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(54) An alarm system and a method for detecting intrusion in a structure by means of acoustic emission

(57) An alarm system for detecting intrusion in a structure by means of acoustic emission, comprising an acoustic emission sensor (22) to be mounted on said structure so as to detect acoustic emission signals propagated through it, a processor (12, 14) for analysing the detected signal and determining if the detected signal exceeds a parameter threshold value, and an alarm unit (12) for providing an alarm signal if the detected signal exceeds the parameter threshold value. The alarm system further comprises an actuator for generating an acoustic emission test signal through the structure, which test signal is to be detected by the acoustic emission sensor (22). The processor (12, 14) is adapted to analyse the detected test signal to determine material properties of the structure, and select the parameter threshold value according to the determined material properties of the structure. The invention also relates to a method for detecting intrusion in a structure by means of acoustic emission.

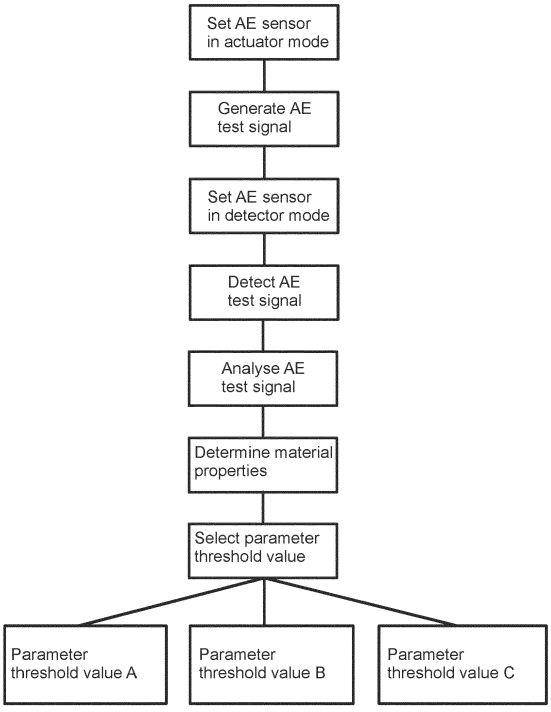


Fig. 6

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Description

TECHNICAL FIELD

[0001] The invention relates to an alarm system and a method for detecting intrusion in a structure by means of acoustic emission. Systems of this type comprise an acoustic emission sensor for detecting acoustic emission signals in a structure, a processor for processing the detected signal and an alarm unit for providing an alarm signal when a predetermined threshold value of the detected signal is exceeded. Such systems are commonly used in domestic houses and office premises as well as other buildings as alarm systems to detect unauthorised intrusion such as burglary, damages and similar.

PRIOR ART

[0002] Acoustic emission (AE) is the propagation of mechanical waves in a solid caused by breakage or fracture of the material. When a material cracks the material emits energy in the form of transient elastic waves that propagates through the material and can be detected by means of different types of sensors, such as piezo-electric sensors. The properties of AE can be a frequency of 10 kHz to over 1 MHz and with an amplitude in the order of nm.

[0003] Alarm systems for detecting intrusion in a structure by means of acoustic emission are known in the prior art. Acoustic emission (AE) sensors are used in alarm systems for measuring acoustic emission in order to detect when glass is breaking. Hence, in such a case acoustic emission is the propagation of mechanical waves in the glass, wherein acoustic emission signals exceeding a predetermined threshold value set off an alarm.

[0004] One problem with such prior art systems for detecting intrusion in a structure by means of acoustic emission is that they quite often can be inaccurate and set off false alarms.

[0005] Another problem with such prior art systems for detecting intrusion in a structure by means of AE is that they lack in flexibility and can result in expensive alarm systems.

[0006] One drawback with such prior art systems for detecting intrusion in a structure by means of AE is that they can be difficult to set up appropriately.

SUMMARY OF THE INVENTION

[0007] An object of the present invention is to avoid the drawbacks and problems of the prior art. The system and method according to the invention result in a reliable and flexible alarm system which is easy to set up and can be used on different types of structures.

[0008] The present invention relates to an alarm system for detecting intrusion in a structure by means of AE, comprising an AE sensor to be mounted on said structure so as to detect AE signals propagated through it, a processor for analysing the detected signal and determining if the detected signal exceeds a parameter threshold value, and an alarm unit for providing an alarm signal if the detected signal exceeds the parameter threshold value, characterised by an actuator for generating an AE test signal through the structure, which test signal is to be detected by the AE sensor, the processor being adapted to analyse the detected test signal to determine material properties of the structure, and select the parameter threshold value according to the determined material properties of the structure. Hence, according to the invention an AE sensor, such as a conventional AE sensor, can be mounted on different structures, such as glass, wood or metal structures, to detect fractures therein due to intrusion. The invention result in a flexible alarm system which can be used in several different applications without any time consuming modifications and settings, such as manual modifications and settings at the location of the structure, which possibly also result in inaccurate settings triggering false alarms. Also, the detector algorithms for different materials may be different. Hence, the processor can be adapted to select a suitable detector algorithm according to the determined material properties of the structure. The processor can be arranged so as to select a suitable detector algorithm from a set of predetermined detector algorithms for different materials.

[0009] The AE sensor can be arranged as the actuator for generating the AE test signal through the structure. Hence, the same AE sensor can be used both as the actuator and detector, which results in a simple and cost efficient alarm system for use on different types of materials. For this purpose, the alarm system can comprise a switch for switching the acoustic emission sensor between an actuator mode and a detection mode. Alternatively, first and second AE sensors can be used, wherein the first AE sensor is arranged as the actuator and the second AE sensor is arranged as the detector. Alternatively, the test signal is generated by hitting the structure, e.g. by knocking on the structure by hand or hitting the structure with an object, such as a small hammer, pen or similar.

[0010] The processor can be adapted to automatically select the parameter threshold value according to the determined material properties of the structure. The processor can also be adapted to automatically select the detector algorithm to be used. Hence, the setup of the alarm system after mounting can be substantially or entirely automatic, which in most cases results in a very simple and effective installation of the alarm system. For example, the alarm system can be set up substantially or entirely automatically regardless of whether the AE sensor is mounted on the glass of a window pane or the wood of a window frame, a door or a door frame.

[0011] The processor can be provided with a plurality of predetermined classes corresponding to material properties for different materials. Software used in the processor can be provided with algorithms for a plurality

of different materials. Further, the processor can be adapted to classify the material of the structure and select a detector algorithm and/or a parameter threshold value in accordance with the selected class. Classes can be provided for a desired number of materials. Hence, the alarm system can determine the material properties of the structure in great detail and select appropriate algorithms in accordance with the determined material properties so as to provide reliable parameter threshold values for triggering the alarm.

[0012] The invention also relates to a method of detecting intrusion in a structure by means of acoustic emission, including the steps of

a) mounting an acoustic emission sensor on the structure,
b) generating an acoustic emission test signal through the structure,
c) detecting the test signal by the acoustic emission sensor,
d) analysing the detected test signal and determining material properties of the structure by means of a processor,
e) selecting a parameter threshold value according to the determined material properties of the structure, and
f) setting off an alarm if a signal detected by the acoustic emission sensor exceeds the selected parameter threshold value.

[0013] Hence, the method provides a simple and reliable detection of intrusion in a structure. The method also provides a simple and reliable set up of an alarm system.

[0014] Further characteristics and advantages of the present invention will become apparent from the description of the embodiments below, the appended drawings and the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] In order that the manner in which the above recited and other advantages and objects of the invention are obtained will be readily understood, a more particular description of the invention briefly described above will be rendered by reference to specific embodiments thereof which are illustrated in the appended drawings.

[0016] Understanding that these drawings depict only typical embodiments of the invention and are not therefore to be considered to be limiting of its scope, the invention will be described and explained with additional specificity and detail through the use of the accompanying drawings in which:

Fig. 1 is a schematic view of an alarm system installed in a building in accordance with one embodiment of the invention,

Fig. 2 is a schematic view of a structure in the form of a door and a door frame, wherein an AE sensor of an alarm system is mounted on the door frame,

Fig. 3 is a schematic view of a structure in the form of a door and a door frame, wherein the AE sensor of an alarm system is mounted on the door,

Fig. 4 is a schematic view of a structure in the form of a door and a door frame, wherein the AE sensor is combined with a magnetic contact in an alarm system and mounted on the door and the door frame,

Fig. 5 is a schematic view of a structure in the form of a window, wherein the AE sensor of an alarm system is mounted on the window pane,

Fig. 6 is a schematic block diagram showing a function of the alarm system according to one embodiment of the invention,

Fig. 7 is a flowchart showing an example of an algorithm for detecting intrusion in a wood structure, and

Fig. 8 is a flowchart showing an example of an algorithm for detecting intrusion in a glass structure.

DETAILED DESCRIPTION

[0017] In Fig. 1 an alarm system is arranged in a building 10. The alarm system comprises a control panel also referred to as a gateway 12 that, for example, includes a processor and an alarm unit for providing an alarm signal when the alarm is set off. In the embodiment of Fig. 1 the gateway 12 is connected to a central station 14, either by a telephone line or by a wireless telecommunications system such as GSM or other radio frequency systems. The connection also can be through the internet 16. The central station can be connected to an alarm receiving office centre, such as a remote alarm receiving office centre. The gateway can be provided with input means or be activated and controlled by control device such as a keypad 18 which can be a wireless remote device. The keypad 18 is arranged in the vicinity of an entrance door 20. Alternatively, the keypad 18 is arranged in any suitable location or is a portable device.

[0018] The alarm system comprises at least one acoustic emission sensor 22 for detecting acoustic emission (AE) due to fracture of the material in the structure on which the AE sensor 22 is mounted. For example, the AE sensor 22 is a piezoelectric sensor or any other type of suitable AE sensor. For example, the AE sensor 22 includes a piezoelectric ceramic or a piezoelectric plastic film. In the embodiment of Fig. 1 the AE sensor 22 is mounted on structures in the form of windows 24 and the door 20 to detect fracture of the glass in the windows and

the material of the door 20, such as wood, metal or any other type of material. Optionally, the alarm system comprises also other types of detectors or sensors 26, such as perimeter alarm detectors, magnetic sensors, infrared detectors, etc.

[0019] The AE sensor 22 is connected to the processor, for example through a wireless connection. For example, the processor is included in the AE sensor 22, wherein the processor is a part of the AE sensor 22 or a unit including the AE sensor 22. Alternatively, the processor ise located in the central station 14, in the gateway 12 or in any other suitable location. The processor is arranged for analysing a signal from the AE sensor and determining if the signal exceeds a threshold value for setting off the alarm.

[0020] With reference to Fig. 2 the AE sensor 22 is mounted on a door frame 28 for detecting fracture in the material of the door frame 28. The AE sensor is mounted in the vicinity of an expected breakage area, such as close to a lock 30 and handle 32 of the door 20. For example, the door frame 28 is made of wood. Due to the large amounts of irregularities found in wood, for example, knots and growth rings, attenuation is greater in a wooden material than in e.g. glass or metal. This result in difficulties measuring AE on large distances and the AE sensor should, if possible, be arranged close to the source of activity, i.e. the breakage area. For example, the AE sensor is mounted 0-2 m, 0-1 m, 0-0.5 m or 0-0.2 m from the expected breakage area. In Fig. 3 the AE sensor 22 is mounted on the door 20. The AE sensor 22 is mounted in a side of the door 20 opposite the hinges and in the same side of the door 20 as the handle 32. The AE sensor 22 can, as part of an alarm system for detecting intrusion, be mounted on any suitable structure, such as a house, building, locker, safe and similar, to detect fracture therein. In Fig. 4 the AE sensor 22 is integrated with a magnetic contact and mounted on the door 20 and/or doorframe 28. Then, the AE sensor 22 detects fractures in the door 20 and/or doorframe 28, and the magnetic contact detects opening of the door 20. With reference to Fig. 5, the AE sensor is mounted on the glass of a window 24.

[0021] The alarm system according to the invention is arranged for detecting intrusion in a plurality of different structures comprising different materials. Hence, the alarm system can easily be set up for detecting fracture by means of AE in a first structure comprising a first material or a second structure comprising a second material. For example, the first structure is a window made of glass and the second structure is a door frame made of wood.

[0022] With reference to Fig. 6 a function of the alarm system according to one embodiment is illustrated schematically by means of a block diagram. After mounting on the structure, the AE sensor 22 is arranged in an actuator mode for generating an AE test signal through the structure. For example, a voltage is applied to the AE sensor 22 in the form of a piezoelectric sensor to obtain the AE test signal. Then, the AE sensor 22 is set in a detector mode for detecting the test signal propagated through the structure. For example, the alarm system comprises a switch for switching the AE sensor 22 between the actuator mode and the detector mode. Hence, according to one embodiment of the invention the AE sensor 22 functions both as actuator for generating the test signal and detector for detecting said test signal, i.e. detecting the test signal generated by itself.

[0023] The test signal is received by the processor, wherein the processor is arranged for analysing the detected test signal to determine material properties of the structure. Hence, the processor is arranged for classifying the structure according to the detected test signal. For example, the processor is provided with stored data of material properties for a plurality of different materials. Said data can be arranged in predetermined classes, each class representing a particular material, such as glass, wood or any other material, wherein the detected test signal is compared to said classes to select the suitable class. Each class sets one or more detector algorithms and/or parameter threshold values for activating the alarm unit and setting off the alarm. Hence, the processor is adapted to analyse the detected AE test signal from the structure to be protected, determine the material properties of the structure and select detector algorithms and/or parameter threshold values according to the determined material properties. The selected parameter threshold values are, for example, set to indicate fracture of the material in the structure to detect intrusion therein, such as a window cracking or a door frame splintering or similar, wherein an alarm is set off when one or more parameter threshold values are exceeded. Hence, a single AE sensor is used for generating the test signal, detecting the test signal and, after setting up the threshold parameters for triggering an alarm in accordance with the detected test signal, also detecting events for triggering the alarm due to fracture in the material in the protected structure.

[0024] In an alternative embodiment a first AE sensor 22 is used as an actuator to generate the AE test signal, wherein a second AE sensor is used for detecting said signal. For example, the first and second AE sensors are arranged in a single housing forming a single sensor unit. Alternatively, the test signal is generated by hitting the structure, e.g. by an object, such as a small hammer, pen or similar, wherein the AE sensor 22 is arranged as a detector. Hence, according to the invention the same sensor 22 or sensor unit can be used in an alarm system for detecting intrusion through different materials. Also the same processor including suitable software can be used. Hence, a single alarm system can be used on different materials, such as glass, wood, metal, etc., for detecting fracture by means of AE. Depending on the processor and the software used, the alarm system can be adapted to different types of wood, different glass structures, etc.

[0025] According to one alternative embodiment the processor is adapted to calculate appropriate parameter

threshold values according to the detected test signal to obtain suitable parameter threshold values for the material of the structure. For example, the processor is adapted to select a detector algorithm according to the analysed test signal and calculate or select parameter threshold values indicating unauthorised tampering of the structure, such as fracture of the material, hitting the material with an object in order to break it or similar.

[0026] For example, the alarm system is configured so that analyse of the AE test signal and the selection of parameter threshold values are performed automatically. If applicable, also selection of detector algorithm is performed automatically. Hence, the alarm system is set up automatically according to the material of the structure to be protected. For example, the alarm system is also configured to automatically generate the test signal when initially turned on after mounting on the structure. Optionally, also the switch from actuator mode to detector mode of the AE sensor is performed automatically after generating the test signal, such as after a predetermined period of time.

[0027] For example, the processor comprises software with an algorithm for determination and separation of fracture signals for a plurality of different materials, such as glass and wood, and optionally also materials in different types of structures, such as glass of a specific thickness and wood of a specific type. Different types of wood have different characteristics and results in differences in AE signal propagation through the material. For example, oak is a more dense material than pine. However both are used in doors, door frames and window frames. The processor can contain a large number of classes or algorithms for determining the material properties of the structure by calculation, so that a very accurate determination of the material properties can be obtained and false alarms be avoided. The algorithm is arranged to determine whether to classify or calculate an AE signal as an alarm signal or not, i.e. whether or not the detected AE signal is to set off the alarm or not.

[0028] The processor can be adapted to take a plurality of different parameters into account when determining the material properties and also when determining if a detected signal is to set off the alarm or not. For example, the parameters includes one or more of frequency content, time signal, amplitude, pulse duration and rise time, calculated as the duration from passing a predetermined value to reaching its peak amplitude. According to one embodiment, the algorithms of the processor are arranged for considering a combination of methods where both the time signal and frequency spectrum is analysed. For example, in a power spectrum, the number of detected peaks is counted and the area is calculated. Different band-pass filters can be applied. In a time signal, the mean value of a number of the largest peaks is calculated and a peak is detected. Also in this case, different band-pass filters can be applied. These algorithms made it possible to distinguish fractures from other signals due to the difference in appearance and characteristics. All signals can be classified or categorised by specific parameters.

[0029] Fracture in a material can be determined by counting number of AE events detected. Depending on the application, an alarm system could be designed to not trigger an alarm until a certain number of AE events have occurred in a given timeframe. The signal recorded and analysed with suitable algorithms are e.g. 100 ms. With the introduction of a buffer memory, a longer signal could be recorded and analyzed in intervals of 100 ms once the system is triggered.

[0030] When studying a frequency spectrum, AE signals associated with crack formation in wood generally have larger response in the higher regions. Crack formation in oak is associated with a strong frequency response from 25 kHz to ca 60 kHz, while in pine which is a softer material and thus more efficient in dampening higher frequencies, this corresponding region is instead seen from 15 kHz to 40-45 kHz. Further, in some events responses associated with cracks also contain frequency response in the region 100-300 kHz for both pine and oak and, sometimes, a larger amount of detected frequencies. One example of a flowchart of the algorithms used to detect crack formations is illustrated in Fig. 7. In addition a threshold for allowed amplitudes and the time-signal optionally is included to faster detect clearly suspicious signals by counting the number of peaks.

[0031] Because of the different characteristics of dense and softer wood, different parameters are set for e.g. oak and pine. A mean value for a number of the maximal peaks in the time signal is calculated. Even if a signal is not associated with a crack formation it might be desired to trigger an alarm if the amplitude is high, resulting from e.g. a hammer strike or similar. This threshold could be changed or completely disregarded depending on the application. Fracture signals can in most cases be separated from other disturbances, e.g. hand-knocks that probably are the most common signal to be analysed in a door application, merely by considering the time signal. By analysing the time signal under 30 kHz and calculating the number of peaks, most disturbances are disregarded and some of the fractures are detected without performing a more complex and time-consuming FFT. The signal is disregarded and considered a non-fracture if the calculated number of peaks falls under the first threshold. If the number of calculated peaks is more than the second threshold it is considered a fracture and immediately triggers an alarm. If the calculated peaks are greater than the first threshold but lower than the second it is considered a possible fracture and an FFT is performed with a band-pass filter in the range 300 Hz to 100 kHz to further study the frequency content associated with AE. If the area of the frequency spectrum, in the range 20- 100 kHz, and the number of detected frequencies are above the threshold the signal is considered a fracture.

[0032] AE signals acquired in glass have higher frequency content than the corresponding signals in wood.

Also since the attenuation is much lower, more details in the power spectrum could be observed. For example, an algorithm for detecting fracture in glass only analyses the frequency domain.

[0033] Non-destructive signals, i.e. signals not related to fracture of the material, have a response up to ca. 50 kHz, with exception for some events that have a frequency content up to 160 kHz. However, fracture of glass, such as by breakage or cut, generally have frequencies around and above 200 kHz. Some of the signals from non-destructing events also had similarly high frequencies, but filtering the signal 10 kHz to 500 kHz and using a combination of peak detection in the power spectrum and area calculation between 150-500 kHz, they could be separated from the fracture signals. A flowchart showing one example of the detector of glass fractures can be seen in Fig. 8.

[0034] For example, the same software handles a plurality of different materials. When the kind of material the current measurements are performed on has been determined, the software sets the variables used in the suitable algorithms.

[0035] Due to the lower signal attenuation in glass, more details of the signals can be observed and makes it possible to have fewer tests than in the wood detector. As in the wood detector, the parameters are obtained from start, when the material properties have been selected as a response to the detected AE test signal. The signal is filtered with a band-pass filter with cut-off frequencies 100 Hz and 500 kHz. This is basically the whole signal content with exceptions of very high and low frequencies with no significance to the tests. Then a power spectrum is performed, and the area is calculated from 60 to 100 kHz. This is due to the high frequency content obtained in glass material failure. If the area calculated is below a specific threshold, the detector indicates no alarm, but if the area is sufficient, it is treated as a suspicious signal and further testing is performed. Before the second test the signal is filtered with the same type of band-pass filter, but with the cut-off frequencies 10 to 500 kHz. Peak detection is performed on the power spectrum to calculate the number of detected frequencies and if the number is below a specific threshold, again no alarm is indicated. If the threshold is exceeded, a final test is done to make sure it is really a fracture signal. The area of the power spectrum between 150 and 500 kHz is calculated, and if the threshold for this is exceeded, alarm is indicated

[0036] While certain illustrative embodiments of the invention have been described in particularity, it will be understood that various other modifications will be readily apparent to those skilled in the art without departing from the scope and spirit of the invention. Accordingly, it is not intended that the scope of the claims appended hereto be limited to the description set forth herein but rather that the claims be construed as encompassing all equivalents of the present invention which are apparent to those skilled in the art to which the invention pertains.

Claims

1. An alarm system for detecting intrusion in a structure by means of acoustic emission, comprising
an acoustic emission sensor (22) to be mounted on said structure so as to detect acoustic emission signals propagated through it,
a processor (12, 14) for analysing the detected signal and determining if the detected signal exceeds a parameter threshold value, and
an alarm unit (12) for providing an alarm signal if the detected signal exceeds the parameter threshold value,
characterised **by**
an actuator for generating an acoustic emission test signal through the structure, which test signal is to be detected by the acoustic emission sensor (22),
the processor (12, 14) being adapted to analyse the detected test signal to determine material properties of the structure, and select the parameter threshold value according to the determined material properties of the structure.

2. A system according to claim, wherein the actuator for generating the acoustic emission test signal through the structure is the acoustic emission sensor, and wherein the system includes a switch for switching the acoustic emission sensor between an actuator mode and a detection mode.

3. A system according to claim 1 or 2, wherein the processor is adapted to automatically select the parameter threshold value according to the determined material properties of the structure.

4. A system according to any of the preceding claims, wherein the processor is provided with a plurality of predetermined classes corresponding to material properties for different materials, and wherein the processor is adapted to classify the material of the structure and select a parameter threshold value in accordance with the selected class.

5. A system according to claim 4, wherein the processor is provided with predetermined classes corresponding to material properties for glass and/or wood and/or metal.

6. A system according to claim 5, wherein the processor is provided with predetermined classes corresponding to material properties for different types of glass and/or different types of wood and/or different types of metal.

7. A system according to any of the preceding claims, wherein the parameter threshold value corresponds to fracture in the material of the structure.

8. A method of detecting intrusion in a structure by means of acoustic emission, including the steps of

a) mounting an acoustic emission sensor on the structure,
b) generating an acoustic emission test signal through the structure,
c) detecting the test signal by the acoustic emission sensor,
d) analysing the detected test signal and determining material properties of the structure by means of a processor,
e) selecting a parameter threshold value according to the determined material properties of the structure, and
f) setting off an alarm if a signal detected by the acoustic emission sensor exceeds the selected parameter threshold value.

9. A method according to claim 8, including the step of setting the acoustic emission sensor in an actuator mode for generating the acoustic emission test signal through the structure.

10. A method according to claim 9, including the step of switching the acoustic emission sensor from the actuator mode to a detection mode for detecting acoustic emission signals through the structure.

11. A method according to any of claims 8-10, including the step of automatically selecting the parameter threshold value according to the determined material properties of the structure.

12. A method according to any of claims 8-11, including the step of selecting, from a plurality of predetermined classes for different materials, a class corresponding to the determined material properties of the structure, and setting the parameter threshold value in accordance with the selected class.

13. A method according to claim 12, including the step of selecting a class from a set of predetermined classes corresponding to material properties for glass and/or wood and/or metal.

14. A method according to claim 13, including the step of selecting a class from a set of predetermined classes corresponding to material properties for different types of glass and/or different types of wood and/or different types of metal.

15. A method according to any of the preceding claims, including the step of setting off the alarm if a signal detected by the acoustic emission sensor exceeds a parameter threshold value corresponding to fracture in the material of the structure.

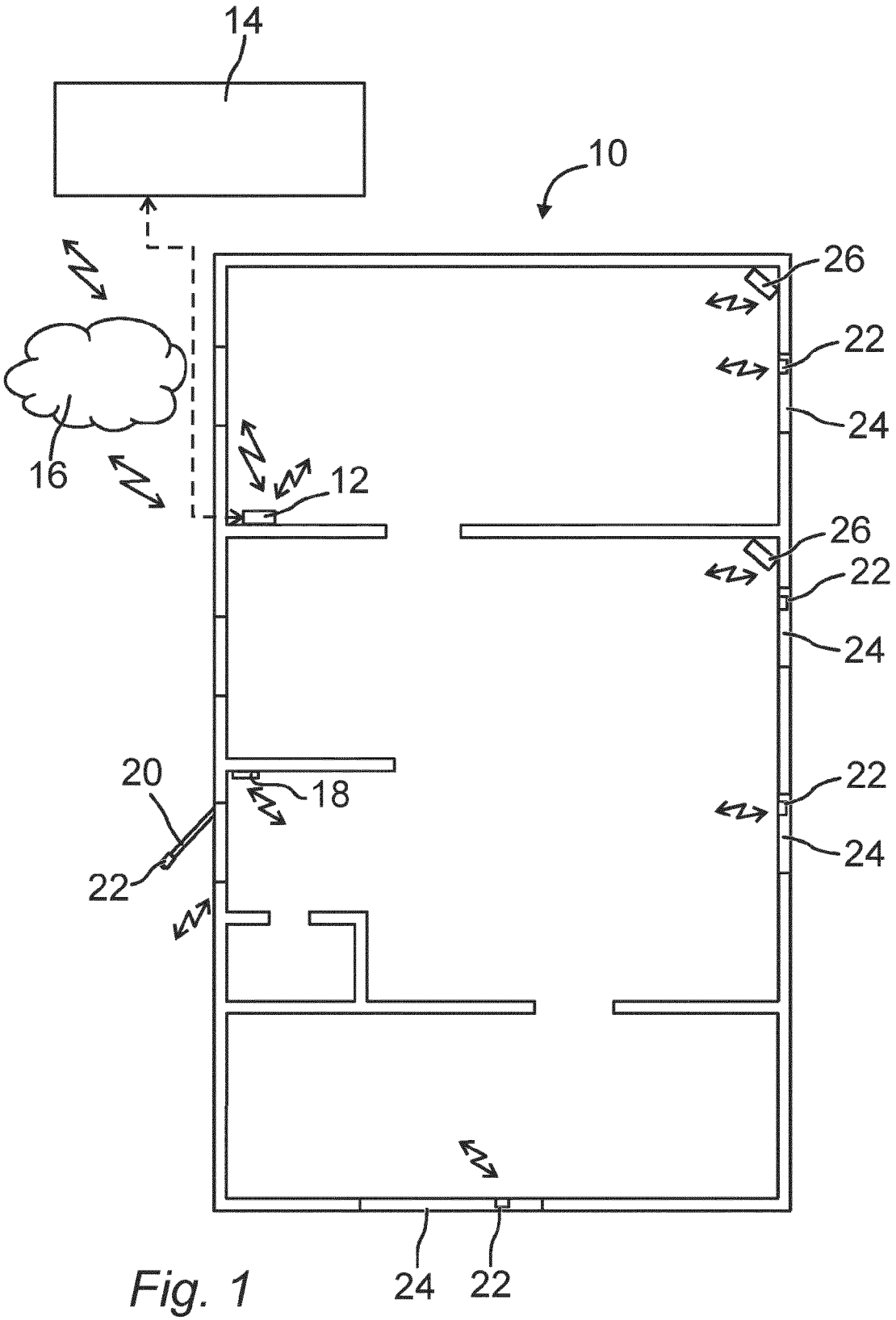


Fig. 1

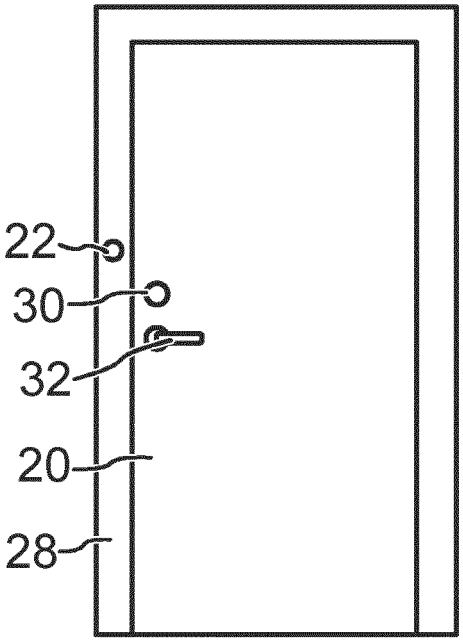


Fig. 2

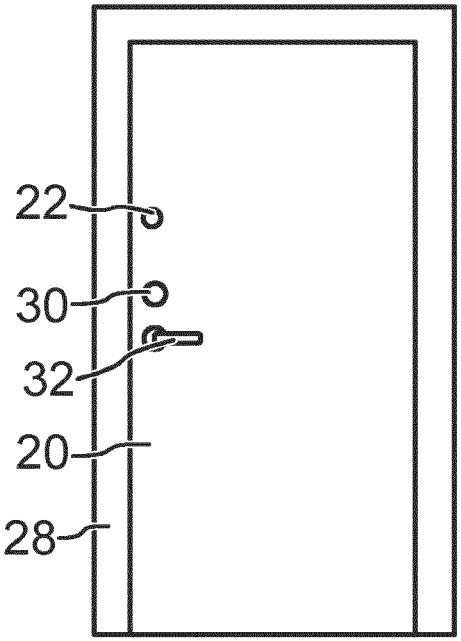


Fig. 3

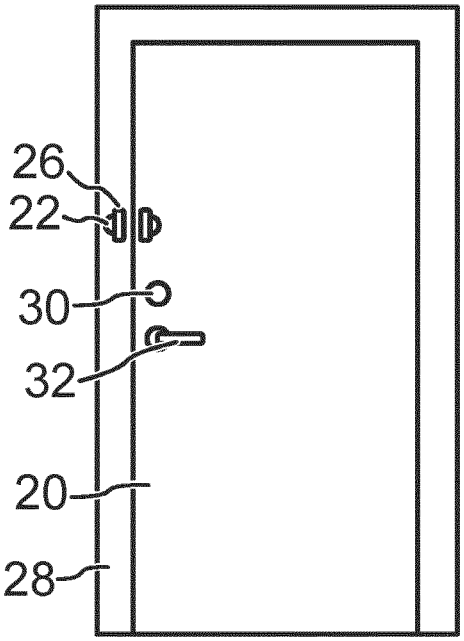


Fig. 4

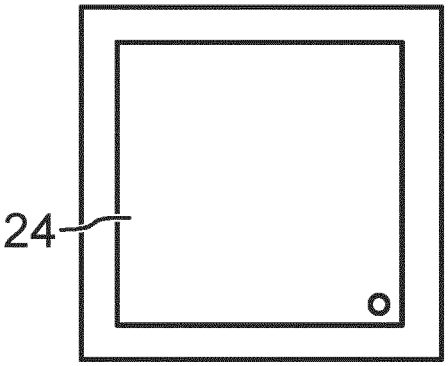


Fig. 5

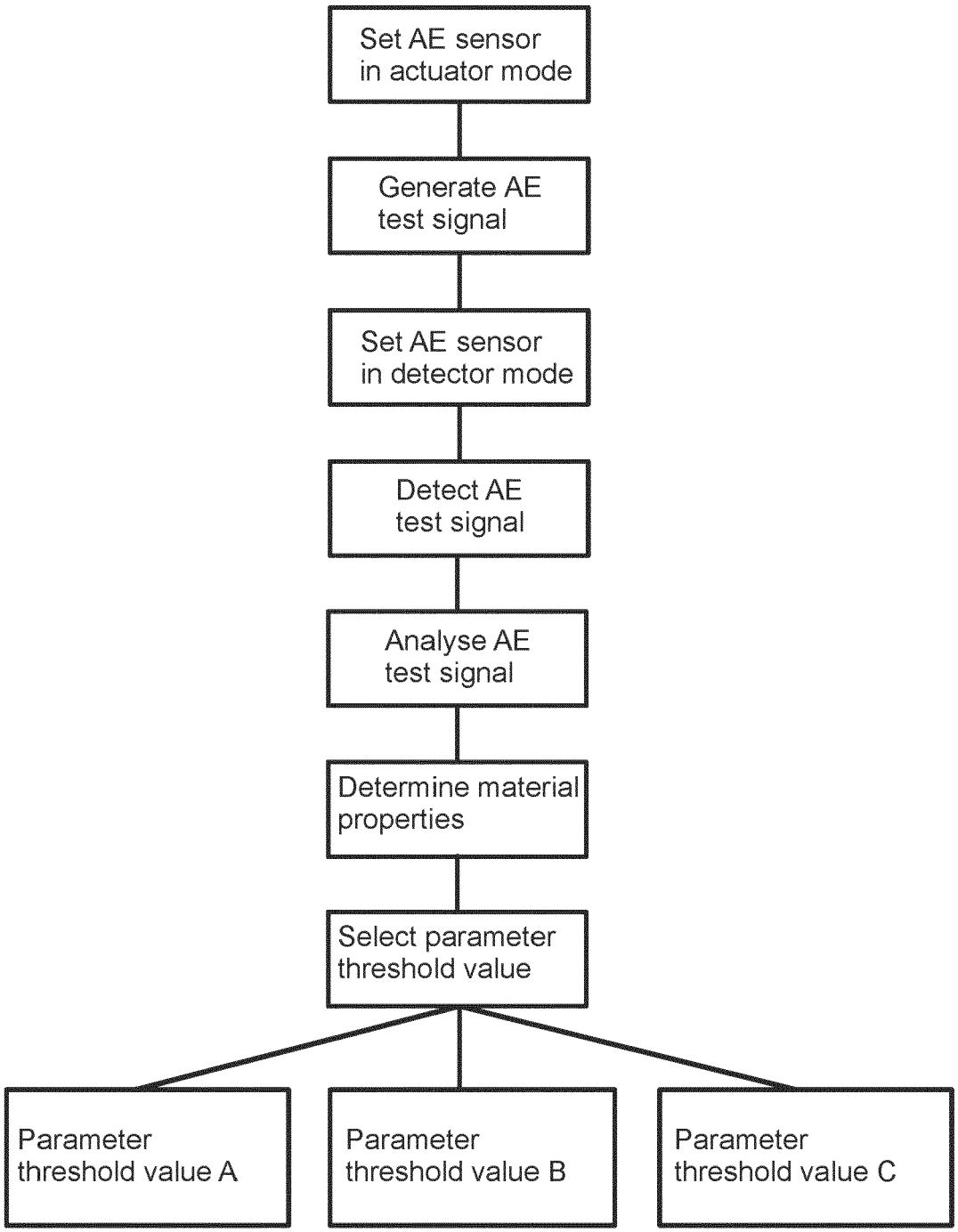

Set AE sensor in actuator mode
Generate AE test signal
Set AE sensor in detector mode
Detect AE test signal
Analyse AE test signal
Determine material properties
Select parameter threshold value
Parameter threshold value A
Parameter threshold value B
Parameter threshold value C

Fig. 6

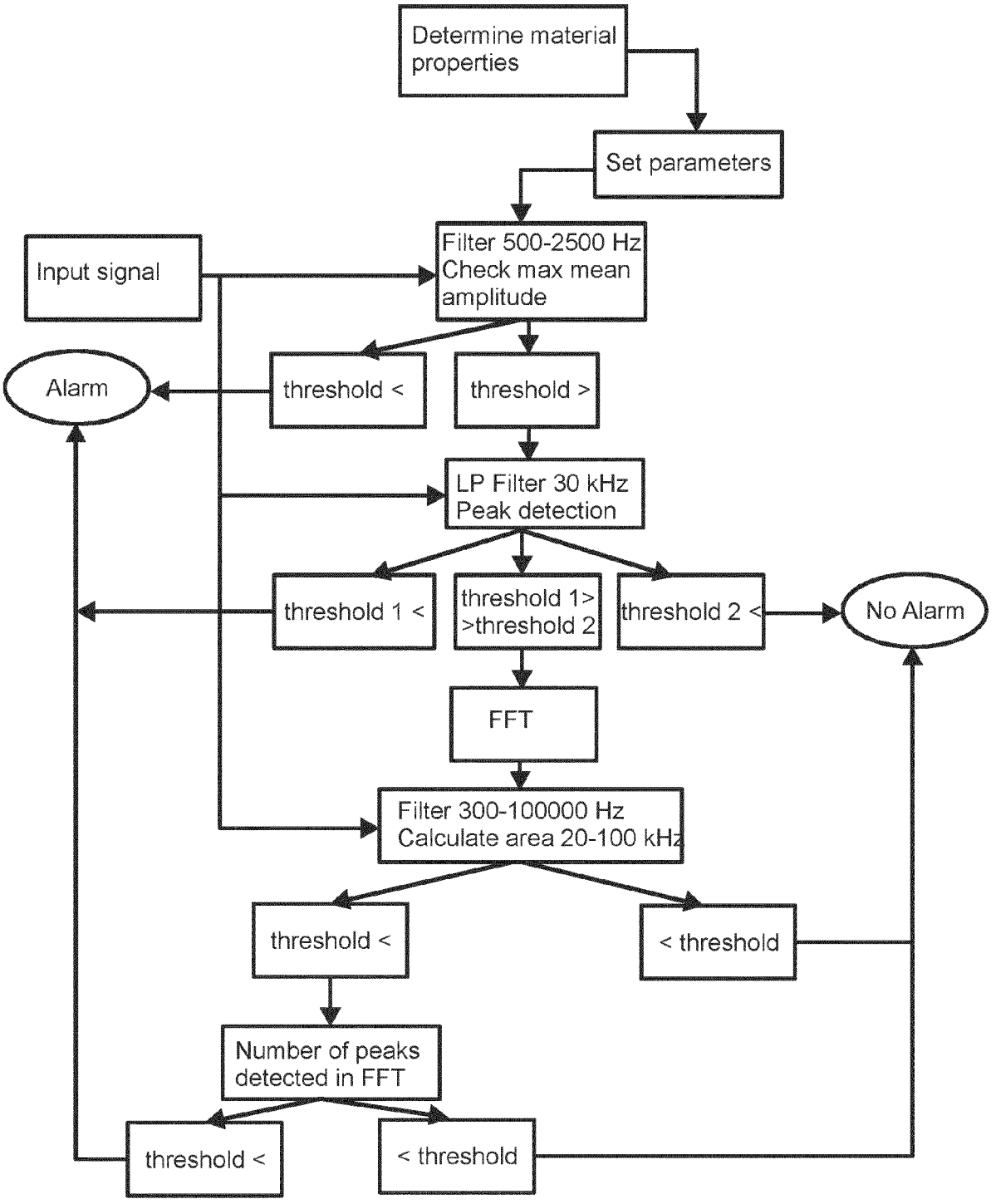

Determine material properties
Set parameters
Input signal
Filter 500-2500 Hz
Check max mean amplitude
Alarm
threshold <
threshold >
LP Filter 30 kHz
Peak detection
threshold 1 <
threshold 1>
>threshold 2
threshold 2 <
No Alarm
FFT
Filter 300-100000 Hz
Calculate area 20-100 kHz
threshold <
< threshold
Number of peaks
detected in FFT
threshold <
< threshold

Fig. 7

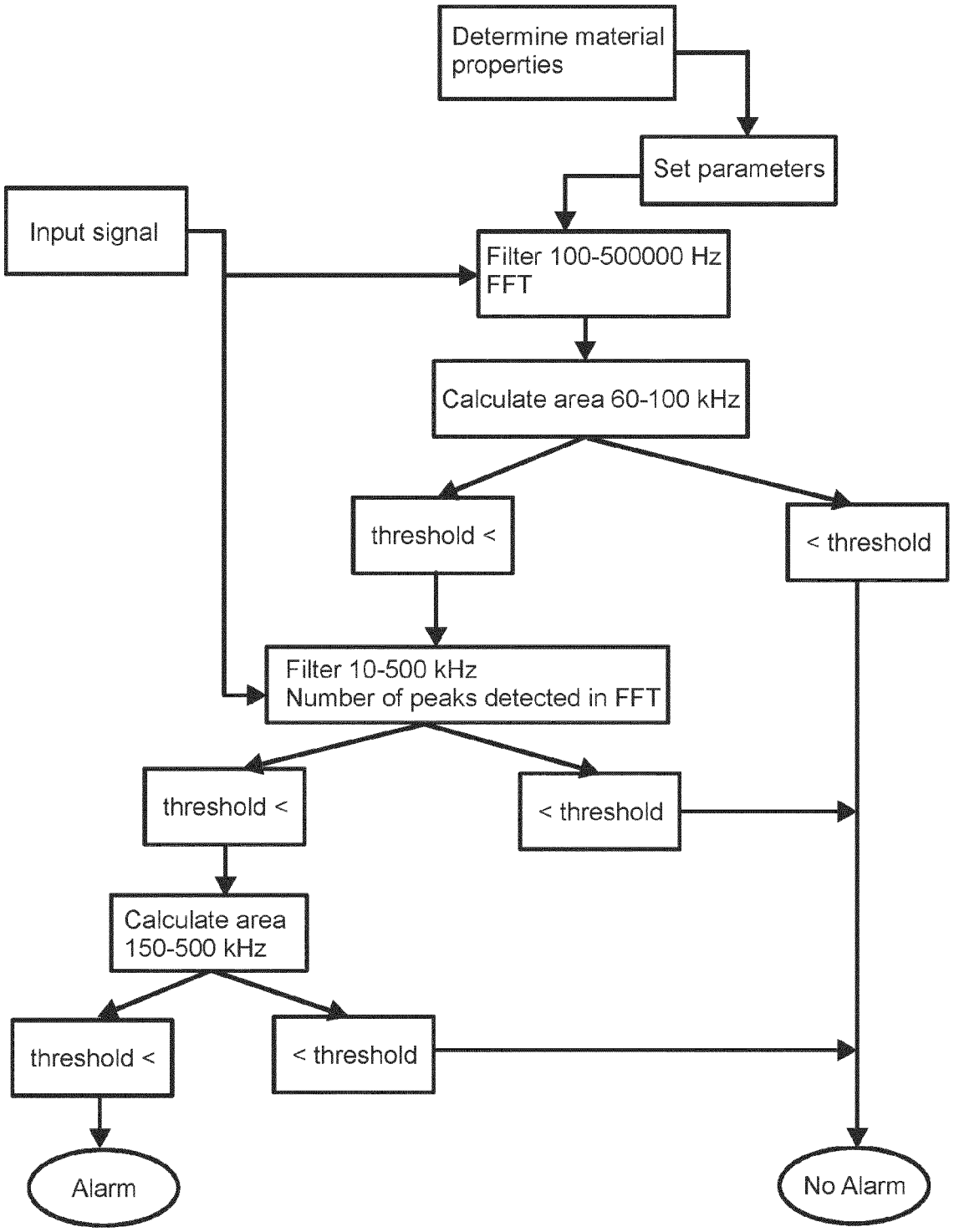

Determine material properties
Set parameters
Input signal
Filter 100-500000 Hz FFT
Calculate area 60-100 kHz
threshold <
< threshold
Filter 10-500 kHz Number of peaks detected in FFT
threshold <
< threshold
Calculate area 150-500 kHz
threshold <
< threshold
Alarm
No Alarm

Fig. 8

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 11 19 3091

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	WO 2009/144724 A1 (SABRA DE FENCE TECHNOLOGIES LT [IL]; KALO ARIE [IL]; GILBOHA NIR [IL]) 3 December 2009 (2009-12-03)	1,8	INV. G08B13/02 G08B13/16
A	* figures 1-11 * * page 1, lines 20-35 * * page 6, lines 10-20 * * page 7, lines 1-8 * * page 8, lines 17-28 * * page 15, lines 6-25 *	2-7,9-15	
A	DE 26 46 160 A1 (CERBERUS AG) 23 June 1977 (1977-06-23) * figures 1-3 * * claims 1,8,13 * * page 9, paragraph 2 * * page 12, paragraphs 2,3 * * page 13, paragraphs 1,2 * * page 14, paragraph 3 * * page 16, paragraph 1 *	1-15	
A	US 5 640 142 A (MATATALL JR RICHARD LEWIS [US] ET AL) 17 June 1997 (1997-06-17) * figures 1-3 * * claim 1 * * column 2, lines 10-30 * * column 3, lines 15-30 *	1-15	TECHNICAL FIELDS SEARCHED (IPC) G08B G01V
A	US 4 196 423 A (CRAVER DONALD W [US] ET AL) 1 April 1980 (1980-04-01) * figures 1-3 * * claim 1 * * column 3, lines 50-60 * * column 4, lines 5-50 *	1-15	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	3 April 2012	Coffa, Andrew

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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L : document cited for other reasons

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 11 19 3091

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
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03-04-2012

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2009144724 A1	03-12-2009	US 2011102178 A1	05-05-2011
		WO 2009144724 A1	03-12-2009
DE 2646160 A1	23-06-1977	DE 2646160 A1	23-06-1977
		GB 1517628 A	12-07-1978
		JP 1292560 C	16-12-1985
		JP 52071999 A	15-06-1977
		JP 60016000 B	23-04-1985
		US 4142188 A	27-02-1979
		US 4225859 A	30-09-1980
US 5640142 A	17-06-1997	NONE	
US 4196423 A	01-04-1980	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82