated under some circumstances (e.g. if the error sensing means is only partially obstructed) than if the error signal was used fully or not at all.

The noise cancellation means 140 is arranged to output the noise cancellation signal 141 to at least one audio output means for reducing noise in the vehicle. The audio output means may comprise a speaker or other suitable vibro-acoustic device. In an embodiment of the invention, the noise cancellation means 140 is arranged to output sound corresponding to the noise cancellation signal 141 to reduce noise within one or more noise cancellations zones in the vehicle.

In an embodiment of the invention, determining the noise cancellation signal 141 may include the noise cancellation means 140 receiving at least one proximity signal 132, 134 from at least one proximity sensing device 131, 133. The noise cancellation means 140 is arranged to determine the noise cancellation signal 141 in dependence on the noise signal 112, 114, the error signal 122, 124 and the proximity signal 132, 134. The noise cancellation means may be arranged to control the weight value associated with the error signal 122, 124 in the determination of the noise cancellation signal 141 in dependence on the proximity signal 132, 134 corresponding to the error sensing means 121, 123 associated with the proximity sensing means 131, 133 having provided the proximity signal 132, 134.

In some embodiments, the noise cancellation means 140 may reduce the weight value of the error signal 122, 124 in dependence on the proximity signal 132, 134. For example, a proximity sensing device 131 may detect a corresponding error sensing device 121 is covered or obstructed by an object within the vehicle. For example, an occupant may have hung a jacket from a hook to obstruct, at least partially, the error sensing means 121, 123. In this case, the error signal 122 received by the noise cancellation means 140 is likely to not accurately reflect the noise cancellation error in the vehicle due to the obstruction. As previously mentioned, the noise cancellation means 140 includes a feedback loop wherein the error signals 122, 124 are used to calculate subsequent noise cancellation signals 141. The feedback loop associated with generating the noise cancellation signal 141 by the noise cancellation means 140 may become unstable if the error sensing means 121, 123 is obstructed. An obstructed error sensing device 121, 123 may result in the noise cancellation means 140 not responding to changes in the output of the noise cancellation system 100. Thus, as a result, the system may increase the magnitude of the noise cancellation signal 141, thereby causing unwanted noise

within the cabin. Advantageously, the noise cancellation system 100 detects the incorrect operation of the noise input error sensing means 121, 123, such as caused by the obstruction, in dependence on the proximity signal.

5 In some embodiments, the weight value of the error signal 122, 124 is substantially reduced to zero in dependence on the proximity signal 132, 134. In some cases, the weight value of the error signal 122, 124 is reduced to an intermediate value between zero and one in dependence on the proximity signal 132, 134.

10 Advantageously, by detecting the obstruction to the error sensing device 121 via the proximity sensing device 131, the influence of the error signal 122 received from the error sensing means 120 can be reduced in determination of the noise cancellation signal 141, thus reducing a likelihood of a potentially unstable feedback loop, and allowing the noise cancellation means 140 to maintain a stable noise cancellation
15 signal 141.

In some embodiments, in dependence on receiving a proximity signal 132, 134 indicating an obstruction, the noise cancellation means 140 may assign the error signal 122, 124 a predetermined value in dependence on the proximity signal 132,
20 134. For example, the noise cancellation means 140 may assign the error signal value to a predetermined 'good' level or value for determining the noise cancellation signal 141.

In some embodiments, on receiving a proximity signal 132, 134 indicating an
25 obstruction, the noise cancellation means 140 may assign a historic value to the error signal 122, 124 for determining the noise cancellation signal 141. For example, on receiving the proximity signal 132, 134 the last known 'good' error signal value before the obstruction was detected may be used for determining the noise cancellation signal 141. One or more previous values of the error signal may be stored in the
30 memory of the noise cancellation means 140 and periodically updated.

In some embodiments, each error sensing means 120 may be arranged to measure a Sound Pressure Level, SPL. The noise cancellation means 140 may be arranged to reduce the weight value of the received error signal 122, 124 based on a
35 difference in SPL measured by the error sensing device 121, 123, in dependence on the difference exceeding a predetermined threshold.

Figure 2 shows a noise cancellation means 200, which may correspond to the noise cancellation means 140 of Figure 1, in more detail. In some embodiments, the noise cancellation means 200 comprises a processing means 210 and a data storage means 220. The processing means 210 is arranged to receive the one or more noise signals 112, 114 from the noise input means 110. The processing means 210 may be arranged to receive the one or more error signals 122, 124 and the one or more proximity signals 132, 134 from the error sensing means 120 and the proximity sensing means 130, respectively. The processing means 210 is arranged to determine the noise cancellation signal 141 in dependence on the received noise signals 112, 114, error signals 122, 124. As described above, the weight value of the error signals 122, 124 is controlled, such as being reduced, in dependence on the received one or more proximity signals 132, 134. In some embodiments, values of the received signals may be stored in the data storage means 220. In some embodiments, values associated with the generated noise cancellation signal 141 are stored in the data storage means 220. The data storage means 220 may thus be used to store the last known 'good' signal values. A 'good' signal value may comprise the last signal that was received or output, or a signal that is within a predetermined threshold. A 'good' signal value may also comprise a signal wherein one or more predetermined conditions are met. For example, a 'good' error signal value may comprise an error signal value with an associated proximity signal value that is below a predetermined threshold.

Figure 3 illustrates a method 300 according to an embodiment of the present invention. The method 300 is a method of processing noise signals and proximity signals from noise input means and proximity input means within a vehicle, and generating a noise cancellation signal wherein the noise is substantially reduced. The method 300 may be performed by the noise cancellation system 100 as described above according to an embodiment of the present invention.

In step 310, one or more noise signals indicative of noise, such as ambient or operational noise, associated with the vehicle is generated from at least one noise input means. In some embodiments, the one or more noise signals may be indicative of noise heard within one or more noise zones within the vehicle. In one embodiment, substantially the entire interior of the vehicle is considered as one noise zone. However, in some embodiments, a plurality of noise zones are located in the vehicle. At least one specific noise signal may be generated for each respective noise zone.

That is, different noise signals corresponding to each respective noise zone may be generated.

5 In step 320, one or more error signals indicative of a noise cancellation error is generated by at least one error sensing means. In an embodiment of the invention, the one or more error signals may correspond to the noise zones, such that each error signal may be associated with a respective noise signal. However in other embodiments more than one error signal may be associated with one noise zone.

10 In step 330, one or more proximity signals indicative of an obstruction in proximity to the error sensing means is generated by proximity sensing means. In an embodiment of the invention, each proximity signal may be associated with a respective error signal.

15 In step 340, a noise cancellation signal is determined in dependence on the one or more noise signals and the one or more error signals. The noise cancellation signal may be arranged such that the filter coefficients used in calculating the noise cancellation signal are modified in dependence on the received error signal. For example, a high error signal indicates an inaccurate noise cancellation signal. The
20 filter coefficients used in calculating subsequent noise cancellation signals may therefore be modified to try and minimise the error, thereby forming a feedback loop.

In an embodiment of the invention, the noise cancellation signal may further be determined based on the one or more proximity signals. In an embodiment of the
25 invention, determining the noise cancellation signal may involve receiving at least one proximity signal and controlling the weight value of the error signal corresponding with the received proximity signal. In some embodiments, the weight value of the error signal is reduced in dependence on the proximity signal being indicative of an obstruction. In some embodiments, the weight value of the error
30 signal is substantially reduced to zero on receipt of a corresponding proximity signal. For example, a proximity signal may indicate that an error signal is dampened or muffled, due to obstruction of the error sensing means. In this case, the error signal will not accurately reflect the error signal in the vehicle due to the obstruction. Subsequent noise cancellation signals will thus become unstable if a muffled error
35 signal is used to determine the noise cancellation signal. This result in the system will rapidly increase its output causing unwanted noise within the cabin. Alternatively, as discussed above, the weight value of the error signal may be reduced to an

intermediate value between zero and one on receipt of a corresponding proximity signal.

5 By reducing the weight value, and thus the influence, of the error signal that is associated with a proximity signal indicative of an obstruction in proximity error sensing means, the determined noise cancellation signal advantageously provides for a more accurate reflection of the signal that is utilised in reducing noise in the vehicle.

10 In some embodiments, when a proximity signal is generated indicative of an obstruction in proximity to the error sensing means, a predetermined value in dependence on the proximity signal may be assigned to the error signal. For example, the error signal may be assigned to a predetermined 'good' value for determining the noise cancellation signal 141.

15 In some embodiments, on receiving a proximity signal indicative of an obstruction in proximity to the error sensing means a historic value may be assigned to the error signal 122, 124 for determining the noise cancellation signal 141. For example, on receiving the proximity signal the last known 'good' error signal value before the
20 obstruction was detected may be used for determining the noise cancellation signal 141.

In some embodiments, the noise input means 110 may be arranged to measure a Sound Pressure Level, SPL. The active noise cancellation means 130 may then be
25 arranged to reduce the weight value of an error signal 122, 124 based on a difference in SPL measured by the noise input devices 121, 123, wherein the difference exceeds a predetermined threshold.

Figure 4 shows a vehicle according to an embodiment of the invention. The vehicle
30 may be a wheeled vehicle. However embodiments of the invention are also useful with water- or aircraft.

It will be appreciated that embodiments of the present invention can be realised in the form of hardware, software or a combination of hardware and software. Any such
35 software may be stored in the form of volatile or non-volatile storage such as, for example, a storage device like a ROM, whether erasable or rewritable or not, or in the form of memory such as, for example, RAM, memory chips, device or integrated

circuits or on an optically or magnetically readable medium such as, for example, a CD, DVD, magnetic disk or magnetic tape. It will be appreciated that the storage devices and storage media are embodiments of machine-readable storage that are suitable for storing a program or programs that, when executed, implement
5 embodiments of the present invention. Accordingly, embodiments provide a program comprising code for implementing a system or method as claimed in any preceding claim and a machine readable storage storing such a program. Still further, embodiments of the present invention may be conveyed electronically via any medium such as a communication signal carried over a wired or wireless connection
10 and embodiments suitably encompass the same.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least
15 some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless
20 expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of any foregoing embodiments. The invention extends to any novel one, or any novel combination, of the features
25 disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed. The claims should not be construed to cover merely the foregoing embodiments, but also any embodiments which fall within the scope of the claims.

CLAIMS

1. A system for a vehicle, the system comprising:
 - noise input means for generating a noise signal indicative of noise;
 - 5 error sensing means for generating an error signal indicative of a noise cancellation error at a location in the vehicle;
 - proximity sensing means for generating a signal indicative of an obstruction proximal to the error sensing means and outputting a proximity signal in dependence thereon; and
 - 10 noise cancellation means arranged to determine a noise cancellation signal in dependence on the noise signal, the error signal and the proximity signal, and to output the noise cancellation signal to an audio output means for reducing noise in the vehicle,
 - wherein the noise cancellation means is arranged to control a weight
 - 15 value associated with the error signal in the determination of the noise cancellation signal, wherein said weight value is controlled in dependence on the proximity signal.
2. A system as claimed in claim 1, wherein the noise cancellation means is
- 20 arranged to reduce said weight value in dependence on the proximity signal.
3. A system as claimed in claim 2, wherein the weight value is reduced substantially to zero in dependence on the proximity signal.
- 25 4. A system as claimed in claim 1 or claim 2, wherein the noise cancellation means is arranged to assign a predetermined value to the error signal in dependence on the proximity signal.
5. A system as claimed in claim 1 or claim 2, wherein the noise cancellation
- 30 means is arranged to assign a value to the error signal equivalent to the value prior to the obstruction proximal to the error sensing means being detected by the proximity sensing means.
6. A system as claimed in any preceding claim, wherein the proximity sensing
- 35 means comprises an optical detector arranged to determine an optical parameter from which the presence of an obstruction proximal to the error sensing means can be determined.

7. A system as claimed in claim 6 wherein the optical parameter is an ambient light level at the optical detector and the proximity signal is indicative of a reduction in the ambient light level.
- 5 8. A system as claimed in claim 7, wherein the proximity sensing means comprises a light emitter and the optical detector is arranged for detecting reflected light from the light emitter.
- 10 9. A system as claimed in claim 8, wherein the optical detector is arranged to output the proximity signal indicative of the intensity of the reflected light.
10. A system as claimed in any of claims 1 to 9, wherein the proximity sensing means comprises a capacitive sensor.
- 15 11. A system as claimed in any of claims 1 to 9, wherein the proximity sensing means comprises an ultrasonic transceiver arranged to output the proximity signal in dependence on reflected ultrasonic signals.
- 20 12. A system as claimed in any preceding claim, wherein the noise input means is arranged to measure a sound pressure level, SPL.
13. A system as claimed in claim 12, wherein the noise cancellation means is arranged to reduce the weight value of the error signal when a difference in SPL is above a predetermined threshold.
- 25 14. A system as claimed in any preceding claim, wherein the noise input means comprises one or more vibro-acoustic devices.
- 30 15. A system as claimed in any preceding claim wherein the weight value is set to an intermediate value between zero and one in dependence on the proximity signal.
- 35 16. A method of noise cancellation for a vehicle, the method comprising:
generating a noise signal indicative of noise;
generating an error signal indicative of a noise cancellation error at a location in the vehicle;

generating a proximity signal indicative of an obstruction proximal to the location of the generation of the error signal;

determining a noise cancellation signal in dependence on the noise signal, the proximity signal, and the error signal for reducing noise in the vehicle; and

outputting the noise cancellation signal to an audio output means for reducing noise in the vehicle,

wherein, when determining the noise cancellation signal, a weight value associated with the error signal is controlled in dependence on the received proximity signal.

17. A method as claimed in claim 16, wherein the weight value is reduced in dependence on the proximity signal.

18. A method as claimed in claim 17, wherein the weight value is reduced substantially to zero in dependence on the proximity signal.

19. A method as claimed in claim 16 or claim 17, comprising assigning a predetermined value to the error signal in dependence on the received proximity signal.

20. A method as claimed in claim 16 or claim 17, comprising assigning a value to the error signal equivalent to the value prior to the obstruction proximal to the error sensing means being detected.

21. A method as claimed in any of claims 16 to 20 wherein the generation of the noise signal comprises determining a sound pressure level, SPL.

22. A method as claimed in claim 21, comprising reducing the weight value of the received error signal when a difference in determined SPL is above a predetermined threshold.

23. A method as claimed in any of claims 16 to 22 wherein the weight value associated with the error signal is set to an intermediate value between zero and one in dependence on the proximity signal.

24. A controller for a noise cancellation system, the controller comprising:
an input for receiving a noise signal indicative of noise;

an input for receiving an error signal indicative of a noise cancellation error at a location in a vehicle;

an input for receiving a proximity signal indicative of an obstruction proximal to the error input means; and

5 processing means for determining a noise cancellation signal in dependence on the noise signal, the error signal and the proximity signal, and for outputting the noise cancellation signal to an audio output means for reducing the noise in the vehicle,

10 wherein the processing means is arranged to determine the noise cancellation signal by controlling a weight value associated with the error signal in the determination of the noise cancellation signal, wherein said weight value is controlled in dependence on the proximity signal.

15 25. A controller as claimed in claim 24, wherein the processing means is arranged to reduce the weight value of the error signal based on the received proximity signal.

20 26. A controller as claimed in claim 24 or claim 25, wherein the said weight value is set to an intermediate value between zero and one in dependence on the proximity signal.

25 27. A vehicle comprising a system as claimed in any of claims 1 to 15 or the controller of any of claims 24 to 26, or arranged to perform a method according to any of claims 16 to 23.

28. Computer software which, when executed by a processor, performs the method according to any of claims 16 to 23.

30 29. A computer readable storage medium comprising the computer software of claim 28; optionally wherein the computer readable storage medium is a non-transitory medium.

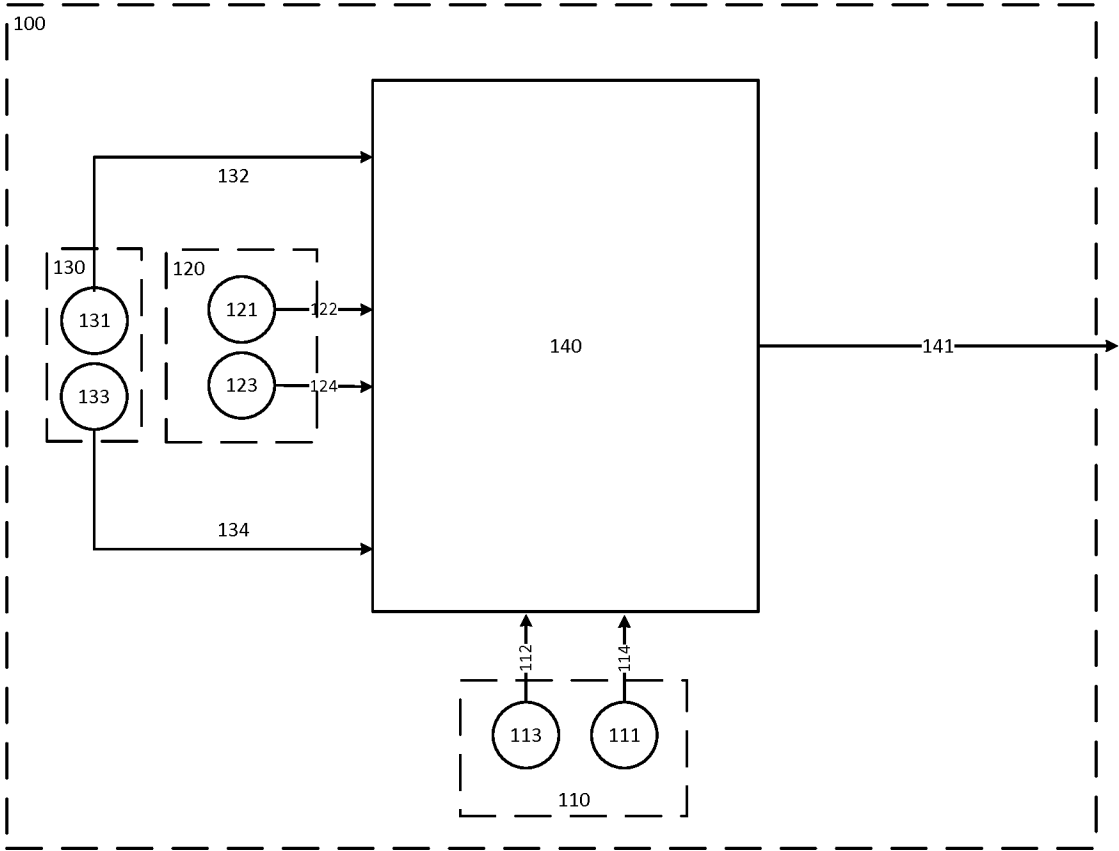


Fig. 1

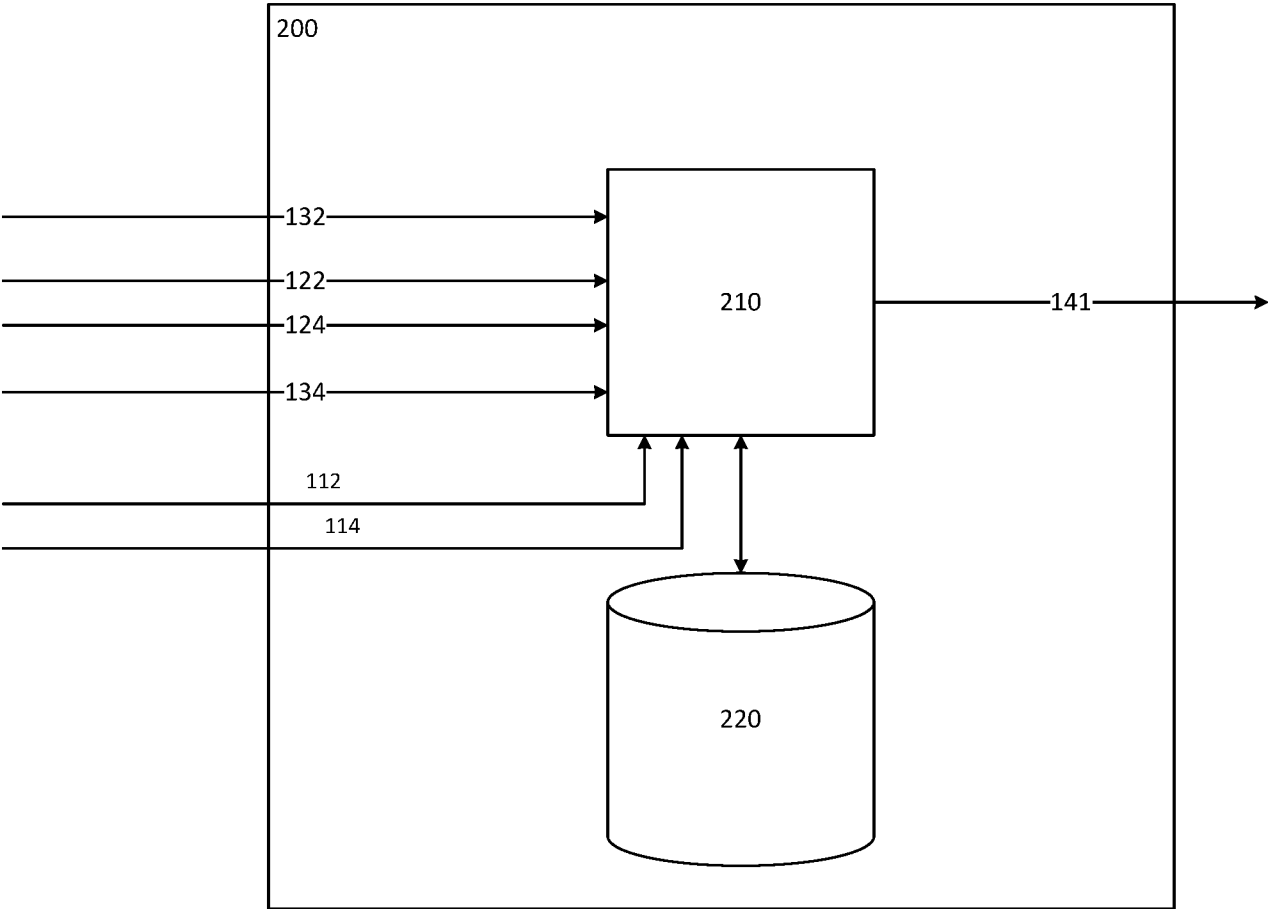


Fig. 2

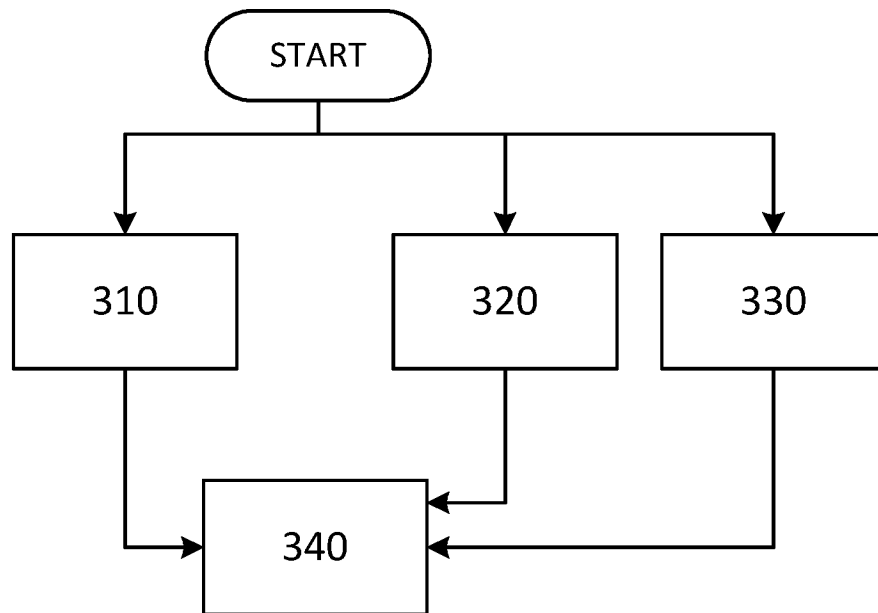


Fig. 3

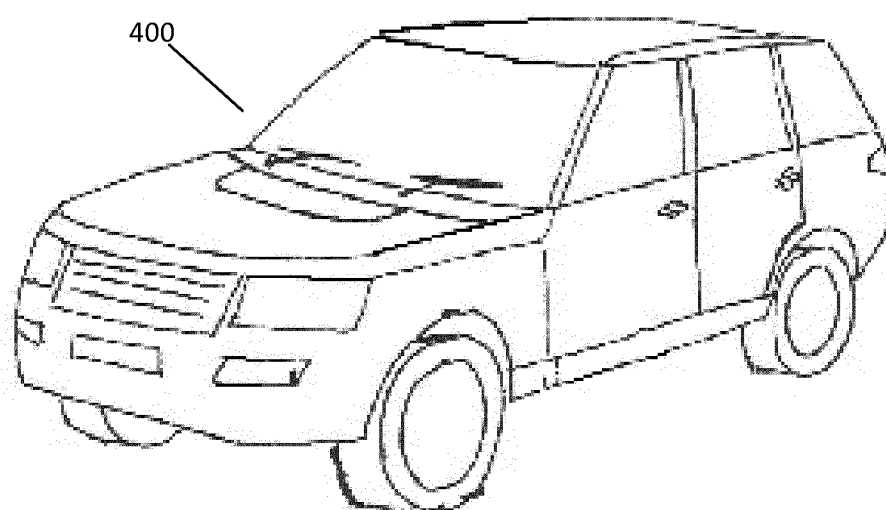


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2018/054874

A. CLASSIFICATION OF SUBJECT MATTER
 INV. G10K11/178
 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)
 G10K

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

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X	US 2010/124337 A1 (WERTZ DUANE [US] ET AL) 20 May 2010 (2010-05-20) figures 3,6,7,8 abstract paragraphs [0009] - [0011] paragraphs [0073], [0075], [0081] claim 21 ----- -/-	1-3, 15-18, 23-29



Further documents are listed in the continuation of Box C.



See patent family annex.

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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

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"&" document member of the same patent family

Date of the actual completion of the international search

7 June 2018

Date of mailing of the international search report

19/06/2018

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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2018/054874

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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Information on patent family members

International application No

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