



(51) International Patent Classification:
G08B 13/16 (2006.01)

(21) International Application Number:
PCT/IB2019/051202

(22) International Filing Date:
14 February 2019 (14.02.2019)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/631,296 15 February 2018 (15.02.2018) US
62/637,161 01 March 2018 (01.03.2018) US

(71) Applicant: TYCO FIRE & SECURITY GMBH [CH/CH]; Victor von Bruns-Strasse 21, 8212 Neuhausen am Rheinfall (CH).

(72) Inventor: CONNELL II, Thomas Wysong; 108 Turnpike Road, Westminster, Massachusetts 01473 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,

(54) Title: GUNSHOT DETECTION SYSTEM WITH FORENSIC DATA RETENTION, LIVE AUDIO MONITORING, AND TWO-WAY COMMUNICATION

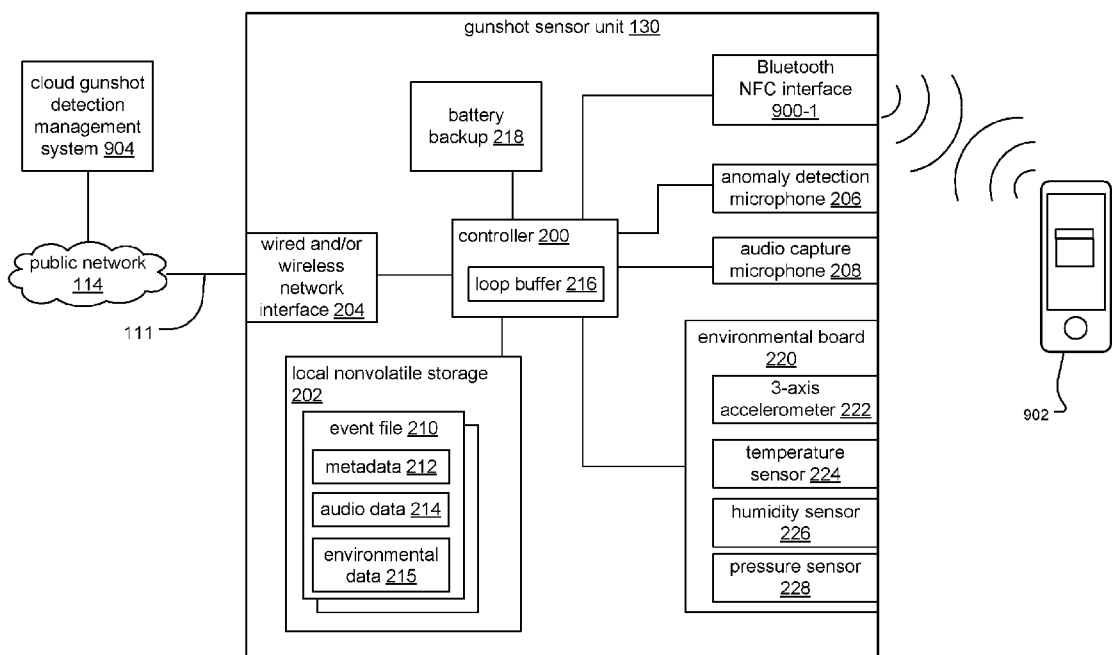


FIG. 9A

(57) Abstract: A gunshot detection system includes gunshot sensor units with microphones for detecting gunshots and capturing audio data depicting the detected gunshots and other ambient sounds, an environmental board with various environmental sensors for generating environmental data indicating environmental conditions. The audio data, environmental data, and position information can be stored locally on local nonvolatile storage of the gunshot sensor unit for later retrieval by law enforcement entities. In one embodiment, the gunshot sensor units include a wired and/or wireless data transfer interface for transferring the audio data, environmental data and/or position information to handheld units of law enforcement entities. The gunshot sensor unit can also stream live captured audio data for live monitoring by a control panel, and might also include speakers for providing audio playback of audio data from the control panel.



TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

GUNSHOT DETECTION SYSTEM WITH FORENSIC DATA RETENTION, LIVE
AUDIO MONITORING, AND TWO-WAY COMMUNICATION

RELATED APPLICATIONS

[0001] This application claims the benefit under 35 USC 119(e) of U.S. Provisional Application No. 62/631,296, filed on February 15, 2018, and U.S. Provisional Application No. 62/637,161, filed on March 1, 2018, both of which are incorporated herein by reference in their entirety.

[0002] This application is related to:

[0003] International Application number _____ filed on an even date herewith, entitled “Gunshot detection system with master slave timing architecture,” attorney docket number 0324.0046WO2 (F-FD-00191.1 WO), now International Patent Publication No.: _____;

[0004] International Application number _____ filed on an even date herewith, entitled “Gunshot detection system with encrypted, wireless transmission,” attorney docket number 0324.0046WO3 (F-FD-00191.2 WO), now International Patent Publication No.: _____;

[0005] International Application number _____ filed on an even date herewith, entitled “Gunshot detection system with building management system integration,” attorney docket number 0324.0046WO4 (F-FD-00191.3 WO), now International Patent Publication No.: _____;

[0006] International Application number _____ filed on an even date herewith, entitled “Gunshot detection system anti-tampering protection,” attorney docket number 0324.0046WO5 (F-FD-00191.4 WO), now International Patent Publication No.: _____;

[0007] International Application number _____ filed on an even date herewith, entitled “Gunshot detection system with ambient noise modeling and monitoring,” attorney docket number 0324.0046WO6 (F-FD-00191.5 WO), now International Patent Publication No.: _____;

[0008] International Application number _____ filed on an even date herewith, entitled “Gunshot detection system with fire alarm system integration,” attorney docket

number 0324.0046WO7 (F-FD-00191.6 WO), now International Patent Publication No.: _____;

[0009] International Application number _____ filed on an even date herewith, entitled “Gunshot detection sensors incorporated into building management devices,” attorney docket number 0324.0046WO8 (F-FD-00191.7 WO), now International Patent Publication No.: _____; and

[0010] International Application number _____ filed on an even date herewith, entitled “Gunshot detection system with location tracking,” attorney docket number 0324.0046WO9 (F-FD-00191.8 WO), now International Patent Publication No.: _____.

[0011] All of the afore-mentioned applications are incorporated herein by this reference in their entirety.

BACKGROUND OF THE INVENTION

[0012] Shooting incidents, involving active shooters shooting victims within buildings such as schools or malls, are increasingly a concern. Identifying and reacting quickly to such incidents can reduce loss of life. For example, first responders need to know if gunshots have actually been fired and the location and number of the fired shots.

[0013] In confined areas, such as in a school or a private or public building, detecting and locating the source of gunshots is a complicated problem. A gunshot typically generates several sounds including the gunshot itself, the bullet's bow shockwave, noise from bullet impacts and noise of reflected gunshot sounds. In addition, numerous noises are generated in buildings that may be mistakenly identified as gunshots.

[0014] The broad concept of detecting gunshots utilizing acoustics is known. More specifically, it is known to provide a gunshot detection system including an array of acoustic sensors positioned in a pattern which enables signals from the sensors to be employed to not only detect the firing of a gunshot but to also locate the origin of the shot. One main requirement of such a system is the need to accurately distinguish between the sound produced from a gunshot and a host of other ambient sounds. In at least one known arrangement, a microphone is used to detect each sound, which is then amplified, converted to an electrical signal and then the electrical signal is compared with a threshold value above which a gunshot sound is expected to exceed.

[0015] Recently, gunshot detection systems with improved accuracy, dependability, and effectiveness have been described. One such system is described in International Publication Number WO 2018/044553, published on March 8, 2018 and entitled “System and Method for Acoustically Identifying Gunshots Fired Indoors.” This system provides for low false alarms or false positives and high detection rates by employing two microelectromechanical microphones (MEMs) having different sensitivity levels. Acoustic signals from a first microphone with lower sensitivity (for example, making the anomaly detection microphone essentially deaf to routine sounds) are first analyzed for a peak amplitude level large enough to be a potential gunshot. Then acoustic signals from a second microphone having a higher sensitivity are then analyzed further to confirm that the sound was a gunshot.

[0016] Gunshot detection methods have also been proposed that can count the number of gunshots fired, particularly from an automatic or fast acting weapon. One such method is described in International Publication Number WO 2018/044556, published on March 8, 2018 and entitled “Method for Acoustically Counting Gunshots Fired Indoors.” In this method, an acoustic signature of captured noise is analyzed to accurately count how many shots are fired. The method can be employed to identify that the gun is an automatic or rapid fire weapon, which information can be provided to emergency personnel.

[0017] Additionally, gunshot detection system that can accurately determine where sensed events are located have been proposed. One such system is described in International Publication Number WO 2018/185723, published on October 11, 2018 and entitled “System and Method for Identifying and Locating Sensed Events.” Here, a sensor network is employed to detect an event in the form of an audible signal. The event is time stamped and sent to a controller, which evaluates the event as either unique or a multiple detection using the sensor’s time of alarm to determine which sensor activated first and to suppress subsequent alarms for the same event. This process is known as de-confliction.

SUMMARY OF THE INVENTION

[0018] Features can be added to these gunshot detection systems to make them more useful in a wider range of contexts. For example, audio capture and recording, live monitoring and two-way communication via distributed gunshot sensor units would be useful. Moreover, in many cases it would be beneficial to retain all recorded event data

and/or audio data for the data for forensic processing, for example, by law enforcement entities.

[0019] Various innovations to gunshot detection systems are proposed. For example, the gunshot detection systems might include gunshot sensor units equipped with anomaly detection microphones for detecting the gunshots and an audio capture microphones for capturing and recording audio data depicting detected gunshots as well as other ambient sounds. Further, gunshot sensor units with environmental boards with various environmental sensors (e.g. accelerometers, temperature sensors, humidity sensors, pressure sensors) could generate environmental data indicating environmental conditions surrounding the gunshot sensor units or the units themselves. In addition, the gunshot sensor units could include RADAR sensors for generating position information indicating positions of bodies with respect to the gunshot sensor units within the area surrounding the gunshot sensor units, including, for example, any active shooter. The audio data, environmental data, and position information might also be stored locally on local nonvolatile storage of the gunshot sensor units for later retrieval by law enforcement entities. Further, the gunshot sensor units could include wired and/or wireless data transfer interfaces for transferring the audio data, environmental data and/or position information to handheld units of law enforcement entities.

[0020] The gunshot sensor units might autonomously analyze captured sounds to determine whether to locally store the event data, or they might operate in conjunction with a control panel and/or remote system such as a cloud management system, which is accessible only over public networks. For example, upon de-confliction of received event data indicating potential gunshots, the control panel might instruct the de-conflicted gunshot sensor units, or the gunshot sensor units themselves might decide, to encrypt and/or permanently store the event data in local nonvolatile storage for later retrieval. Further, the control panel could include speakers for providing audio playback of audio data sent from the gunshot sensor units to the control panel, including the locally stored audio data, which can be streamed from the gunshot sensor units to the control panel. The control panel can also instruct the gunshot sensor units to capture and stream live audio data for audio playback via the speakers at the control panel.

[0021] Because of the sensitive nature of audio capture and recording, the gunshot detection system should also include features for preventing the gunshot sensor units from

indiscriminately capturing audio data and for restricting access to the audio data to proper authorities. The gunshot sensor units might thus include functionality for detecting speech sounds and automatically deleting any audio data depicting the speech sounds.

Additionally, special inputs (e.g. keys, codes, decryption keys for encrypted audio data, multi-factor authentication queries, physical tokens, biometric information generated by biometric sensors) could be required for super-user access to stored audio data and/or live monitoring. Thus in one example, the control panel could also include a microphone, allowing two-way communication between the control panel and gunshot sensor units equipped with speakers. In addition, the control panel could include a display on which a graphical user interface (GUI) is presented. The GUI presents sensor information for the gunshot sensor units and receives input indicating selections of different options for each unit. These options might include local event data retrieval, live monitoring and/or two-way communication, among other examples.

[0022] In general, according to one aspect, the invention features a system for detecting gunshots within a premises. The system includes gunshot sensor units for detecting the gunshots. These units comprise one or more microphones that detect acoustic anomalies indicating potential gunshots and generate audio data depicting the acoustic anomalies. The gunshot sensor units include controllers, which generate event data based on the detected acoustic anomalies. The audio data and event data are locally stored by the gunshot sensor units in the gunshot sensor units' nonvolatile storage.

[0023] In embodiments, the system might further comprise a control panel, which receives the event data and the audio data from the gunshot sensor units. The control panel could instruct the gunshot sensor units to send the audio data to the control panel and/or to locally store the audio data and the event data based on the received event data. Alternatively, the control panel might receive truncated audio data depicting only the acoustic anomalies (e.g. gunshots) and instruct the gunshot sensor units to send the full audio data to the control panel or otherwise to encrypt and/or locally store the full audio data and all of the event data based on the received truncated audio data. Typically, the control panel might determine which one of the gunshot sensor units is closest to the source of the acoustic anomaly based on the received event data and instruct the de-conflicted gunshot sensor units that are not closest to the source to locally store the audio data. During this process, the control panel would also generate and store order information

indicating an order in which the gunshot sensor units detected the acoustic anomalies based on the received event data.

[0024] In addition, the control panel might generate and display a graphical user interface, on a touch-screen display panel, for example, for providing sensor information to an operator and for receiving input from the operator indicating selections of different gunshot sensor units for retrieval of the locally stored audio data and/or event data.

[0025] The gunshot sensor units can send the locally stored audio data and/or event data to computing devices of law enforcement entities and/or to a cloud gunshot detection management system. Such a cloud gunshot detection management system would generally be characterized as a system of application servers and databases that are only accessible over data connections that include public networks among other networks.

[0026] In addition to the audio data, the gunshot sensor units can also generate environmental data indicating environmental conditions in an area surrounding the gunshot sensor unit or the unit itself. This environmental data is generated via environmental sensors of the gunshot sensor units, including accelerometers, temperature sensors, humidity sensors, pressure sensors, e.g., barometric pressure sensors, and/or low frequency radar sensors.

[0027] In general, according to another aspect, the invention features a method for detecting gunshots within a premises. Acoustic anomalies indicating potential gunshots are detected via one or more microphones of gunshot sensor units. Audio data is generated depicting the acoustic anomalies, and event data is generated based on the detected acoustic anomalies. The audio data and event data are stored in nonvolatile storage of the gunshot sensor units.

[0028] In general, according to another aspect, the invention features a system for detecting gunshots within a premises. The system comprises gunshot sensor units and a control panel. The gunshot sensor units, which detect the gunshots, comprise one or more microphones for detecting acoustic anomalies indicating potential gunshots and for generating audio data depicting the acoustic anomalies and controllers for generating event data based on the detected acoustic anomalies. The control panel receives the event data and the audio data from the gunshot sensor units and provides audio playback of the audio data received from the gunshot sensor units via speakers of the control panel.

[0029] In general, according to another aspect, the invention features a method for detecting gunshots within a premises. Acoustic anomalies indicating potential gunshots are detected, and audio data depicting the acoustic anomalies are generated via one or more microphones of gunshot sensor units. Event data is generated based on the detected acoustic anomalies. Audio playback of the audio data is provided via speakers of a control panel, wherein the control panel receives the event data and the audio data from the gunshot sensor units.

[0030] In general, according to another aspect, the invention features a system for detecting gunshots within a premises. Gunshot sensor units, which detect the gunshots, comprise one or more microphones for detecting acoustic anomalies indicating potential gunshots and for generating audio data depicting the acoustic anomalies, nonvolatile storage for locally storing the audio data, and controllers for filtering speech sounds from the audio data.

[0031] In general, according to another aspect, the invention features a method for detecting gunshots within a premises. Acoustic anomalies indicating potential gunshots are detected and audio data depicting the acoustic anomalies are via one or more microphones of gunshot sensor units. The audio data is locally stored in nonvolatile storage of the gunshot sensor units, and speech sounds are filtered from the audio data.

[0032] In general, according to another aspect, the invention features a system for detecting gunshots within a premises. The system comprises gunshot sensor units for detecting the gunshots and a control panel. The gunshot sensor units comprise one or more microphones for detecting acoustic anomalies indicating potential gunshots and for generating audio data depicting the acoustic anomalies. The control panel comprises an audio buffer for storing streaming audio data received from the gunshot sensor units. The gunshot sensor units stream the audio data to the control panel for a higher level analysis in response to determining that a level of certainty of the audio data depicting gunshots is below a predetermined threshold. The control panel instructs the gunshot sensor units to locally store or delete the audio data based on whether the higher level analysis indicates that the streamed audio data depicts gunshots.

[0033] In general, according to another aspect, the invention features a method for detecting gunshots within a premises. Acoustic anomalies indicating potential gunshots are detected and audio data depicting the acoustic anomalies are via one or more microphones

of gunshot sensor units. Streaming audio data from the gunshot sensor units is stored in an audio buffer of a control panel. The gunshot sensor units stream the audio data to the control panel for a higher level analysis in response to determining that a level of certainty of the audio data depicting gunshots is below a predetermined threshold. The control panel instructs the gunshot sensor units to locally store or delete the audio data based on whether the higher level analysis indicates that the streamed audio data depicts gunshots.

[0034] In general, according to another aspect, the invention features a system for detecting gunshots within a premises. The system comprises gunshot sensor units for detecting the gunshots. The gunshot sensor units comprise one or more microphones for detecting acoustic anomalies indicating potential gunshots and for generating audio data depicting the acoustic anomalies, controllers for generating event data based on the detected acoustic anomalies, and nonvolatile storage for locally storing the audio data and the event data. The gunshot sensor units also comprise wired and/or wireless interfaces for sending the locally stored audio data and event data to computing devices of law enforcement entities.

[0035] In general, according to another aspect, the invention features a method for detecting gunshots within a premises. Acoustic anomalies indicating potential gunshots are detected and audio data depicting the acoustic anomalies are via one or more microphones of gunshot sensor units. Event data is generated based on the detected acoustic anomalies. The audio data and event data are locally stored in nonvolatile storage of the gunshot sensor units. The locally stored audio data and event data are sent to computing devices of law enforcement entities via wired and/or wireless interfaces of the gunshot sensor units.

[0036] In general, according to another aspect, the invention features a system for detecting gunshots within a premises. The system comprises gunshot sensor units for detecting the gunshots and a control panel. The gunshot sensor units comprise one or more microphones for detecting acoustic anomalies indicating potential gunshots and for generating audio data depicting the acoustic anomalies and controllers for generating event data based on the detected acoustic anomalies. The control panel receives the audio data and/or the event data from the gunshot sensor units and generates and sends live monitoring instructions to the gunshot sensor units. In response to receiving the live monitoring instructions, the gunshot sensor units generate and stream live audio data depicting ambient sound to the control panel.

[0037] In embodiments, the control panel might further include a user interface for receiving a special authorization input for super-user access from an operator of the control panel, and the control panel generates and sends the live monitoring instructions only in response to receiving the special authorization input. The control panel might also comprise a microphone for generating audio data that is live streamed to the gunshot sensor units, in which case the gunshot sensor units further comprise speakers for providing audio playback of the live audio data streamed from the control panel.

[0038] In general, according to another aspect, the invention features a method for detecting gunshots within a premises. Acoustic anomalies indicating potential gunshots are detected and audio data depicting the acoustic anomalies are via one or more microphones of gunshot sensor units. Event data is generated based on the detected acoustic anomalies. Live monitoring instructions are generated and sent to the gunshot sensor units. The gunshot sensor units generate and stream live audio data depicting ambient sound to a control panel in response to the live monitoring instructions.

[0039] In general, according to another aspect, the invention features a system for detecting gunshots within a premises. The system comprises gunshot sensor units for detecting the gunshots and a control panel. The gunshot sensor units comprise one or more microphones for detecting acoustic anomalies indicating potential gunshots and for generating audio data depicting the acoustic anomalies, controllers for generating event data based on the detected acoustic anomalies, and nonvolatile storage for locally storing the audio data and event and other meta data. The control panel, which receives the audio data and/or the event data from the gunshot sensor units, comprises a microphone for generating audio data of a panel operator's speech, speakers for providing audio playback of audio data for the operator, and a graphical user interface. The graphical user interface, rendered on a touch-screen display panel, for example, provides sensor information to the operator of the control panel and receives input from the operator indicating selections of different gunshot sensor units for retrieval of locally stored audio data and event data, live audio data streaming from the gunshot sensor units, and/or two-way communication between the control panel and the gunshot sensor units.

[0040] In general, according to another aspect, the invention features a method for detecting gunshots within a premises. Acoustic anomalies indicating potential gunshots are detected and audio data depicting the acoustic anomalies are via one or more microphones

of gunshot sensor units. Event data is generated based on the detected acoustic anomalies. The audio data and event data are locally stored in nonvolatile storage of the gunshot sensor units. Via a graphical user interface, sensor information is provided to an operator of a control panel, and input is received from the operator, the input indicating selections of different gunshot sensor units for retrieval of the locally stored audio data and event data, live audio data streaming from the gunshot sensor units, and/or two-way communication between a control panel and the gunshot sensor units via a microphone for generating audio data and speakers for providing audio playback of audio data of the control panel.

[0041] In general, according to another aspect, the invention features a system for detecting gunshots within a premises. The system comprises gunshot sensor units for detecting the gunshots. The gunshot sensor units comprise one or more microphones for detecting acoustic anomalies indicating potential gunshots and for generating audio data depicting the acoustic anomalies. Controllers of the gunshot sensor units generate event data based on the detected acoustic anomalies, and the gunshot sensor units send the event data and audio data to a cloud gunshot detection management system via wired and/or wireless interfaces of the gunshots sensor units and a public network.

[0042] In general, according to another aspect, the invention features a method for detecting gunshots within a premises. Acoustic anomalies indicating potential gunshots are detected, and audio data depicting the acoustic anomalies is generated via one or more microphones of gunshot sensor units. Event data is generated based on the detected acoustic anomalies. The audio data and event data are sent to a cloud gunshot detection management system via wired and/or wireless interfaces of the gunshot sensor units and a public network.

[0043] The above and other features of the invention including various novel details of construction and combinations of parts, and other advantages, will now be more particularly described with reference to the accompanying drawings and pointed out in the claims. It will be understood that the particular method and device embodying the invention are shown by way of illustration and not as a limitation of the invention. The principles and features of this invention may be employed in various and numerous embodiments without departing from the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0044] In the accompanying drawings, reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale; emphasis has instead been placed upon illustrating the principles of the invention. Of the drawings:

[0045] Fig. 1 is a schematic diagram of an exemplary gunshot detection system showing a common context for embodiments of the present invention;

[0046] Fig. 2A is a block diagram showing an exemplary gunshot sensor unit of the gunshot detection system according to the present invention;

[0047] Fig. 2B is a block diagram showing an exemplary gunshot sensor unit according to another embodiment of the present invention in which the gunshot sensor unit includes speakers according to the present invention;

[0048] Fig. 2C is a block diagram showing an exemplary gunshot sensor unit according to another embodiment of the present invention in which the gunshot sensor unit includes a low frequency radar sensor according to the present invention;

[0049] Fig. 3 is a block diagram showing an exemplary control panel of the gunshot detection system according to the present invention;

[0050] Fig. 4A is a sequence diagram illustrating an exemplary process by which the gunshot detection system detects gunshots, locally stores event data, analyzes the event data and provides the event data to a law enforcement entity;

[0051] Fig. 4B is a sequence diagram illustrating an exemplary process by which the control panel retrieves locally stored event data from the gunshot sensor units;

[0052] Fig. 5 is a sequence diagram illustrating an exemplary process by which the gunshot detection system provides live audio monitoring and two-way communication;

[0053] Fig. 6 is an illustration of an exemplary screen of a graphical user interface presented on a touch screen graphics display of the control panel;

[0054] Fig. 7 is a flow diagram illustrating functionality of the gunshot sensor unit during an operation in which anomalies are detected across both the individual gunshot sensor units and the control panel;

[0055] Fig. 8 is a flow diagram illustrating functionality of the control panel during an operation in which anomalies are detected across both the individual gunshot sensor units and the control panel;

[0056] Fig. 9A is a block diagram showing an exemplary embodiment of the gunshot sensor unit, in which the gunshot sensor unit includes a wireless data transfer interface;

[0057] Fig. 9B is a block diagram showing an exemplary embodiment of the gunshot sensor unit, in which the gunshot sensor unit includes a wired data transfer interface; and

[0058] Fig. 10 is a flow diagram illustrating an exemplary process by which the gunshot sensor unit autonomously performs the gunshot detection functions without a control panel;

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0059] The invention now will be described more fully hereinafter with reference to the accompanying drawings, in which illustrative embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art.

[0060] As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. Further, the singular forms and the articles "a", "an" and "the" are intended to include the plural forms as well, unless expressly stated otherwise. It will be further understood that the terms: includes, comprises, including and/or comprising, when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. Further, it will be understood that when an element, including component or subsystem, is referred to and/or shown as being connected or coupled to another element, it can be directly connected or coupled to the other element or intervening elements may be present.

[0061] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those

defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0062] Fig. 1 is a schematic diagram of an exemplary gunshot detection system 100.

[0063] In general, the gunshot detection system 100 monitors, detects and reports the occurrence of gunshots or other emergencies within a premises 50 such as a building (e.g. office, hospital, warehouse, retail establishment, shopping mall, school, multi-unit dwelling, government building).

[0064] In the illustrated example, the premises 50 is a simplified floor example of a building with three areas 52, a lecture hall 52-1, classroom A 52-2, and classroom B 52-3. Two gunshot sensor units 130-1, 130-2 are located in the lecture hall 52-1, while one gunshot sensor unit 130-2 is located in classroom A 52-2, and one gunshot sensor unit 130-3 is located in classroom B 52-3.

[0065] In the illustrated embodiment, the gunshot detection system 100 includes gunshot sensor units 130, a control panel 116, and a communication network 111. In general, and in one configuration, the gunshot sensor units 130 detect conditions indicative of the gunshots or other emergencies and alert the control panel 116, which takes one or more responsive actions such as alerting building personnel, law enforcement, and/or a monitoring center, or collecting and presenting data pertaining to the detected gunshots to an operator of the control panel 116. The gunshot sensor units 130 and the control panel 116 communicate over the communication network 111.

[0066] More specifically, the gunshot sensor units 130 are distributed throughout the premises 50, for example, in areas 52 of the premises such as rooms, hallways, lobbies or stairways, to name a few examples. The gunshot sensor units 130 detect acoustic anomalies indicating potential gunshots and generate audio data depicting the acoustic anomalies. The gunshot sensor units 130 also generate event data based on and descriptive of the acoustic anomalies and locally store and/or send the event data to the control panel 116.

[0067] The event data often includes: audio data (e.g. digitized audio clips) depicting the acoustic anomalies; metadata including, for example, time information indicating when the acoustic anomalies started and/or stopped, duration information for the acoustic anomalies and/or the audio data depicting the acoustic anomalies, file information, and

identification information for the gunshot sensor unit 130; environmental data indicating environmental conditions in the areas 52 where the gunshot sensor units 130 are located; position information indicating positions of detected bodies (e.g. an active shooter, occupants of the premises 50) with respect to the gunshot sensor unit 130; and other sensor data generated by the gunshot sensor unit 130. The event data can be locally stored, collected by the control panel 116, transferred to remote servers, and/or transferred to devices of law enforcement entities for forensic analysis, for example. Additionally, some event data might be generated by other devices such as distributed devices of building management systems via environmental sensors of the distributed devices, for example.

[0068] On the other hand, the control panel 116 directs the overall functionality of the gunshot detection system 100 by sending instructions (e.g. control messages) to be executed by the gunshot sensor units 130, receiving the event data from the gunshot sensor units 130 and taking the responsive actions based on the event data. The control panel 116 might receive preliminary event data (e.g. metadata indicating time information, or truncated audio data) from multiple gunshot sensor units 130 and perform a de-confliction process in order to determine which event data from the different sensor units 130 pertains to the same detected acoustic anomaly and which of the gunshot sensor units 130 is closest to the source of the acoustic anomaly based on, for example, which of the units first detected the acoustic anomaly. The control panel 116 might then send instructions to the gunshot sensor unit 130 closest to the source to send full event data (e.g. including a full audio data sample, environmental data, and other sensor data) to the control panel 116 for further processing and/or to be presented to the operator. At the same time, the control panel 116 instructs de-conflicted gunshot sensor units 130 that were not closest to the source to locally store the full event data for future retrieval.

[0069] It should be noted that the analytical processes performed by the control panel 116 and/or the gunshot sensor units 130 to be described might be performed in any combination of steps, using any combination of the described features of each of the devices, including omitting steps and/or features.

[0070] Fig. 2A is a block diagram showing an exemplary gunshot sensor unit 130.

[0071] The gunshot sensor unit 130 includes a controller 200, local nonvolatile storage 202, a wired and/or wireless network interface 204, a battery backup 218, an anomaly

detection microphone 206, an audio capture microphone 208, and an environmental board 220.

[0072] The controller 200 executes firmware/operating system instructions and generally directs the functionality of the gunshot sensor unit 130. In one example, the controller 200 is small single-board computer. In other examples, the controller is a microcontroller unit or a system on a chip (SoC), including one or more processor cores along with memory and programmable input/output peripherals such as analog to digital converts and digital to analog converters.

[0073] The wired and/or wireless network interface 204 provides connectivity with the control panel 116 and possibly other devices via the communication network 111. In addition, the network might also provide power to the device, in many examples. Direct current (DC) might be superimposed upon the data that is transmitted between the devices and other nodes on the network such as in Power over Ethernet (PoE) systems. In other examples, the gunshot sensor units 130 might receive power from alternative power supplies such as a supervised power circuit, ambient solar power, or motion harvesting power generation.

[0074] The battery backup 218 provides backup power to the gunshot sensor unit 130, which might normally receive power from a primary power source such as over the networks or such as a mains power line (not pictured) supplying alternating current electric power to the gunshot sensor unit 130, typically at voltages ranging from 110 to 240 Volts. In one embodiment, the mains power line or house power provides power at 120 or 240 Volts (V) to the control panel 116, which then feeds the power to the gunshot sensor units 130 through a supervised power circuit at 24 V. In the event that the primary power source could not provide power (e.g. due to being damaged in a shooting incident), the battery backup 218 would continue to power the gunshot sensor unit 130 typically at 24 V.

[0075] The anomaly detection microphone 206 detects the acoustic anomalies, while the audio capture microphone 208 captures ambient sound and generates the audio data. In one embodiment, both microphones 206, 208 are micro electro-mechanical system (MEMS) microphones having different sensitivity levels, and the controller 200 is configured to sample the microphones 206, 208 such that outputs from the microphones can be continuously analyzed in near real time for an acoustic signature. The anomaly detection microphone 206 has the lower sensitivity level and a high clipping level, while

the audio capture microphone 208 has the higher sensitivity level. The audio capture microphone 208 continuously captures ambient sound, which is stored in a loop of a preconfigured buffer duration (e.g. 9.9 seconds) in a ring buffer 216 of the controller 200. At the same time, incoming acoustic signals from the anomaly detection microphone 206 are continuously analyzed to detect acoustic anomalies, particularly by searching the incoming acoustic signal for a peak amplitude level large enough to be at least preliminarily identified as a gunshot.

[0076] Once an indication of a possible gunshot has been triggered utilizing the anomaly detection microphone 208, further processing may be performed by the controller 200. The controller 200 analyzes the sound stored in the loop to confirm that the acoustic anomaly is a gunshot. If confirmed as a gunshot, the controller 200 stores the captured sound in the loop buffer 216, which would include the acoustic anomaly and the previously captured sound (up to the entirety of the preconfigured buffer duration, which is 9.9 seconds in this example) as audio data 214 in the local nonvolatile storage 202 associated with different event files 210 or instances of event data for different gunshot detection events, along with the metadata 212 and the environmental data 215 for the events. In embodiments, the local nonvolatile storage 202 could be fixed storage such as flash memory, or removable storage such as an SD card, among other examples.

[0077] In another example, the gunshot sensor unit 130 includes one or more additional microphones for generating audio data to be live-streamed to the control panel 116 for the purposes of live-monitoring and/or two-way communication. This configuration allows the anomaly detection microphone 206 and the audio capture microphone 208 to be used exclusively for the primary purpose of the units, namely, detecting gunshots.

[0078] The environmental board 220 includes a series of environmental sensors for generating the environmental data. In the illustrated example, the environmental board 220 includes a 3-axis accelerometer 222, which detects the orientation of the gunshot sensor unit in the earth's gravitational field and movements of the unit, a temperature sensor 224, which detects ambient air temperature, a humidity sensor 226, which detects the humidity of the ambient air, a pressure sensor 228, which detects the atmospheric pressure of the ambient air, a gas detector 229 which detects the presence of gases such as carbon monoxide (CO) and ammonia (NH₃), which are typical components of fumes from firing

weapons, and a smoke sensor 231 for detecting smoke and/or other airborne particles emitted from firing a weapon.

[0079] Fig. 2B is a block diagram showing an exemplary gunshot sensor unit 130 according to another embodiment of the present invention. Here, the gunshot sensor unit includes speakers 230 for providing audio playback of audio data streamed from the control panel 116 or another source. The speakers 230, in combination with the unit's microphone(s) enable two-way communication between, for example, an operator of the control panel 116 and individuals in the area 52 where the gunshot sensor unit 130 is located, such as an active shooter or occupants of the premises 50.

[0080] Fig. 2C is a block diagram showing an exemplary gunshot sensor unit 130 according to another embodiment of the present invention. Here, the gunshot sensor unit includes a low frequency RADAR sensor 240 (operating in a 3-80 GHz range, for example), which is used to generate position information 217 indicating positions with respect to the gunshot sensor unit 130 of bodies in the area 52 where the gunshot sensor unit 130 is located, such as those of an active shooter or occupants of the premises 50. The position information preferably further includes information indicating relative spatial position as well as body position (e.g. upright, prone), along with physiological indicators. The position information 217 is generated and stored with the event data in the local nonvolatile storage 202, sent to the control panel 116, and/or provided to law enforcement.

[0081] In one embodiment, the low frequency RADAR sensor 240 could operate in conjunction with a wireless receiver and/or antenna (e.g. of the wired and/or wireless network interface 204) for receiving radiofrequency signals according to IEEE 802.15 standards such as Bluetooth or Bluetooth Low Energy, among other examples. Individuals such as occupants, armed personnel including law enforcement officers or security personnel and/or first responders are then equipped with passive or active tags which broadcast wireless signals including, for example, identification information for the tags and/or the individuals. Each gunshot sensor unit 130 receives the broadcast identification information via the wireless receiver and sends the information to the control panel 116, which resolves the identity and location of the individual based on the identification information and the location of the gunshot sensor unit 130. The control panel 116 also determines whether there were individuals detected via the low frequency RADAR sensor 240 that were not detected via the wireless receiver and infer that the unidentified

individual (e.g. without an actively transmitting tag) is the active shooter and/or a victim/civilian.

[0082] Fig. 3 is a block diagram showing an exemplary control panel 116.

[0083] The control panel 116 includes a central processing unit (CPU) 300, nonvolatile memory 302, a wired and/or wireless network interface 304, a display 310, a microphone 306, and speakers 308.

[0084] Similar to analogous components on the gunshot sensor units 130, the wired and/or wireless network interface 304 provides connectivity with the gunshot sensor units 130 and possibly other devices via the communication network 111. In some examples, the control panel may also supply power to the units.

[0085] The speakers 308 provide audio playback of streamed audio data from the gunshot sensor units 130. The audio data can be the locally stored audio data 214 depicting the acoustic anomalies or can be captured and streamed live for live monitoring of the ambient sound in the area 52 where the gunshot sensor unit 130 is located.

[0086] The microphone 306 is used to capture speech sound from the operator of the control panel 116 for generating audio data to be streamed back to the gunshot sensor units 130 during two-way communication between the control panel 116 and the gunshot sensor units 130.

[0087] The CPU 300 executes firmware instructions and an operating system (OS) 312 and generally directs the functionality of the control panel 116. The OS 312 interfaces with the hardware components of the control panel 116 for access by an audio analytics module 314 and a command and control application 316, which are software processes executing on top of the OS 312.

[0088] The audio analytics module 314 performs a higher-level analysis of audio data received from the gunshot sensor units 130, for example, in order to confirm that the audio data depicts gunshots when a first analysis by the controller 200 of the gunshot sensor unit 130 is unable to confirm the gunshots with a certainty above a predetermined threshold. The audio analytics module 314 performs the analysis by retrieving audio data files from a first-in-first-out (FIFO) audio buffer 320 in the nonvolatile memory 302, determining whether the ambient sound and/or acoustic anomalies depicted in the audio data files include gunshots and instructing the gunshot sensor unit 130 to either delete or

permanently store the audio data and/or event data in local nonvolatile storage 202. The higher-level analysis might also include analyzing the sensor data generated by the sensors of the environmental board 220 of the gunshot sensor units 130 for contextual information that might confirm that an acoustic anomaly was a gunshot. In one example, the audio analytics module 314 could isolate a loud acoustic signature in the audio data that could be a gunshot and determine whether the sensor data indicates that the presence of gases such as carbon monoxide (CO) and ammonia (NH₃) and/or smoke and other airborne particles were detected by the gas detector 229 and the smoke sensor 231 shortly after the occurrence of the acoustic anomaly.

[0089] The command and control application 316, in general, generates a graphical user interface (GUI) 318 that is rendered on the display 310 (e.g. touchscreen display) of the control panel 116. The GUI 318 presents gunshot sensor unit information to the operator and receives input indicating selections of various options for controlling the gunshot sensor units 130 such as retrieving locally stored event data and/or audio data, initiating live monitoring, and/or initiating two-way communication between the control panel 116 and the gunshot sensor units 130. Based on the received input, the command and control application 316 generates instructions (e.g. control messages) to be executed by the gunshot sensor units 130, for example.

[0090] The gunshot detection system 100 also includes a gunshot event database 321 for storing event data, audio data, environmental data, position information, and any generated audio, event and/or environmental data analytics information, such as forensic data generated as a result of processing the data received from the gunshot sensor units 130, or order information indicating the order in which the gunshot sensor units 130 detected the gunshots. In the illustrated example, the gunshot event database 321 is stored in the nonvolatile memory 302 of the control panel 116. However, in other examples, the gunshot event database 321 might be part of a cloud management system and/or connected services system, which is accessible only over public networks, or even on the local nonvolatile storage 202 of the gunshot sensor units 102 themselves.

[0091] Fig. 4A is a sequence diagram illustrating an exemplary process by which the gunshot detection system 100 detects gunshots, locally stores event data and/or audio data, analyzes the event data and/or audio data and provides the event data and/or audio data to a law enforcement entity 70.

[0092] First, in step 400, three different gunshot sensor units 130-1, 130-2, 130-3 detect gunshots at different times relative to each other. This is a common scenario since the sound of the same gunshot will have different propagation delays to different sensors at different distances from the gunshot. The gunshot sensor units 130 detect acoustic anomalies indicative of the gunshot via the anomaly detection microphones 206, for example, by searching the incoming acoustic signal from the anomaly detection microphone 206 for a peak amplitude level large enough to be identified as a gunshot. The timing of when the gunshot sensor units 130 detect the same gunshots relative to each other is significant, because the first gunshot sensor unit 130 to detect an acoustic anomaly can be inferred to be closest to the source of the acoustic anomaly and thus closest to an active shooter. In the illustrated example, the gunshot sensor unit 130-2 detects the gunshots first, followed by the gunshot sensor units 130-1, 130-3.

[0093] In step 402, each of the three gunshot sensor units 130-1, 130-2, 130-3, having detected the gunshots, generate and locally store event data based on the acoustic anomaly including metadata indicating the timing of the gunshots, audio data depicting the gunshots and any other ambient sound captured by the audio capture microphone 208 (e.g. audio data starting at a preconfigured buffer duration such as 9 seconds before the gunshots were detected and proceeding through the gunshot sounds and after), environmental data generated by the sensors of the environmental board 220, and/or position information generated by the low frequency radar sensor 240.

[0094] In step 404, the three gunshot sensor units 130-1, 130-2, 130-3 alert the control panel 116 that gunshots were detected and send at least some of the event data to the control panel 116. In one example, the gunshot sensor units 130 might send only a preliminary portion of the event data to the control panel 116, such as the metadata indicating the timing information for the gunshots. In another example, the gunshot sensor units 130 might send truncated audio data, i.e., audio data representing less than 1 second of sound, depicting only the acoustic anomalies (e.g. with ambient sound before and after the acoustic anomalies removed). In another example, the gunshot sensor units 130 might stream the captured audio data to the control panel 116 for higher level analysis and include audio data representing more than 1 second of sound, such as the entire preconfigured buffer duration (e.g. all 9 seconds) of buffered audio data. In yet another

example, the gunshot sensor units 130 might send all of the recorded event data to the control panel 116.

[0095] In step 406, the control panel 116 performs a de-confliction process and determines which gunshot sensor unit 130 was closest to the source of the acoustic anomaly based on the received event data and/or truncated audio data. As previously described, this process involves determining which event data received from the gunshot sensor units 130 pertain to the same acoustic anomalies and then determining which of the gunshot sensor units 130 detected each of the acoustic anomalies first (e.g. based on the metadata indicating the timing information for the gunshots). The control panel 116 generates and stores, for example, in the gunshot event database 321 of the gunshot detection system 100, order information indicating an order in which the gunshot sensor units 130 detected each of the gunshots.

[0096] In step 408, the control panel 116 sends instructions to the gunshot sensor unit 130-2 that was determined to be closest to the gunshots to send its full event data, including a full captured audio data sample depicting the gunshots and any ambient sound before and/or after the gunshots. In response, the gunshot sensor unit 130-2 sends the full event data including the full audio data sample to the control panel 116. In one example, full the event includes the 9 seconds of buffered audio data and possibly more than 1 minute of stored audio data from after the gunshot. In addition, full event data also includes, in some examples, acceleration information from the 3-axis accelerometer 222, detected temperature from the temperature sensor 224, detected humidity from the humidity sensor 226, detected pressure from the pressure sensor 228 along with position information from the RADAR sensor 240, detected gases from the gas detector 229, and detected smoke and/or particles from the smoke sensor 231.

[0097] In step 412, the control panel 116 sends instructions to the de-conflicted gunshot sensor units 130 that were not closest to the source of the gunshots to encrypt and/or permanently store the event data and/or audio data in the local nonvolatile storage 202. In response, the de-conflicted gunshot sensor units 130-1, 130-3 permanently store the event data and/or audio data in the local nonvolatile storage 202 as encrypted or plaintext event files 210, including the metadata 212, audio data 214, environmental data 215 and position information. In some examples, the control panel instructs the gunshot sensor units 130 to save only the preconfigured buffer duration (e.g. 9 seconds) of buffered audio

data. In other examples, the control panel instructs the gunshot sensor units 130 to save longer periods of audio data such audio data depicting longer than 30 seconds of audio stretching from before the occurrence of the gunshot to after the gunshot.

[0098] In step 416, the control panel 116 provides audio playback of the audio data received from the gunshot sensor unit 130-2 closest to the source of the gunshots to the operator of the control panel 116 via the speakers 308. In one example, the operator might confirm the gunshots or determine, based on the audio playback, that the acoustic anomalies were not gunshots.

[0099] At this point, the control panel 116, possibly based on input received from the operator via the GUI 318, can take any number of responsive actions such as alerting law enforcement 70, initiating building security procedures, or dismissing the alerts based on determining that the acoustic anomalies were not gunshots, among other examples.

[0100] In the illustrated example, the control panel 116, in step 418, proceeds to analyze the event data, including the audio data and environmental data, for example, to confirm the gunshots, detect destructive events such as explosions from an improvised explosive device (IED) based on the environmental data, detect seismic activity such as earthquakes based on the environmental data, or generate forensic data to be later used by law enforcement 70 or other entities in investigating the event.

[0101] In step 420, the gunshot detection system 100 provides the event data, including the audio data, and any generated analytics information to law enforcement entities 70. This might include transferring the data to computing devices of the law enforcement entities 70. This data could also be transferred to remote servers, for example, of a cloud gunshot detection management system. Of note here is that in addition to the control panel 116 transferring the event data, the de-conflicted gunshot sensor units 130-1, 130-3 can also be equipped to transfer the locally stored and/or encrypted event data from the local nonvolatile storage 202 to the law enforcement entities 70, for example, via wired and/or wireless data transfer ports of the gunshot sensor units 130 in response to receiving credentials for superuser access and based on predetermined permissions settings, in examples.

[0102] Fig. 4B is a sequence diagram illustrating an exemplary process by which the control panel 116 retrieves locally stored event data from the gunshot sensor units 130.

Specifically, in the illustrated example, the control panel 116 retrieves and presents the audio data to the operator via the speakers 308.

[0103] First, steps 400 through 414 proceed as previously described, as the gunshot sensor units 130 detect the gunshots, generate the event data, and locally store the event data in the local nonvolatile storage 202.

[0104] Then, in step 450, the control panel 116 receives, for example, from an officer of a law enforcement entity 70 a special input for superuser access. The special input might include a code or other credentials entered via the GUI 318, or possibly a key inserted into an interface of the control panel 116. The superuser access allows retrieval and/or decryption of the locally stored and/or encrypted event data from the gunshot sensor units 130 and/or the control panel 116 itself. In the preferred embodiment, superuser access is granted only in response to receiving the special input. The business entities administering the gunshot detection system 100 might have a policy for providing the superuser access to technicians, including doing so only in response to a subpoena or other official directive. The key and/or code for obtaining superuser access might even be held by a third party such as law enforcement.

[0105] In step 452, having received the special input, the control panel 116 presents to the law enforcement officer 70 gunshot sensor unit information (e.g. identification information, location information, proximity information to the source of the detected gunshots, or other information) pertaining to the different gunshot sensor units 130 of the gunshot detection system 100. In step 454, the law enforcement officer 70 selects a particular gunshot sensor unit 130 for audio playback.

[0106] In step 456, the control panel 116 sends instructions to the selected gunshot sensor unit 130-3, which in the illustrated example is one of the two de-conflicted gunshot sensor units 130-1, 130-3, to stream the locally stored audio data. The gunshot sensor unit 130-3 streams the locally stored audio data in step 458.

[0107] In step 460, the control panel 116 presents the streaming audio data from the gunshot sensor unit 130-3 to the law enforcement officer 70 via the speakers 308.

[0108] Fig. 5 is a sequence diagram illustrating an exemplary process by which the gunshot detection system 100 provides live monitoring of ambient sound in the areas 52 where the gunshot sensor units 130 are located and two-way communication between

individuals in the areas 52 where the gunshot sensor units 130 are located and operators of the control panel 116 such as law enforcement officers 70 or other authorized individuals.

[0109] First, in step 502, the authorized individual such as the law enforcement officer 70 enters the special input (e.g. keys, codes, , decryption keys for encrypted audio data, multi-factor authentication queries, physical tokens, biometric information generated by biometric sensors) for superuser access via the GUI 318 and/or other interfaces of the control panel 116. In step 504, the control panel 116 presents the gunshot sensor unit information to the law enforcement officer 70 via the GUI 318. This process is similar to the analogous process described in steps 450 and 452 with respect to Fig. 4B.

[0110] In step 506, the GUI 318 receives input from the law enforcement officer 70 indicating selection of a gunshot sensor unit 130 for live audio monitoring. In one example, the law enforcement officer 70 might select the gunshot sensor unit 130 closest to the source of the gunshots with hopes of communicating with the shooter or victims.

[0111] In step 508, the control panel 116 generates and sends live monitoring instructions to the selected gunshot sensor unit 130-2 to stream live audio data.

[0112] In step 510, in response to receiving the live monitoring instructions, the gunshot sensor unit 130-2 captures ambient sound via the audio capture microphone 208, generates audio data depicting the ambient sound, and streams live audio data to the control panel 116 in real time. The control panel 116, in step 512, presents the streamed live audio data to the law enforcement officer 70 via the speakers 308.

[0113] In this way, the gunshot detection system 100 provides the live monitoring functionality.

[0114] In order to initiate two-way communication, in step 514, the law enforcement officer 70 selects an option for providing audio input (e.g. a “push to talk” button on the GUI 318). The GUI 318 receives the input from the law enforcement officer 70 indicating selection of the gunshot sensor unit 130 for two-way communication, and in step 516, the control panel 116 prompts the law enforcement officer 70 for audio input.

[0115] In step 518, the microphone 306 of the control panel 116 receives the audio input from the law enforcement officer 70 (e.g. captured speech sounds), and the control panel 116 generates audio data based on the audio input.

[0116] In step 520, the control panel 116 streams the audio data back to the selected gunshot sensor unit 130-2.

[0117] In step 522, the gunshot sensor unit 130-2 outputs the audio data received from the control panel 116 via the speakers 308, thus presenting the captured speech sounds from the law enforcement office 70 to any individuals in the area 52 where the gunshot sensor unit 130-2 is located.

[0118] Fig. 6 is an illustration of an exemplary screen of the GUI 318 presented on the display 310 of the control panel 116. This screen is displayed, for example, at steps 452 and 504, which were previously described with respect to Figs. 4B and 5 respectively. In general, the screen includes graphical elements 600, 602, 604, 606 such as indicators for presenting information and/or virtual buttons for receiving user input. In particular, the gunshot sensor unit information indicators 600 present the gunshot sensor unit information for different gunshot sensor units 130. Virtual buttons 602, 604, 606 are associated with each of the gunshot sensor unit information indicators 600. Of these, the get local data button 602 provides an option for retrieving the event data and/or audio data locally stored on the gunshot sensor units 130, the live monitoring button 604 provides an option for live monitoring of ambient sound captured by the gunshot sensor units 130, and the push to talk button 606 provides an option for two-way communication between the control panel 116 and the gunshot sensor unit 130.

[0119] Figs. 7 and 8 are flow diagrams illustrating an operation in which anomalies are detected across both the individual gunshot sensor units 130 and the control panel 116.

[0120] Fig. 7 shows the operation of the gunshot sensor unit 130.

[0121] In step 700, the gunshot sensor unit 130 detects an acoustic anomaly via the anomaly detection microphone 206 and generates audio data depicting ambient sound including the acoustic anomaly.

[0122] In step 702, the gunshot sensor unit 130 determines whether the ambient sound depicted in the audio data is in fact speech sounds. If so, in step 710, the gunshot sensor unit 130 deletes the audio data and returns to step 700.

[0123] If the ambient sound does not include speech sounds, however, in step 704, the gunshot sensor unit 130 determines whether the captured ambient sound might include

gunshots. If not, the gunshot sensor unit 130 deletes the audio data as previously described in step 710 and returns to step 700.

[0124] However, in step 706, if the ambient sound could include gunshots, the gunshot sensor unit 130 determines whether a certainty of the ambient sound including gunshots is above a predetermined threshold. If so, in step 712, the gunshot sensor unit 130 alerts the control panel 116 of gunshots, sends the event data to the control panel 116 and then returns to step 700.

[0125] The processes for evaluating whether the ambient sound could include gunshots in steps 704 and/or 706 might include analyzing the sensor data generated by the sensors of the environmental board 220. In one example, the gunshot sensor unit 130 isolates a loud acoustic signature in the audio data that could be a gunshot and determines whether the sensor data indicates that the presence of gases indicative of the discharge of a weapon such as carbon monoxide (CO) and ammonia (NH₃) and/or smoke and other airborne particles were detected by the gas detector 229 and the smoke sensor 231 shortly after the occurrence of the acoustic anomaly.

[0126] In step 708, if the certainty of the ambient sound including gunshots is not above a predetermined threshold, the gunshot sensor unit 130 streams the audio data to the control panel 116 to be stored in the FIFO audio buffer 320. At this point, the gunshot sensor unit 130 returns to step 700.

[0127] The gunshot detection operation is then resumed by the control panel 116, as shown in Fig. 8.

[0128] In step 800, the control panel 116 retrieves the next audio data file from its FIFO audio buffer 320.

[0129] In step 802, the control panel 116 performs a higher level analysis on the audio data, which might not be possible for the gunshot sensor units 116 to perform due to limited processing capability, for example. In some example, the control panel employs a machine learning algorithm that compares the audio data to learned gunshot sounds to identify less common sounds such as gunshots from a suppressed gun and gunshots from subsonic ammunition.

[0130] In step 804, the control panel 116 confirms whether or not the ambient sound includes gunshots. If so, in step 808, the control panel 116 retrieves the event data from the

gunshot sensor unit 130 and instructs the gunshot sensor unit 130 to permanently store the event data and/or audio data in local nonvolatile storage 202.

[0131] In step 806, if the ambient sound is determined by the control panel 116 to not include gunshots, the control panel 116 instructs the gunshot sensor unit 130 to delete the event data and/or audio data from its local nonvolatile storage 202.

[0132] In either case, the control panel 116 returns to step 800 and repeats the process with the next audio file.

[0133] Figs. 9A and 9B are block diagrams showing an exemplary embodiment of the gunshot sensor unit 130, in which the gunshot sensor unit 130 includes a data transfer interface 900 for transferring the locally stored event data 210 to computing devices of law enforcement entities such as handheld units 902 or other mobile computing devices. In both examples, the gunshot sensor unit 130 also connects to a cloud gunshot detection management system 904, which might be a remote server operated by law enforcement 70 or other entities. The gunshot sensor unit 130 transfers the event data 210 to the cloud gunshot detection management system 904 via the wired and/or wireless network interface 204, the communication network 111, and a public network such as the internet to which the cloud gunshot detection management system 904 and the communication network 111 are both connected.

[0134] In particular, the illustrated example of Fig. 9A shows a Bluetooth and/or near field communication (NFC) interface 900-1, through which the gunshot sensor unit 130 wirelessly transmits the event data 210 to the law enforcement handheld unit 902.

[0135] The illustrated example depicted in Fig. 9B, on the other hand, shows a wired data transfer interface 900-2, through which the gunshot sensor unit 130 transmits the event data 210 to the law enforcement handheld unit 902.

[0136] Fig. 10 is a flow diagram illustrating an exemplary process by which the gunshot sensor unit 130 autonomously performs the gunshot detection functions without a control panel 116. In this example, the gunshot detection system 100 may not include a control panel 116 (e.g. for a small business entity at a smaller premises 50), or the control panel 116 may be disabled or disconnected from the communication network 111.

[0137] Steps 700 through 702 proceed as previously described, as the gunshot sensor unit 130 generates the audio data, determines whether the ambient sound depicted in the audio data is speech, and deletes the audio if so in step 710.

[0138] Now, however, the gunshot sensor unit 130 autonomously determines whether the ambient sound includes gunshots in step 1000. If not, the gunshot sensor unit 130 deletes the audio data in step 710 and returns to step 700.

[0139] If the ambient sound does include gunshots, however, in step 1002, the gunshot sensor unit 130 encrypts and permanently stores the event data including the audio data, metadata and environmental data in local storage 202.

[0140] In step 1004, the gunshot sensor unit alerts the cloud gunshot detection management system 904 that gunshots were detected.

[0141] In step 1006, the gunshot sensor unit receives the special input for superuser access (e.g. code or other credentials, key, decryption key), and in step 1008, the gunshot sensor unit decrypts and transfers the locally stored event data 210 to a requesting device such as the law enforcement handheld unit 902 or the cloud gunshot detection management system 904.

[0142] In this way, the gunshot sensor units 130 perform the gunshot detection functionality of the gunshot detection system autonomously without direction or participation of a control panel 116.

[0143] While this invention has been particularly shown and described with references to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention encompassed by the appended claims.

CLAIMS

What is claimed is:

1. A system for detecting gunshots within a premises, the system comprising:
gunshot sensor units for detecting the gunshots, the gunshot sensor units comprising one or more microphones for detecting acoustic anomalies indicating potential gunshots and for generating audio data depicting the acoustic anomalies, controllers for generating event data based on the detected acoustic anomalies, and nonvolatile storage for locally storing the audio data and the event data.
2. The system as claimed in claim 1, further comprising a control panel for receiving the event data and the audio data from the gunshot sensor units.
3. The system as claimed in claim 2, wherein the control panel receives the event data from the gunshot sensor units and instructs the gunshot sensor units to send the audio data to the control panel and/or locally store the audio data and the event data based on the received event data.
4. The system as claimed in claim 2, wherein the control panel receives truncated audio data depicting only the acoustic anomalies and instructs the gunshot sensor units to send full audio data to the control panel and/or locally store the full audio data and the event data based on the received truncated audio data.
5. The system as claimed in claim 2, wherein the control panel determines which one of the gunshot sensor units is closest to a source of the acoustic anomaly based on the received event data, instructs the gunshot sensor unit closest to the source to send the audio data to the control panel, and instructs de-conflicted gunshot sensor units that are not closest to the source to locally store the audio data.
6. The system as claimed in claim 5, wherein the control panel generates and stores order information indicating an order in which the gunshot sensor units detected the acoustic anomalies based on the received event data.

7. The system as claimed in claim 2, wherein the control panel further comprises a graphical user interface for providing sensor information to an operator of the control panel and for receiving input from the operator indicating selections of different gunshot sensor units for retrieval of the locally stored audio data and/or event data.

8. The system as claimed in claim 1, wherein the gunshot sensor units send the locally stored audio data and/or event data to computing devices of law enforcement entities for forensic processing and/or to a cloud gunshot detection management system.

9. The system as claimed in claim 1, wherein the event data includes environmental data generated by environmental sensors of the gunshot sensor units, the environmental data indicating environmental conditions of an area surrounding the gunshot sensor unit.

10. The system as claimed in claim 9, wherein the environmental sensors include accelerometers, temperature sensors, humidity sensors, pressure sensors, and/or low frequency radar sensors.

11. A method for detecting gunshots within a premises, the method comprising:
detecting acoustic anomalies indicating potential gunshots via one or more microphones of gunshot sensor units;
generating audio data depicting the acoustic anomalies;
generating event data based on the detected acoustic anomalies; and
storing the audio data and the event data in nonvolatile storage of the gunshot sensor units.

12. The method as claimed in claim 11, further comprising the gunshot sensor units sending the audio data and the event data to a control panel.

13. The method as claimed in claim 12, further comprising the control panel receiving the event data from the gunshot sensor units and instructing the gunshot sensor units to send the audio data to the control panel and/or locally store the audio data and the event data based on the received event data.

14. The method as claimed in claim 12, further comprising the control panel receiving truncated audio data depicting only the acoustic anomalies and instructing the gunshot sensor units to send full audio data to the control panel and/or locally store the full audio data and the event data based on the received truncated audio data.

15. The method as claimed in claim 12, further comprising the control panel determining which one of the gunshot sensor units is closest to a source of the acoustic anomaly based on the received event data, instructing the gunshot sensor unit closest to the source to send the audio data to the control panel, and instructing de-conflicted gunshot sensor units that are not closest to the source to locally store the audio data and the event data.

16. The method as claimed in claim 15, further comprising the control panel generating and storing order information indicating an order in which the gunshot sensor units detected the acoustic anomalies based on the received event data.

17. The method as claimed in claim 12, further comprising the control panel providing sensor information to an operator of the control panel and receiving input from the operator via a graphical user interface of the control panel, the input indicating selections of different gunshot sensor units for retrieval of the locally stored audio data and/or event data.

18. The method as claimed in claim 11, further comprising the gunshot sensor units sending for forensic processing the locally stored audio data and event data to computing devices of law enforcement entities and/or to a cloud gunshot detection management system.

19. The method as claimed in claim 11, wherein the event data includes environmental data generated by environmental sensors of the gunshot sensor units, the environmental data indicating environmental conditions of an area surrounding the gunshot sensor unit.

20. The method as claimed in claim 19, wherein the environmental sensors include accelerometers, temperature sensors, humidity sensors, pressure sensors, and/or low frequency radar sensors.
21. A system for detecting gunshots within a premises, the system comprising:
gunshot sensor units for detecting the gunshots, the gunshot sensor units comprising one or more microphones for detecting acoustic anomalies indicating potential gunshots and for generating audio data depicting the acoustic anomalies, and controllers for generating event data based on the detected acoustic anomalies; and
a control panel for receiving the event data and the audio data from the gunshot sensor units, the control panel comprising speakers for providing audio playback of the audio data received from the gunshot sensor units.
22. A method for detecting gunshots within a premises, the method comprising:
detecting acoustic anomalies indicating potential gunshots and generating audio data depicting the acoustic anomalies via one or more microphones of gunshot sensor units;
generating event data based on the detected acoustic anomalies; and
providing audio playback of the audio data received from the gunshot sensor units via speakers of a control panel for receiving the event data and the audio data.
23. A system for detecting gunshots within a premises, the system comprising:
gunshot sensor units for detecting the gunshots, the gunshot sensor units comprising one or more microphones for detecting acoustic anomalies indicating potential gunshots and for generating audio data depicting the acoustic anomalies, nonvolatile storage for locally storing the audio data, and controllers for filtering speech sounds from the audio data.
24. A method for detecting gunshots within a premises, the method comprising:
detecting acoustic anomalies indicating potential gunshots and generating audio data depicting the acoustic anomalies via one or more microphones of gunshot sensor units;

locally storing the audio data in nonvolatile storage of the gunshot sensor units;
and
filtering speech sounds from the audio data.

25. A system for detecting gunshots within a premises, the system comprising:
gunshot sensor units for detecting the gunshots, the gunshot sensor units
comprising one or more microphones for detecting acoustic anomalies
indicating potential gunshots and for generating audio data depicting the
acoustic anomalies; and
a control panel for receiving the audio data from the gunshot sensor units, the
control panel comprising an audio buffer for storing streaming audio data
from the gunshot sensor units, wherein the gunshot sensor units stream the
audio data to the control panel for a higher level analysis in response to
determining that a level of certainty of the audio data depicting gunshots is
below a predetermined threshold, and the control panel instructs the gunshot
sensor units to locally store or delete the audio data based on whether the
higher level analysis indicates that the streamed audio data depicts
gunshots.
26. A method for detecting gunshots within a premises, the method comprising:
detecting acoustic anomalies indicating potential gunshots and generating audio
data depicting the acoustic anomalies via one or more microphones of
gunshot sensor units; and
storing streaming audio data from the gunshot sensor units in an audio buffer of
a control panel, wherein the gunshot sensor units stream the audio data to
the control panel for a higher level analysis in response to determining that
a level of certainty of the audio data depicting gunshots is below a
predetermined threshold, and the control panel instructs the gunshot sensor
units to locally store or delete the audio data based on whether the higher
level analysis indicates that the streamed audio data depicts gunshots.
27. A system for detecting gunshots within a premises, the system comprising:
gunshot sensor units for detecting the gunshots, the gunshot sensor units
comprising one or more microphones for detecting acoustic anomalies

indicating potential gunshots and for generating audio data depicting the acoustic anomalies, controllers for generating event data based on the detected acoustic anomalies, nonvolatile storage for locally storing the audio data and the event data, and wired and/or wireless interfaces for sending the locally stored audio data and event data to computing devices of law enforcement entities.

28. A method for detecting gunshots within a premises, the method comprising:
detecting acoustic anomalies indicating potential gunshots and generating audio data depicting the acoustic anomalies via one or more microphones of gunshot sensor units;
generating event data based on the detected acoustic anomalies;
locally storing the audio data and the event data in nonvolatile storage of the gunshot sensor units; and
sending the locally stored audio data and event data to computing devices of law enforcement entities via wired and/or wireless interfaces of the gunshot sensor units.
29. A system for detecting gunshots within a premises, the system comprising:
gunshot sensor units for detecting the gunshots, the gunshot sensor units comprising one or more microphones for detecting acoustic anomalies indicating potential gunshots and for generating audio data depicting the acoustic anomalies and controllers for generating event data based on the detected acoustic anomalies; and
a control panel for receiving the audio data and/or the event data from the gunshot sensor units and for generating and sending live monitoring instructions to the gunshot sensor units,
wherein the gunshot sensor units generate and stream live audio data depicting ambient sound to the control panel in response to the live monitoring instructions.
30. The system as claimed in claim 25, wherein the control panel further includes a user interface for receiving a special authorization input for super-user access from an operator of the control panel, and the control panel generates and sends the live

monitoring instructions only in response to receiving the special authorization input.

31. The system as claimed in claim 25, wherein the control panel further comprises a microphone for generating audio data that is live streamed to the gunshot sensor units, and the gunshot sensor units further comprise speakers for providing audio playback of the live audio data streamed from the control panel.

32. A method for detecting gunshots within a premises, the method comprising:
detecting acoustic anomalies indicating potential gunshots and generating audio data depicting the acoustic anomalies via one or more microphones of gunshot sensor units;
generating event data based on the detected acoustic anomalies;
generating and sending live monitoring instructions to the gunshot sensor units, wherein the gunshot sensor units generate and stream live audio data depicting ambient sound to a control panel in response to the live monitoring instructions.

33. A system for detecting gunshots within a premises, the system comprising:
gunshot sensor units for detecting the gunshots, the gunshot sensor units comprising one or more microphones for detecting acoustic anomalies indicating potential gunshots and for generating audio data depicting the acoustic anomalies, controllers for generating event data based on the detected acoustic anomalies, and nonvolatile storage for locally storing the audio data and event data; and
a control panel for receiving the audio data and/or the event data from the gunshot sensor units, the control panel comprising a microphone for generating audio data, speakers for providing audio playback of audio data, and a graphical user interface for providing sensor information to an operator of the control panel and for receiving input from the operator indicating selections of different gunshot sensor units for retrieval of locally stored audio data and event data, live audio data streaming from the gunshot sensor units, and/or two-way communication between the control panel and the gunshot sensor units.

34. A method for detecting gunshots within a premises, the method comprising:
detecting acoustic anomalies indicating potential gunshots and generating audio data depicting the acoustic anomalies via one or more microphones of gunshot sensor units;
generating event data based on the detected acoustic anomalies;
locally storing the audio data and event data in nonvolatile storage of the gunshot sensor units;
providing sensor information to an operator of a control panel and receiving input from the operating via a graphical user interface, the received input indicating selections of different gunshot sensor units for retrieval of the locally stored audio data and event data, live audio data streaming from the gunshot sensor units, and/or two-way communication between a control panel and the gunshot sensor units via a microphone for generating audio data and speakers for providing audio playback of audio data of the control panel.
35. A system for detecting gunshots within a premises, the system comprising:
gunshot sensor units for detecting the gunshots, the gunshot sensor units comprising one or more microphones for detecting acoustic anomalies indicating potential gunshots and for generating audio data depicting the acoustic anomalies, controllers for generating event data based on the detected acoustic anomalies, and wired and/or wireless interfaces for sending the audio data and event data to a cloud gunshot detection management system via a public network.
36. A method for detecting gunshots within a premises, the method comprising:
detecting acoustic anomalies indicating potential gunshots and generating audio data depicting the acoustic anomalies via one or more microphones of gunshot sensor units;
generating event data based on the detected acoustic anomalies;
sending the audio data and event data to a cloud gunshot detection management system via wired and/or wireless interfaces of the gunshot sensor units and a public network.

100 ↘

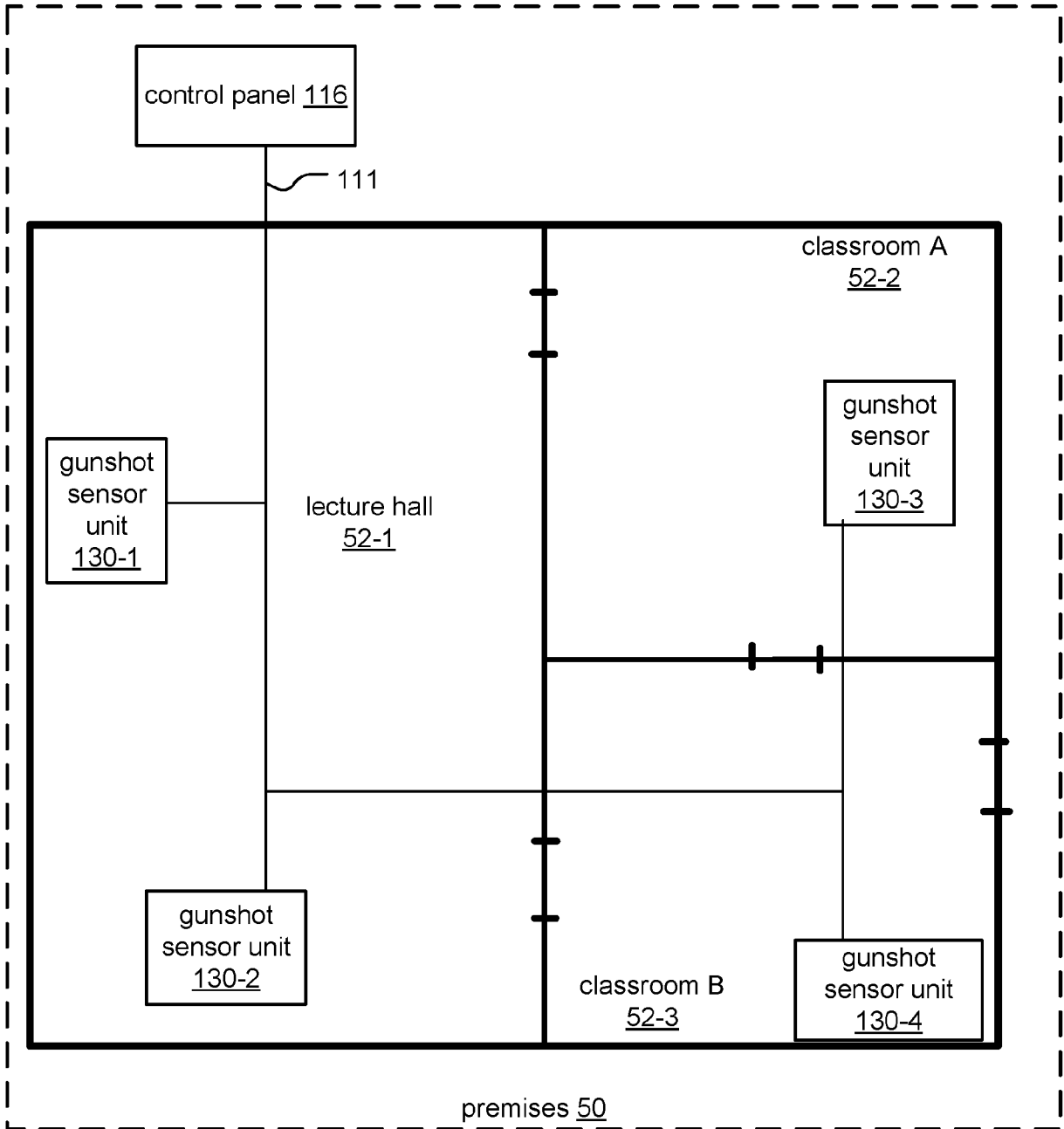


FIG. 1

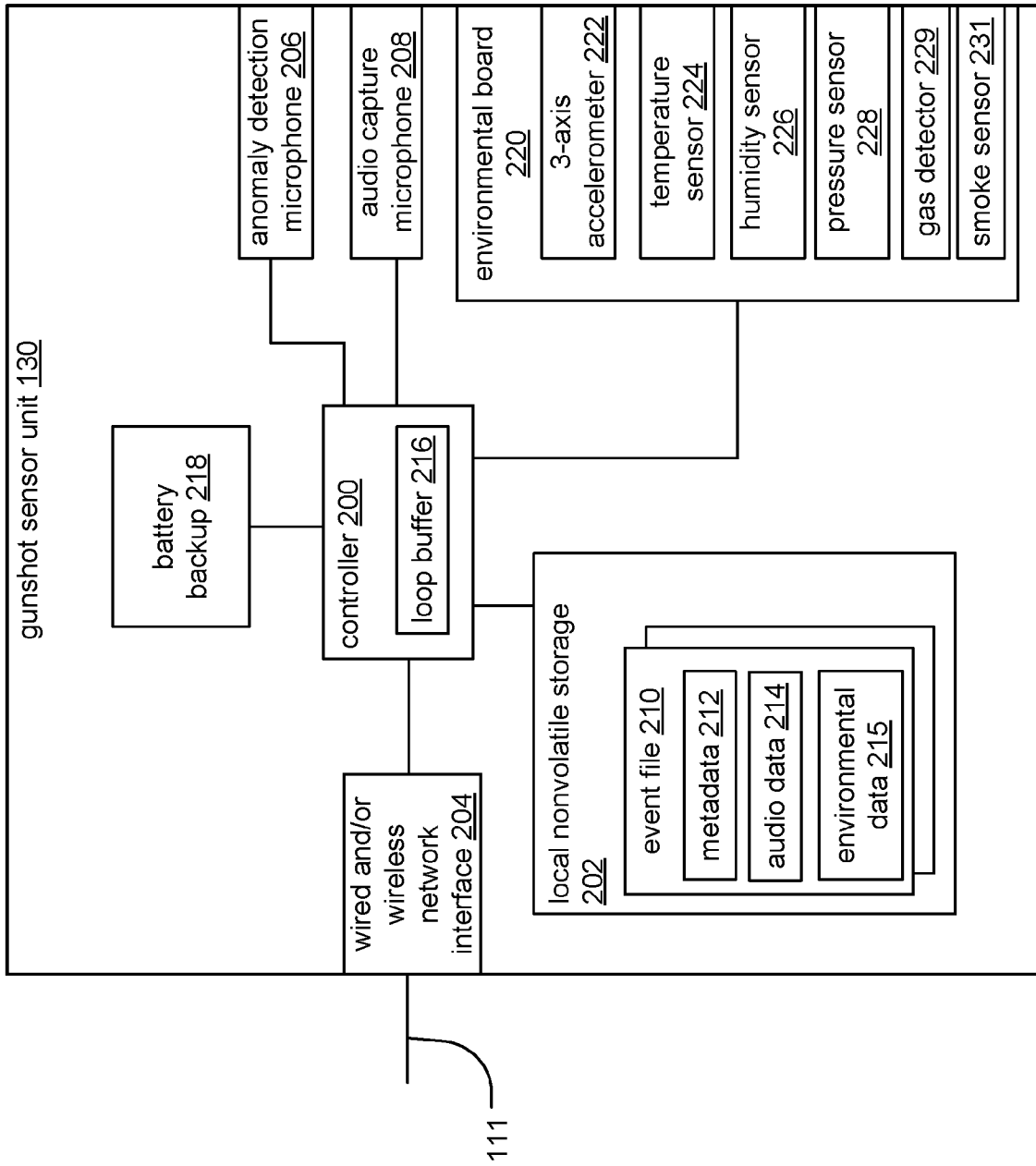


FIG. 2A

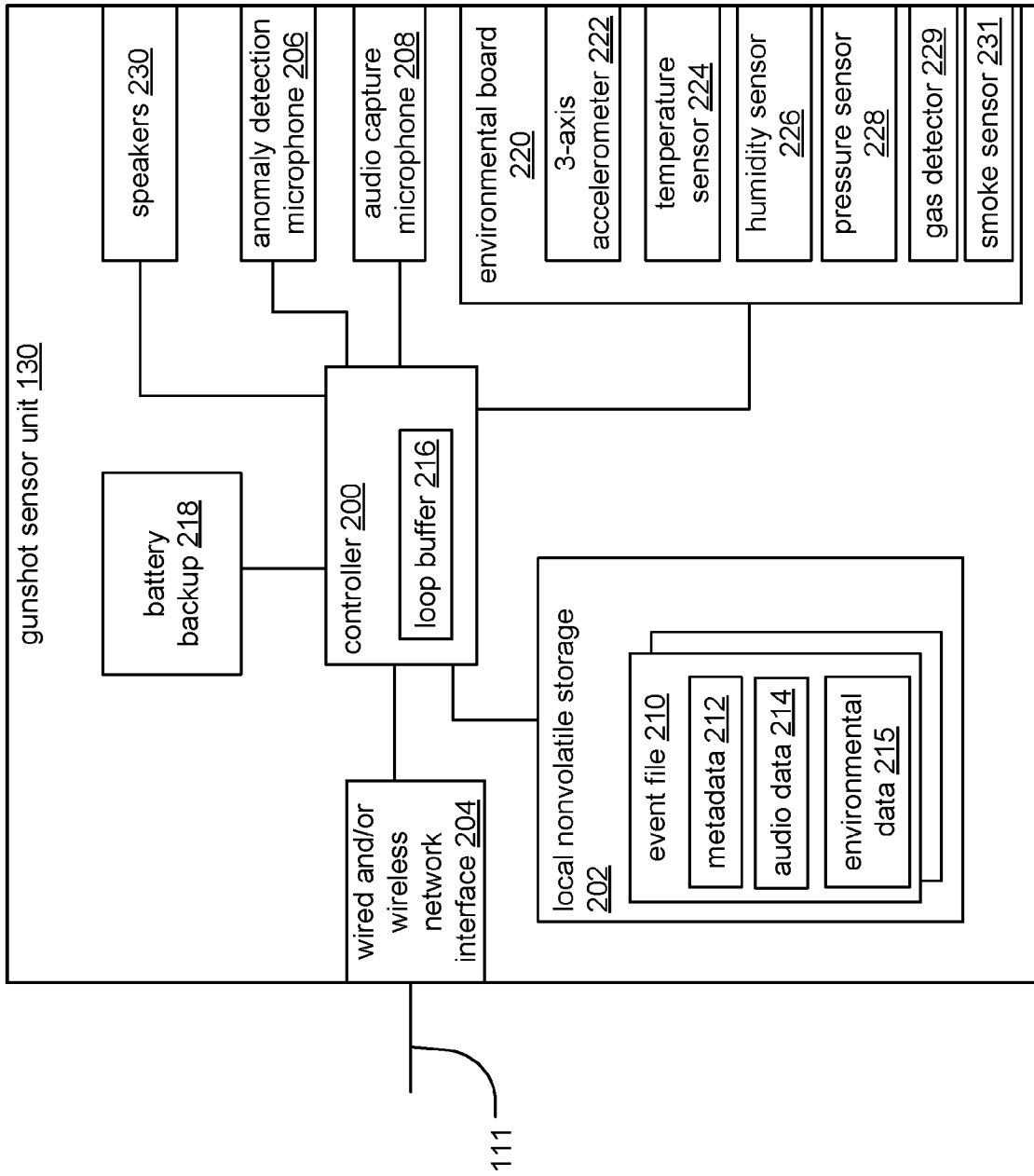


FIG. 2B

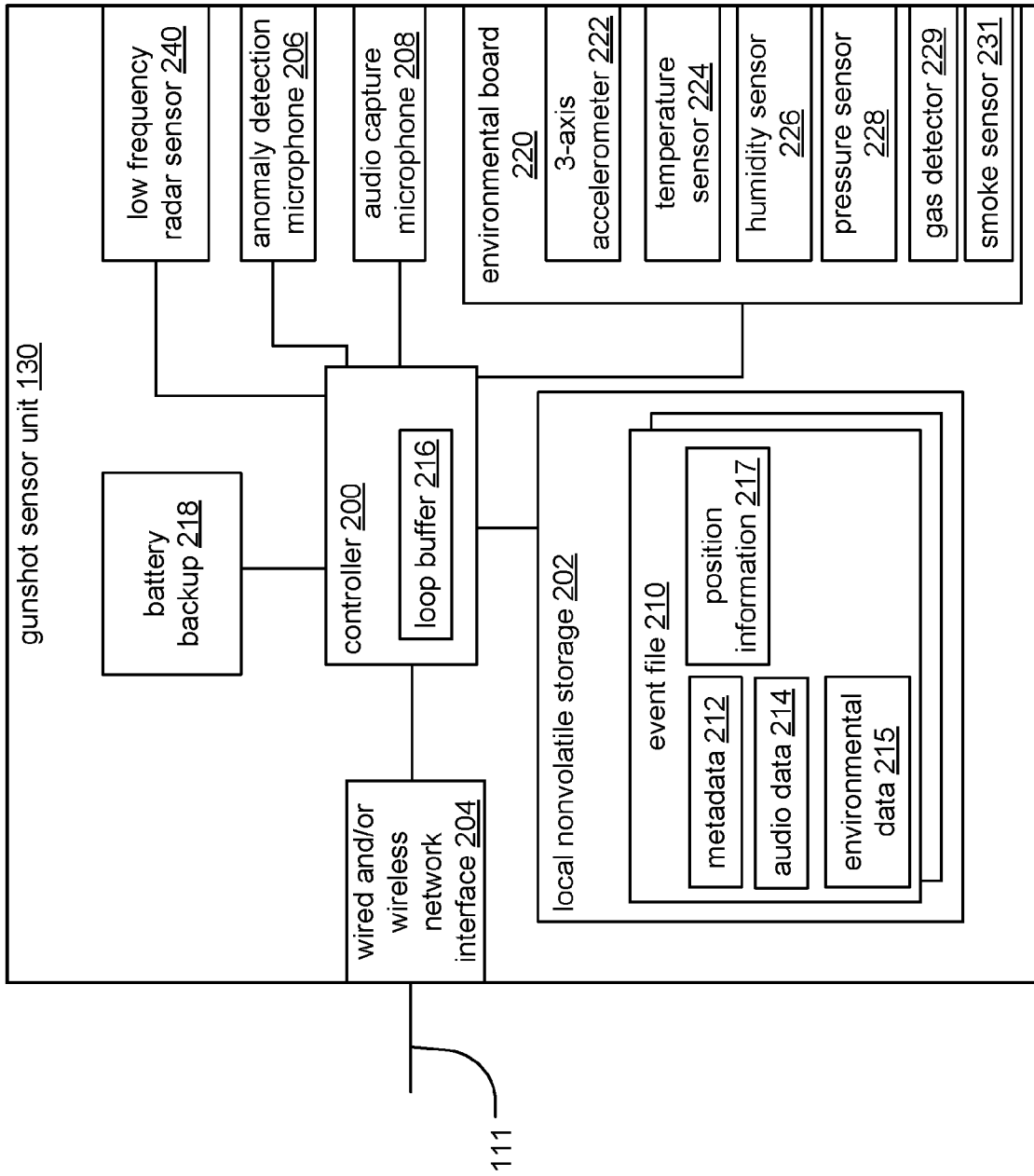


FIG. 2C

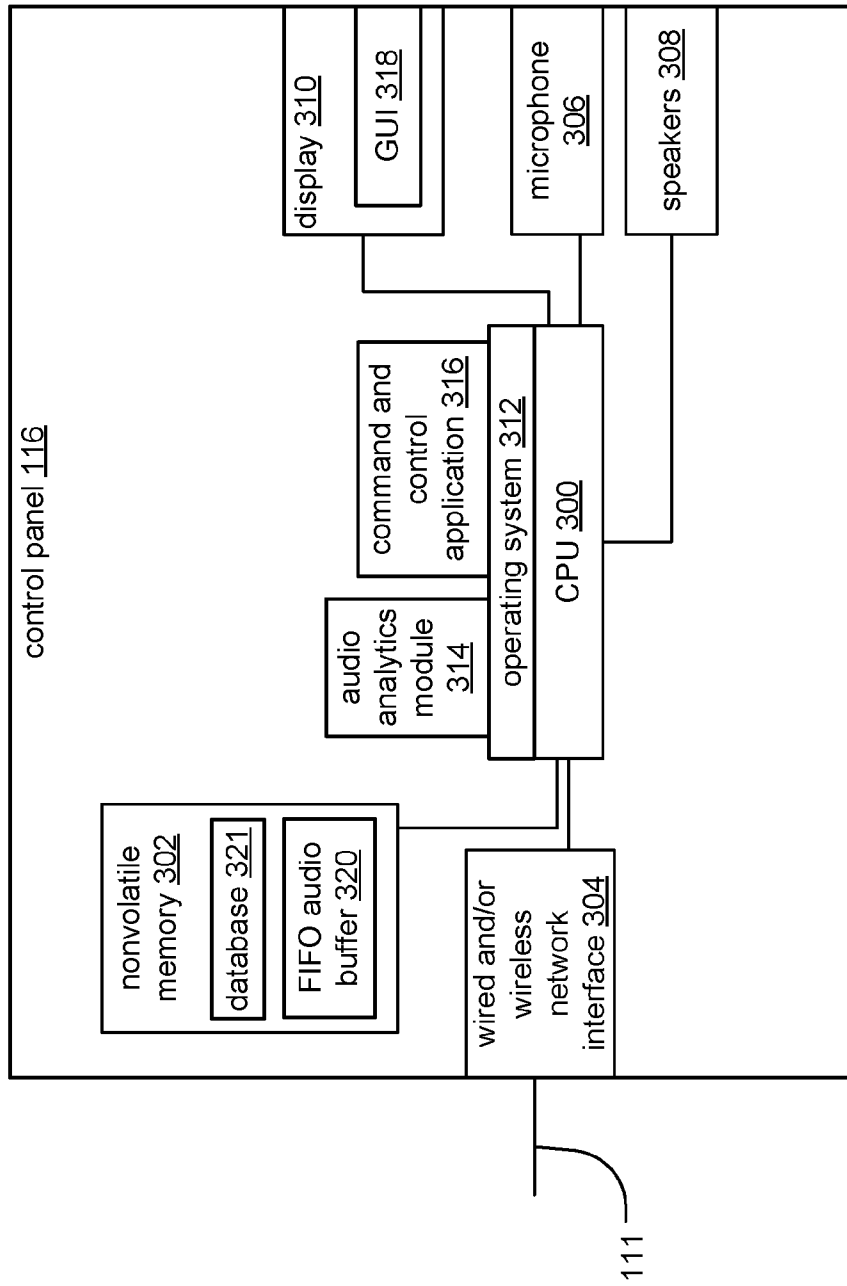


FIG. 3

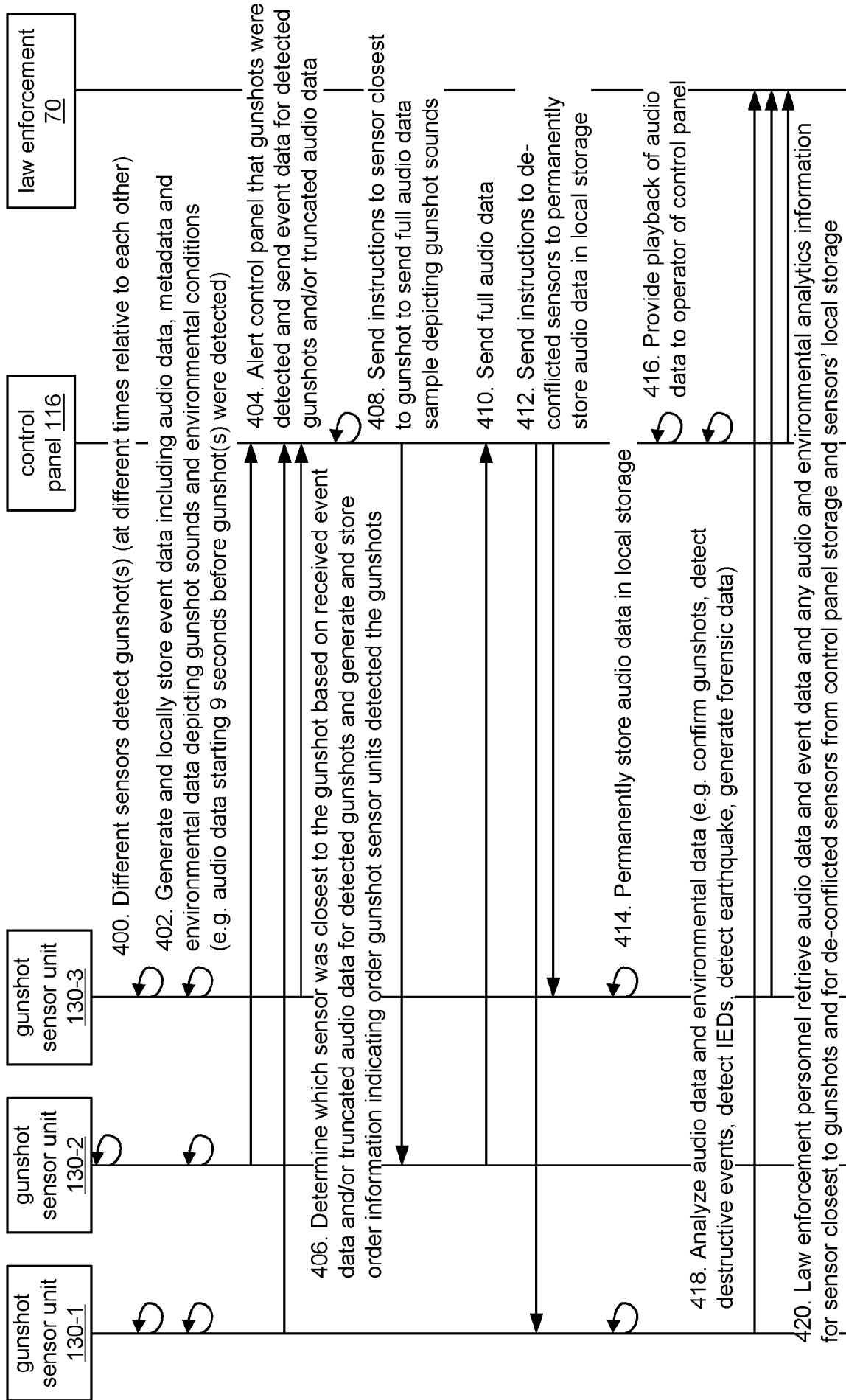


FIG. 4A

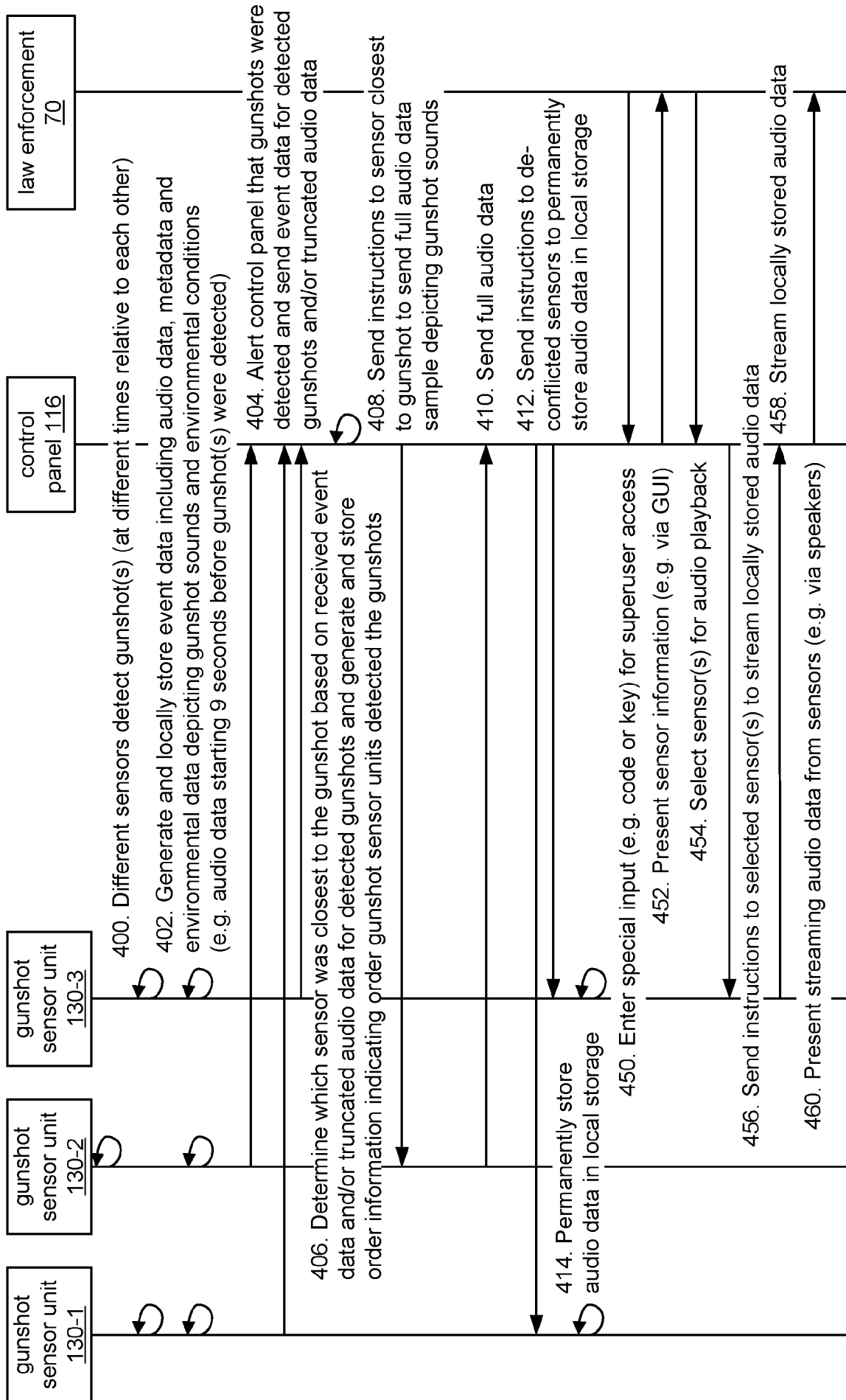


FIG. 4B

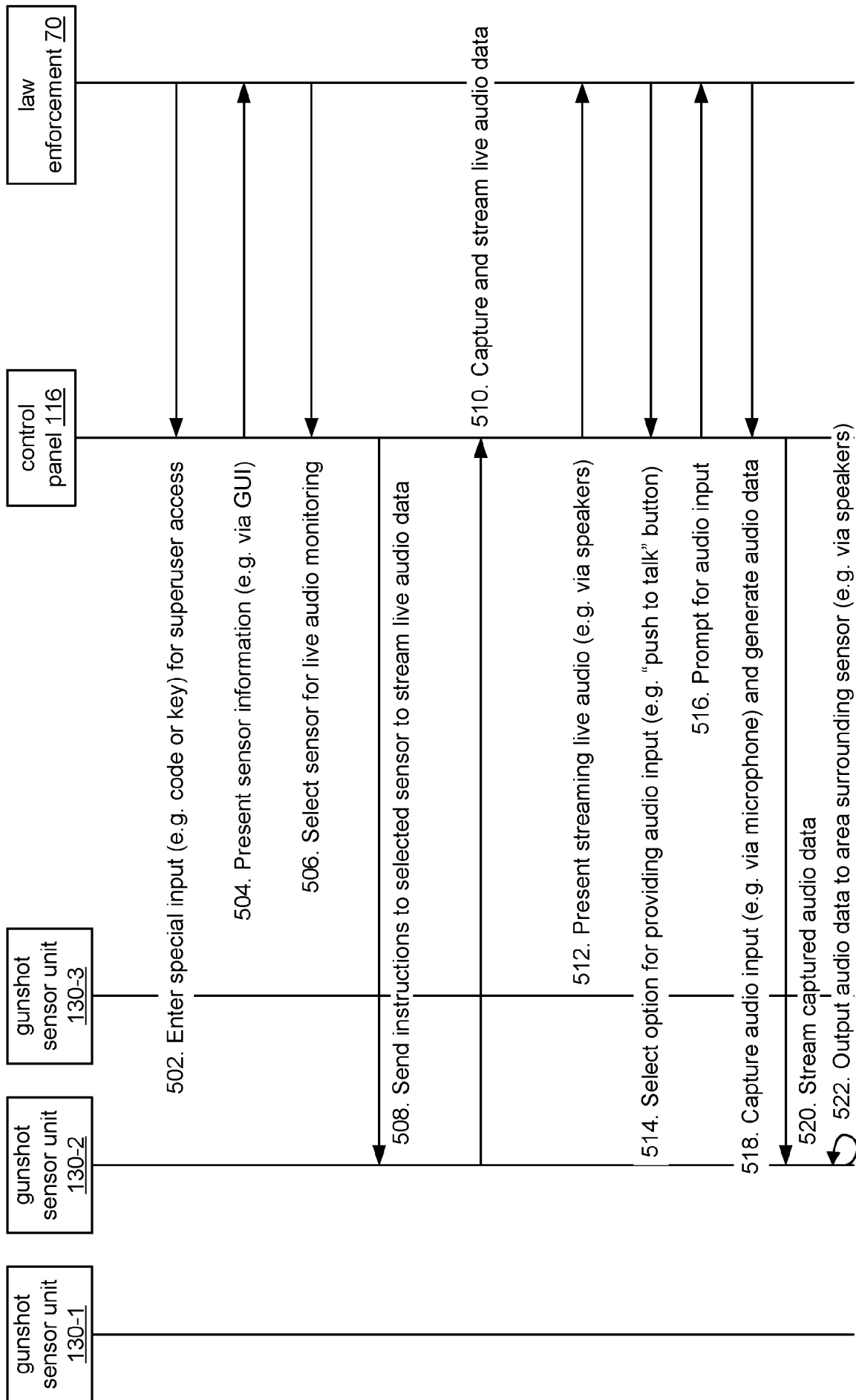


FIG. 5

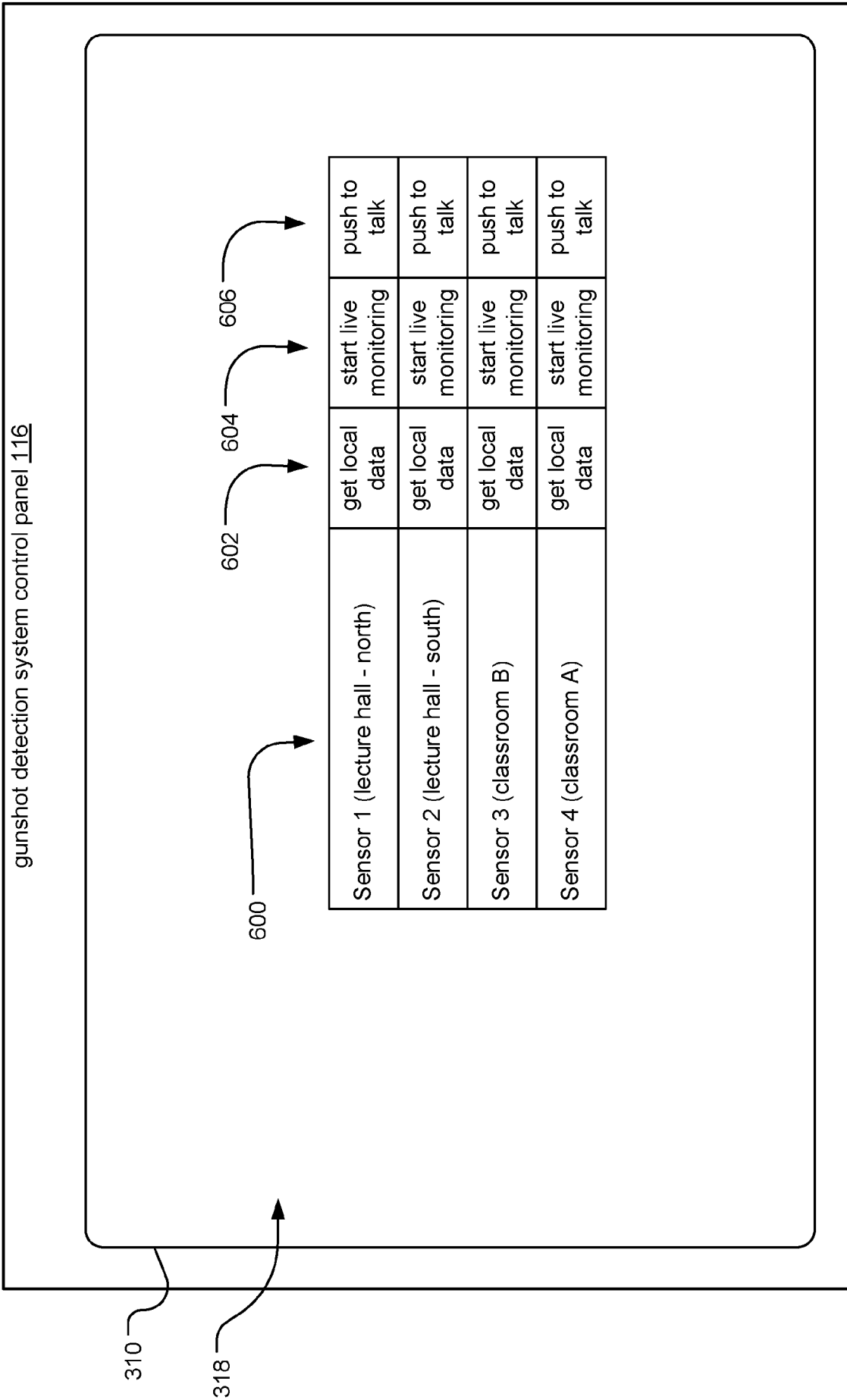


FIG. 6

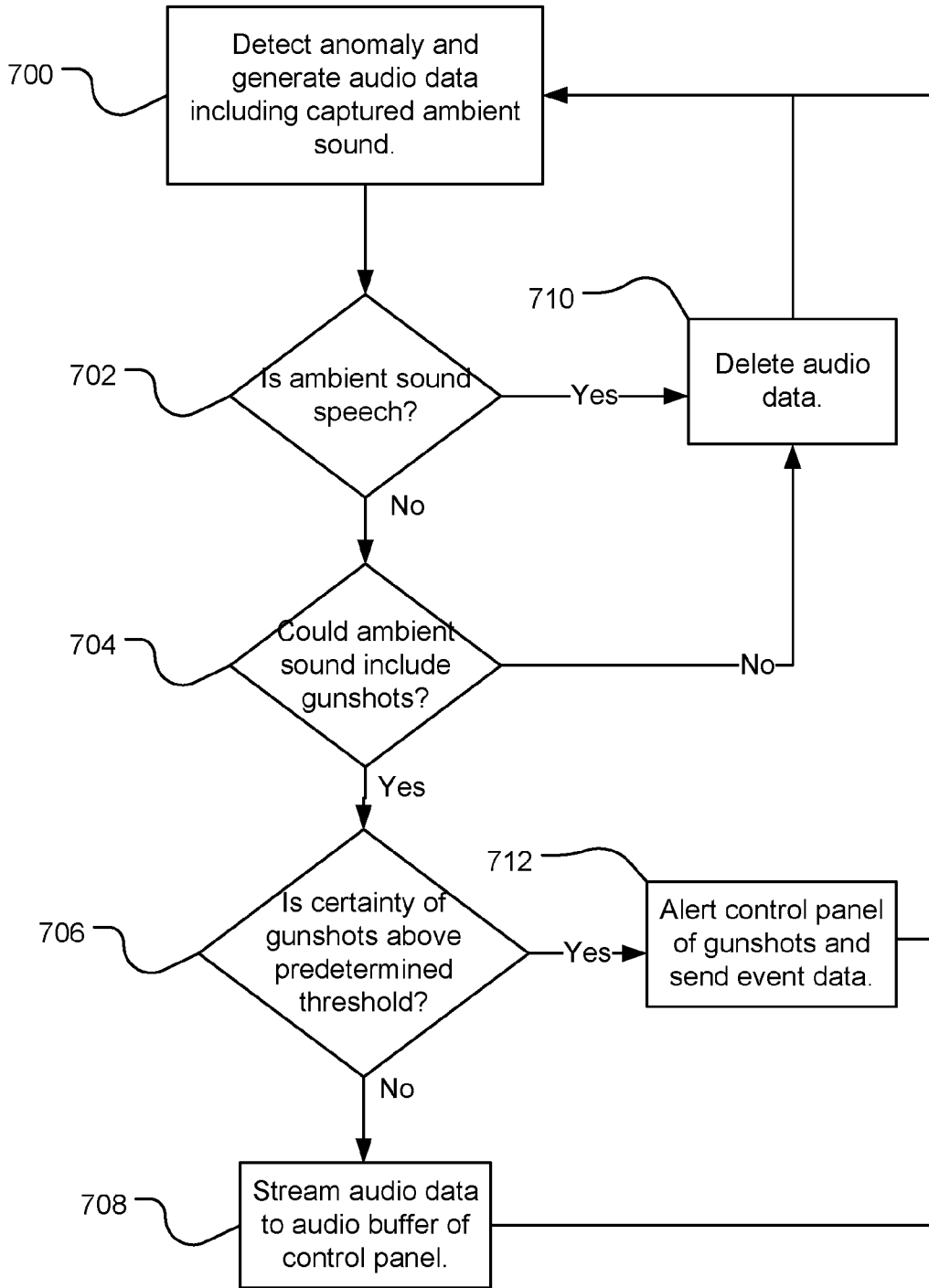


FIG. 7

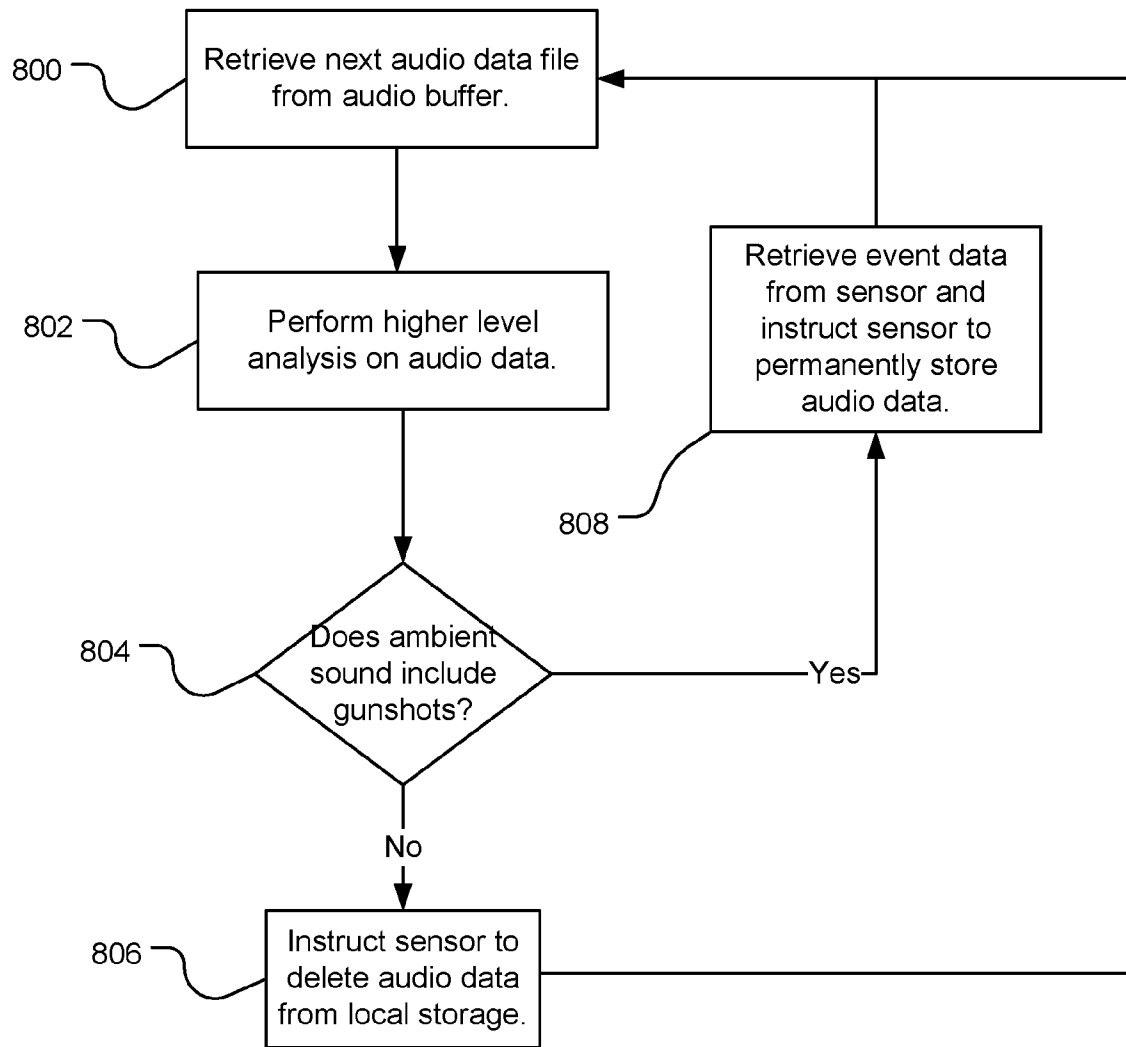


FIG. 8

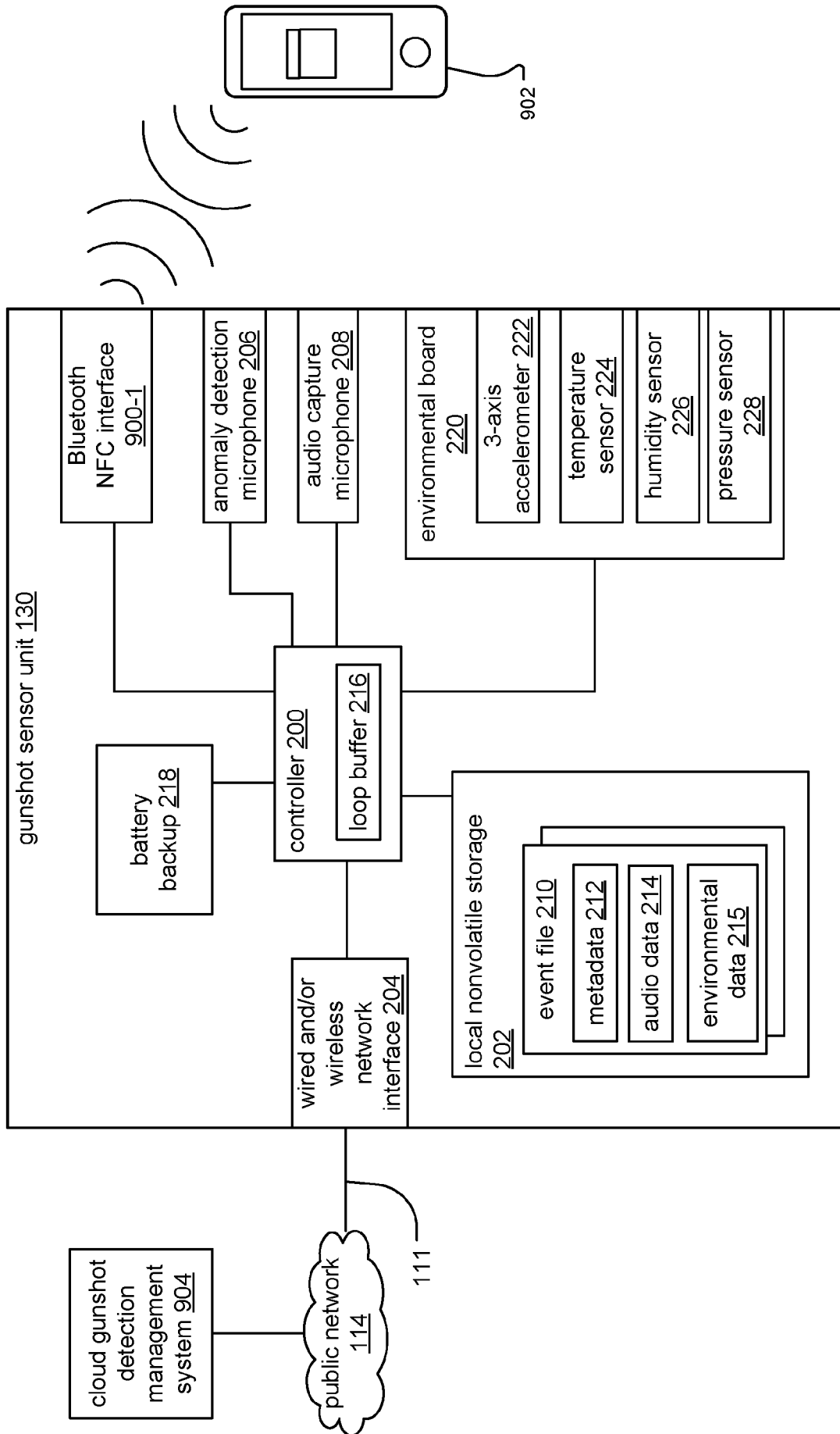


FIG. 9A

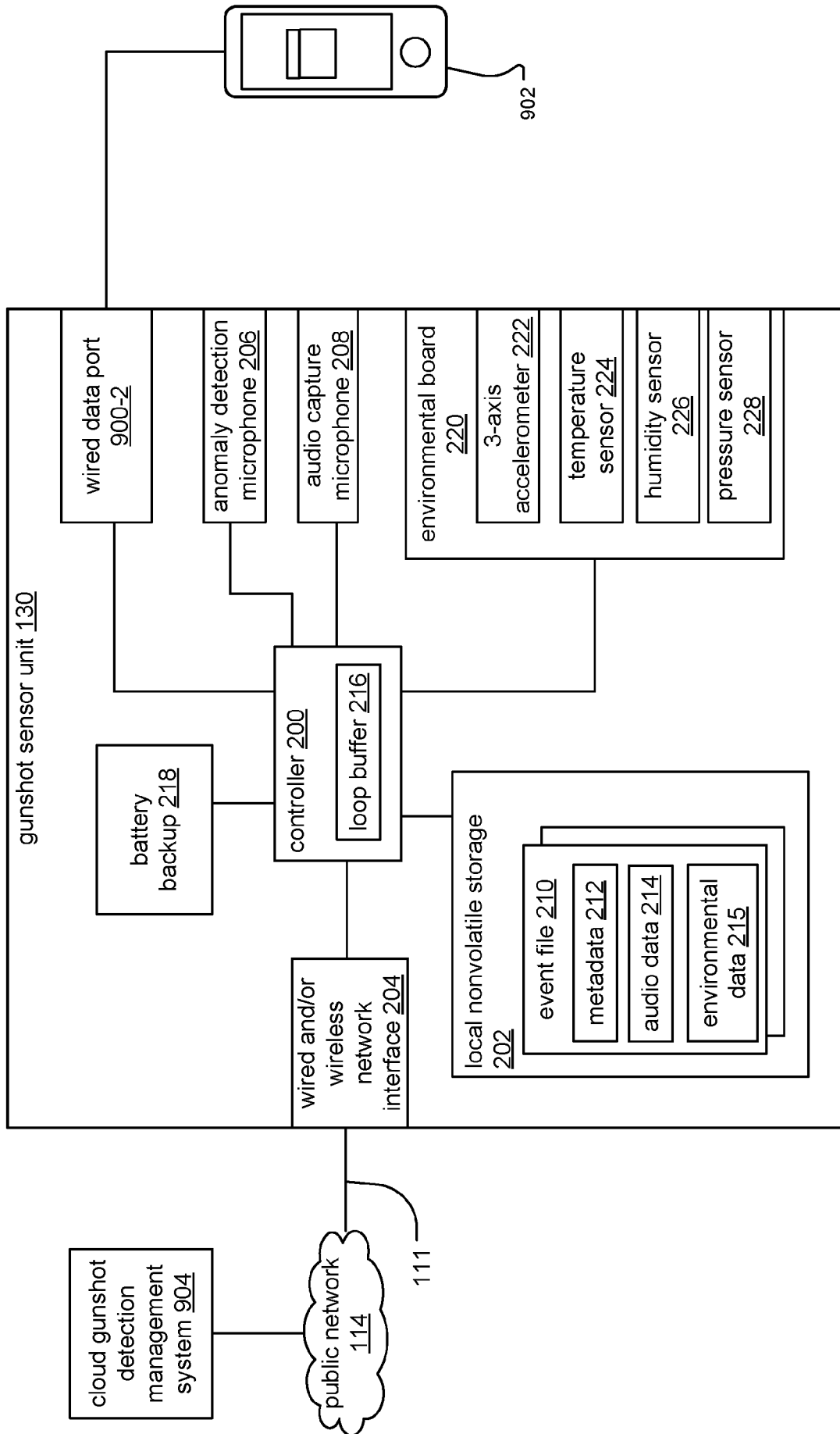


FIG. 9B

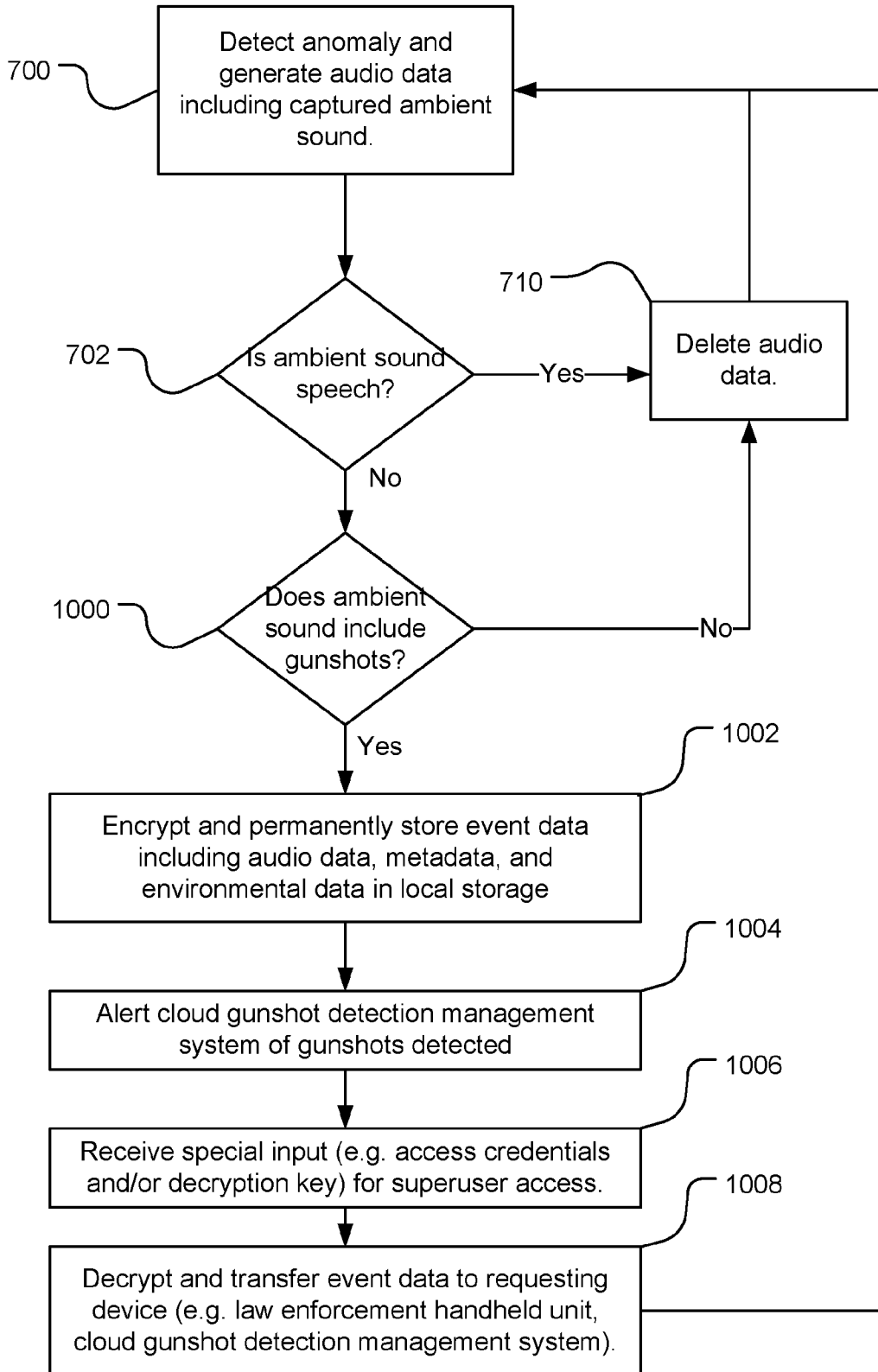


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2019/051202

A. CLASSIFICATION OF SUBJECT MATTER INV. G08B13/16 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) G08B		
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		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 2016/232774 A1 (NOLAND BRYAN LEE [US] ET AL) 11 August 2016 (2016-08-11) paragraph [0002] paragraph [0019] paragraph [0062] paragraphs [0065], [0066] paragraphs [0068] - [0072] paragraphs [0074] - [0076] paragraphs [0078], [0079] paragraph [0127] paragraphs [0130], [0131] paragraph [0135] paragraph [0139] paragraph [0146] paragraph [0172] paragraphs [0174], [0175] paragraph [0231] paragraphs [0237], [0238] paragraphs [0242] - [0247]	1-3, 9-13, 19, 20 4, 14
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents :		
"A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family	
Date of the actual completion of the international search <p style="text-align: center; font-size: 1.2em;">15 April 2019</p>	Date of mailing of the international search report <p style="text-align: center; font-size: 1.2em;">18/06/2019</p>	
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer <p style="text-align: center; font-size: 1.2em;">Meister, Mark</p>	

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2019/051202

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	paragraph [0267] figures 1a-1e,2a,4,8 -----	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2019/051202

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-4, 9-14, 19, 20

Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-4, 9-14, 19, 20

A system for detecting gunshots within a premises, the system comprising: gunshot sensor units for detecting the gunshots, the gunshot sensor units comprising one or more microphones for detecting acoustic anomalies indicating potential gunshots and for generating audio data depicting the acoustic anomalies, controllers for generating event data based on the detected acoustic anomalies, and nonvolatile storage for locally storing the audio data and the event data, wherein the system further comprises a control panel for receiving the event data and the audio data from the gunshot sensor units, wherein the control panel receives truncated audio data depicting only the acoustic anomalies and instructs the gunshot sensor units to send full audio data to the control panel and/or locally store the full audio data and the event data based on the received truncated audio data.

2. claims: 1, 2, 5, 6, 11, 12, 15, 16

A system for detecting gunshots within a premises, the system comprising: gunshot sensor units for detecting the gunshots, the gunshot sensor units comprising one or more microphones for detecting acoustic anomalies indicating potential gunshots and for generating audio data depicting the acoustic anomalies, controllers for generating event data based on the detected acoustic anomalies, and nonvolatile storage for locally storing the audio data and the event data, wherein the system further comprises a control panel for receiving the event data and the audio data from the gunshot sensor units, wherein the control panel determines which one of the gunshot sensor units is closest to a source of the acoustic anomaly based on the received event data, instructs the gunshot sensor unit closest to the source to send the audio data to the control panel, and instructs de-conflicted gunshot sensor units that are not closest to the source to locally store the audio data.

3. claims: 1, 2, 7, 8, 11, 12, 17, 18, 27, 28, 35, 36(completely);
33, 34(partially)

A system for detecting gunshots within a premises, the system comprising: gunshot sensor units for detecting the gunshots, the gunshot sensor units comprising one or more microphones for detecting acoustic anomalies indicating potential gunshots and for generating audio data depicting the acoustic anomalies, controllers for generating event data based on the detected acoustic anomalies, and

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

nonvolatile storage for locally storing the audio data and the event data, wherein the system further comprises a control panel for receiving the event data and the audio data from the gunshot sensor units, wherein the control panel further comprises a graphical user interface for providing sensor information to an operator of the control panel and for receiving input from the operator indicating selections of different gunshot sensor units for retrieval of the locally stored audio data and/or event data.

4. claims: 21, 22, 29-32(completely); 33, 34(partially)

A system for detecting gunshots within a premises, the system comprising: gunshot sensor units for detecting the gunshots, the gunshot sensor units comprising one or more microphones for detecting acoustic anomalies indicating potential gunshots and for generating audio data depicting the acoustic anomalies, and controllers for generating event data based on the detected acoustic anomalies; anda control panel for receiving the event data and the audio data from the gunshot sensor units, the control panel comprising speakers for providing audio playback of the audio data received from the gunshot sensor units.

5. claims: 23, 24

A system for detecting gunshots within a premises, the system comprising: gunshot sensor units for detecting the gunshots, the gunshot sensor units comprising one or more microphones for detecting acoustic anomalies indicating potential gunshots and for generating audio data depicting the acoustic anomalies, nonvolatile storage for locally storing the audio data, and controllers for filtering speech sounds from the audio data.

6. claims: 25, 26

A system for detecting gunshots within a premises, the system comprising:gunshot sensor units for detecting the gunshots, the gunshot sensor units comprising one or more microphones for detecting acoustic anomalies indicating potential gunshots and for generating audio data depicting the acoustic anomalies; anda control panel for receiving the audio data from the gunshot sensor units, the control panel comprising an audio buffer for storing streaming audio data from the gunshot sensor units, wherein the gunshot sensor units stream the audio data to the control panel for a higher level analysis in response to determining that a level of certainty of the audio data depicting gunshots is below a predetermined threshold, and the control panel instructs the gunshot sensor units to locally store or delete the audio data based on whether the higher level

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

analysis indicates that the streamed audio data depicts
gunshots.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2019/051202

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2016232774 A1	11-08-2016	US 2016232774 A1	11-08-2016
		US 2018158305 A1	07-06-2018
		WO 2014134217 A1	04-09-2014
