



(11)

**EP 3 382 663 A1**

(12)

**EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
**03.10.2018 Bulletin 2018/40**

(51) Int Cl.:  
**G08B 3/10 (2006.01) G08B 29/10 (2006.01)**

(21) Application number: **18164555.7**

(22) Date of filing: **28.03.2018**

(84) Designated Contracting States:  
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**  
Designated Extension States:  
**BA ME**  
Designated Validation States:  
**KH MA MD TN**

(30) Priority: **31.03.2017 IT 201700035966**

(71) Applicant: **Magneti Marelli S.p.A.**  
**20011 Corbetta (MI) (IT)**

(72) Inventors:  
• **MAGLIO, Gianluca**  
**I-20011 Corbetta (Milano) (IT)**  
• **MASSIMINO, Paolo**  
**I-20011 Corbetta (Milano) (IT)**  
• **GHAZZA, Matteo**  
**I-20011 Corbetta (Milano) (IT)**  
• **CATALDO, Gianmarco**  
**I-20011 Corbetta (Milano) (IT)**

(74) Representative: **Crovini, Giorgio**  
**Buzzi, Notaro & Antonielli d'Oulx**  
**Via Maria Vittoria, 18**  
**10123 Torino (IT)**

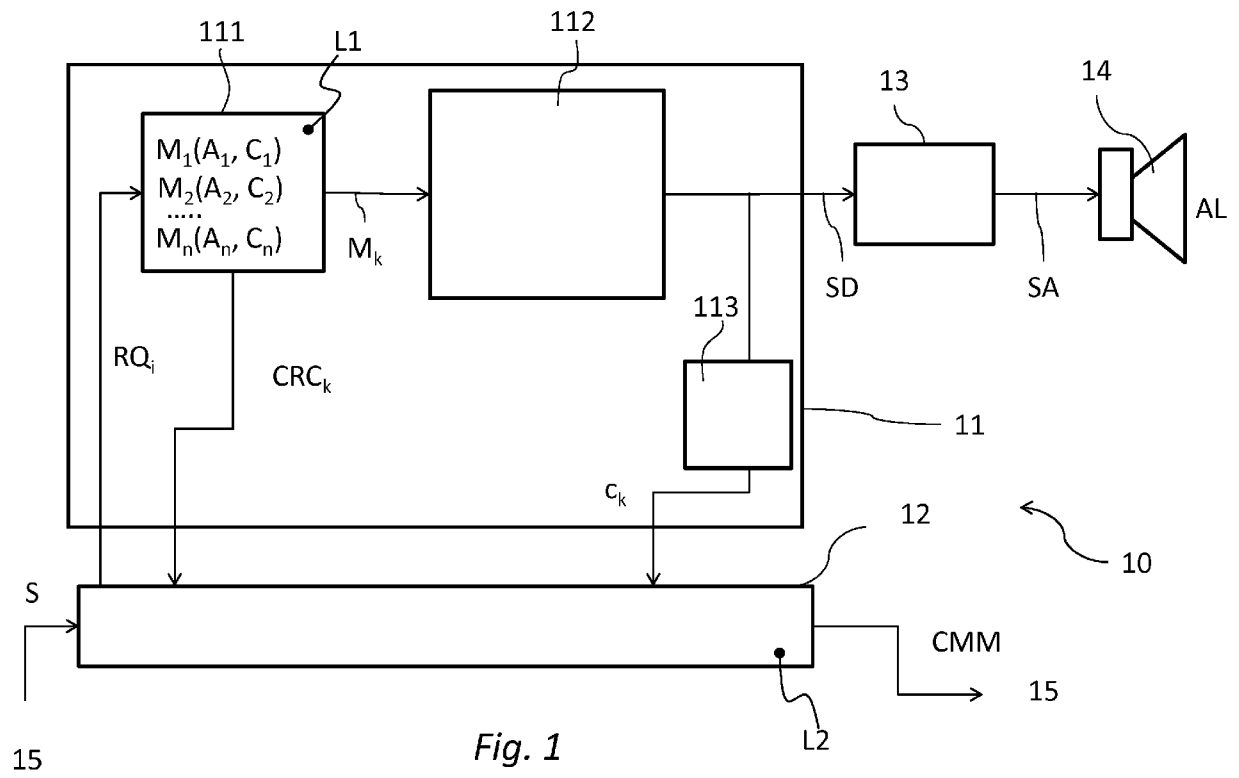
(54) **METHOD FOR GENERATING AND PROPAGATING IN A VEHICLE AN AUDIO ALARM WARNING AND CORRESPONDING APPARATUS**

(57) Described herein is a method for generating and propagating, in a vehicle, an audio alarm warning (AL), operating with a given first class of risk in regard to functional safety (L1), which comprises:  
providing (105), stored, a plurality of acoustic-alarm audio signals (A<sub>i</sub>),  
selecting (120), in said plurality of acoustic-alarm audio signals (A<sub>i</sub>) stored, an acoustic-alarm audio signal (A<sub>i</sub>) to be propagated in the audio alarm warning (AL) and fetching said acoustic-alarm audio signal (A<sub>i</sub>), and  
carrying out audio reproduction (190) of said acoustic-alarm audio signal (A<sub>i</sub>)-

The method described envisages:  
providing (105), stored, operating with a second class of risk in regard to functional safety (L2), lower than said first class of risk (L1), a plurality of combined audio signals (M<sub>i</sub>) comprising said acoustic-alarm audio signals (A<sub>i</sub>) associated to respective identification signals (C<sub>i</sub>)

that represent respective identifier codes (c<sub>i</sub>),  
selecting (120), in said plurality of combined audio signals (M<sub>1</sub>, ..., M<sub>n</sub>) a combined audio signal (M<sub>i</sub>) that corresponds to the acoustic-alarm audio signal (A<sub>i</sub>) to be propagated in the audio alarm warning (AL), and fetching said combined audio signal (M<sub>k</sub>) from the plurality of combined audio signals (M<sub>i</sub>),  
extracting (130), from said combined audio signal (M<sub>k</sub>) fetched, said identification signal (C<sub>i</sub>), and extracting (130), from said identification signal (C<sub>i</sub>), said identifier code (c<sub>i</sub>),  
verifying (150), operating according to said first class of risk (L1), the correspondence between said identifier code (c<sub>k</sub>) of the combined audio signal (M<sub>k</sub>) fetched and the identifier code (c<sub>i</sub>) of the acoustic-alarm audio signal (A<sub>i</sub>) to be propagated in the audio alarm warning (AL).

**EP 3 382 663 A1**



**Description****TEXT OF THE DESCRIPTION**

**[0001]** The present invention relates to techniques for generating and propagating an audio alarm warning in a vehicle, in particular an automotive vehicle or a motorcycle, with a given class of risk in regard to functional safety.

**[0002]** In the field of electronic safety, in particular applied to the automotive sector, standards apply for ensuring functional safety. In particular, for example, ISO26262 standard regards functional safety of road vehicles, with reference to safety of the electrical and/or electronic systems in production automobiles and has been defined by the International Organization for Standardization (ISO) in 2011.

**[0003]** The above standards require, for example, that the audio alarms emitted by a vehicle, in particular within the passenger compartment, for an alarm warning that can notify that the safety belts are not fastened, or else lane departure, or else a parking distance, must be emitted via components and procedures that comply with a given safety level, for example an ASIL (Automotive Safety Integrity Level) in such a way that the presence of a known acoustic alarm within an audio stream that is sent to the speaker or audio-player systems is verified in a safe way. It should be emphasized that the above stream in general comprises, in addition to the alarm, an arbitrary set of other audio sources.

**[0004]** In general, this is obtained by generating the alarm signals necessary in a digital way, for example by processing them via a DSP (Digital Signal Processing) circuit and sending them to an amplifier that creates an amplified analog signal for a speaker, which propagates the alarm signal within the passenger compartment, generation of the alarm signals being carried out via an electronic module, usually a SoC (System-on-Chip), in which all the components respect the required class of risk or safety level, for example ASIL. In this way, it is possible to ensure the presence of a known acoustic alarm within a digital or analog audio stream that is the result of mixing of an arbitrary set of other audio sources.

**[0005]** However, since the components qualified with a given ASIL are in general more costly, the above solution presents the drawback of being as a whole very costly.

**[0006]** The object of the present invention is to provide a method for generating and propagating an audio alarm warning in a vehicle with a given required safety level that will be less costly.

**[0007]** According to the present invention, the above object is achieved thanks to a method for generating and propagating an audio alarm warning in a vehicle, as well as to a corresponding apparatus for generating and propagating an audio alarm warning in a vehicle that present the characteristics recalled specifically in the ensuing claims.

**[0008]** The invention will now be described with reference to the annexed drawings, which are provided purely by way of non-limiting example and in which:

- Figure 1 is a schematic illustration of an apparatus for generating and propagating a signal, which operates according to the method described herein;
- Figure 2 illustrates in greater detail the apparatus of Figure 1;
- Figures 3A, 3B, and 3C illustrate spectra of signals transmitted in the apparatus of Figure 1;
- Figure 4 illustrates a flowchart that represents an embodiment of the method described herein;
- Figure 5 illustrates a spectrum of a signal measured in an implementation of the apparatus of Figure 1; and
- Figures 6A, 6B, and 6C illustrate three different configurations of the apparatus that implements the method described herein.

**[0009]** In brief, the solution described herein envisages insertion, within the alarm to be verified, of encoded information, preferably such as to be non-audible to the human ear, which is able to carry information useful for determining the presence of the signal in question.

**[0010]** The final result is determination of the presence or absence of the alarm to be verified within the digital or analog audio stream.

**[0011]** This enables determination of the presence or absence of the alarm to be verified within the digital or analog audio stream.

**[0012]** Figure 1 shows a block diagram representing an apparatus for generating and propagating an audio alarm acoustic warning AL, designated as a whole by the reference number 10, which implements the method described herein.

**[0013]** Designated by the reference number 11 is an electronic module, more specifically a SoC (System-on-Chip), configured for generating a digital audio signal SD, which is then supplied to an amplifier 13, which in turn supplies at output an analog audio signal SA to a audio-player apparatus 14, specifically a speaker, which propagates an audio alarm acoustic warning AL in the passenger compartment of a vehicle. The audio-player apparatus 14 may correspond to a dedicated speaker, such as a stereo speaker with which the vehicle is equipped. Moreover represented in Figure 1 is a control module 12, which may, for example, be obtained via the microprocessor or control unit of the vehicle responsible for the safety functions (for example, the instrument panel, the body computer, etc.). The control module 12 in practice receives sensor signals S from one or more sensors of the vehicle (not represented in Figure 1), which contain measurement values, for example measured values of pressure of the tyres, or else alarm warnings processed locally by the sensor on the basis of the measurements or detections, for example an alarm notifying that the safety belts are not fastened, or an LDW (Lane-Departure

Warning), alarms concerning breakdown of driver-assistance or autonomous-drive systems, etc.

**[0014]** The module 11 for generation of a digital audio signal SD, according to the solution described herein, comprises a memory module 111, stored in which is a plurality of combined alarm messages,  $M_1, M_2, \dots, M_i, \dots, M_n$ , where  $n$  is the number of combined alarm messages  $M_i$  stored and  $i$  is the index of the generic  $i$ -th combined alarm message. Each  $i$ -th combined alarm message  $M_i$  comprises an acoustic-alarm audio signal  $A_i$ , which corresponds to a warning for a given type of alarm, for example a repeated tone to notify that a safety belt is not fastened. The acoustic-alarm audio signal  $A_i$  is preferably stored as a compressed audio file, for example of an MP3 (Moving Picture Expert Group-1/2 Audio Layer 3) type, even though other types of compression algorithms may be applied. The acoustic-alarm audio signal  $A_i$  is stored in the combined alarm message  $M_i$  associated to an alarm-identifier signal  $C_i$ , which is a signal encoded in which, via digital encoding, is an alarm-identifier code  $c_i$ , for example a number expressed in binary code. This digital encoding is, for example, obtained via PM (Phase Modulation) with minimal spectral occupation, such as to reach bit rates of 100 b/s or higher.

**[0015]** Figure 3A represents in this regard the frequency spectrum  $f$  of the combined alarm message  $M_i$ , which comprises a first frequency band of the acoustic-alarm audio signal  $A_i$ , which is preferably comprised in the human audible frequency range, for example, between 50 Hz and 20 kHz, and a second frequency band, which is the frequency band of the alarm-identifier signal  $C_i$  and is preferably located at the upper limit of the first frequency band, hence around the upper limit or beyond the upper limit of the first frequency band, in particular the band of the audible frequencies, for example around 19-20 kHz. Thanks to the particular characteristics of frequency and amplitude, the encoding signal  $C_i$  will thus be substantially non-audible to the human ear.

**[0016]** Hence, the alarm-identifier signal  $C_i$  and the acoustic-alarm audio signal  $A_i$  are signals having the spectra shown in Figure 3A. Preferably stored in the memory 111 is the message  $M_i$  in the time domain, which substantially corresponds to the superposition, i.e., to the summation of the acoustic-alarm audio signal  $A_i$  and of the alarm-identifier signal  $C_i$ , compressed via encoding, for example, MP3 encoding.

**[0017]** Designated herein by  $M_k$  is the combined alarm message read from the memory module 111 following upon a request  $RQ_i$  made by the control module 12 because it is necessary to verify that the combined alarm message read  $M_k$  corresponds to the combined alarm message  $M_i$  selected. The combined alarm message read  $M_k$  is then sent to a processing module 112 comprised in the electronic module 11, for example, a DSP (Digital Signal Processing) module, which carries out the signal-processing operations necessary for supplying a digital audio signal SD to the amplifier 13, which in turn derives the analog audio signal SA for driving the speaker

14. The processing module 12 carries out, for example, decompression of the combined message read  $M_k$ , compressed with MP3 compression, and operates as digital player. Provided downstream of the output of the processing module 112 is a code-extraction module 113, which selects from the combined audio message read  $M_k$ , for example via frequency filtering, for instance via a band-pass filter with characteristics substantially corresponding, as regards central frequency and bandwidth, to those of the identification signal  $C_i$ , the identification signal  $C_k$  and, moreover, extracts from the identification signal  $C_k$  filtered, the identifier code  $c_k$ , carrying out digital decoding, in the case described by decoding the phase-modulation encoding. In this way, the identifier code  $c_k$  is obtained, which, as has been said, is, for example, a number expressed in binary code, e.g., 0101.

**[0018]** The above identifier code  $c_k$  is sent to the control module 12 to verify that it corresponds to the identifier code  $c_i$  of the combined audio message  $M_i$  selected.

**[0019]** According to an important aspect of the solution described herein, the control module 12 is an electronic component distinguished by a first class of risk L1, for example a given integrity level, specifically a given ASIL (Automotive Safety Integrity Level). The memory module 111 presents a second class of risk L2, which is lower than the first class of risk L1, for example of a QM (Quality Management) type. Alternatively, the second class of risk L2 may correspond to a lower ASIL; for example, the control module 12 has an ASIL D, which is the highest level, whereas the memory module 12 has an ASIL A. In the embodiment described with reference to Figure 1, only the control module 12 is distinguished by the first class of risk L1, whereas the processing module 112, the code-extraction module 113, the amplifier 13, and the audio-player systems 14 are distinguished by the second, lower, class of risk L2.

**[0020]** The control module 12 is configured for evaluating the content of the sensor signals  $S$ , measurements or warnings, and, if the content so requires, for sending to the module 11 for generation of a digital audio signal SD a request  $RQ_i$ , as mentioned previously, that identifies, in the example described herein via the index  $i$  that operates as pointer to the combined message  $M_i$  to be selected, a specific alarm warning to be generated and propagated as audio alarm acoustic warning AL in response to the warnings in the sensor signals  $S$ . The module 11 for generation of a digital audio signal SD is configured for fetching, from the memory module 111, the combined message  $M_i$  with index corresponding to the request  $RQ_i$  and sending it to the speaker 14 so that it is emitted as audio alarm acoustic warning AL, via the chain of modules 11, 13, 14 described above.

**[0021]** It should be noted that, when the combined alarm message  $M_i$  is selected following upon the request  $RQ_i$ , an error-correction code  $CRC_k$  is calculated by computing the checksum of the file corresponding to the combined alarm message  $M_k$  read and is sent to the control module 12 for checking integrity of the combined alarm

message  $M_k$ . In general, if the control module 12, following upon this check, finds that the combined alarm message read  $M_k$  is not intact, it inhibits operation of the apparatus 10 or sends a recovery command CMM as described in greater detail in what follows.

**[0022]** Then, the identifier code  $c_k$  of the message  $M_k$  read is sent to the control module 12 by the code-extraction module 113 so that the control module 12 will verify that the identifier code  $c_k$  of the combined message  $M_k$  read corresponds to the alarm that is actually to be notified, distinguished by the index  $i$ .

**[0023]** Hence, the control module 12, which operates with the first class of risk L1, following upon the result of the verification, can validate or not the identifier code  $c_k$  read.

**[0024]** If the identifier code read  $c_k$  is validated, for example the control module 12 does not carry out any action, and the alarm warning AL is propagated through the audio-player system 14. If the identifier code  $c_i$  is not validated, for example the control module 12 issues a command for carrying out a recovery action CMM on a bus 15 that distributes the signals to the electronic modules and control units of the vehicle, for example a CAN (Controller Area Network) Bus. It should be noted that also the sensor signals  $S$  are preferably carried by the sensors on said CAN Bus to the control module 12. The above recovery action CMM may, for example, envisage repeating the request  $RQ_i$ , i.e., repeating generation of the audio signal by the generation module 11, or else issuing a command for issuing an alternative warning, possibly via a different audio device. Basically, the apparatus of Figure 1 hence makes it possible to obtain a validation at the level of the first class of risk L1, via the control module 12 that is distinguished by the aforesaid first class of risk L1, carrying out a safe monitoring of emission of the correct alarm warning AL, even though the modules for generating a digital audio signal SD do not present the required safety level, i.e., class L1, but a lower level, i.e., class L2. This is obtained by inserting an encoding code  $C_i$  that does not perturb reproduction of the warning; in fact, in general, reaching the audio-player apparatus 14 are also other audio signals  $E$ , the spectrum of which is shown in Figure 3B, where the same frequency and amplitude scales as those of the plot of Figure 3A are used. Usually, when an alarm warning AL is issued, the generation module 11 is configured for reducing the volume of the other audio signals  $E$  in such a way that they do not exceed the alarm warning AL. It should be noted that the other audio signals  $E$  are also generated within the module 11 configured for generating a digital audio signal SD. The processing module 112, in addition to carrying out decompression of the combined message  $M_k$  read, carries out mixing thereof with the other audio sources  $E$ , after prior reduction of their volume. For this purpose, in Figure 3C, the other audio sources with reduced volume, i.e., amplitude, are designated by the reference  $e$ .

**[0025]** Figure 3C hence shows a frequency spectrum

resulting from the sum of the combined message  $M_i$  and of the other audio signals  $e$ , as obtained from the reduction of volume of the other audio signals  $E$  originated by the module 11. As may be noted, a sum signal  $U$  sums the amplitudes in the first frequency band, i.e., the audible frequency band, but the identification signal  $C_i$  is not modified.

**[0026]** Figure 2 shows schematically, but in greater detail, the apparatus 10 of Figure 1. Associated to the memory module 111 is a module for calculation of the error-correction code 1111, which calculates the error-correction code  $CRC_k$ , i.e., the checksum of the message  $M_k$  read to be supplied to the control module 12 in order to verify whether the message  $M_k$  is corrupt. The processing module 112 comprises a decompression module 1121, which supplies a decompressed signal  $dM_i$  to a digital audio-player module 1122, which generates the digital audio signal AD.

**[0027]** The code-extraction module 113 comprises a filtering module 1131, for example a band-pass filter, with central frequency and bandwidth corresponding to those of the identification signal  $C_i$ , so as to receive the digital signal AD and supply at output just the identification signal  $C_k$  on the message  $M_k$  read. This identification signal  $C_k$  is then received by a decoding module 1132, which is configured for decoding the modulation encoding, for example, the phase modulation, and supplying the value, in particular the binary value, of the code  $c_k$  of the combined audio message  $M_k$  read from the memory 111 to the control module 12. The processing module 112 and the extraction module 113 are preferably implemented via the DSP module itself, which in Figure 2 is represented by a dashed block designated by the reference 114.

**[0028]** The control module 12 comprises a further memory 121, stored in which are the error-correction codes  $CRC_1, \dots, CRC_n$  corresponding to the combined messages  $M_1, \dots, M_n$  in the memory module 111, so that the error-correction code  $CRC_k$  calculated in the module 1111 can be compared in the module 12 with the error-correction code stored in order to check the integrity of the message  $M_i$ . The control module 12 comprises a memory 122, stored in which are the identifier codes  $c_1, \dots, c_n$  corresponding to the combined messages  $M_1, \dots, M_n$  in the memory 111, so that the identifier code  $c_k$  extracted by the code-extraction module 113 can be compared with the identifier code  $c_i$  stored, to which the index  $i$  of the request  $RQ_i$  points.

**[0029]** Designated by 123 is a first logic module of the control module 12, which receives the sensor signals  $S$  and generates the corresponding alarm request  $RQ_i$ . The index  $i$  of the alarm request  $RQ_i$  is also sent to a second logic module 124, which is configured for verifying the identifier code  $c_k$  coming from the code-extraction module 113 and the error-correction code  $CRC_k$  coming from the calculation module 1111. The second logic module 124 uses the index  $i$  as pointer for accessing, in the memories 121 and 122, the identifier code  $c_i$  and the error-correction code  $CRC_i$  corresponding to the alarm request

$RQ_i$  and for comparing them with the identifier code  $c_k$  and the error-correction code  $CRC_k$  of the combined audio message  $M_k$  read from the memory 111 that are received via the modules 113 and 1111. The second logic module 124 is then configured for operating also as decider block and, on the basis of the result of the operations of verification on the identifier code and on the error-correction code, for governing actions, for example for issuing the recovery command CMM. It is clear that the logic modules 123 and 124 are preferably implemented via the same programmed microprocessor of the control module 12, and likewise the memories 121 and 122 may preferably be obtained from a memory of the control module or microprocessor itself.

**[0030]** Figure 4 shows a flowchart representing the method for generating and propagating in a vehicle an audio alarm acoustic warning AL having a given required first class of risk L1, in particular implemented in the apparatus 10 of Figure 1.

**[0031]** Designated by 105 is an operation of storing in memory means, in particular in the memory module 111, that present the second class of risk L2 lower than the first class L1, a plurality of combined audio signals  $M_1, \dots, M_n$  that comprise acoustic-alarm audio signals  $A_i$  associated to respective identification signals  $C_i$ , which represent respective identifier codes  $c_i$ . As explained with reference to Figure 3A, the acoustic-alarm audio signals  $A_i$  have a frequency spectrum in a respective band in the audio range, and the identification signals  $C_i$  have a spectrum located in a respective frequency band centred at a frequency higher than the frequencies of the band of the acoustic-alarm audio signal  $A_i$ .

**[0032]** Designated by 110 is an operation of evaluating, in the control module 12, the sensor signals S and sending or not, to the generation module 11, an alarm request  $RQ_i$  for a specific acoustic-alarm audio signal  $A_i$ , on the basis of the contents of the sensor signals S.

**[0033]** Designated by 120 is an operation of reading, in the plurality of combined audio signals  $M_i$ , the combined audio signal  $M_i$  to be selected according to the request  $RQ_i$  and corresponding to an acoustic-alarm audio signal  $A_i$  to be propagated as audio alarm acoustic warning AL. The combined audio message  $M_k$  actually read, the correspondence of which to the combined message  $M_i$  to be selected is to be verified, is subjected, in the course of the operation 120, to an operation of calculation of the error-correction code  $CRC_k$ , for example in the module 1111 of Figure 2, the code  $CRC_k$  being sent on to an operation 140 of error-correction-code verification. If the check on integrity of the combined alarm message  $M_k$  is negative, i.e., the combined alarm message  $M_i$  [ $M_k$ ] is not intact, in a decision step 160 operation of the apparatus 10 is inhibited or a recovery command CMM 12 is issued, as described in further detail in what follows.

**[0034]** Designated by 125 is an operation of processing the above combined audio message  $M_k$  via processing means 112, in particular having the second class of risk

L2.

**[0035]** The combined audio message  $M_k$  is then sent on to an audio-playing step 190, for example via the amplifier 13 and the speaker 14.

**[0036]** Designated by 130 is the operation of extracting, downstream of the processing means 112 via the code-extraction module 113, which carries out a frequency filtering, the identification signal  $C_k$  from the combined audio message  $M_k$  read from the memory 111 and extracting the identifier code  $c_k$  from the identification signal  $C_k$ . Designated by 150 is an operation of verifying the correspondence between the identifier code  $c_k$  and the audio signal  $A_i$  of the alarm warning AL to be notified, i.e., verifying the correspondence with the identifier code  $c_i$  corresponding to the request  $RQ_i$ , in the control module 12, in particular, the microprocessor, having the first class of risk L1.

**[0037]** In the case of positive outcome in step 150, i.e., in the case where the identifier code  $c_k$  read from the memory 111 is validated, namely, it corresponds to the identifier code  $c_i$  required via the request  $RQ_i$ , in the decision step 160 a command is issued not to carry out any action, and the alarm warning AL is propagated through the audio-player systems 14. In the case of negative outcome in step 150, i.e., if the identifier code  $c_k$  read from the memory 111 in step 120 and extracted in step 130 is not validated, for example in the decision step 160 a command is issued for carrying out an action of recovery CMM on a bus 15 that distributes the signals to the electronic modules and control units of the vehicle, for example a CAN Bus. This recovery action CMM may, for example, envisage repeating the request  $RQ_i$ , i.e., repeating generation of the audio signal by the module 11, or else governing issuing of an alternative warning, possibly via a different audio device.

**[0038]** Figure 5 shows a diagram that represents a spectrum of the message  $M_i$  actually measured. The signal  $A_i$  in this case has a peak around 500 Hz, in the frequency range of audible signals, whereas the identification signal  $C_i$  has a peak at approximately 20 kHz.

**[0039]** Figures 6A, 6B, and 6C represent three possible different embodiments of the method and apparatus described herein.

**[0040]** In Figure 6A, the identification signal  $C_k$  is acquired upstream of the amplifier 13, as in Figure 1.

**[0041]** In Figure 6B, the identification signal  $C_i$  is acquired downstream of the amplifier 13 and upstream of the audio-player systems 14. Since the signal is analog, it is supplied to an analog-to-digital converter 16 so that the signal can be sent back to the module 12.

**[0042]** In Figure 6C, the identification signal  $C_i$  is acquired downstream of the audio-player systems 14 via a microphone 17 and the analog-to-digital converter 16.

**[0043]** In all three cases, at least the memory module 111 and the processing module 112 are distinguished by the second class of risk L2, for example QM, whereas at least the control module 12 is distinguished by the first class of risk L1, for example ASIL D. Preferably, also the

module 112 belongs to the lower class of risk.

[0044] Hence, from what has been described above, the advantages of the solution proposed emerge clearly.

[0045] The method and apparatus described enable generation of an alarm with the desired class of risk, using components with a lower class of risk and hence less costly. This is obtained by using an encoding of the alarms that advantageously does not disturb reproduction of the signal.

[0046] It should be noted that preferably the first frequency band, of the acoustic-alarm audio signal, is in the audible frequency range. However, the first frequency band may have portions also outside of the audible frequency range. The second frequency band, of the identifier signal, is preferably set at the upper limit or beyond the upper limit of the frequencies of the first frequency band of the acoustic-alarm audio signals, in order not to disturb reproduction of the audio signal, but falling within the scope of the solution described herein are also other positionings in frequency of the second frequency band of the identifier signal.

## Claims

1. A method for generating and propagating in a vehicle an audio alarm warning (AL) operating with a given first class of risk in regard to functional safety (L1), which comprises:

providing (105), stored, a plurality of acoustic-alarm audio signals ( $A_i$ ),  
selecting (120), in said plurality of acoustic-alarm audio signals ( $A_i$ ) stored, an acoustic-alarm audio signal ( $A_i$ ) to be propagated in the audio alarm warning (AL) and fetching said acoustic-alarm audio signal ( $A_i$ ), and  
carrying out audio reproduction (190) of said acoustic-alarm audio signal ( $A_i$ )  
said method being **characterized by**:

providing (105), stored, operating with a second class of risk in regard to functional safety (L2), lower than said first class of risk (L1), a plurality of combined audio signals ( $M_i$ ) comprising said acoustic-alarm audio signals ( $A_i$ ) associated to respective identification signals ( $C_i$ ) that represent respective identifier codes ( $c_i$ ),  
selecting (120), in said plurality of combined audio signals ( $M_1, \dots, M_n$ ) a combined audio signal ( $M_i$ ) that corresponds to the acoustic-alarm audio signal ( $A_i$ ) to be propagated in the audio alarm warning (AL), and fetching said combined audio signal ( $M_k$ ) from the plurality of combined audio signals ( $M_i$ ),  
extracting (130), from said combined audio signal ( $M_k$ ) fetched, said identification signal

( $C_i$ ), and extracting (130), from said identification signal ( $C_i$ ), said identifier code ( $c_i$ ),  
verifying (150), operating according to said first class of risk (L1), the correspondence between said identifier code ( $c_k$ ) of the combined audio signal ( $M_k$ ) fetched and the identifier code ( $c_i$ ) of the acoustic-alarm audio signal ( $A_i$ ) to be propagated in the audio alarm warning (AL).

2. The method according to Claim 1, **characterized in that** said acoustic-alarm audio signals ( $A_i$ ) have a frequency spectrum in a respective first frequency band, in particular in the human audible frequency range, and said identification signals ( $C_i$ ) have a spectrum positioned in a respective second frequency band, in particular located at a frequency positioned at the upper limit or beyond the upper limit of the frequencies of the first frequency band of the acoustic-alarm audio signals ( $A_i$ ).
3. The method according to Claim 1 or Claim 2, **characterized in that** it comprises processing (125) said combined audio signal ( $M_k$ ) fetched via processing means (112) configured for generating a digital audio signal (SD), and extracting (130), downstream of said processing means (112), said identification signal ( $C_k$ ) from said combined audio signal ( $M_k$ ).
4. The method according to Claim 3, **characterized in that** said processing operation (125) comprises carrying out a decompression of the combined audio signal ( $M_k$ ) and a digital reproduction of the combined audio signal ( $M_k$ ).
5. The method according to any one of the preceding claims, **characterized in that** said processing operation (125) is implemented via processing means (112) that operate with said second class of risk (L2).
6. The method according to any one of the preceding claims, **characterized in that** said operation of extracting (130) from said combined audio signal ( $M_k$ ) fetched said identification signal ( $C_i$ ) comprises a frequency filtering (113), and said operation of extracting (130) from said identification signal ( $C_k$ ) said identifier code ( $c_k$ ) comprises carrying out a decoding of the identification signal ( $C_k$ ).
7. The method according to any one of the preceding claims, **characterized in that** it comprises calculating (1111) an error-correction code (CRC<sub>k</sub>) of the combined audio signal ( $M_k$ ) fetched to verify integrity thereof.
8. The method according to any one of the preceding claims, **characterized in that** said plurality of combined audio signals ( $M_i$ ) is stored compressed, in

particular in MP3 format.

comprises a memory (122) in which the identifier codes ( $c_i$ ) are stored.

9. An apparatus for generating and propagating in a vehicle an audio alarm warning (AL) having a given first class of risk in regard to the required functional safety (L1), which implements the method according to any one of Claims 1 to 8, said apparatus (10) comprising:
  - memory means (111) having said second class of risk in regard to the required functional safety (L2), stored (105) in which is said plurality of combined audio signals ( $M_i$ );
  - a control module (12), in particular a microprocessor, operating in said first class of risk in regard to the required functional safety (L1), configured for:
    - selecting (120) in said plurality of combined audio signals ( $M_i$ ) a combined audio signal ( $M_k$ ) corresponding to the acoustic-alarm audio signal ( $A_i$ ) to be propagated in the audio alarm warning (AL) and fetching said combined audio signal ( $M_k$ ) from the plurality of combined audio signals ( $M_i$ ), and
    - verifying (150) the correspondence between said identifier code ( $c_k$ ) of the combined audio signal ( $M_k$ ) fetched and the identifier code ( $c_i$ ) of the acoustic-alarm audio signal ( $A_i$ ) to be propagated in the audio alarm warning (AL); and
    - an extraction module (113), configured for extracting (130) from said combined audio signal ( $M_k$ ) fetched said identification signal ( $C_i$ ), and extracting (130) from said identification signal ( $C_i$ ) said identifier code ( $c_i$ ).
10. The apparatus according to Claim 9, **characterized in that** it comprises processing means (112), in particular a DSP (Digital Signal Processing) module, which are configured for processing (125) said combined audio signal ( $M_k$ ) fetched and **in that** said extraction module (113) is set downstream of said processing means (112).
11. The apparatus according to Claim 9 or Claim 10, **characterized in that** said processing means (112) operate with said second class of risk (L2).
12. The apparatus according to any one of Claims 9 to 11, **characterized in that** it comprises a module for calculating (1111) an error-correction code ( $CRC_k$ ) of the combined audio signal ( $M_k$ ) fetched to verify integrity thereof.
13. The apparatus according to any one of Claims 9 to 12, **characterized in that** said control module (12)

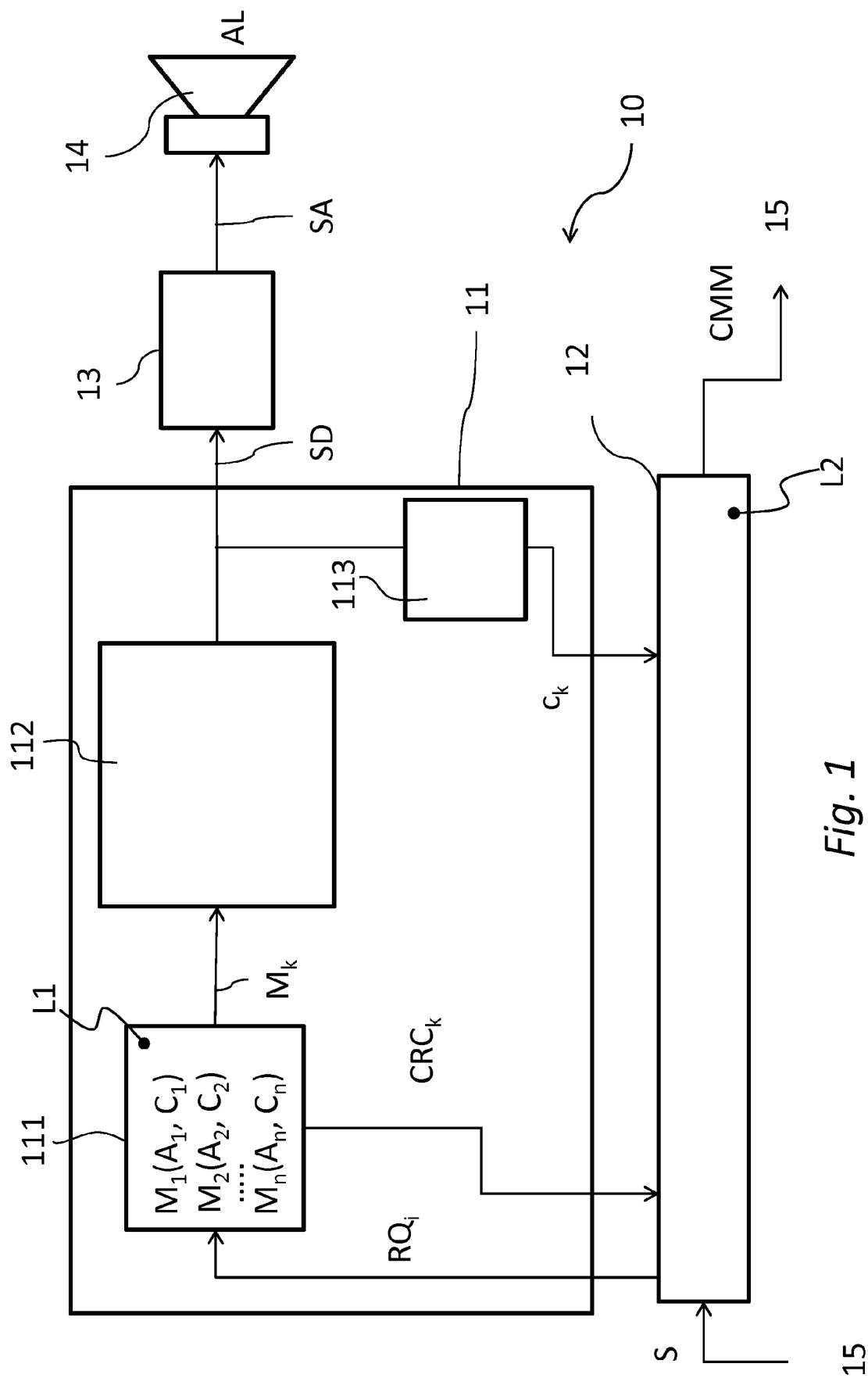
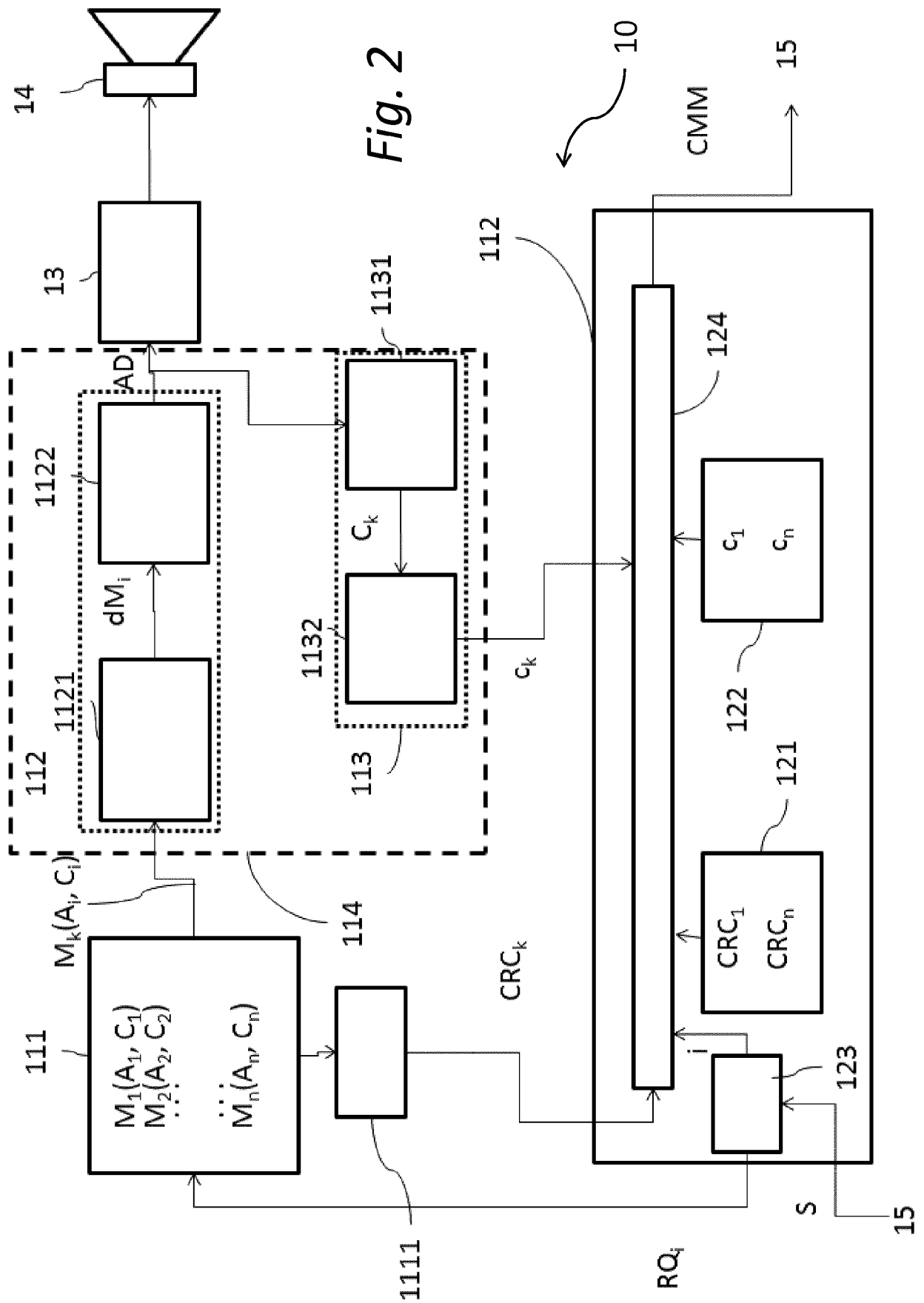


Fig. 1



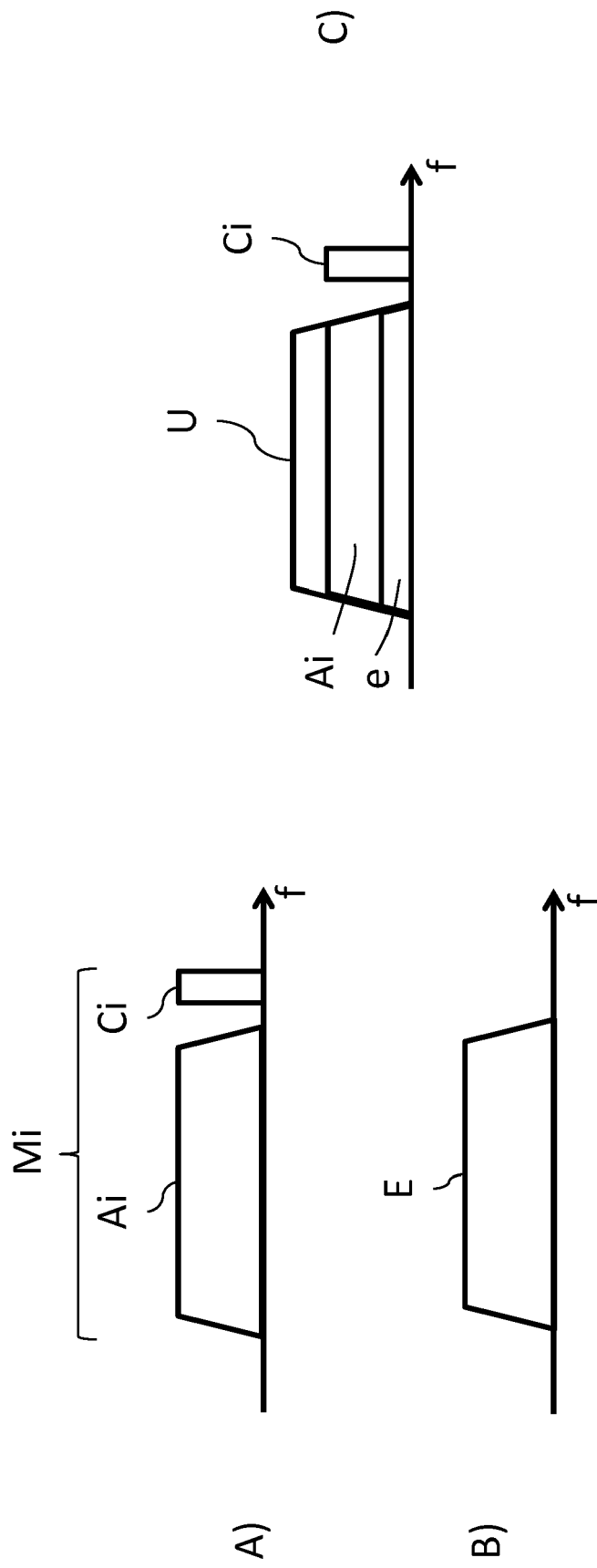
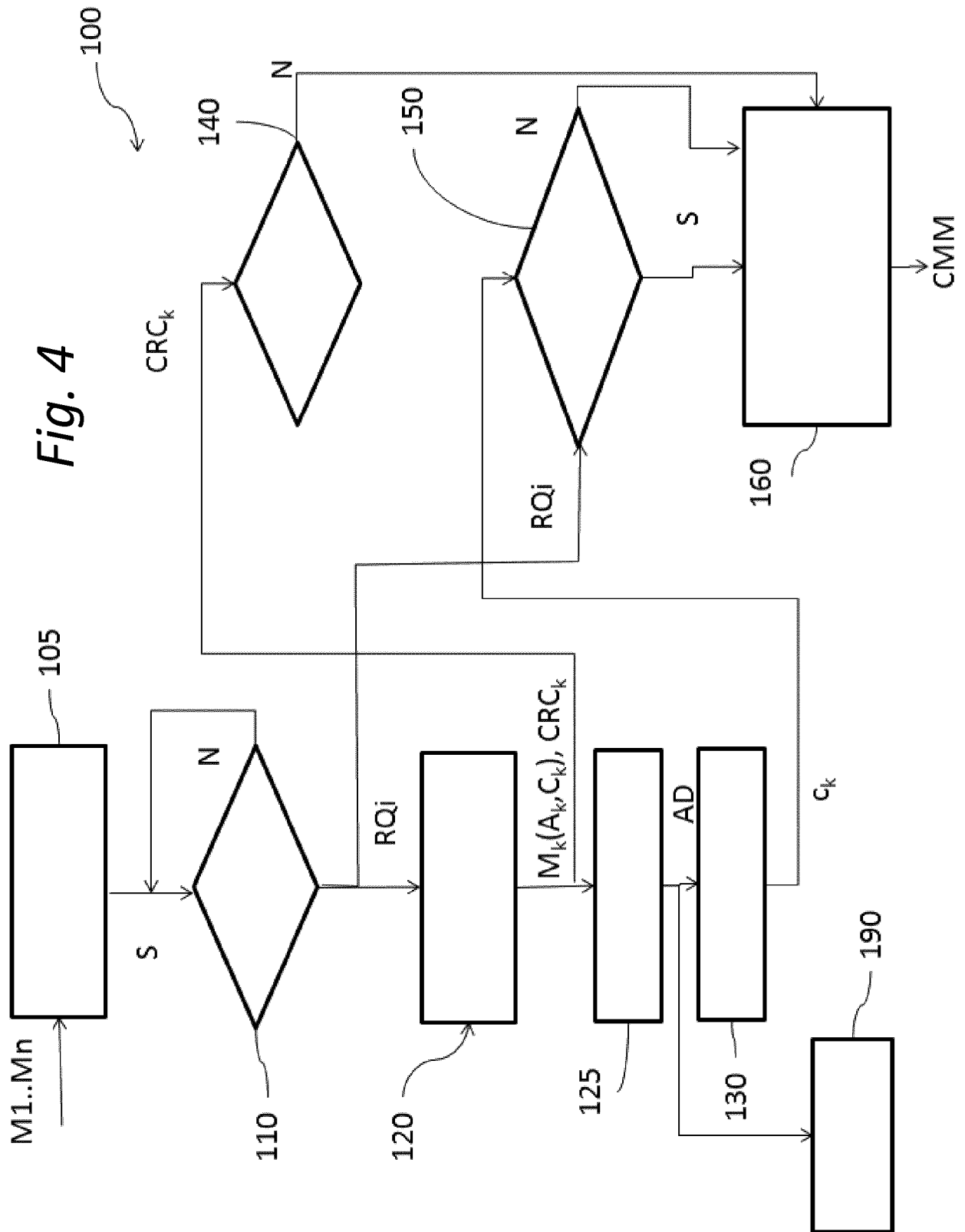
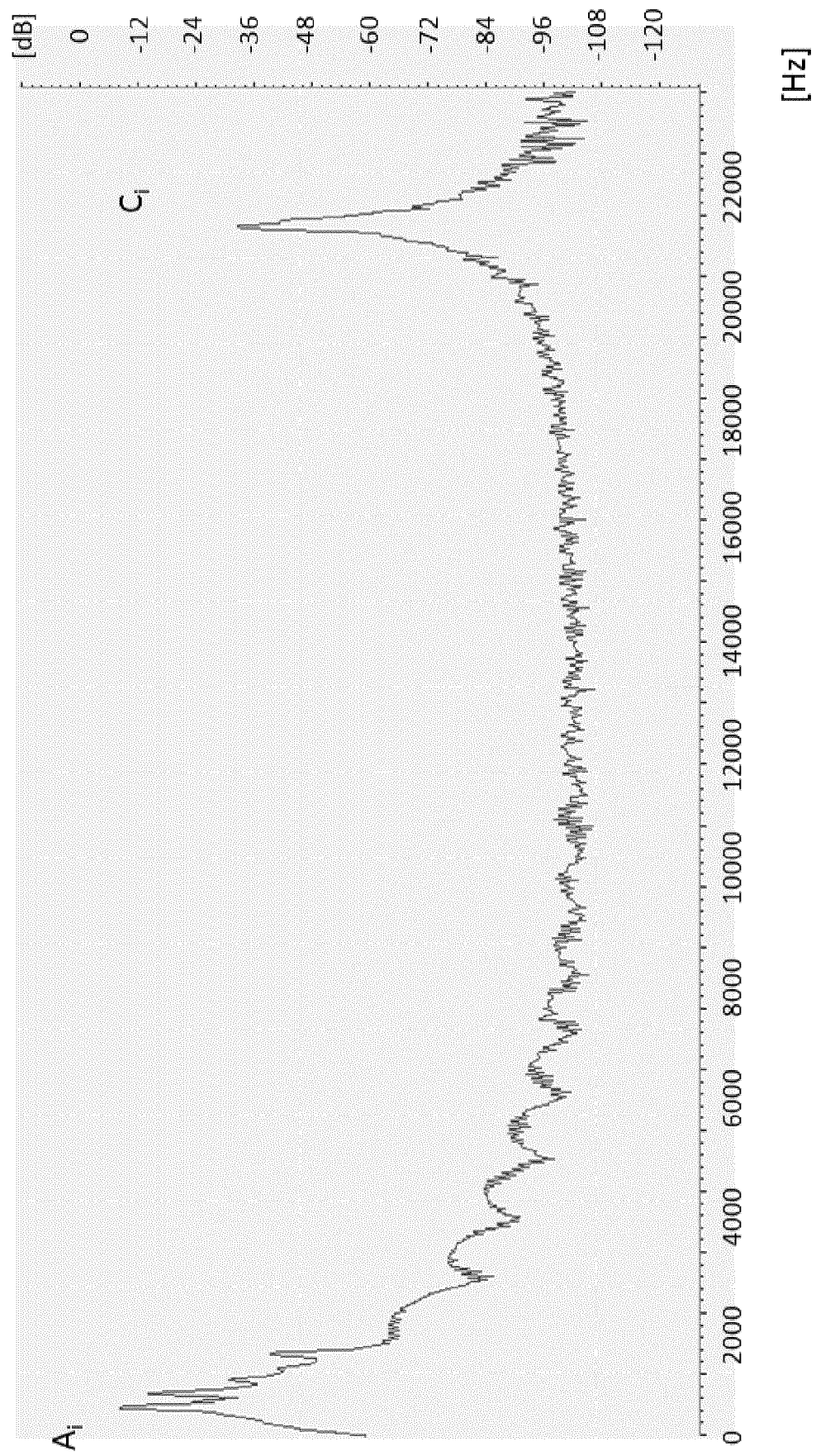
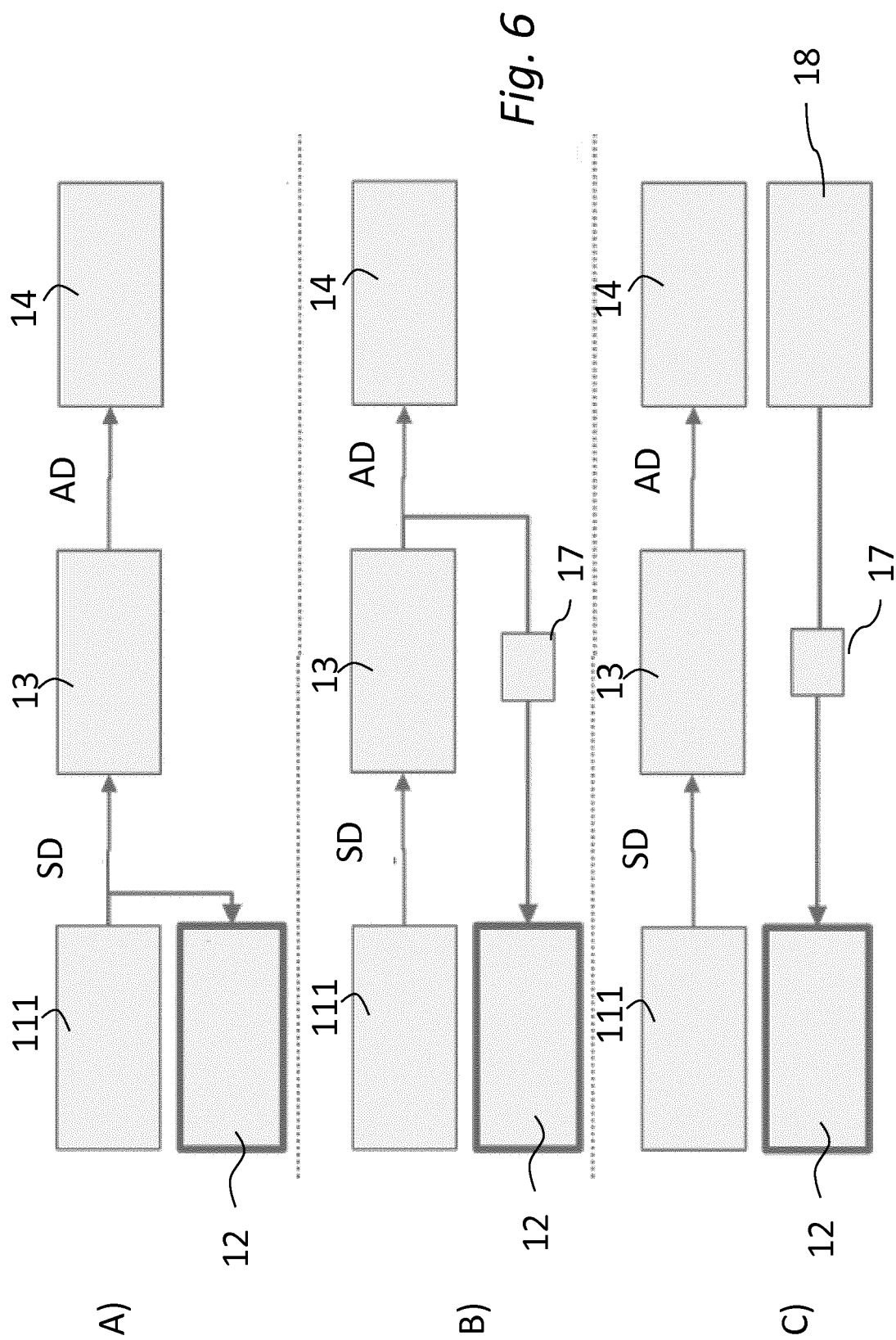


Fig. 3

**Fig. 4**



*Fig. 5*





## EUROPEAN SEARCH REPORT

Application Number  
EP 18 16 4555

5

10

15

20

25

30

35

40

45

50

55

| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                    |                                                                                                                                              |                                                                                                                                                                                                                                                                                       |                                         |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|
| Category                                                                                                                                                                                                                                               | Citation of document with indication, where appropriate, of relevant passages                                                                | Relevant to claim                                                                                                                                                                                                                                                                     | CLASSIFICATION OF THE APPLICATION (IPC) |
| X                                                                                                                                                                                                                                                      | US 2015/289072 A1 (GYLLENSWARD ERIK [SE]<br>ET AL) 8 October 2015 (2015-10-08)<br>* paragraph [0052] - paragraph [0067] *<br>* figures 2-3 * | 1-13                                                                                                                                                                                                                                                                                  | INV.<br>G08B3/10<br>G08B29/10           |
| A                                                                                                                                                                                                                                                      | US 2010/161089 A1 (PHELIPPEAU JACQUES [FR]<br>ET AL) 24 June 2010 (2010-06-24)<br>* figure 2 *<br>* paragraphs [0002], [0030] - [0050] *     | 1-13                                                                                                                                                                                                                                                                                  |                                         |
|                                                                                                                                                                                                                                                        |                                                                                                                                              |                                                                                                                                                                                                                                                                                       | TECHNICAL FIELDS<br>SEARCHED (IPC)      |
|                                                                                                                                                                                                                                                        |                                                                                                                                              |                                                                                                                                                                                                                                                                                       | G08B                                    |
| The present search report has been drawn up for all claims                                                                                                                                                                                             |                                                                                                                                              |                                                                                                                                                                                                                                                                                       |                                         |
| Place of search<br><b>The Hague</b>                                                                                                                                                                                                                    |                                                                                                                                              | Date of completion of the search<br><b>8 June 2018</b>                                                                                                                                                                                                                                | Examiner<br><b>Gioè, Pietro</b>         |
| CATEGORY OF CITED DOCUMENTS<br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document |                                                                                                                                              | T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>.....<br>& : member of the same patent family, corresponding document |                                         |

EPO FORM 1503 03.02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 18 16 4555

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

08-06-2018

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) | Publication<br>date |
|-------------------------------------------|---------------------|----------------------------|---------------------|
| US 2015289072 A1                          | 08-10-2015          | AU 2013349848 A1           | 21-05-2015          |
|                                           |                     | CN 104854635 A             | 19-08-2015          |
|                                           |                     | EP 2733685 A1              | 21-05-2014          |
|                                           |                     | ES 2545824 T3              | 16-09-2015          |
|                                           |                     | JP 6250692 B2              | 20-12-2017          |
|                                           |                     | JP 2016508243 A            | 17-03-2016          |
|                                           |                     | KR 20150087269 A           | 29-07-2015          |
|                                           |                     | US 2015289072 A1           | 08-10-2015          |
|                                           |                     | WO 2014079823 A1           | 30-05-2014          |
| US 2010161089 A1                          | 24-06-2010          | FR 2940565 A1              | 25-06-2010          |
|                                           |                     | US 2010161089 A1           | 24-06-2010          |