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(54) **Title:** SYSTEMS AND METHODS FOR OPTIMIZING THE WORKING ENVIRONMENT IN A DRILLING CONTROL ROOM

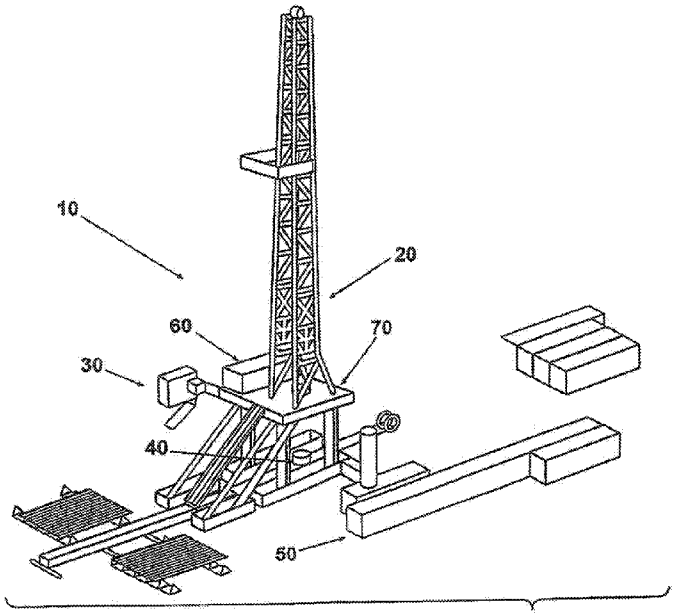

Fig. 1

(57) **Abstract:** Systems and methods for optimizing the working environment in a drilling control room may include (i) systems and methods to selectively actively attenuate one or more noise sources affecting the noise level within the drilling control room and (ii) systems and methods to control the transmission and reflection of sunlight through the windows of the drilling control room without obstructing the operator's field of vision. Systems and methods for improving communication, such as heads-up displays, voice feedback systems, and telephone and public announcement/talkback systems that are integrated into an operator's control chair or workstation, may also be included.

[Continued on next page]

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SYSTEMS AND METHODS FOR OPTIMIZING THE WORKING ENVIRONMENT IN A DRILLING CONTROL ROOM

BACKGROUND

This section is intended to introduce the reader to various aspects of art that may be related to various aspects of the present disclosure, which are described or claimed below. This discussion is believed to be helpful in providing the reader with background information to facilitate a better understanding of the various aspects of the present disclosure. Accordingly, it should be understood that these statements are to be read in this light, and not as admissions of prior art.

This present disclosure relates to systems and methods for optimizing the working environment in a drilling control room such as a drillers control room, crane cabin, or mud control room. More specifically, this disclosure may include systems and methods to selectively actively attenuate noise within a drilling control room. The disclosure may also include systems and methods to automatically adjust reflection and transmission of sunlight through the windows of the drilling control room as well as systems and methods to improve operator communication.

Drilling control room personnel must be adequately protected from a variety of environmental factors, including noise and sunlight. Noise sources in a drilling control room may include the drawworks or other lifting system, top drive, HVAC system, and pipe handling equipment and pipes, as well as generators, centrifuges, pumps, fans, and other noise-generating equipment on or near the drill floor. Similarly, crane cabin operators must be adequately protected from noise sources such as the electric motor, hydraulic pump, and HVAC system. Because the noise level of equipment and other noise sources in proximity to the

control room or cabin may exceed 100 dB(A), regulatory standards and/or design specifications for the project may require the noise level in the drilling control room to be limited.

Passive noise cancelling or suppression means, such as noise insulating materials or panels, equipment blankets or shrouds, and vibration dampening structures may be used to reduce the noise level. While a combination of passive noise suppression means may be adequate to achieve a desired noise reduction, further reducing the noise level in the control room improves the quality of the working environment and allows the drilling rig to comply with stricter noise level standards. However, reducing noise (including vibration) to inaudible levels may not be desirable in some cases because certain noises can provide operators with additional feedback to determine whether an operation is being properly performed or equipment is properly functioning.

Sunlight may adversely affect the working environment in the drilling control room, particularly for operators who work in control rooms or cabins with large windows. Although the windows allow the operators to monitor and manage various activities, they also allow glare and heat into the control room or cabin. Controlling the amount and/or angle of sunlight that enters the control room or cabin **without obstructing the operator's field of vision** may provide increased comfort and safety for these operators. Furthermore, controlling the reflection or transmission of sunlight in the control room or cabin may improve energy efficiency by reducing the need or size of a dedicated HVAC unit.

Communications within the drilling control room may also be difficult for operators. As an example, operators are responsible for moving machinery and observing activities outside the control room. However, their human-**machine interface ("HMI")** screens may be positioned so that the operators must look away from the on-going activities to review the information displayed on the screens. Projecting the information onto the windows or other surfaces in front of the operator, *i.e.*, a head-up display, may allow the operator to receive

information without looking away from the monitored activities, thereby increasing safety for everyone involved in the operation. A head-up display may also improve workplace ergonomics, as operators would not be required to repeatedly turn their heads to view the screens, and increased efficiency, as operators would not have to stop activities in order to review the information on the screens.

Due to on-going activities and the amount of incoming information, operators may not be able to recognize particular information or alarms in a timely manner. Voice feedback systems, which speak certain information aloud instead of or in addition to displaying it on an operator's HMI screens, may allow operators to immediately identify alarms and other particular information and to differentiate between alarms, even when they are not looking at the screens. Such systems may increase safety, decrease response times, and reduce operator stress.

Communications with other operators, employees and contractors who are working at other locations on or near the drilling rig, and third parties located off-site may be difficult if operators cannot easily access telephones or public announcement/talkback systems from their control chairs or if the telephone or public announcement/talkback systems are not in their direct line of sight while monitoring on-going activities or HMI screens. Integrating telephone or public announcement/talkback systems, or both, into the existing computer and software systems for the operator control chairs or workstations may improve communication. In addition, integrated telephone or public announcement/talkback systems may simplify the installation and commissioning of the drilling control room, crane cabin, or mud control room, reduce the number of interface points and networks required in the control room, improve the appearance of the control room, allow the telephone or public announcement/talkback systems to operate through the internet (VoIP), improve workplace ergonomics and comfort for the

operators, and provide the option of recording voices during emergencies, incidents, or other selected circumstances.

SUMMARY

This summary is provided to introduce a selection of concepts that are further described below in the detailed description. This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining or limiting the scope of the claimed subject matter as set forth in the claims.

Embodiments of systems for optimizing the working environment in a drilling control room such as a drillers control room, crane cabin, or mud control room may include a subsystem for at least one of the following: selectively actively attenuating one or more noise sources affecting the noise level within the control room, controlling the reflection and transmission of sunlight through the windows of the control room, one or more head-up displays so that information that would otherwise be limited to display on the HMI screens is visible in the same line of sight as the machinery or activities the operator is required to observe, voice feedback systems to provide audible information to the operator, and telephone and/or public announcement/talkback systems to convey information to or from the operator. The system may also include at least one microprocessor with associated software that is in electronic communication with the subsystem.

Embodiments of methods for optimizing the working environment in a drilling control room such as a drillers control room, crane cabin, or mud control room may include selectively changing an environmental condition of the drilling control room. The environmental condition, which may be in electronic communication with a microprocessor and associated software, may be a noise level within the control room, transmission and reflection of sunlight

through the windows of the control room, a head-up display, audible information, or conveying information.

Embodiments of systems and methods to selectively actively attenuate one or more noise sources affecting the noise level within a drilling control room may make use of active noise cancelling or suppression technology arranged about the control room in combination with user-defined and source-specific noise attenuation modes. Possible attenuation modes include:

1. Fixed (but not complete) attenuation of one or more pre-determined or selected noise sources to a pre-determined or pre-defined noise level specified by a user, customer, or regulation;

2. User-defined adjustable (but not complete) attenuation of one or more of the noise sources;

3. Selected bandwidth (frequency range) attenuation of one or more of the noise sources;

4. Attenuation to an ideal noise level profile for one or more of the noise sources; and

5. Some combination of the above.

The active noise cancelling technology may be of a kind known in the active noise control art that reduces or cancels the noise coming from a source by sending out sound waves with an inverted or anti-phase to that of the noise (*see e.g.*, U.S. 6,343,127 B1, which is incorporated by reference herein). The original and inverted waves combine to form a new wave and effectively cancel each other out, an effect which is called destructive interference.

The described systems and methods may selectively attenuate the noise level of certain noise sources to a drilling control room while leaving other noise levels unchanged or at a different sound level. Such systems and methods may permit an operator within the same

control room to selectively reduce or increase a noise level suitable for her or his purpose relative to other operators without violating required maximum room or cabin sound levels, comply with working environment standards including but not limited to 65dBA, and lower the noise level inside the control room, thereby improving the working environment for the operators.

Embodiments of systems and methods to control the reflection and transmission of sunlight through the windows of the drilling control room may include a glass system with electronic or electrochromic tinted glass, or equivalent or similar technology, that may be used to adjust the reflection of sunlight based on the degree of sun exposure and/or the temperature of the working environment within the control room. The electronic tinting or reflection of the glass may be manually adjusted. Alternatively, the tinting or reflection may be automatically adjusted based upon information received by one or more light sensors and/or cameras, daytime light calculations related to the location of the control room on earth, self-learning computer modes based on input from the light sensors or cameras, or a combination thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

The subject disclosure is further described in the following detailed description, and the accompanying drawing and schematic of non-limiting embodiment of the subject disclosure. The features depicted in the figure are not necessarily shown to scale. Certain features of the embodiments may be shown exaggerated in scale or in somewhat schematic form, and some details of elements may not be shown in the interest of clarity and conciseness.

FIG. 1 is a representation of an example of the environment for embodiments of the drilling control room of the disclosure.

FIG. 2 is a schematic of an embodiment of a system and method for selectively actively attenuating a noise source to control a noise level within a drilling control room.

FIG. 3 is a representation of an embodiment of a system and method for controlling the transmission and reflection of sunlight through the windows of a drilling control room.

FIG. 4 is a schematic of the embodiment of FIG. 3.

FIG. 5 is a schematic of an embodiment of a system and method for improving operator communications in a drilling control room, including a head-up display, voice feedback system, and telephone or public announcement/talkback system.

Elements and Numbering Used in the Drawing and Detailed Description

10	Land rig
20	Tubular handing equipment
30	Controls skid
40	Pressure control system
50	Manifold system
60	Drilling control room
70	Drilling rig floor
80	System and method for noise attenuation
90	Speaker or speaker array
100	Receiver (input interface)
110	Noise profile processing unit (active noise cancellation engine)
120	Speaker controller (output interface)
130	User control unit
132	Microphone or sensor
134	Accelerometer or sensor
140	Tinted window
150	User control unit
160	Light sensor
165	Camera
170	Head-up display
180	Projector
200	Voice feedback system
205	Speaker or speaker array
210	Operator control chair
220	Telephone or public announcement/talkback system
224	Microphone
226	Speaker or speaker array
230	Control system for operator control chair 210

DETAILED DESCRIPTION

One or more specific embodiments of the present disclosure will be described below. These described embodiments are only exemplary of the present disclosure. Additionally, in an effort to provide a concise description of these exemplary embodiments, all features of an actual implementation may not be described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

Embodiments of systems and methods for optimizing the working environment in a drilling control room such as a drillers control room, crane cabin, or mud control room may include systems and methods to selectively actively attenuate one or more noise sources affecting the noise level within the control room, systems and methods to control the reflection and transmission of sunlight through control room windows, and systems and methods to improve operator communication such as head-up displays, voice feedback systems, and integrated telephone and/or public announcement/talkback systems. One, all, or any subset of the identified systems and methods may be placed in a drilling control room, depending upon the characteristics of that particular project and location.

FIG. 1 is a diagram illustrating an example of the environment in which one or more of the systems and methods of the present disclosure might be deployed. A land rig 10 is shown which comprises drilling equipment to drill a subterranean well and produce hydrocarbon-bearing fluid from subterranean rock formations. The land rig 10 includes tubular handling

equipment generally shown as 20, controls skid 30 to power and functionally control the drilling and pressure control equipment, a pressure control system 40 like a Blowout Preventer ("BOP") to control pressure of the well, and a manifold system 50 to direct and manage fluids to and from mud pumps. The various equipment and tools of the land rig 10 are monitored and controlled from a drilling control room 60, which is located on or near the drilling rig floor 70. In other cases, the environment might be offshore and the drilling control room may be located near a drill floor on a hull self-elevated by legs penetrating the sea base (jack-up environments) or on the hull of a drill ship (floaters environments). In many of these cases, the drilling control room is directly exposed to the exterior environment and thus operators working in the control room are directly exposed to noise from surrounding equipment and operations and to the sun's rays and heat.

An embodiment for a system and method 80 to selectively actively attenuate noise sources affecting the noise level within a drilling control room is shown in FIG. 2. The speakers 90 are in communication with a receiver 100 that receives an analog signal from a noise source "N" and passes the signal to a noise profile processing unit 110. The noise profile processing unit 110 includes at least one microprocessor with associated software (or their equivalent) that implements one or more algorithms known in the art for analyzing incoming sound waves and generating remedial noise profiles. The processing unit 110 passes the analog signal through an A/D converter and processes the digital signal to provide a remedial noise (attenuation) profile (*see e.g.*, U.S. 2005/0226434 A1, which is incorporated by reference herein). The profile, which may be an inverted or anti-phase sound wave, is passed through a D/A converter and onto a speaker controller 120 connected to the speaker or speaker array 90. The speaker controller 120 may include a microprocessor and associated software (or their equivalent).

Noise sources N_1 to N_N for a drilling control room may include, but are not limited to, the drawworks (or other lifting equipment), top drive, HVAC system, and pipe handling

equipment and pipes, as well as generators, centrifuges, pumps, fans, and other noise-generating equipment on or near the drill floor. Noise sources N_1 to N_N for a crane cabin may include, but are not limited to, the electric motor, hydraulic pump, and HVAC system.

A user control unit 130 is in communication with the noise profile processing unit 110. In embodiments, the user control unit 130 may include human-machine interface ("HMI") displays arranged about the operator control chair 210. The user control unit 130 may be a centralized unit including a microprocessor and associated software (or their equivalent) configured to control the noise level within the entire drilling control room 60, two or more decentralized units configured to control the noise level at individual operator workstations, or configured for some combination of centralized and decentralized control. The user control unit 130 may be located within the drilling control room 60 with the operator operating it while sitting in her or his control chair 210.

The user control unit 130 may provide different attenuation modes, which may include:

1. Fixed (but not complete) attenuation of one or more pre-determined or selected noise sources N to a pre-determined or pre-defined noise level specified by a user, customer, or regulation;

2. User-defined adjustable (but not complete) attenuation of one or more of the noise sources N;

3. Selected bandwidth (frequency range) attenuation of one or more of the noise sources N (*see e.g.*, U.S. 2014/0314241 A1, which is incorporated by reference herein);

4. Attenuation to an ideal noise level profile for one or more of the noise sources; and

5. Some combination of the above.

The ideal noise level profile also may be used to compare a noise source's current sound with that of the ideal sound. The phrase "but not complete" means attenuation in a range of

about 1% to about 99% of the noise source N unattenuated noise level, with the unattenuated noise level including any passive noise reduction methods currently employed with that noise source.

One or more accelerometers 134 may be placed outside of or within the drilling control room 60 to sense any vibrations running through the room's framing structure. One or more accelerometers 134 may also be placed directly on the noise source N. The noise profile processing unit 110 can analyze these vibrations to determine the sound effect created by the vibrations. Similarly, one or more microphones (or other sound sensors) 132 may be placed at or near a noise source N or arranged within the control room 60 to sense noise signals, including modal responses of the control room 60, and to send those signals and responses to the noise profile processing unit 110.

An embodiment of a system and method for controlling the transmission and reflection of sunlight through the windows of the drilling control room is shown in FIG. 3 and FIG. 4. The drilling control room 60 is equipped with glass windows 140 with electronic tinting, electrochromic tinting, or equivalent or similar technology which allow for adjustable sun-shading inside the control room 60 without obstructing the operator's field of vision. The electronic control of the tinting or reflection of the windows 140 allows the reflection and transmission of the incoming sunlight to be adjusted, which may reduce heat and sun-glare inside the drilling control room 60. Such control of tinting or reflection may reduce strain on the HVAC system for the control room 60, enabling it to work more efficiently and reducing energy costs, or allow the size and/or weight of the HVAC system to be reduced. Tinting may also increase operator comfort and safety inside the control room 60, even in hot ambient temperatures and sunny climates, and eliminate the use of manual sunshades inside the control room 60.

An operator may manually control the reflection and transmission of sunlight through the windows 140 of the drilling control room 60. For example, the reflection and transmission may be adjusted by user control unit 150, which may be in electronic communication with the control system 230 (which may include a microprocessor, software, and user interface) for the operator control chair 210. Alternatively or in combination with other embodiments, the reflection and transmission of sunlight may be directly controlled by the control system 230. The control system 230 may use one or more light sensors 160 and/or one or more cameras 165 to automatically adjust the amount of incoming sunlight. The cameras 165 may be dedicated to controlling the reflection and transmission of sunlight or used in combination with one or more other systems. Alternatively or in combination with other embodiments, the adjustments of the control system 230 may be based on the use of daytime light calculations related to the location of the control room 60 on the earth or on self-learning modes embedded in supporting software that receives data from the light sensors 160 or cameras 165.

Referring to FIG. 5, an embodiment of a system and method for improving operator communication may include one or more head-up displays 170, which project information onto the windows 140 or other surfaces in front of an operator so that the operator has the selected information in his or her direct line of sight and does not have to look away from the drilling rig floor 70 during operations. The head-up display 170 may include one or more projectors 180 mounted in the same or different locations in the drilling control room 60, with each projector in electronic communication with the control system 230. Each location may be selected so that the projector 180 is not a hazard or obstacle to the operator or others working in the control room 60, is easily accessible for adjustment and repair, and displays information in the same line of sight as the on-going activities the operator is monitoring. Alternatives for a head-up display 170 for a drilling control room 60 include, but are not limited to, fixed

position combiner-based image displays, fixed position transparent displays, and head-mounted displays.

An embodiment of a system and method for improving operator communication may include voice feedback systems 200, which may replace or supplement the information available to an operator on HMI screens by speaking certain information audibly through the speakers or speaker arrays 205. The speakers or speaker arrays 205 may be dedicated to the voice feedback system 200 or used in combination with one or more other systems, such as the system and method for noise attenuation 80 or the telephone or public announcement/talkback system 220. Voice feedback systems 200 may be provided for each operator and controlled by the control system 230 **associated with that operator's** control chair 210 or workstation. Alternatively, a single voice feedback system 200 may be provided for a group of operators, with the system 200 controlled by a designated operator or from a central location. The information that will be spoken aloud by the voice feedback system 200 may be pre-determined or selected by the individual operator.

An embodiment of a system and method for improving communication between operators, employees and contractors who are working at other locations on or near the drilling rig, and third parties located off-site may include telephone or public announcement/talkback systems 220, or both, that may be integrated into the control system 230 for an operator control chair 210 or workstation. For example, the telephone or public announcement/talkback systems 220 may be integrated into the operator control chair 210 using one or more microphones 224 and one or more speakers or speaker arrays 226. The speaker or speaker arrays 226 may be dedicated to the telephone or public announcement/talkback system 220 or used in combination with one or more other systems, such as the system and method for noise attenuation 80 or the voice feedback system 200. Speakers or speaker arrays 226 may also be mounted outside the drilling control room 60 on the drilling rig site to facilitate communication

with other operators, employees and contractors who are working at other locations on or near the drilling rig. Operation of the integrated system 220 may be controlled from the existing touchpads or switches on the operator control chair 210. In circumstances where power to the drilling control room 60 may be shut down (such as the detection of gas at the air inlet of the control room 60) and communication through the integrated system 220 may not be possible, the drilling control room 60 may also be equipped with explosion-proof telephone or public announcement/talkback systems.

While the disclosure may be susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and have been described in detail herein. However, it should be understood that the disclosure is not intended to be limited to the particular forms disclosed. Rather, the disclosure is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the disclosure as defined by the following appended claims.

The techniques presented and claimed herein are referenced and applied to material objects and concrete examples of a practical nature that demonstrably improve the present technical field and, as such, are not abstract, intangible or purely theoretical. Further, if any claims appended to the end of this specification contain one or more elements designated as **"means for" or "step for" performing a function, it is intended that such elements are to be** interpreted under 35 U.S.C. 112(f). However, for any claims containing elements designated in any other manner, it is intended that such elements are not to be interpreted under 35 U.S.C. 112(f).

SYSTEMS AND METHODS FOR OPTIMIZING THE WORKING ENVIRONMENT IN A DRILLING CONTROL ROOM

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CROSS-REFERENCE TO PENDING APPLICATIONS

This application claims priority to U.S. Provisional Patent Application No. 62/382,360 filed with the U.S. Patent and Trademark Office ("USPTO") on September 1, 2016, and to U.S. Provisional Patent Application No. 62/453,547 filed with the USPTO on February 2, 2017.

BACKGROUND

This section is intended to introduce the reader to various aspects of art that may be related to various aspects of the present disclosure, which are described or claimed below. This discussion is believed to be helpful in providing the reader with background information to facilitate a better understanding of the various aspects of the present disclosure. Accordingly, it should be understood that these statements are to be read in this light, and not as admissions of prior art.

This present disclosure relates to systems and methods for optimizing the working environment in a drilling control room such as a drillers control room, crane cabin, or mud control room. More specifically, this disclosure relates to systems and methods to selectively actively attenuate noise within a drilling control room. The disclosure may also include systems and

methods to automatically adjust reflection and transmission of sunlight through the windows of the drilling control room as well as systems and methods to improve operator communication.

Drilling control room personnel must be adequately protected from a variety of environmental factors, including noise and sunlight. Noise sources in a drilling control room may include the drawworks or other lifting system, top drive, HVAC system, and pipe handling equipment and pipes, as well as generators, centrifuges, pumps, fans, and other noise-generating equipment on or near the drill floor. Similarly, crane cabin operators must be adequately protected from noise sources such as the electric motor, hydraulic pump, and HVAC system. Because the noise level of equipment and other noise sources in proximity to the control room or cabin may exceed 100 dB(A), regulatory standards and/or design specifications for the project may require the noise level in the drilling control room to be limited.

Passive noise cancelling or suppression means, such as noise insulating materials or panels, equipment blankets or shrouds, and vibration dampening structures may be used to reduce the noise level. While a combination of passive noise suppression means may be adequate to achieve a desired noise reduction, further reducing the noise level in the control room improves the quality of the working environment and allows the drilling rig to comply with stricter noise level standards. However, reducing noise (including vibration) to inaudible levels may not be desirable in some cases because certain noises can provide operators with additional feedback to determine whether an operation is being properly performed or equipment is properly functioning.

Sunlight may adversely affect the working environment in the drilling control room, particularly for operators who work in control rooms or cabins with large windows. Although the windows allow the operators to monitor and manage various activities, they also allow glare and heat into the control room or cabin. Adjusting the amount and angle of sunlight that enters the

control room or cabin without obstructing the operator's field of vision may provide increased comfort and safety for these operators. Furthermore, adjusting the reflection or transmission of sunlight in the control room or cabin may improve energy efficiency by reducing the need or size of a dedicated HVAC unit.

Communications within the drilling control room may also be difficult for operators. As an example, operators are responsible for moving machinery and observing activities outside the control room. However, their human-machine interface ("HMI") screens may be positioned so that the operators must look away from the on-going activities to review the information displayed on the screens. Projecting the information onto the windows or other surfaces in front of the operator, *i.e.*, a heads-up display, may allow the operator to receive information without looking away from the monitored activities, thereby increasing safety for everyone involved in the operation. A heads-up display may also improve workplace ergonomics, as operators would not be required to repeatedly turn their heads to view the screens, and increased efficiency, as operators would not have to stop activities in order to review the information on the screens.

Due to on-going activities and the amount of incoming information, operators may not be able to recognize particular information or alarms in a timely manner. Voice feedback systems, which speak certain information aloud instead of or in addition to displaying it on an operator's HMI screens, may allow operators to immediately identify alarms and other particular information and to differentiate between alarms, even when they are not looking at the screens. Such systems may increase safety, decrease response times, and reduce operator stress.

Communications with other operators, employees and contractors who are working at other locations on or near the drilling rig, and third parties located off-site may be difficult if operators cannot easily access telephones or public announcement/talkback systems from their control chairs

or if the telephone and talkback systems are not in their direct line of sight while monitoring on-going activities or HMI screens. Integrating telephone and talkback systems into the existing computer and software systems for the operator control chairs or workstations may improve communication. In addition, integrated telephone and talkback systems may simplify the installation and commissioning of the drilling control room, reduce the number of interface points and networks required in the control room, improve the appearance of the control room, allow the telephone and talkback systems to operate through the internet (VoIP), improve workplace ergonomics and comfort for the operators, and provide the option of recording voices during emergencies, incidents, or other selected circumstances.

SUMMARY

This summary is provided to introduce a selection of concepts that are further described below in the detailed description. This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining or limiting the scope of the claimed subject matter as set forth in the claims.

Embodiments of systems and methods for optimizing the working environment in a drilling control room may include systems and methods to selectively actively attenuate one or more noise sources affecting the noise level within the control room, systems and methods to adjust the reflection and transmission of sunlight, and systems and methods to improve operator communication.

Embodiments of systems and methods to selectively actively attenuate one or more noise sources affecting the noise level within a drilling control room may make use of active noise

cancelling or suppression technology arranged about the control room in combination with user-defined and source-specific noise attenuation modes. Possible attenuation modes include:

1. Fixed (but not complete) attenuation of one or more pre-determined or selected noise sources to a pre-determined or pre-defined noise level such as a customer- or regulation-specified noise limit;

2. User-defined variable (but not complete) attenuation of one or more of the noise sources;

3. Selected bandwidth (frequency range) attenuation of one or more of the noise sources;

4. Attenuation to an ideal noise level profile for one or more of the noise sources; and

5. Some combination of the above.

The active noise cancelling technology may be of a kind known in the active noise control art that reduces or cancels the noise coming from a source by sending out sound waves with an inverted or anti-phase to that of the noise (*see e.g.*, U.S. 6,343,127 B1, which is incorporated by reference herein). The original and inverted waves combine to form a new wave and effectively cancel each other out, an effect which is called destructive interference.

The described systems and methods may selectively attenuate the noise level of certain noise sources to a drilling control room while leaving other noise levels unchanged or at a different sound level. Such systems and methods may permit an operator within the same control room to selectively reduce or increase a noise level suitable for her or his purpose relative to other operators without violating required maximum room or cabin sound levels, comply with working environment standards including but not limited to 65dBA, and lower the noise level inside the control room, thereby improving the working environment for the operators.

Embodiments of systems and methods to adjust the reflection and transmission of sunlight through the windows of the drilling control room may include a glass system with electronic or electrochromic tinted glass that may be used to adjust the reflection of sunlight based on the degree of sun exposure and/or the temperature of the working environment within the control room. The glass system may also include a control system that automatically adjusts the electronic tinting of the glass in response to a determined parameter. The determined parameter may be provided by one or more light sensors. Alternatively, the parameter may be based on daytime light calculations related to the location of the control room on earth or on self-learning computer modes based on input from the light sensors.

Embodiments of systems and methods to improve operator communication may include one or more heads-up displays so that information that would otherwise be limited to display on the HMI screens is visible in the same line of sight as the machinery or activities the operator is required to observe. Voice feedback systems as well as telephone and public announcement/talkback systems that are integrated into the existing computer and software systems for an operator's control chair or workstation may also be included.

BRIEF DESCRIPTION OF THE DRAWINGS

The subject disclosure is further described in the following detailed description, and the accompanying drawing and schematic of non-limiting embodiment of the subject disclosure. The features depicted in the figure are not necessarily shown to scale. Certain features of the embodiments may be shown exaggerated in scale or in somewhat schematic form, and some details of elements may not be shown in the interest of clarity and conciseness.

FIG. 1 is a representation of an example of the environment for embodiments of the drilling control room of the disclosure.

FIG. 2 is a schematic of an embodiment of a system and method to optimize the working environment in a drilling control room.

FIG. 3 is a representation of an embodiment of a system and method for adjusting the transmission and reflection of sunlight through the windows of a drilling control room.

Elements and Numbering Used in the Drawing and Detailed Description

10	Land rig
20	Tubular handing equipment
30	Controls skid
40	Pressure control system
50	Manifold system
60	Drilling control room
70	Drilling rig floor
80	System and method for noise attenuation
90	Speaker or speaker array
100	Receiver (input interface)
110	Noise profile processing unit (active noise cancellation engine)
120	Speaker controller (output interface)
130	User control unit
132	Microphone or sensor
134	Accelerometer or sensor
140	Electronic (electrochromic) tinted window

150	Control system
160	Light sensor
170	Heads-up display
180	Projector
190	Camera
200	Voice feedback system
210	Operator control chair
220	Telephone or public announcement/talkback system
230	Existing control system for operator control chair 210
N	Noise source

DETAILED DESCRIPTION

One or more specific embodiments of the present disclosure will be described below. These described embodiments are only exemplary of the present disclosure. Additionally, in an effort to provide a concise description of these exemplary embodiments, all features of an actual implementation may not be described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

Embodiments of systems and methods for optimizing the working environment in a drilling control room may include systems and methods to selectively actively attenuate one or more noise sources affecting the noise level within the control room, systems and methods to adjust the reflection and transmission of sunlight through control room windows, and systems and methods to improve operator communication such as heads-up displays, voice feedback systems, and integrated telephone and public announcement/talkback systems.

FIG. 1 is a diagram illustrating an example of the environment in which one or more of the systems and methods of the present disclosure might be deployed. A land rig 10 is shown which comprises drilling equipment to drill a subterranean well and produce hydrocarbon-bearing fluid from subterranean rock formations. The land rig 10 includes tubular handling equipment generally shown as 20, controls skid 30 to power and functionally control the drilling and pressure control equipment, a pressure control system 40 like a Blowout Preventer ("BOP") to control pressure of the well, and a manifold system 50 to direct and manage fluids to and from mud pumps. The various equipment and tools of the land rig 10 are monitored and controlled from a drilling control room 60, which is located on the drilling rig floor 70. In other cases, the environment might be offshore and the drilling control room may be located near a drill floor on a hull self-elevated by legs penetrating the sea base (jack-up environments) or on the hull of a drill ship (floaters environments). In many of these cases, the drilling control room is directly exposed to the exterior environment and thus operators working in the control room are directly exposed to noise from surrounding equipment and operations and to the sun's rays and heat.

An embodiment for a system and method 80 to selectively actively attenuate noise sources affecting the noise level within a drilling control room is shown in FIG. 2. The speakers 90 are in communication with a receiver 100 that receives an analog signal from a noise source "N" and

passes the signal to a noise profile processing unit 110. The noise profile processing unit 110 includes at least one microprocessor with associated software (or their equivalent) that implements one or more algorithms known in the art for analyzing incoming sound waves and generating remedial noise profiles. The processing unit 110 passes the analog signal through an A/D converter and processes the digital signal to provide a remedial noise (attenuation) profile (*see e.g.*, U.S. 2005/0226434 A1, which is incorporated by reference herein). The profile, which may be an inverted or anti-phase sound wave, is passed through a D/A converter and onto a speaker controller 120 connected to the speaker or speaker array 90. The speaker controller 120 may include a microprocessor and associated software (or their equivalent).

Noise sources N_1 to N_N for a drilling control room may include, but are not limited to, the drawworks (or other lifting equipment), top drive, HVAC system, and pipe handling equipment and pipes, as well as generators, centrifuges, pumps, fans, and other noise-generating equipment on or near the drill floor. Noise sources N_1 to N_N for a crane cabin may include, but are not limited to, the electric motor, hydraulic pump, and HVAC system.

A user control unit 130 is in communication with the noise profile processing unit 110. In embodiments, the user control unit 130 may include human-machine interface ("HMI") displays arranged about the operator control chair 210. The user control unit 130 may be a centralized unit including a microprocessor and associated software (or their equivalent) configured to control the noise level within the entire drilling control room 60, two or more decentralized units configured to control the noise level at individual operator workstations, or configured for some combination of centralized and decentralized control. The user control unit 130 may be located within the drilling control room 60 with the operator operating it while sitting in her or his control chair 210.

The user control unit 130 may provide different attenuation modes, which may include:

1. Fixed (but not complete) attenuation of one or more pre-determined or selected noise sources N to a pre-determined or pre-defined noise level such as a customer- or regulation-specified noise limit;

2. User-defined variable (but not complete) attenuation of one or more of the noise sources N;

3. Selected bandwidth (frequency range) attenuation of one or more of the noise sources N (*see e.g.*, U.S. 2014/0314241 A1, which is incorporated by reference herein);

4. Attenuation to an ideal noise level profile for one or more of the noise sources; and

5. Some combination of the above.

The ideal noise level profile also may be used to compare a noise source's current sound with that of the ideal sound. The phrase "but not complete" means attenuation in a range of about 1% to about 99% of the noise source N unattenuated noise level, with the unattenuated noise level including any passive noise reduction methods currently employed with that noise source.

One or more accelerometers 134 may be placed outside of or within the drilling control room 60 to sense any vibrations running through the room's framing structure. One or more accelerometers 134 may also be placed directly on the noise source N. The noise profile processing unit 110 can analyze these vibrations to determine the sound effect created by the vibrations. Similarly, one or more microphones (or other sound sensors) 132 may be placed at or near a noise source N or arranged within the control room 60 to sense noise signals, including modal responses of the control room 60, and to send those signals and responses to the noise profile processing unit 110.

An embodiment of a system and method for adjusting the transmission and reflection of sunlight through the windows of the drilling control room is shown in FIG. 2 and FIG. 3. The

drilling control room 60 is equipped with glass windows 140 with electronic or electrochromic tinting, which allow for adjustable sun-shading inside the control room 60 without obstructing the operator's field of vision. Such windows 140 may not increase the size of the drilling control room 60 and may provide a comfortable working environment for the operators in the control room 60, even in hot ambient temperatures and sunny climates.

The electronic control of the tinting of the windows 140 allows the reflection and transmission of the incoming sunlight to be adjusted, which may reduce heat and sun-glare inside the drilling control room 60. Using electronic tinting may reduce strain on the HVAC system for the control room 60, enabling it to work more efficiently and reducing energy costs, or allow the size and/or weight of the HVAC system to be reduced. Electronic tinting may also increase operator comfort inside the control room 60 (with corresponding increases in safety) and eliminate the use of manual sunshades inside the control room 60.

An operator may manually control the reflection and transmission of sunlight through the windows 140 of the drilling control room 60. For example, the reflection and transmission may be adjusted electronically when the operator presses a button. Alternatively or in combination with other embodiments, the reflection and transmission of sunlight may be directly controlled by a control system 150. The control system 150 may use one or more light sensors 160 to automatically adjust the amount of incoming sunlight. Alternatively or in combination with other embodiments, the adjustments of the control system 150 may be based on the use of daytime light calculations related to the location of the control room 60 on the earth or on self-learning modes embedded in supporting software that receives data from the light sensors 160. The control system 150 may be independent of or integrated with the existing computer and software systems 230 for the operator control chair 210.

Referring to FIG. 2, an embodiment of a system and method for improving operator communication may include one or more heads-up displays 170, which project information onto the windows 140 or other surfaces in front of an operator so that the operator has the selected information in his or her direct line of sight and does not have to look away from the drilling rig floor 70 during operations. The heads-up display 170 may include one or more projectors 180 mounted in the same or different locations in the drilling control room 60. Each location may be selected so that the projector 180 is not a hazard or obstacle to the operator or others working in the control room 60, is easily accessible for adjustment and repair, and displays information in the same line of sight as the on-going activities the operator is monitoring. The display 170 may also include one or more cameras 190 outside the drilling control room 60 that feed video images and other information to the projectors 180. Alternatives for a heads-up display 170 for a drilling control room 60 include, but are not limited to, fixed position combiner-based image displays, fixed position transparent displays, and head-mounted displays.

An embodiment of a system and method for improving operator communication may include voice feedback systems 200, which may replace or supplement the information available to an operator on HMI screens by speaking certain information audibly. Voice feedback systems 200 may be provided for each operator and controlled by the computer and software systems 230 associated with that operator's control chair 210 or workstation. Alternatively, a single voice feedback system 200 may be provided for a group of operators, with the system 200 controlled by a designated operator or from a central location. The information that will be spoken aloud by the voice feedback system 200 may be pre-determined or selected by the individual operator.

An embodiment of a system and method for improving communication between operators, employees and contractors who are working at other locations on or near the drilling rig, and third

parties located off-site may include telephone and public announcement/talkback systems 220 that are integrated into the existing computer and software systems 230 for an operator control chair 210 or workstation. For example, the telephone and talkback systems 220 may be integrated into the operator control chair 210 using the existing computer, microphone, and speaker that are associated with the chair 210. Operation of the integrated system 220 may be controlled from the existing touchpads or switches on the chair 210. In circumstances where power to the drilling control room 60 may be shut down (such as the detection of gas at the air inlet of the control room 60) and communication through the integrated system 220 may not be possible, the drilling control room 60 may also be equipped with explosion-proof telephone and talkback systems.

While the disclosure may be susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and have been described in detail herein. However, it should be understood that the disclosure is not intended to be limited to the particular forms disclosed. Rather, the disclosure is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the disclosure as defined by the following appended claims.

The techniques presented and claimed herein are referenced and applied to material objects and concrete examples of a practical nature that demonstrably improve the present technical field and, as such, are not abstract, intangible or purely theoretical. Further, if any claims appended to the end of this specification contain one or more elements designated as "means for" or "step for" performing a function, it is intended that such elements are to be interpreted under 35 U.S.C. 112(f). However, for any claims containing elements designated in any other manner, it is intended that such elements are not to be interpreted under 35 U.S.C. 112(f).

WHAT IS CLAIMED

1. A system for optimizing a working environment in a drilling control room (60), the system comprising:

a subsystem for at least one of

selectively actively attenuating a noise source to control a noise level within the drilling control room (60),

controlling a transmission and reflection of sunlight through windows (140) of the drilling control room (60),

providing information to an operator through a head-up display (170),

providing audible information to an operator through a voice feedback system (200), and

conveying information to or from the operator through a telephone or public announcement/talkback system (220); and

at least one microprocessor with associated software, the at least one microprocessor being in electronic communication with the subsystem.

2. The system according to claim 1 wherein the subsystem for selectively actively attenuating a noise source to control a noise level within the drilling control room comprises:

one or more speakers (90) arranged about the drilling control room (60);

a noise profile processing unit (110) in communication with the one or more speakers (90) and at least one noise source; and

a user control unit (130) in communication with the noise profile processing unit (110),

wherein the noise profile processing unit (110) generates a noise profile for use by the one or more speakers (90) based upon a selected attenuation mode of the at least one noise source.

3. The system according to claim 2 wherein the attenuation mode is selected from the group consisting of a variable attenuation mode, a selected bandwidth attenuation mode, and an ideal noise profile mode.

4. The system according to claim 2 wherein the attenuation mode is a combination of two or more modes selected from the group consisting of a fixed attenuation mode, a variable attenuation mode, a selected bandwidth attenuation mode, and an ideal noise profile mode.

5. The system according to claim 2 further comprising one or more sensors arranged in communication with the noise profile processing unit (110) and at least one of the drilling control room (60) and a noise source.

6. The system according to claim 5 wherein the one or more sensors includes a sensor selected from the group consisting of a microphone (132) and an accelerometer (134).

7. The system according to claim 1 wherein the subsystem for controlling transmission and reflection of sunlight through windows (140) of the drilling control room (60) includes electronic or electrochromic tinted glass.

8. The system according to claim 7 further comprising means to control transmission and reflection of sunlight through the electronic or electrochromic tinted glass.

9. The system according to claim 1 wherein the head-up display (170) is selected from a group consisting of a fixed position combiner-based image display, a fixed position transparent display, and a head-mounted display.

10. The system according to claim 1 wherein the telephone or public announcement/talkback system 220 is integrated with an operator control chair (210).

11. A method for optimizing a working environment in a drilling control room (60), the method comprising:

selectively changing an environmental condition of the drilling control room (60), the environmental condition being in electronic communication with a microprocessor and associated software; and

wherein the environment condition is selected from the group consisting of a noise level within the drilling control room (60), transmission and reflection of sunlight through windows (140) of the drilling control room (60), a head-up display 170, audible information, and conveying information.

12. A method according to claim 11 wherein selectively changing the noise level comprises:

arranging one or more speakers (90) about the drilling control room (60), the one or more speakers (90) being in communication with a noise profile processing unit (110), the noise profile processing unit (110) being in

communication with at least one noise source and a user control unit (130);

selecting, using the user control unit (130), an attenuation mode of the at least one noise source; and

sending the attenuation mode to the noise profile processing unit (110), wherein the noise profile processing unit (110) generates a noise profile for use by the one or more speakers (90).

13. The method according to claim 12 wherein the attenuation mode is selected from the group consisting of a variable attenuation mode, a selected bandwidth attenuation mode, and an ideal noise profile mode.

14. The method according to claim 12 wherein the attenuation mode is a combination of two or more modes selected from the group consisting of a fixed attenuation mode, a variable attenuation mode, a selected bandwidth attenuation mode, and an ideal noise profile mode.

15. The method according to claim 12 further comprising temporarily attenuating the at least one noise source using the user control unit (130).

16. The method according to claim 11, wherein selectively changing the transmission and reflection of sunlight through windows (140) of the drilling control room (60) comprises adjusting tinting of electronic or electrochromic glass in the windows (140).

17. The method according to claim 16 wherein the tinting is manually adjusted by an operator.

18. The method according to claim 16 wherein the tinting is automatically adjusted by the microprocessor.

19. The method according to claim 18 wherein adjustments are based upon data provided by at least one light sensor (160) or camera (165), daytime light calculations related to a location of the drilling control room (60) on earth, self-learning computer modes that receive data from the at least one light sensor (160) or camera (165), or a combination thereof.

WHAT IS CLAIMED

1. A system for optimizing the working environment in a drilling control room by selectively actively attenuating a noise source to control a noise level within the drilling control room, the system comprising:

one or more speakers arranged about the drilling control room;

a noise profile processing unit in communication with the one or more speakers and at least one noise source; and

a user control unit in communication with the noise profile processing unit, wherein the noise profile processing unit generates a noise profile for use by the one or more speakers based upon a selected attenuation mode of the at least one noise source.

2. The system according to claim 1 wherein the attenuation mode is selected from the group consisting of a variable attenuation mode, a selected bandwidth attenuation mode, and an ideal noise profile mode.

3. The system according to claim 1 wherein the attenuation mode is a combination of two or more modes selected from the group consisting of a fixed attenuation mode, a variable attenuation mode, a selected bandwidth attenuation mode, and an ideal noise profile mode.

4. The system according to claim 1 wherein the one or more speakers are mounted inverted relative to an interior space of the drilling control room.

5. The system according to claim 1 further comprising one or more sensors arranged in communication with the noise profile processing unit and at least one of the drilling control room and a noise source.

6. The system according to claim 5 wherein the one or more sensors includes a sensor selected from the group consisting of a microphone and an accelerometer.

7. A method for optimizing the working environment in a drilling control room by selectively actively attenuating a noise source to control a noise level within the drilling rig control room, the method comprising:

arranging one or more speakers about the drilling control room, the one or more speakers being in communication with a noise profile processing unit, the noise profile processing unit being in communication with at least one noise source and a user control unit;

selecting, using the user control unit, an attenuation mode of the at least one noise source; and

sending the attenuation mode to the noise profile processing unit, wherein the noise profile processing unit generates a noise profile for use by the one or more speakers.

8. The method according to claim 7 wherein the attenuation mode is selected from the group consisting of a variable attenuation mode, a selected bandwidth attenuation mode, and an ideal noise profile mode.

9. The method according to claim 7 wherein the attenuation mode is a combination of two or more modes selected from the group consisting of a fixed attenuation mode, a variable attenuation mode, a selected bandwidth attenuation mode, and an ideal noise profile mode.

10. The method according to claim 7 further comprising temporarily attenuating the at least one noise source using the user control unit.

11. A system for optimizing the working environment in a drilling control room by controlling the transmission and reflection of sunlight through windows of the drilling control room, the system comprising electronic (electrochromic) tinted glass.

12. The system according to claim 11 further comprising a control system to adjust the transmission and reflection of sunlight through the electronic (electrochromic) tinted glass.

13. A method for optimizing the working environment in a drilling control room by controlling the transmission and reflection of sunlight through windows of the drilling control room, the method comprising adjusting tinting of electronic (electrochromic) glass in the windows.

14. The method according to claim 13 wherein the tinting is manually adjusted by an operator.

15. The method according to claim 13 wherein the tinting is automatically adjusted by a control system.

16. The method according to claim 15 wherein adjustments of the control system are based upon data provided by at least one light sensor, daytime light calculations related to a location of the drilling control room on earth, self-learning computer modes that receive data from the at least one light sensor, or a combination thereof.

17. A system for optimizing the working environment in a drilling control room by improving operator communications, the system comprising a heads-up display.

18. The system according to claim 17 wherein the heads-up display is selected from a group consisting of a fixed position combiner-based image display, a fixed position transparent display, and a head mounted display.

19. The system according to claim 17 further comprising a voice feedback system.

20. The system according to claim 17 further comprising a telephone or public announcement/talkback system that is integrated into computer and software systems for an operator control chair.

21. The system according to claim 20 further comprising a second telephone system or public announcement/talkback system that is explosion-proof.

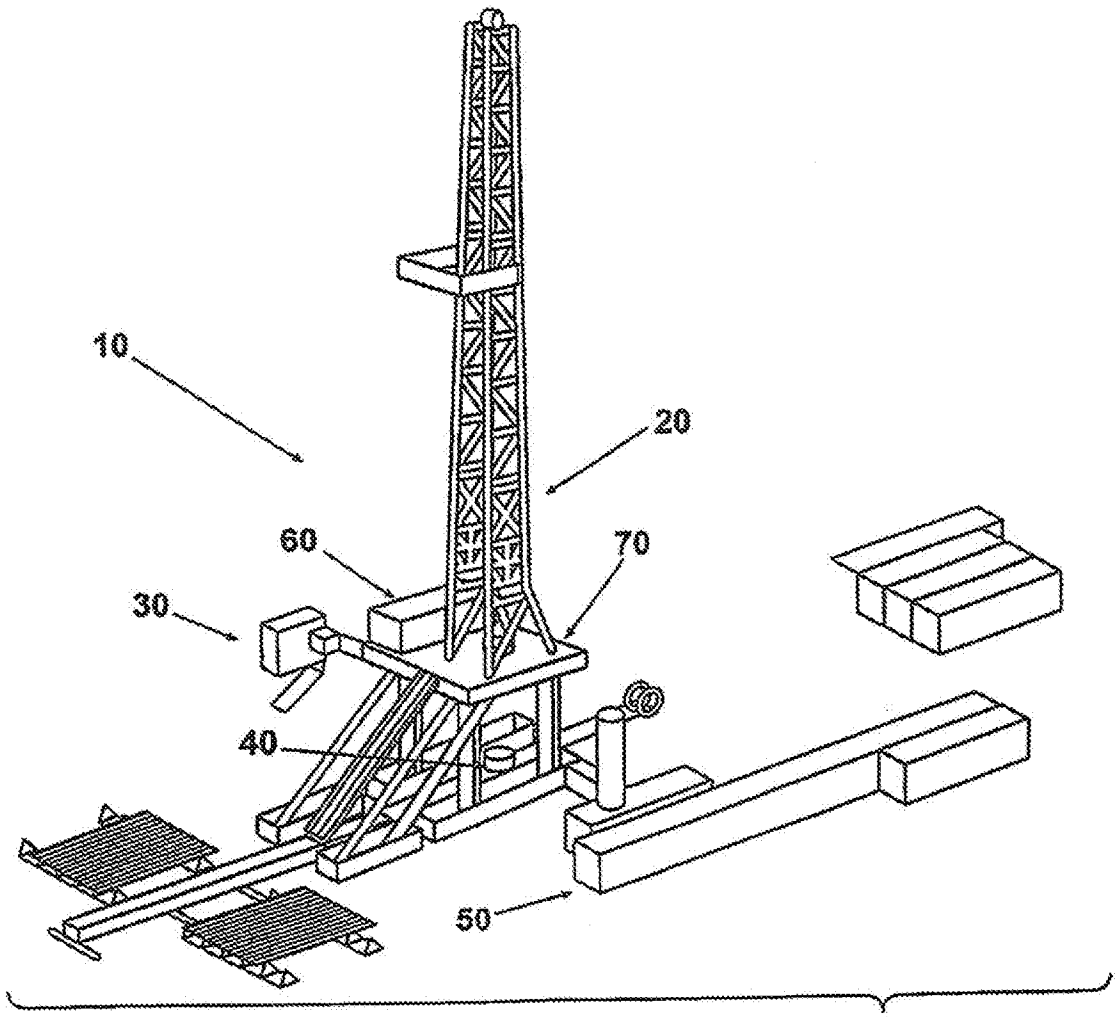
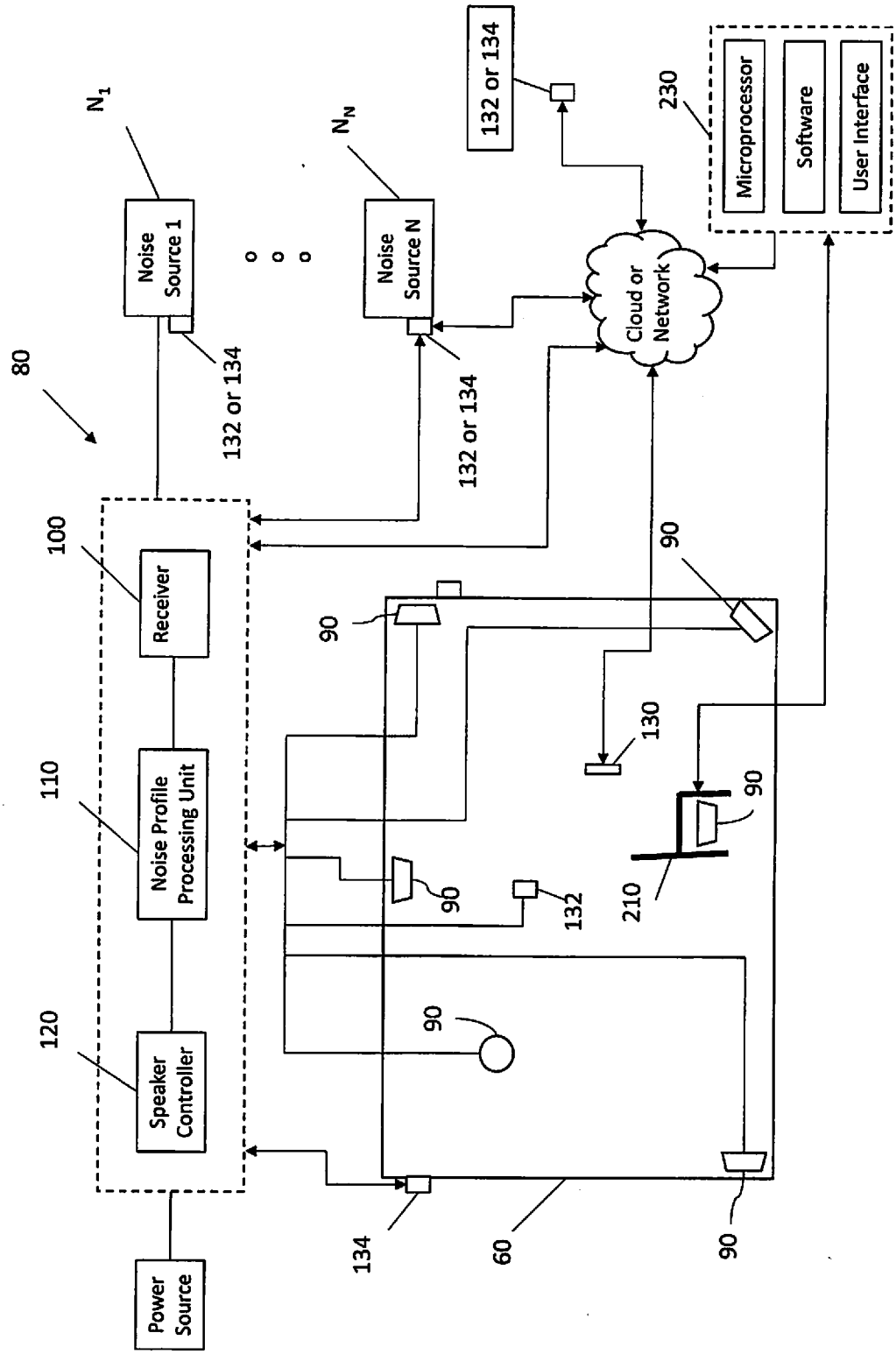


Fig. 1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N_N
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Noise Source N
132 or 134
132 or 134
132 or 134
230
Microprocessor
Software
User Interface
Cloud or Network
80
100
Receiver
110
Noise Profile Processing Unit
120
Speaker Controller
Power Source
90
90
90
90
90
90
130
132
210
134
60

FIG. 2

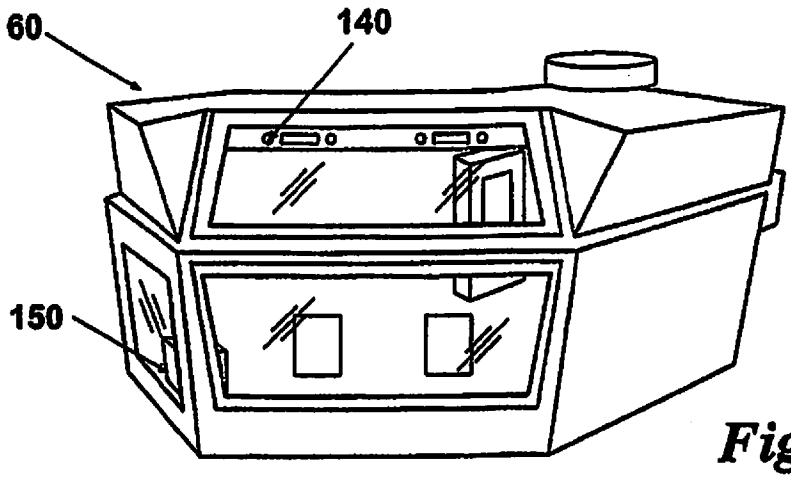

Fig. 3

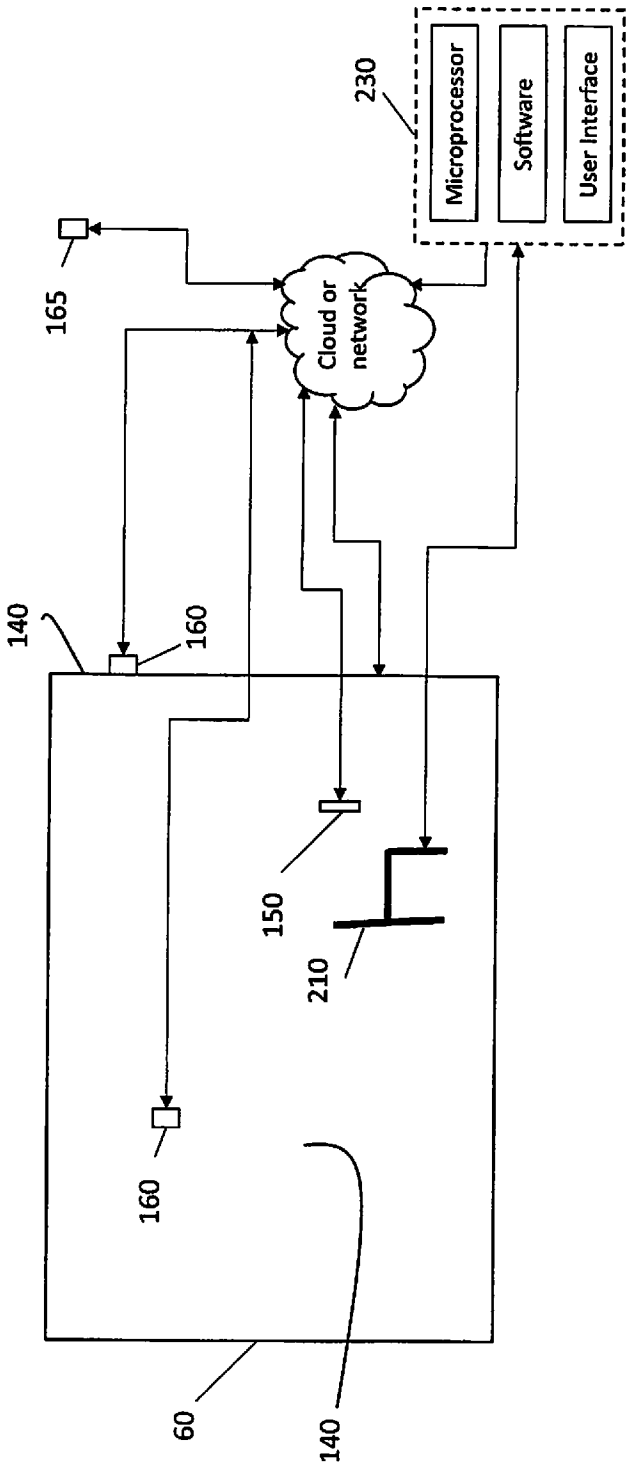
230
Microprocessor
Software
User Interface
165
Cloud or network
140
160
150
210
160
60
140

FIG. 4

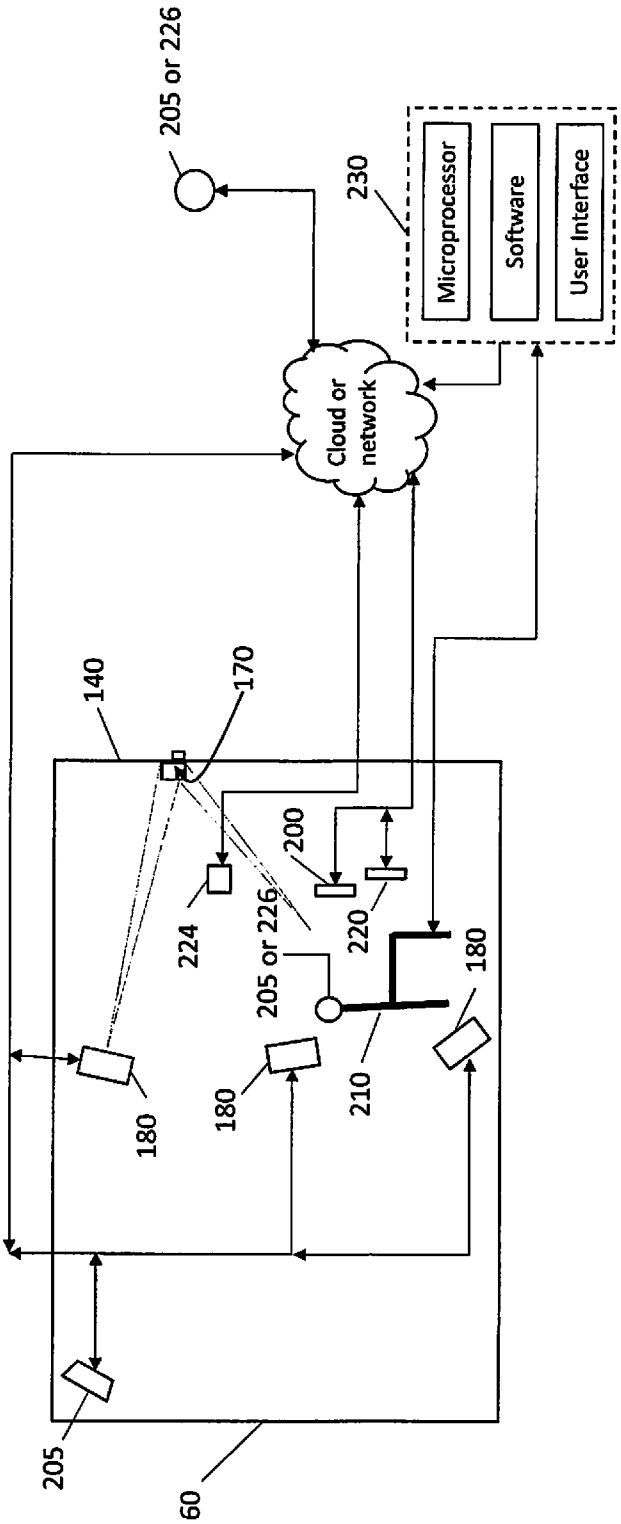
205 or 226
230
Microprocessor
Software
User Interface
Cloud or network
140
170
200
224
205 or 226
220
180
180
180
210
205
60

FIG. 5

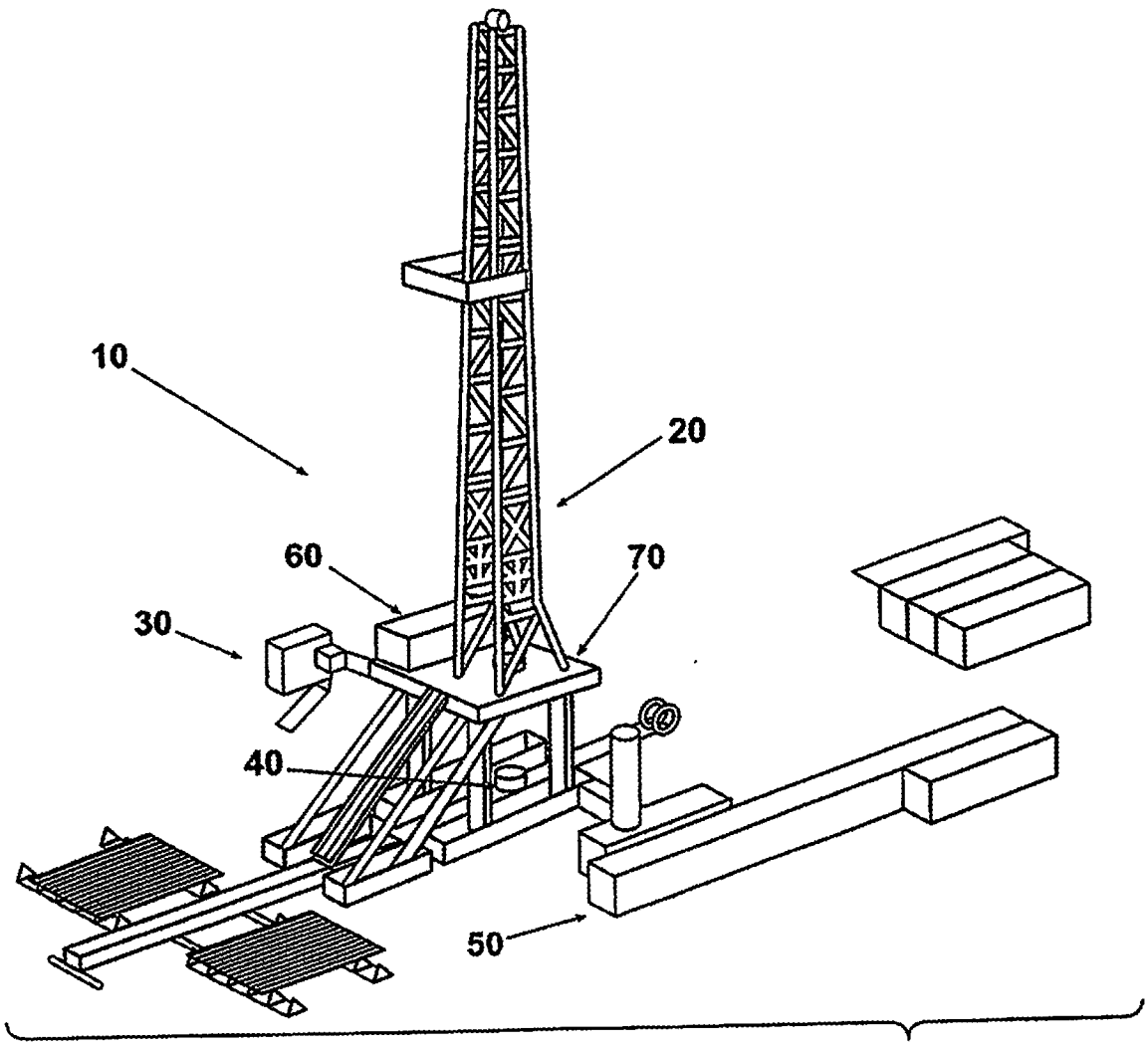

Fig. 1

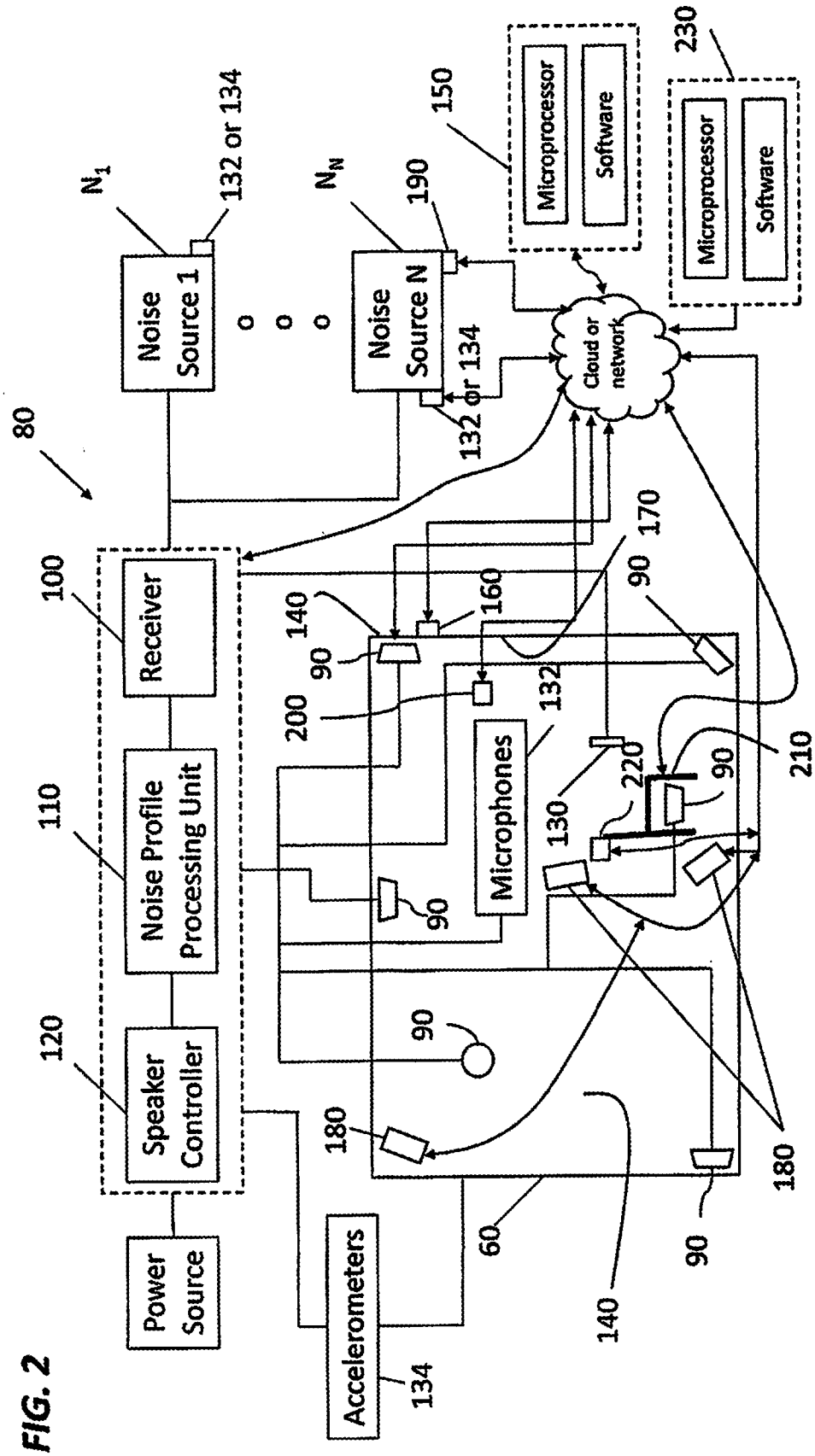
80
Noise Source 1
Noise Source N
N_1
N_N
132 or 134
190
150
Microprocessor
Software
230
Cloud or network
100
Receiver
110
Noise Profile Processing Unit
120
Speaker Controller
Power Source
Accelerometers
134
Microphones
130
132
140
160
170
200
210
220
90
180
60

FIG. 2

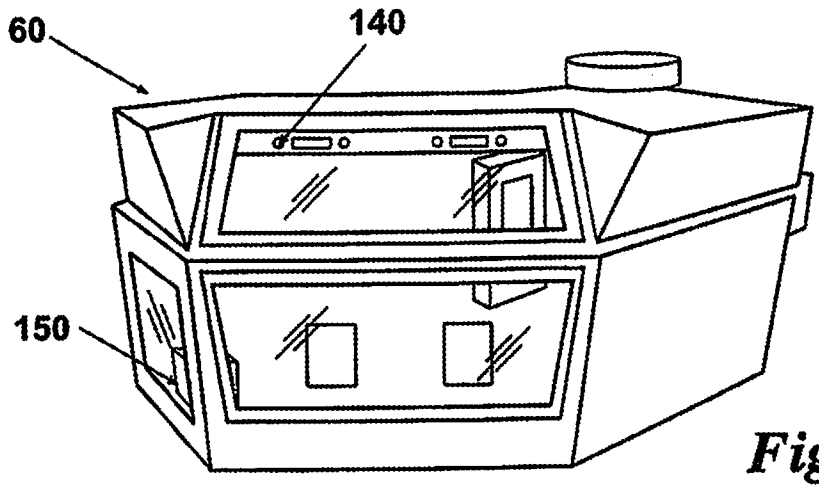

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/049806

A. CLASSIFICATION OF SUBJECT MATTER

E21B 41/00(2006.01)i, E21B 15/00(2006.01)i, G10K 11/16(2006.01)i

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)
E21B 41/00; G10K 11/00; E21B 47/16; G05B 15/02; G01V 11/00; G02F 1/163; G01C 21/36; G01V 1/40; E21B 15/00; G10K 11/16

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: working environment, attenuation noise, transmission and reflection of sunlight, head up display, information

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 1930542 A2 (HALLIBURTON ENERGY SERVICES, INC.) 11 June 2008 See paragraphs [0001]-[0006], claim 5 and figures 1-5.	1-19
Y	US 2014-0236323 A1 (VIEW, INC.) 21 August 2014 See paragraphs [0075]-[0157], claim 13 and figures 4-5, 6A-6C.	1-19
Y	US 2015-0149079 A1 (AMERICAN VEHICULAR SCIENCES LLC.) 28 May 2015 See paragraphs [0053]-[0064] and figures 2, 3A-3G.	1-19
A	US 2013-0083939 A1 (FELLERS et al.) 04 April 2013 See paragraphs [0035]-[0045] and figures 1, 2A-2C.	1-19
A	US 6246962 B1 (SCHULTZ et al.) 12 June 2001 See column 2, line 35 - column 5, line 15 and figures 1-10.	1-19

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

☒ 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	Date of mailing of the international search report
08 January 2018 (08.01.2018)	**08 January 2018 (08.01.2018)**

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Korean Intellectual Property Office
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LEE, Jong Kyung
Telephone No. +82-42-481-3360

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2017/049806

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1930542 A2	11/06/2008	AR 064033 A1	04/03/2009
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		CA 2612698 C	19/04/2011
		CA 2729349 A1	04/06/2008
		CA 2729349 C	18/03/2014
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