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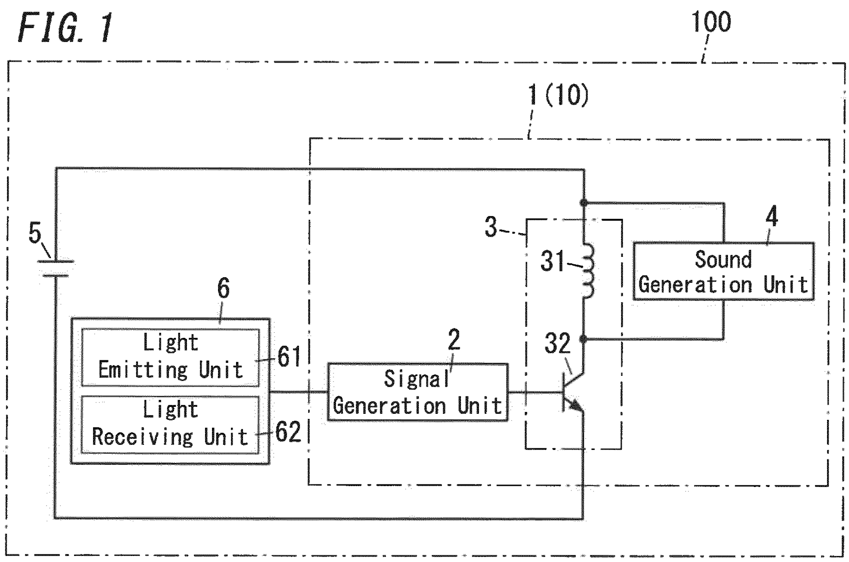
(54) **SOUND-EMITTING DEVICE, NOTIFICATION DEVICE, AND SENSOR**

(57) Provided is a sound-emitting device, an alarm device, and a detector capable of providing sounds in a plurality of patterns having different tones with a common configuration. The sound-emitting device (1) includes a sound generation unit (4), and a signal generation unit (2). The sound generation unit (4) is configured to generate sounds in a plurality of patterns having different tones. The signal generation unit (2) is configured to transmit, to the sound generation unit (4), a signal corresponding to any of the plurality of patterns. The sound generation unit (4) is configured to generate a sound in a pattern according to the signal from the signal generation unit 2).

FIG. 1



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Description

Technical Field

[0001] The present disclosure relates generally to sound-emitting devices, alarm devices, and detectors, and more particularly, to a sound-emitting device, an alarm device, and a detector for emitting sounds in a plurality of frequencies.

Background Art

[0002] There has been known a household alarm device (detector) configured to detect a trouble in a residence such as a fire, a gas leakage and the like to give an alarm (see Patent Literature 1, for example). The household alarm device of Patent Literature 1 includes a sound-emitting device configured to emit, when detecting the trouble, a sweeping sound (alarm sound) whose frequency changes linearly with time.

[0003] This known sound-emitting device is only capable of generating a sound with a single tone or a sound of which tone varies according to a preset constant pattern.

Citation List

Patent Literature

[0004] Patent Literature 1: JP2010-49604A

Summary of Invention

[0005] The present disclosure is developed in view of the above circumstances, and an object thereof is to provide a sound-emitting device, an alarm device, and a detector, capable of providing sounds in a plurality of patterns having different tones with a common configuration.

[0006] A sound-emitting device according to an aspect of the present disclosure includes a signal generation unit and a sound generation unit. The sound generation unit is configured to generate sounds in a plurality of patterns having different tones. The signal generation unit is configured to transmit, to the sound generation unit, a signal corresponding to any of the plurality of patterns. The sound generation unit is configured to generate a sound in a pattern corresponding to the signal from the signal generation unit.

[0007] An alarm device according to an aspect of the present disclosure includes the above sound-emitting device. The sound generation unit is configured to generate an alarm sound.

[0008] A detector according to an aspect of the present disclosure includes the above alarm device, and a detection unit configured to detect a specific event. The alarm device is configured to emit the alarm sound when the detection unit detects the specific event.

Brief Description of Drawings

[0009]

FIG. 1 is a block diagram of a detector including a sound-emitting device according to Embodiment 1 of the present disclosure.

FIG. 2 is a perspective view of the sound-emitting device.

FIG. 3 is a time-chart illustrating a PWM signal generated by a signal generation unit of the sound-emitting device.

FIG. 4 is a time-chart illustrating a frequency and a duty cycle of the PWM signal generated by the signal generation unit of the sound-emitting device.

FIG. 5 is a graph illustrating frequency characteristics of a housing of the sound-emitting device.

FIG. 6 is a time-chart illustrating a frequency and a duty cycle of a PWM signal generated by a signal generation unit of a sound-emitting device according to a variation of Embodiment 1 of the present disclosure.

FIG. 7 is a time-chart illustrating a frequency and a duty cycle of a PWM signal generated by a signal generation unit of a sound-emitting device according to another variation of Embodiment 1 of the present disclosure.

FIG 8 is a block diagram of a detector including a sound-emitting device according to Embodiment 2 of the present disclosure.

FIG. 9 is a block diagram of a detector including a sound-emitting device according to a variation of Embodiment 2 of the present disclosure.

Description of Embodiments

[0010] Embodiments of the present disclosure will be described with reference to drawings. Note that the embodiments to be described below are merely examples of embodiments of the present disclosure. Numerous modifications or variations can be readily made by those skilled in the art depending on their design choice or any other factor without departing from the object of the present disclosure.

(1) Embodiment 1

(1.1) Configuration

[0011] FIG. 1 is a block diagram of a detector 100 including a sound-emitting device 1 of the present embodiment. FIG. 2 is an appearance diagram of the detector 100 including the sound-emitting device 1 of the present embodiment. The sound-emitting device 1 of the present embodiment can emit a plurality of sounds having different frequencies within an audible range of human (20 Hz to 20 kHz, for example). The sound-emitting device 1 includes an alarm device 10 configured to emit an alarm sound of which frequency changes with time. The detector 100 of the present embodiment is a smoke detector, and includes the alarm device 10. The detector 100 is configured to emit the alarm sound from the alarm device 10 when detecting the outbreak of smoke.

[0012] The sound-emitting device 1 of the present embodiment will be described in further detail below.

[0013] The sound-emitting device 1 includes a signal generation unit 2, a sound generation unit 4, an acoustic circuit 3, and a housing 11 (see FIG. 2). The housing 11 houses therein the signal generation unit 2, the sound generation unit 4, and the acoustic circuit 3. For example, the housing 11 is attached to a ceiling of a building. The housing 11 is provided therein with a power supply 5 serving as an operation power supply for powering the sound-emitting device 1. The power supply 5 includes a battery. However, the power supply 5 is not limited to include the battery. The sound-emitting device 1 may be configured to operate with an operation power supplied from a commercial power supply, for example.

[0014] The signal generation unit 2 includes a microcomputer for example, and is configured to generate a PWM (Pulse Width Modulation) signal. The signal generation unit 2 is configured to change a frequency of the PWM signal. That is, the signal generation unit 2 is configured to generate a signal (PWM signal) whose frequency and duty cycle are variable. The signal generation unit 2 is configured to transmit the PWM signal to the acoustic circuit 3.

[0015] The acoustic circuit 3 includes an inductor 31, and a switching device 32. The inductor 31 and the switching device 32 are connected in series between output terminals of the power supply 5.

[0016] The inductor 31 may function as a voltage booster inductor. The sound generation unit 4 is connected between both terminals of the inductor 31. The sound generation unit 4 includes a separately excited piezoelectric buzzer, and the sound generation unit 4 is applied thereto a voltage across the inductor 31. The sound generation unit 4 is configured to generate a sound with a frequency corresponding to the frequency of the applied voltage. The housing 11 has a hole(s) for the sound generated by the sound generation unit 4, and the hole(s) facilitates the sound generated by the sound generation unit 4 to travel outside the housing 11. Note that the sound generated by the sound generation unit 4 has an instantaneous sound pressure that varies depending on the amplitude of the voltage applied to the sound generation unit 4. The sound generation unit 4 is not limited to the piezoelectric buzzer, but may be a speaker.

[0017] The switching device 32 may be an NPN transistor, and has a collector connected to the voltage booster inductor, an emitter connected to a negative output terminal of the power supply 5, and a base connected to the signal generation unit 2. The switching device 32 is in an ON state while a signal level of the PWM signal is in a Hi level, and is in an OFF state while the signal level is in a Low level. Therefore, the switching device 32 is turned on and off according to the PWM signal supplied to the base thereof.

[0018] The switching device 32 in the ON state allows a current to flow from the power supply 5 to the inductor 31 to allow energy to be accumulated on the inductor 31. The energy accumulated on the inductor 31 is released upon the switching device 32 being turned off, and a voltage, which has been boosted up from an output voltage of the power supply 5, is applied to the sound generation unit 4. Therefore, the sound generation unit 4 generates a sound with a frequency equal to the frequency of the PWM signal. As an increase in the duty cycle of the switching operation of the switching device 32, the energy accumulated on the inductor 31 and also the voltage to be applied to the sound generation unit 4 increase. Provided that the frequency of the PWM signal is not changed, the instantaneous sound pressure of the sound generated by the sound generation unit 4 increases as the increase in the duty cycle of the PWM signal, although the sound generation unit 4 consumes larger energy as well.

[0019] The signal generation unit 2 is configured to change the frequency of the PWM signal with time, which will be described later in the section "(1. 2) Operation Example". Accordingly, the sound generation unit 4 generates the alarm sound with the frequency that changes with time.

[0020] Alternatively, the switching device 32 may be a PNP transistor, an Insulated Gate Bipolar transistor (IGBT), a Metal Oxide Semiconductor Field Effect Transistor (MOSFET), or the like.

[0021] The detector 100 of the present embodiment includes the alarm device 10 (the sound-emitting device 1) and a detection unit 6.

[0022] The detection unit 6 is configured to detect a specific event. The detection unit 6 of the present embodiment is configured to detect the outbreak of smoke, as the specific event. The detection unit 6 includes a light emitting unit 61 such as a light-emitting diode, and a light receiving unit 62 such as a photo-diode. The light emitting unit 61 and the light receiving unit 62 are arranged such that a light receiving surface of the light receiving unit 62 is off an optical axis of the light emitted from the light emitting unit 61. The housing 11 has a hole(s) allowing the smoke to enter an interior of the housing 11 therethrough. When there is no smoke in the housing 11, most of the light emitted from the light emitting unit 61 cannot reach the light receiving surface of the light receiving unit 62. When there is the smoke inside the housing 11, the light emitted from the light emitting unit 61 is scattered by the smoke and the scattered light partially reaches the light receiving surface of the light receiving unit 62. In short, the detection unit 6 is configured to receive, by the light receiving unit 62, the light emitted from the light emitting unit 61 and scattered by the smoke to detect the outbreak of smoke.

[0023] The detection unit 6 is configured to, when detecting the outbreak of smoke which is the specific event, transmit a detection signal to the signal generation unit 2. The signal generation unit 2 is configured to generate the PWM signal when receiving the detection signal from the detection unit 6 as a trigger. In short, when the detection unit 6 detects the outbreak of smoke, the signal generation unit 2 transmits the PWM signal to the acoustic circuit 3 to cause the sound generation unit 4 to generate the sound (alarm sound).

[0024] A plurality of the detectors 100 may cooperate with a master device to constitute an alarm system. In this case, the detector 100 may further include a communication unit to communicate with the master device. When any of the detectors 100 detects the outbreak of smoke by its detection unit 6, the detector 100 transmits a notification signal to the master device with the communication unit. When receiving the notification signal, the master device allows another detector(s) 100, other than the detector 100 that has transmitted the notification signal, to emit an alarm sound(s). In short, the master device is configured to, when one of the detectors 100 detects the outbreak of smoke, cause another detector(s) 100 to emit the alarm sound(s) together with the detected detector 100.

[0025] The specific event to be detected by the detection unit 6 is not limited to the outbreak of smoke. The detection unit 6 may be configured to detect the generation of heat, for example. In other words, the detector 100 may be a heat detector.

(1. 2) Operation Example

[0026] An operation example of the sound-emitting device 1 (the alarm device 10, the detector 100) of the present embodiment will be described with reference to FIG. 3 and FIG 4.

[0027] The signal generation unit 2 is configured to generate the PWM signal in response to the detection signal as the trigger, which is transmitted from the detection unit 6 when the detection unit 6 detects the outbreak of smoke. The signal generation unit 2 is configured to change the frequency of the PWM signal with time. The signal generation unit 2 of the present embodiment is configured to changes the frequency of the PWM signal to be a first frequency f1 (e.g., 1000Hz) and a second frequency (e.g., 500 Hz) alternately. The frequency of the PWM signal changes between the first frequency f1 and the second frequency f2 with a period T100. Hereinafter, a period, during which the frequency of the PWM signal is the first frequency f1, of the period T100 is referred to as a first period T1 (e.g., 250 ms, 500 ms, or the like), and a period, during which the frequency of the PWM signal is the second frequency f2, of the period T100 is referred to as a second period T2 (e.g., 250 ms, 500 ms, or the like).

[0028] FIG. 5 is a graph illustrating frequency characteristics of the housing 11. The first frequency f1 and the second frequency f2 are set such that a difference between the first frequency f1 and a resonant frequency f0 of the housing 11 is different from a difference between the second frequency f2 and the resonant frequency f0. The resonant frequency f0 is also called a natural frequency, at which the housing 11 tends to oscillate. The resonant frequency f0 depends on the material and the shape of the housing 11, the dimension(s) of the hole(s) for the sound, a resonant frequency of a sound emitter of the sound generation unit 4, and the like. The resonant frequency may be measured by a hammering test, for example. The hammering test may include: hammering, by an impulse hammer, an object to which an acceleration pickup is attached; and analyzing a measurement result of the acceleration pickup with a Fast Fourier Transform (FFT) analyzer to determine a resonant frequency of the object.

[0029] In the present embodiment, the first frequency f1, the second frequency f2, and the resonant frequency f0 have a relation that the value of frequency decreases in the order of the resonant frequency f0, the first frequency f1, and the second frequency f2 (f0>f1>f2). That is, the difference between the first frequency f1 and the resonant frequency f0 is smaller than the difference between the second frequency f2 and the resonant frequency f0. In other words, the first frequency f1 is closer to the resonant frequency f0 than the second frequency f2 is.

[0030] The signal generation unit 2 is configured to change the duty cycle of the PWM signal according to the frequency of the PWM signal. In the present embodiment, a duty cycle of the PWM signal while the frequency of the PWM signal is the first frequency f1 is referred to as a first duty cycle D1, and a duty cycle of the PWM signal while the frequency of the PWM signal is the second frequency f2 is referred to as a second duty cycle D2. The duty cycle of the PWM signal means a proportion of a period of ON time (while the signal level of the PWM signal is in the Hi level) to a period of one cycle. The first duty cycle D1 may be expressed as D1=Ton1/T1, where T1 (=1/f1), which is referred to as a first period, denotes a period of one cycle of the PWM signal while the frequency of the PWM signal is the first frequency f1, and Ton1, which is referred to as a first ON time, denotes a period of ON time of this PWM signal. The second duty cycle D2 may be expressed as D2=Ton2/T2, where T2 (=1/f2), which is referred to as a second period, denotes a period of one cycle of the PWM signal while the frequency of the PWM signal is the second frequency f2, and Ton2, which is referred to as a second ON time, denotes a period of ON time of this PWM signal. The signal generation unit 2 is configured to adjust the period of ON time according to the frequency of the PWM signal to change the duty cycle of the PWM signal.

[0031] In the present embodiment, the first duty cycle D1 and the second duty cycle D2 have a relation that the first duty cycle D1 is larger than the second duty cycle D2 (D1>D2). That is, the first duty cycle D1 of the PWM signal while the frequency of the PWM signal is the first frequency f1, which is one of the first frequency f1 and the second frequency f2 and is closer to the resonant frequency f0, is larger than the second duty cycle D2 of the PWM signal while the frequency of the PWM signal is the second frequency f2.

[0032] As described above, the signal generation unit 2 is configured to change the frequency of the PWM signal alternately to be the first frequency f1 and the second frequency f2 with time, and change the duty cycle of the PWM signal alternately to be the first duty cycle D1 and the second duty cycle D2. The first frequency f1 is closer to the resonant frequency of the housing 11 than the second frequency f2 is. Therefore, the sound with the first frequency f1 is more likely to resonate with the housing 11 than the sound with the second frequency f2 does.

[0033] The signal generation unit 2 is configured to change the duty cycle of the PWM signal such that the first duty cycle D1 of the PWM signal while the frequency of the PWM signal is the first frequency f1, is larger than the second duty cycle D2 of the PWM signal while the frequency of the PWM signal is the second frequency f2. That is, the signal generation unit 2 is configured to change the duty cycle of the PWM signal such that the first duty cycle D1 is larger than the second duty cycle D2, where the first duty cycle D1 is the duty cycle of the PWM signal while the frequency of the PWM signal is the first frequency f1 which is more likely to resonate with the housing 11 than the second frequency f2 does. In other words, the signal generation unit 2 is configured to change the duty cycle of the PWM signal such that the second duty cycle D2 of the PWM signal while the frequency of the PWM signal is the second frequency f2 is comparatively small, where the second frequency f2 is less likely to resonate with the housing 11 than the first frequency f1 does.

[0034] The signal generation unit 2 is configured to make the first duty cycle D1 be larger than the second duty cycle D2 to allow the sound with the first frequency f1 to be larger in the instantaneous sound pressure than the sound with the second frequency f2. The housing 11 tends to resonate with the sound with the first frequency f1 to increase the instantaneous sound pressure of the sound with the first frequency f1. Further, the signal generation unit 2 is configured to make the second duty cycle D2 be less than the first duty cycle D1. Accordingly, the sound generation unit 4 can generate the sound with the second frequency f2 with a less energy consumption, compared to a case of generating the sound with the first frequency f1.

[0035] The above relation between the first frequency f1, the second frequency f2 and the resonant frequency f0 is merely an example, and the relation is not limited thereto. The first frequency f1 and the second frequency f2 may be larger than the resonant frequency f0, or the resonant frequency f0 may have a value between the first frequency f1 and the second frequency f2.

(1.3) Variation

[0036] It is described some of variations of the sound-emitting device 1 according to the present embodiment.

[0037] The signal generation unit 2 may be configured to set the period T100 such that the first period T10 during which the frequency of the PWM signal is the first frequency f1 is longer than the second period T20 during which the frequency of the PWM signal is the second frequency f2. This elongates a period during which the sound with the first frequency f1 is generated, which is more likely to resonate with the housing 11, leading to an increase in the sound pressure of the sound generated by the sound generation unit 4.

[0038] In the above example, the signal generation unit 2 is configured to switch the frequency of the PWM signal between two frequencies (the first frequency f1 and the second frequency f2) alternately with time, but is not limited thereto. The signal generation unit 2 may be configured to change the frequency of the PWM signal to three or more frequencies selectively with time.

[0039] The signal generation unit 2 may be configured to gradually change (sweep) the frequency of the PWM signal with time. In an example, the signal generation unit 2 may be configured to change the frequency of the PWM signal from the second frequency f2 to the first frequency f1 within each period T200 (for example 1 second, 2 second, or the like) (see FIG. 6). Herein, a certain frequency between the first frequency f1 (e.g., 1000 Hz) and the second frequency f2 (e.g., 500 Hz) is referred to as a third frequency (e.g., 900 Hz). Further, a frequency band between the third frequency f3 and the first frequency f1 is referred to as a first frequency band B1, and a frequency band between the second frequency f2 and the third frequency f3 is referred to as a second frequency band B2. In this example, therefore, the signal generation unit 2 is configured to change the frequency of the PWM signal with time over a plurality of frequency bands (the first frequency band B1 and the second frequency band B2). Further, the signal generation unit 2 is configured to change the duty cycle of the PWM signal with each change in the frequency of the PWM signal from one frequency band to another frequency band adjacent to each other, of the plurality of frequency bands. In this example, the signal generation unit 2 is configured to set the duty cycle of the PWM signal be the first duty cycle D1 while the frequency of the PWM signal falls within the first frequency band B1, and also to set the duty cycle of the PWM signal to the second duty cycle D2 while the frequency of the PWM signal falls within the second frequency band B2

[0040] As described above, the signal generation unit 2 of this example is configured to gradually change the frequency of PWM signal, and to change the duty cycle of the PWM signal on a frequency band-by-frequency band basis. This can simplify the processing required for the signal generation unit 2 to generate the PWM signal, compared to a case where both of the frequency and the duty cycle of the PWM signal are gradually changed.

[0041] Further, a change rate of the frequency of the PWM signal (i.e., a sweeping speed of the frequency of the PWM signal) is not limited to be constant. The signal generation unit 2 may be configured to change the frequency of the PWM signal such that a first change rate $\Delta 1$ is smaller than a second change rate $\Delta 1$, where the first change rate indicates a change amount of the frequency per unit time while the frequency of the PWM signal changes within the first frequency band B1 containing the first frequency f1, and the second change rate indicates a change amount of the frequency per unit time while the frequency of the PWM signal changes within the second frequency band B2 containing the second frequency f2. That is, the signal generation unit 2 is configured to make comparatively slow a sweep speed of the frequency while frequency of the PWM signal falls within the first frequency band B1 containing the first frequency f1. This elongates a period during which the sound with a frequency within the first frequency band B1 containing the first frequency f1 is generated, leading to an increase in the sound pressure of the sound generated by the sound generation unit 4.

[0042] In the above example, the signal generation unit 2 is configured to change the frequency of the PWM signal over two frequency bands, but alternatively, may be configured to change the frequency of the PWM signal over three or more frequency bands.

[0043] In the above example, the signal generation unit 2 is configured to change the duty cycle of the PWM signal with each change in the frequency of the PWM signal from one frequency band to another frequency band, of the plurality of frequency bands, but is not limited thereto. The signal generation unit 2 may be configured to gradually change the frequency of the PWM signal with time, and to further change the duty cycle of the PWM signal with time so that the duty cycle of the PWM signal changes according to the frequency of the PWM signal in one-to-one correspondence. That is, the signal generation unit 2 is configured to gradually change the duty cycle of the PWM signal from the second duty cycle D2 to the first duty cycle D1 according to the change in the frequency of the PWM signal from the second frequency f2 to the first frequency f1 (see FIG. 7). Accordingly, the sound generation unit 4 generates the sound of which sound pressure gradually changes.

[0044] Preferably, the signal generation unit 2 is configured to change the duty cycle of the PWM signal such that a change width of the duty cycle of the PWM signal falls within a predetermined range. This can prevent a variation in the instantaneous sound pressure caused by the frequency change from becoming too large.

[0045] The signal generation unit 2 may be configured to, based on a plurality of desired frequencies entered by a user, set the duty cycle such that the change width of the duty cycle of the PWM signal falls within a predetermined range. The sound-emitting device 1 can generate the sounds of the plurality of desired frequencies entered by the user with a less energy consumption. Preferably, the signal generation unit 2 is configured to set the duty cycle of the PWM signal to be larger than or equal to a lower limit. This can prevent a sound pressure of a sound, which is generated during a period in which the duty cycle of the PWM signal is comparatively small, from becoming too small.

[0046] The signal generation unit 2 in the above example is configured to change the duty cycle of the PWM signal with reference to the resonant frequency f0 of the housing 11, but is not limited thereto. The signal generation unit 2 may be configured to change the duty cycle of the PWM signal based on a radiation characteristic of the sound emitted to an outside the housing 11 from the sound generation unit 4. The radiation characteristic of the present embodiment means a relationship between the frequency of the sound and the sound pressure level of the sound emitted from the housing 11 under a condition where the sound pressure level of the sound generated by the generation unit 4 is constant. The radiation characteristic depends on the resonant frequency f0 of the housing 11, the resonant frequency of the sound generation unit 4, a position of the sound generation unit 4 inside the housing 11, and the like. The signal generation unit 2 is configured to change the duty cycle of the PWM signal with reference to a frequency (referred to as a "peak frequency f10") at which the sound pressure level has a peak value in the radiation frequency. For example, in a case where the first frequency f1, the second frequency f2, and the peak frequency f10 have such a relation that the value of frequency decreases in the order of the peak frequency f10, the first frequency f1, and the second frequency f2 (f10>f1>f2), the signal generation unit 2 may be configured to set the duty cycle of the PWM signal such that the first duty cycle D1 of the PWM signal while the frequency of the PWM signal is the first frequency f1, which is one of the first frequency f1 and the second frequency f2 and is closer to the peak frequency f10, is larger than the second duty cycle D2 of the PWM signal while the frequency of the PWM signal is the second frequency f2.

[0047] The signal generation unit 2 may be configured to correct the duty cycle of the PWM signal to reduce a difference between the first ON time Ton1 and the second ON time Ton2, where the first ON time Ton1 of the PWM signal corresponds to a period during which the frequency of the PWM signal is the first frequency f1, and the second ON time Ton2 of the PWM signal corresponds to a period during which the frequency of the PWM signal is the second frequency f2. For example, the signal generation unit 2 is configured to, when the first frequency f1 is larger than a first threshold, employ as the first duty cycle D1, a value obtained by multiplying a value of a duty cycle preliminarily defined in association with the first frequency f1 by a first coefficient. The signal generation unit 2 is further configured to, when the second frequency f2 is smaller than a second threshold, employ as the second duty cycle D2, a value obtained by multiplying a value of the duty cycle preliminarily defined in association with the second frequency f2 by a second coefficient. The first coefficient is larger than the second coefficient. The first threshold and the second threshold may be same as or different from each other.

[0048] Since the signal generation unit 2 corrects the duty cycle with the coefficient that is based on the frequency of the PWM signal, it is possible to reduce the difference between the lengths of the ON time before and after the change in the frequency of the PWM signal.

[0049] The correction method of the duty cycle of the PWM signal with the coefficient based on the frequency of the PWM signal is not limited to the above.

[0050] For example, the duty cycle of the PWM signal may be corrected with a coefficient based on the radiation characteristic of the sound emitted to the outside of the housing 11 from the sound generation unit 4. In this case, the coefficient may be set such that a value of the coefficient increases as a value of the frequency of the PWM signal approaches the peak frequency f10. This can increase the sound pressure of the sound generated by the sound generation unit 4

[0051] The duty cycle of the PWM signal may be corrected with a coefficient based on a frequency of sound sensitive to the human's ear. In this case, the coefficient may be set to have a larger value as the frequency of the PWM signal approaches the frequency sensitive to the human's ear. This allows the human to hear loudly the sound generated by the sound generation unit 4.

[0052] The coefficient may be set such that the coefficient increases as an increase in the frequency of the PWM signal.

[0053] The coefficient may be set based on a period of cycle of change in the frequency of the PWM signal. In this case, the coefficient may be set such that, the longer is a period during which the frequency of the PWM signal is kept at a certain value in the period of cycle of change in the frequency of the PWM signal, the coefficient becomes large. For example, the coefficient may be set based on the first period T10 and the second period T20 in the period T100 of the cycle of change in the frequency of the PWM signal, where the first period T10 is a period during which the frequency of the PWM signal is kept at the first frequency f1, and the second period T20 is a period during which the frequency of the PWM signal is kept at the second frequency f2 (see FIG 3). In this case, a coefficient (first coefficient) to be multiplied by a duty cycle defined in association with the first frequency f1 may have a larger value as an increase in a proportion of the first period T10 accounting for the period T100 (the duty cycle of the first period T10) or an increase in the length of the first period T10. Further, a coefficient (second coefficient) to be multiplied by a duty cycle defined in association with the second frequency f2 may have a larger value as an increase in a proportion of the second frequency T20 accounting for the period T100 (the duty cycle of the second period T20) or an increase in the length of the second period T20. This can increase the sound pressure of the sound, since the duty cycle of the sound with the frequency, which is dominant in the sound generated by the sound generation unit 4, becomes large.

[0054] The coefficient may be equal to or larger than or less than 1.

(2) Embodiment 2

(2. 1) Configuration

[0055] FIG. 8 is a block diagram of a detector 100 including a sound-emitting device 1 of the present embodiment. The sound-emitting device 1 of the present embodiment includes a sound generation unit 4 configured to generate sounds in a plurality of patterns having different tones. Configurations of the present embodiment similar to those of the above Embodiment 1 are designated with same reference signs and explanation thereof will be omitted accordingly.

[0056] In the present embodiment, a plurality of (three in FIG. 8) detectors 100 and a master device 9 cooperate to constitute an alarm system (see FIG. 8). In other words, the alarm system includes the plurality of detectors 100 and the master device 9.

[0057] The detector 100 of the present embodiment includes a sound-emitting device 1 and a communication unit 8. The communication unit 8 is configured to wirelessly communicate with the master device 9. The detector 100 is configured to transmit a notification signal from the communication unit 8 to the master device 9 when the detection unit 6 detects the outbreak of smoke. The master device 9 is configured to, when receiving the notification signal, allow another detector(s) 100, other than the detector 100 that has transmitted the notification signal, to emit an alarm sound(s). In short, the master device 9 is configured to, when one of the detectors 100 detects the outbreak of smoke, cause another detector(s) 100 to emit the alarm sound together with the detected detector 100. The communication unit 8 may be configured to communicate with the master device 9 with wire.

[0058] The sound-emitting device 1 of the present embodiment further includes a sound generation unit 4, a signal generation unit 2 and a setting unit 7. The sound generation unit 4 is configured to generate sounds in a plurality of patterns having different tones. Specifically, the signal generation unit 2 is configured to change a period and a frequency (tone) of a PWM signal, which is to be transmitted to the sound generation unit 4, in a plurality of patterns. Accordingly, the sound generation unit 4 can generate the sounds in the plurality of patterns. The sounds in the plurality of patterns may include the sounds having patterns in conformity with ISO 8201, DIN 33404-3, BS 5839-1, NF S32-001, NEN 2575 and the like, for example. Pieces of data (including periods, frequencies, duty cycles and the like) of the PWM signal corresponding to the sounds in the plurality of patterns may be stored in a storage device 70 such as a Read

Only Memory (ROM).

[0059] The signal generation unit 2 is further configured to change the duty cycle of the PWM signal with reference to a resonant frequency f0 of a housing 11 (or a peak frequency f10), as with Embodiment 1. The signal generation unit 2 is configured to change the duty cycle such that a duty cycle corresponding to a period during which the PWM signal has a frequency closer to the resonant frequency f0 (or the peak frequency f10) is larger than a duty cycle corresponding to a period during which the PWM signal has a frequency farther from the resonant frequency f0 (or the peak frequency f10).

[0060] The setting unit 7 is configured to set, in the signal generation unit 2, a pattern of a sound corresponding to a PWM signal to be transmitted from the signal generation unit 2 to the sound generation unit 4. In other words, the setting unit 7 is configured to determine the pattern of the sound corresponding to the PWM signal to be transmitted from the signal generation unit 2 to the sound generation unit 4. The signal generation unit 2 is configured to transmit the PWM signal corresponding to the pattern set (determined) by the setting unit 7, of the plurality of patterns.

[0061] The master device 9 is configured to transmit a setting signal to the detector 100 (the communication unit 8) in response to a manual operation by a user. The setting signal includes data indicating the pattern of the sound to be generated by the sound-emitting device 1 (the sound generation unit 4) of the detector 100. The setting unit 7 is configured to determine, based on the setting signal transmitted to the communication unit 8 from the master device 9, the pattern to be set in the signal generation unit 2 from the plurality of patterns. The master device 9 may be configured to transmit the setting signal to the detector 100 during an initial setting after the installation of the master device 9 and the detector 100.

[0062] As described above, the sound-emitting device 1 of the present embodiment is configured to generate sounds in the plurality patterns. The sound-emitting device 1 is configured to, when the detection unit 6 detects the outbreak of smoke, emit an alarm sound which is a sound of a pattern set by the master device 9, of the plurality of patterns. The pattern of the sound defined as the alarm sound may differ on a country basis for example, but it is possible to emit the sounds in a plurality of patterns defined as the alarm sound in respective countries with the (single) sound-emitting device 1 (the detector 100) alone. In short, the sound-emitting device 1 (the detector 100) can be commonly used for the respective countries.

(2. 2) Variations

[0063] FIG. 9 illustrates a variation of the sound-emitting device 1 of the present embodiment.

[0064] According to the sound-emitting device 1 of the variation, the setting unit 7 includes an operation unit 71, and allows a user to change the pattern of the sound to be generated as the alarm sound in response to the manual operation by a user on the operation unit 71.

[0065] The operation unit 71 may include a DIP switch including a plurality of switches for example, and accept operational input from a user. The operation unit 71 may include a plurality of slide switches to define a plurality of states, which are associated with the sounds in the plurality of patterns. The setting unit 7 is configured to determine, based on an operation signal transmitted from the operation unit 71, a pattern to be set in the signal generation unit 2 out of the plurality of pattern. The operation signal indicates a set of states of the plurality of slide switches of the operation unit 71. That is, the operation signal indicates a sound of a pattern selected by the user from the sounds in the plurality of patterns. The signal generation unit 2 is configured to transmit, to the sound generation unit 4, a PWM signal corresponding to a pattern set (determined) by the setting unit 7, of the plurality of patterns.

[0066] As described above, the sound-emitting device 1 of this example is configured to, when the detection unit 6 detects the outbreak of smoke, generate a sound of a pattern set by a user with the operation unit 71, of the plurality of patterns.

[0067] In the above example, the signal generation unit 2 is configured to change the pattern of the sound to be generated from the sound generation unit 4 by changing the period and the frequency of the PWM signal in a plurality of patterns, but is not limited thereto. For example, the signal generation unit 2 may be configured to play a WAV file (RIFF waveform Audio Format, RIFF: Resource Interchange File Format) to generate the sound from the sound generation unit 4. In this disclosure, "play a WAV file" means transmitting a signal for instructing the sound generation unit 4 to generate the sound. The WAV file may be stored in the storage device 70 provided in the sound-emitting device 1. The storage device 70 may store a plurality of WAV files corresponding to the sounds in the plurality of patterns. The signal generation unit 2 is configured to extract, from the storage device 70, a WAV file corresponding to a pattern set by the setting unit 7 to play the extracted WAV file. That is, the sound generation unit 4 is configured to generate a sound of a pattern corresponding to the signal from the signal generation unit 2. Accordingly, the sound generation unit 4 generates a sound of a pattern set by the setting unit 7 as the alarm sound.

(3) (Resume)

[0068] A sound-emitting device 1 according to a first aspect includes a sound generation unit 4, and a signal generation unit 2. The sound generation unit 4 is configured to generate sounds in a plurality of patterns having different tones. The signal generation unit 2 is configured to transmit, to the sound generation unit 4, a signal corresponding to any of the plurality of patterns. The sound generation unit 4 is configured to generate a sound in a pattern according to the signal from the signal generation unit 2.

[0069] With this configuration, the sound-emitting device 1 can generate the sounds in the plurality of patterns having different tones with a common configuration, without modifying the configuration of the sound-emitting device 1 according to the sounds in the plurality of patterns.

[0070] A sound-emitting device 1 according to a second aspect, realized in combination with the first aspect, further includes a setting unit 7 configured to set, in the signal generation unit 2, the pattern corresponding to the signal to be transmitted from the signal generation unit 2 to the sound generation unit 4.

[0071] With this configuration, it is possible to set the pattern of the sound generated from the sound generation unit 4.

[0072] In a sound-emitting device 1 according to a third aspect, realized in combination with the second aspect, the setting unit 7 is configured to set, in the signal generation unit 2, the pattern that is based on a setting signal transmitted from a master device 9.

[0073] With this configuration, it is possible to set the pattern of the sound generated from the sound generation unit 4 with the master device 9 provided separately from the sound-emitting device 1.

[0074] In a sound-emitting device 1 according to a fourth aspect, realized in combination with the second aspect, the setting unit 7 includes an operation unit 71 configured to accept operational input from a user. The setting unit 7 is configured to set, in the signal generation unit 2, the pattern that is based on an operation signal transmitted from the operation unit 71.

[0075] With this configuration, it is possible to set the pattern of the sound generated from the sound generation unit 4 with the sound-emitting device 1 alone.

[0076] In a sound-emitting device 1 according to a fifth aspect, realized in combination with any one of the first to fourth aspects, the signal generation unit 2 is configured to generate, as the signal, a PWM signal and to change a frequency of the PWM signal. The sound generation unit 4 is configured to generate a sound according to the frequency and a duty cycle of the PWM signal generated. The signal generation unit 2 is configured to change the frequency of the PWM signal, and to further change the duty cycle of the PWM signal according to the change in the frequency of the PWM signal.

[0077] Since the sound-emitting device 1 has a period during which the PWM signal has a comparatively small duty cycle, this configuration can reduce energy consumption compared to a case where the duty cycle of the PWM signal is constant.

[0078] A sound-emitting device 1 according to a six aspect, realized in combination with the fifth aspect, further includes a housing 11 that houses therein the sound generation unit 4. The signal generation unit 2 is configured to change the frequency of the PWM signal to be a first frequency f1 or a second frequency f2. The housing 11 has a resonant frequency f0. A difference between the resonant frequency f0 and the first frequency f1 is smaller than a difference between the resonant frequency f0 and the second frequency f2. The signal generation unit 2 is configured to change the duty cycle of the PMW signal such that a duty cycle of a PWM signal while the frequency of the PWM signal is the first frequency f1 is larger than a duty cycle of a PWM signal while the frequency of the PWM signal is the second frequency f2.

[0079] With this configuration, the duty cycle of the PWM signal for generating the sound with the first frequency f1 that tends to resonate with housing 11 becomes comparatively large, leading to efficiently increase the instantaneous pressure of the sound with the first frequency f1. The sound-emitting device 1 can increase the sound pressure of the sound generated from the sound generation unit 4. The sound-emitting device 1 can increase the volume of the audible sound generated by the sound generation unit 4. Note that this configuration is optional for the sound-emitting device 1. For example, the signal generation unit 2 may be configured to adjust the duty cycle such that a duty cycle of the PWM signal while the PWM signal has a frequency close to a frequency sensitive to the human's ear is larger than a duty cycle of the PWM signal while the PWM signal has a frequency far away from the frequency sensitive to the human's ear.

[0080] In a sound-emitting device 1 according to a seventh aspect, realized in combination with the sixth aspect, the signal generation unit 2 is configured to generate the PWM signal such that a first period T10 during which the frequency of the PWM signal is the first frequency f1 is longer than a second period T20 during which the frequency of the PWM signal is the second frequency f2.

[0081] The sound-emitting device 1 of this configuration has an increased percentage of a period during which the sound with the first frequency f1 that has a comparatively larger instantaneous pressure is generated, leading to an increase in the sound pressure of the sound generated from the sound generation unit 4. Note that this configuration is optional for the sound-emitting device 1. For example, the sound-emitting device 1 may be configured to set the second period T20 during which the PWM signal has the frequency of the second frequency f2 to be longer than the first period T10 during which the PWM signal has the frequency of the first frequency f1. This can reduce the energy consumption.

[0082] In a sound-emitting device 1 according to an eighth aspect, realized in combination with any one of the fifth to seventh aspects, the signal generation unit 2 is configured to gradually change the frequency of the PWM signal with time over a plurality of frequency bands. The signal generation unit 2 is further configured to change the duty cycle of the PWM signal with each change in the frequency from one frequency band to another frequency band adjacent to each other, of the plurality of frequency bands.

[0083] Since the signal generation unit 2 is configured to change the duty cycle of the PWM signal on the frequency band basis, this configuration can simplify the processing required for the signal generation unit 2 to generate the PWM signal compared to a case where both of the frequency and the duty cycle of the PWM signal are gradually changed.

[0084] In a sound-emitting device 1 according to a ninth aspect, realized in combination with any one of the fifth to seventh aspects, the signal generation unit 2 is configured to gradually change the frequency of the PWM signal with time. The signal generation unit 2 is further configured to change the duty cycle of the PWM signal with time such that the duty cycle of the PWM signal changes according to the change in frequency of the PWM signal in one-to-one correspondence.

[0085] With this configuration, the duty cycle of the PWM signal changes gradually according to the change in the PWM signal. The sound-emitting device 1 can gradually change the sound pressure of the sound generated from the sound generation unit 4.

[0086] A sound-emitting device 1 according to a tenth aspect, realized in combination with the fifth aspect, further includes a housing 11 that houses therein the sound generation unit 4. The signal generation unit 2 is configured to gradually change the frequency of the PWM signal with time over a plurality of frequency bands including a first frequency band B1 and a second frequency band B2. The first frequency band B1 contains a first frequency f1. The second frequency band B2 contains a second frequency f2. A difference between the second frequency and a resonant frequency f0 of the housing 11 is larger than a difference between the first frequency f1 and the resonant frequency f0. The signal generation unit 2 is further configured to change the duty cycle of the PWM signal with each change in the frequency from one frequency band to another frequency band adjacent to each other, of the plurality of frequency bands. The signal generation unit 2 is configured to change the frequency of the PWM signal such that a first change rate$\Delta 1$ is smaller than a second change rate $\Delta 2$. The first change rate $\Delta 1$ is a change amount of the frequency of the PWM signal per unit time while the frequency of the PWM signal changes within the first frequency band B1. The second change rate $\Delta 2$ is a change amount of the frequency of the PWM signal per the unit time while the frequency of the PWM signal changes within the second frequency band B2.

[0087] With this configuration, the sound-emitting device 1 can increase a period during which the sound with a frequency within the first frequency band B1 containing the first frequency f1, leading to an increase in the sound pressure of the sound generated from the sound generation unit 4. Note that this configuration is optional for the sound-emitting device 1. For example, the change amount per unit time of the frequency of the PWM signal may be constant.

[0088] A sound-emitting device 1 according to an eleventh aspect, realized in combination with the fifth aspect, further includes a housing 11 that houses therein the sound generation unit 4. The signal generation unit 2 is configured to change, based on a radiation characteristic of sound emitted to an outside of the housing 11 from the sound generation unit 4, the duty cycle of the

[0089] PWM signal.

[0090] The sound-emitting device 1 with this configuration can increase the sound pressure of the sound generated from the sound generation unit 4. The sound-emitting device 1 can increase the volume of the audible sound generated by the sound generation unit 4.

[0091] In a sound-emitting device 1 according to a twelfth aspect, realized in combination with any one of the fifth to eleventh aspects, the signal generation unit 2 is configured to correct the duty cycle of the PWM signal with a coefficient relating to the frequency of the PWM signal.

[0092] This configuration can adjust the sound generated from the sound generation unit 4 according to the frequency of the PWM signal.

[0093] In a sound-emitting device 1 according to a thirteenth aspect, realized in combination with any one of the fifth to twelfth aspects, the signal generation unit 2 is configured to change the duty cycle of the PWM signal such that a change width of the duty cycle of the PWM signal falls within a predetermined range.

[0094] This configuration can prevent a difference in the instantaneous sound pressure between sounds generated from the sound generation unit 4 of the sound-emitting device 1 to be too large. Note that this configuration is optional for the sound-emitting device 1. The change width of the duty cycle may be out of the predetermined range.

[0095] In a sound-emitting device 1 according to a fourteenth aspect, realized in combination with any one of the fifth to thirteenth aspects, the frequency of the PWM signal is equal to or larger than the 20 Hz and is equal to or smaller than 20 kHz.

[0096] The sound-emitting device 1 with this configuration can generate the audible sound with a reduced energy consumption

[0097] An alarm device 10 according to a fifteenth aspect includes the sound-emitting device 1 according to any one of the first to fourteenth aspects. The sound-emitting device 1 is configured to emit an alarm sound.

[0098] Since the alarm device 10 has a period during which the PWM signal has a comparatively small duty cycle, this configuration can reduce energy consumption compared to a case where the duty cycle of the PWM signal is constant.

[0099] A detector 100 according to a sixteenth aspect includes the alarm device 10 according to the fifteenth aspect, and a detection unit 6 configured to detect a specific event. The alarm device 10 is configured to emit the alarm sound when the detection unit 6 detects the specific event.

[0100] Since the detector 100 has a period during which the PWM signal has a comparatively small duty cycle, this configuration can reduce energy consumption compared to a case where the duty cycle of the PWM signal is constant.

Reference Signs List

[0101]

1	Sound-Emitting Device
10	Alarm Device
100	Detector
11	Housing
2	Signal Generation Unit
3	Acoustic Circuit
4	Sound Generation Unit
6	Detection Unit
7	Setting Unit
71	Operation Unit
9	Master Device
f1	First Frequency
f2	Second Frequency
T1	First Period
T2	Second Period
B1	First Frequency Band
B2	Second Frequency Band
Δ1	First Change Rate
Δ2	Second Change Rate

Claims

1. A sound-emitting device, comprising:

a sound generation unit configured to generate sounds in a plurality of patterns having different tones; and
a signal generation unit configured to transmit, to the sound generation unit, a signal corresponding to any of the plurality of patterns,
the sound generation unit being configured to generate a sound in a pattern according to the signal from the signal generation unit.

2. The sound-emitting device of claim 1, further comprising a setting unit configured to set, in the signal generation unit, the pattern corresponding to the signal to be transmitted from the signal generation unit to the sound generation unit.

3. The sound-emitting device of claim 2, wherein the setting unit is configured to set, in the signal generation unit, the pattern that is based on a setting signal transmitted from a master device.

4. The sound-emitting device of claim 2, wherein the setting unit includes an operation unit configured to accept operational input from a user, and is configured to set, in the signal generation unit, the pattern that is based on an operation signal transmitted from the operation unit.

5. The sound-emitting device of any one of claims 1 to 4, wherein
the signal generation unit is configured to generate, as the signal, a PWM signal and to change a frequency of the PWM signal,
the sound generation unit is configured to generate a sound according to the frequency and a duty cycle of the PWM signal generated, and
the signal generation unit is configured to change the frequency of the PWM signal, and to further change the duty cycle of the PWM signal according to the change in the frequency of the PWM signal.

6. The sound-emitting device of claim 5, further comprising a housing that houses therein the sound generation unit, wherein
the signal generation unit is configured to change the frequency of the PWM signal to be a first frequency or a second frequency,
the housing has a resonant frequency, a difference between the resonant frequency and the first frequency being smaller than a difference between the resonant frequency and the second frequency,
the signal generation unit is configured to change the duty cycle of the PMW signal such that a duty cycle of a PWM signal while the frequency of the PWM signal is the first frequency is larger than a duty cycle of a PWM signal while the frequency of the PWM signal is the second frequency.

7. The sound-emitting device of claim 6, wherein the signal generation unit is configured to generate the PWM signal such that a first period during which the frequency of the PWM signal is the first frequency is longer than a second period during which the frequency of the PWM signal is the second frequency.

8. The sound-emitting device of any of claims 5 to 7, wherein the signal generation unit is configured to gradually change the frequency of the PWM signal with time over a plurality of frequency bands, and to further change the duty cycle of the PWM signal with each change in the frequency from one frequency band to another frequency band adjacent to each other, of the plurality of frequency bands.

9. The sound-emitting device of any one of claims 5 to 7, wherein the signal generation unit is configured to gradually change the frequency of the PWM signal with time, and to further change the duty cycle of the PWM signal with time such that the duty cycle of the PWM signal changes according to the change in frequency of the PWM signal in one-to-one correspondence.

10. The sound-emitting device of claim 5, further comprising a housing that houses therein the sound generation unit, wherein
the signal generation unit is configured to gradually change the frequency of the PWM signal with time over a plurality of frequency bands including a first frequency band and a second frequency band, and to further change the duty cycle of the PWM signal with each change in the frequency from one frequency band to another frequency band adjacent to each other, of the plurality of frequency bands, the first frequency band containing a first frequency, the second frequency band containing a second frequency, a difference between the second frequency and a resonant frequency of the housing being larger than a difference between the first frequency and the resonant frequency,
the signal generation unit is configured to change the frequency of the PWM signal such that a first change rate is smaller than a second change rate, where the first change rate is a change amount of the frequency of the PWM signal per unit time while the frequency of the PWM signal changes within the first frequency band, and the second change rate is a change amount of the frequency of the PWM signal per the unit time while the frequency of the PWM signal changes within the second frequency band.

11. The sound-emitting device of claim 5, further comprising a housing that houses therein the sound generation unit, wherein
the signal generation unit is configured to change, based on a radiation characteristic of sound emitted to an outside of the housing from the sound generation unit, the duty cycle of the PWM signal.

12. The sound-emitting device of any one of claims 5 to 11, wherein the signal generation unit is configured to correct the duty cycle of the PWM signal with a coefficient relating to the frequency of the PWM signal.

13. The sound-emitting device of any one of claims 5 to 12, wherein the signal generation unit is configured to change the duty cycle of the PWM signal such that a change width of the duty cycle of the PWM signal falls within a predetermined range.

14. The sound-emitting device of any one of claims 5 to 13, wherein the frequency of the PWM signal is equal to or larger than the 20 Hz and is equal to or smaller than 20 kHz.

15. An alarm device, comprising: the sound-emitting device of any one of claims 1 to 14, wherein
the sound-emitting device is configured to emit an alarm sound.

16. A detector, comprising:

the alarm device of claim 15; and
a detection unit configured to detect a specific event, wherein
the alarm device is configured to emit the alarm sound when the detection unit detects the specific event.

FIG. 1

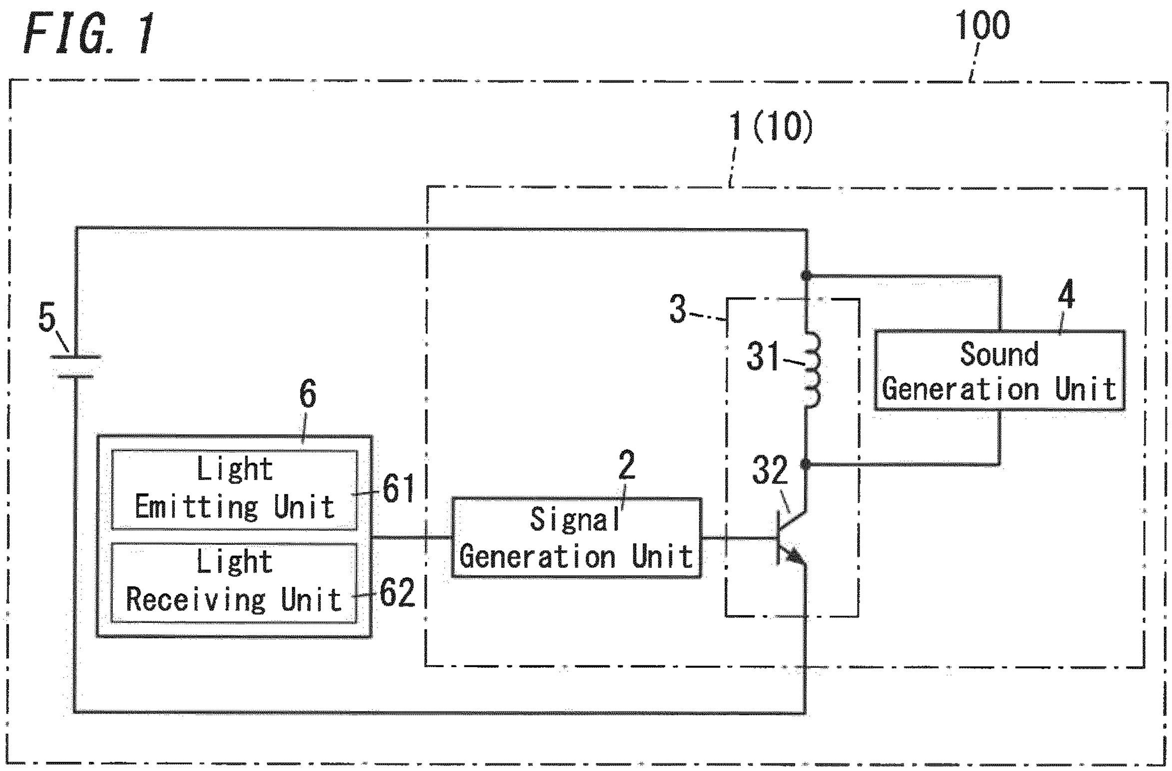

100
1(10)
5
3
31
4
Sound Generation Unit
6
Light Emitting Unit
61
Light Receiving Unit
62
2
Signal Generation Unit
32

FIG. 2

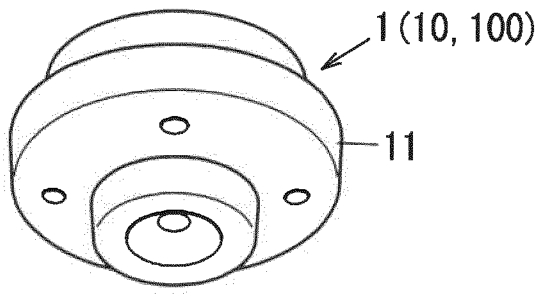


FIG. 3

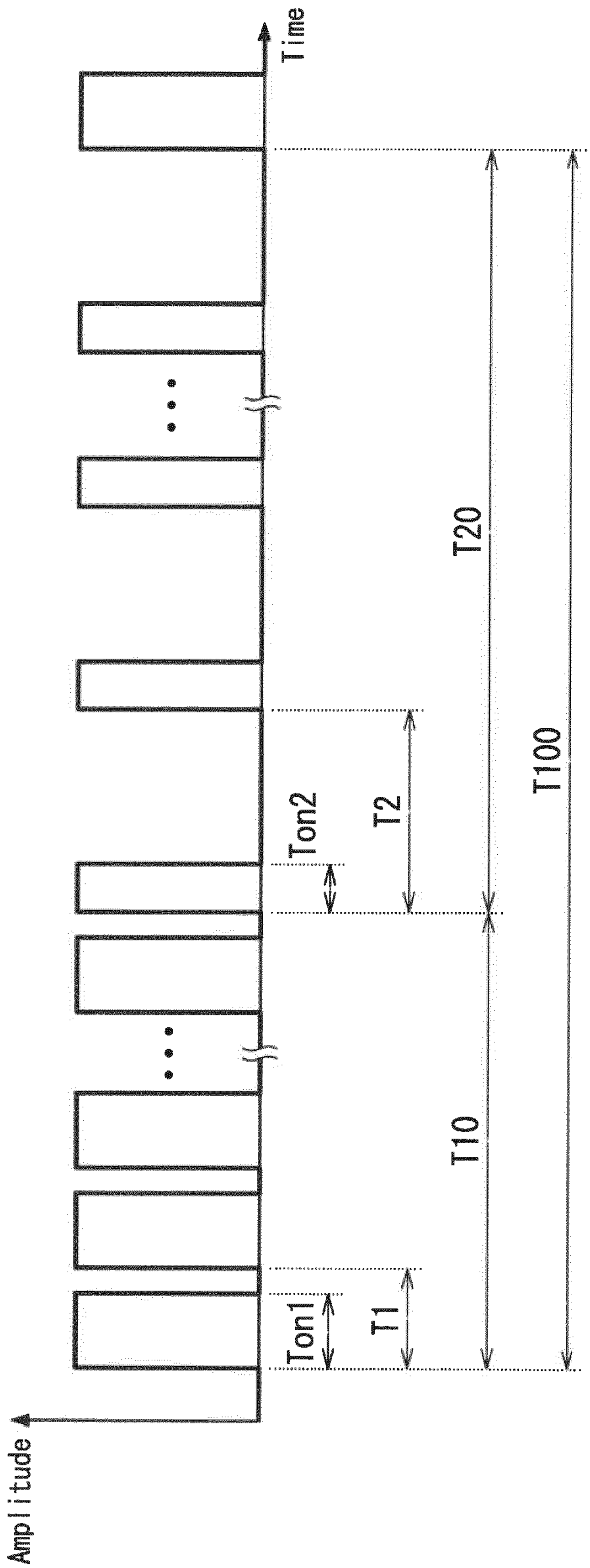


FIG. 4

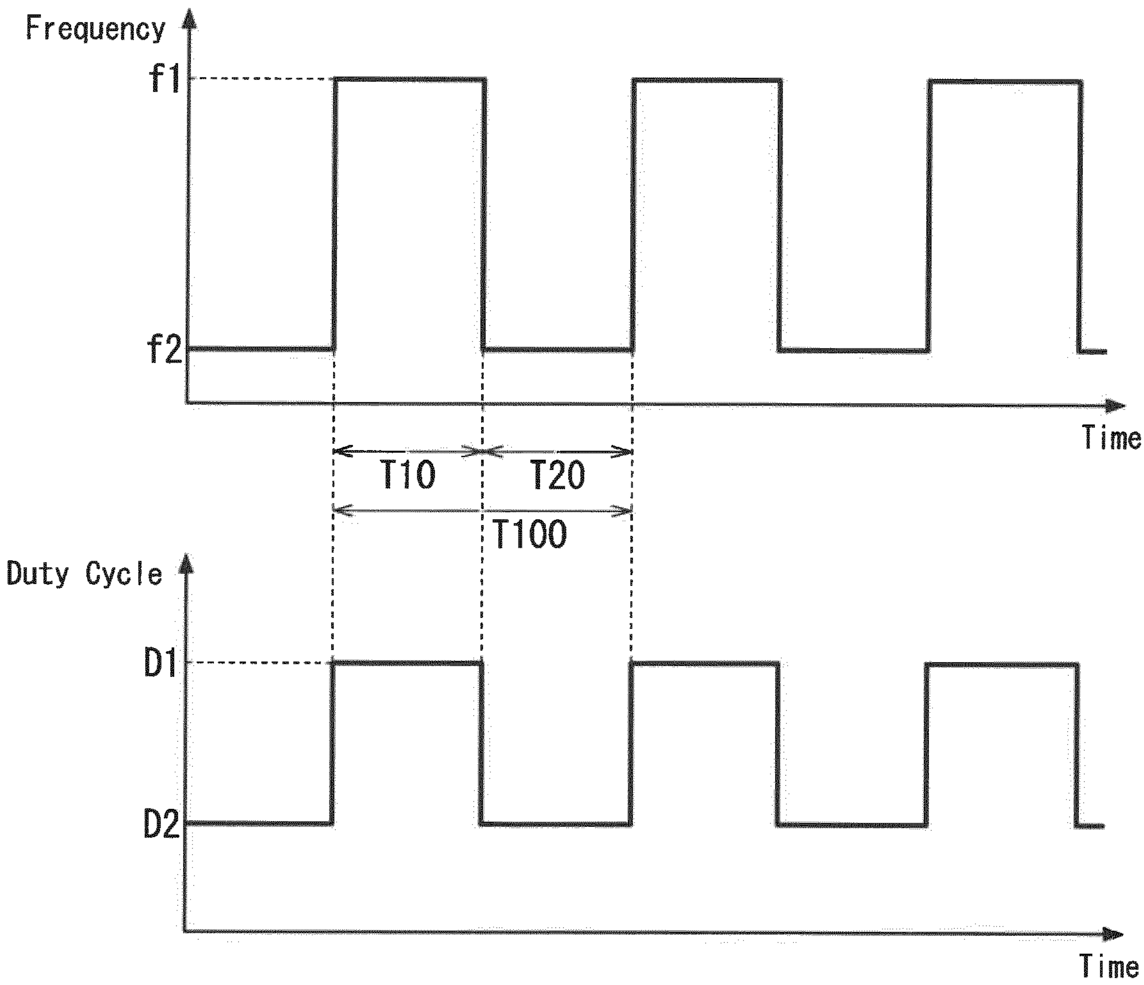


FIG. 5

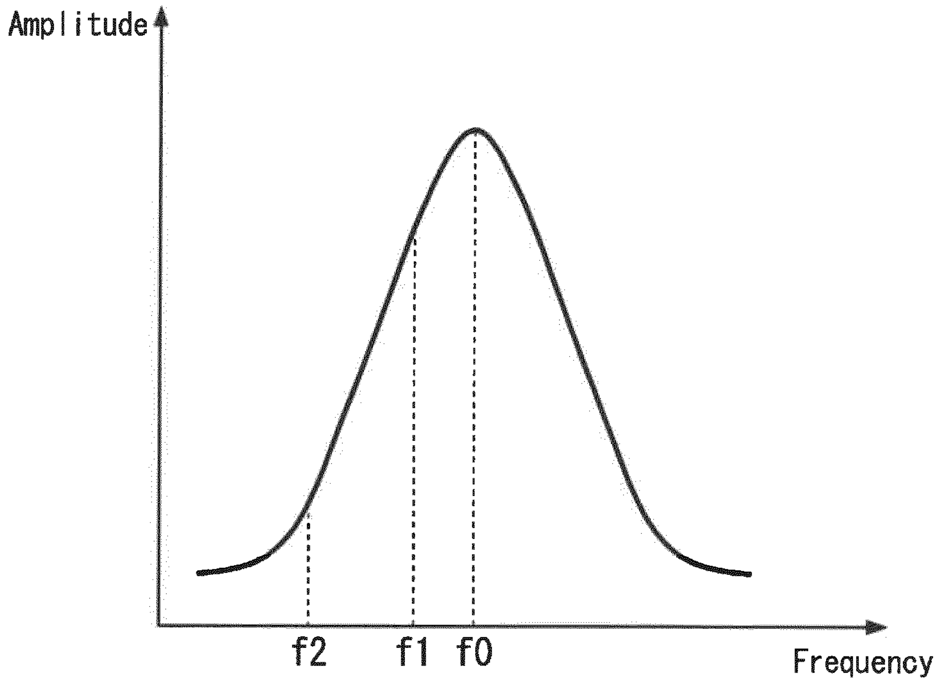


FIG. 6

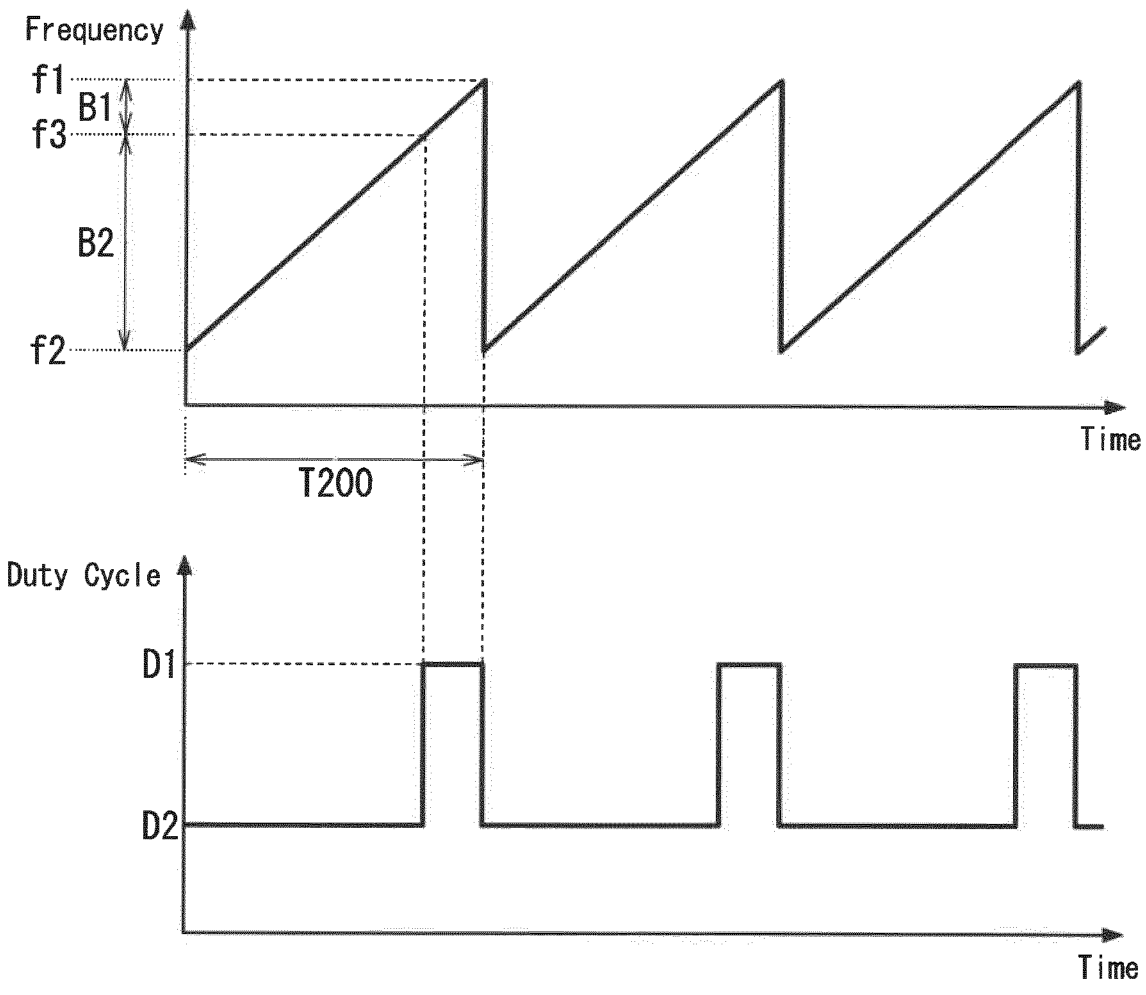


FIG. 7

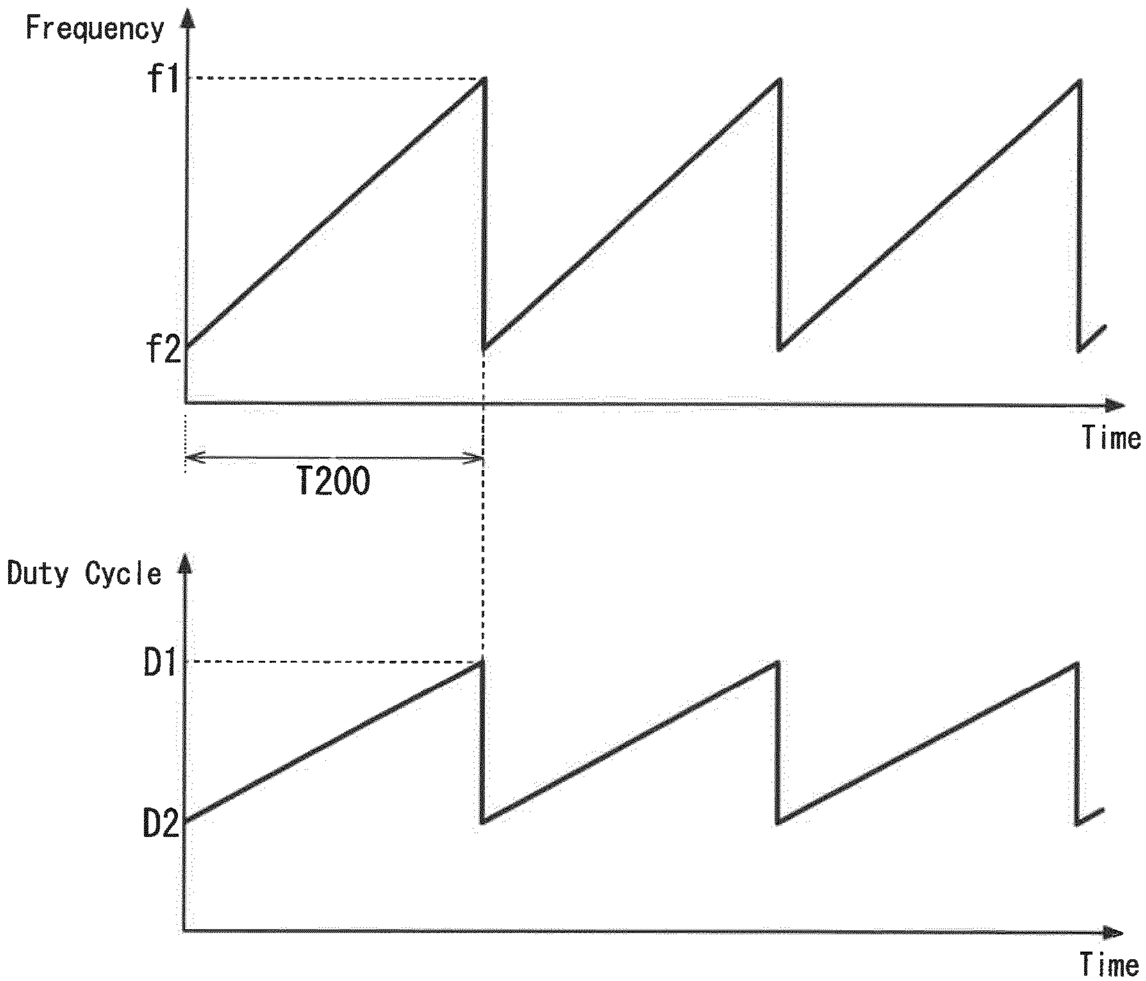
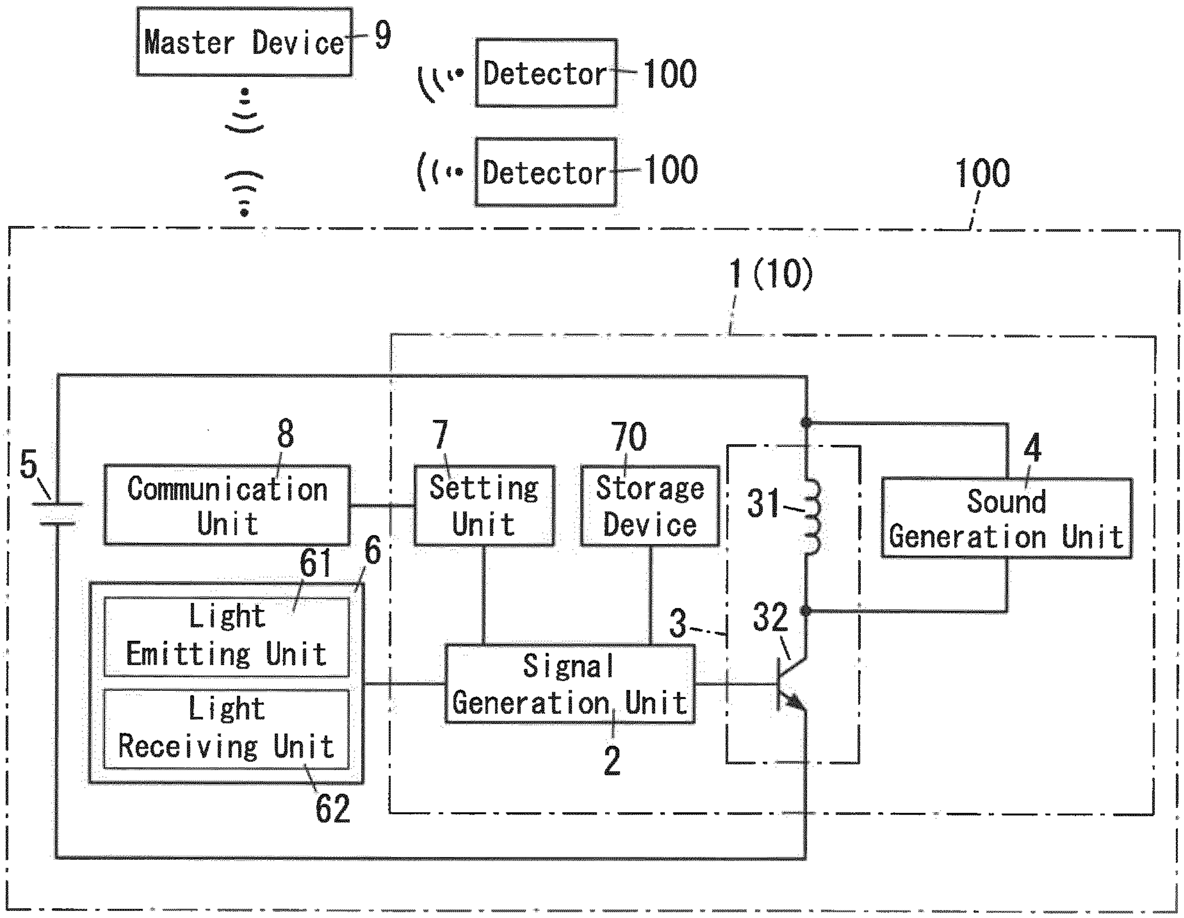
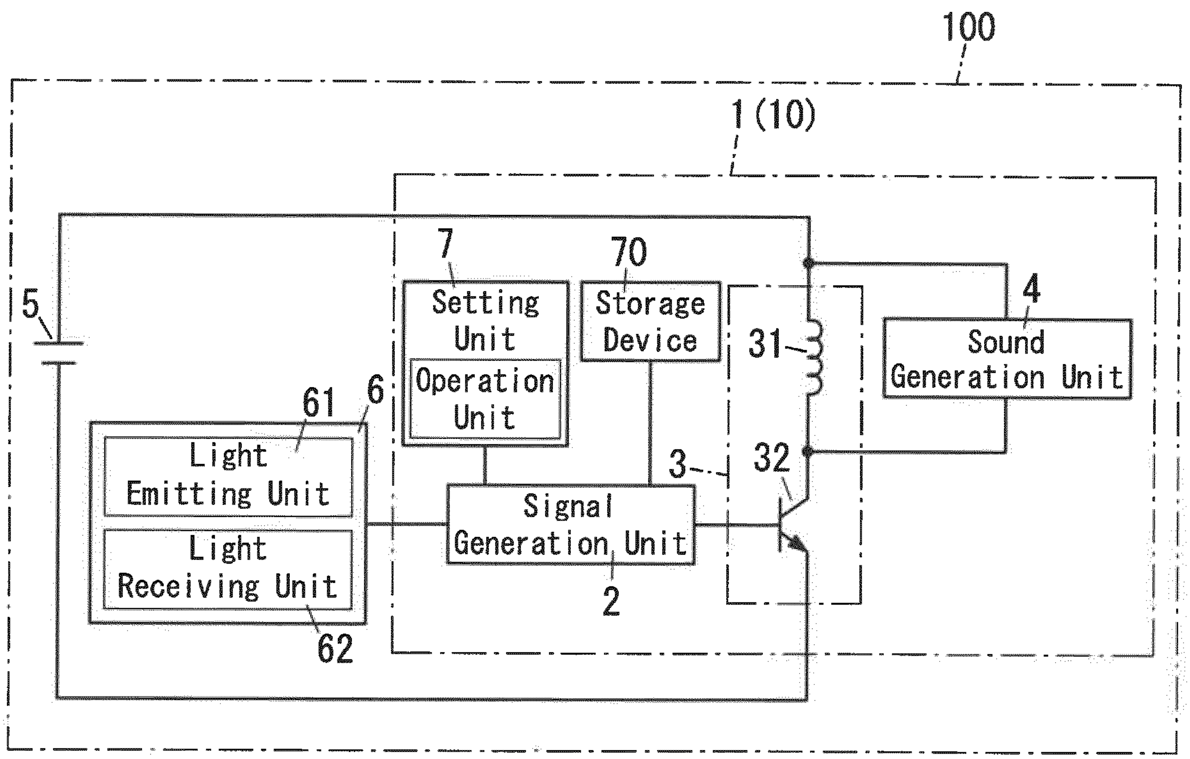


FIG. 8



Master Device
9
Detector
100
Detector
100
100
1 (10)
5
8
Communication Unit
7
Setting Unit
70
Storage Device
31
4
Sound Generation Unit
61
6
Light Emitting Unit
Light Receiving Unit
62
3
32
Signal Generation Unit
2

FIG. 9


100
1 (10)
5
7
Setting Unit
Operation Unit
70
Storage Device
31
4
Sound Generation Unit
61
6
Light Emitting Unit
Light Receiving Unit
62
3
32
Signal Generation Unit
2

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2017/034105

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. G10K9/12(2006.01)i, G08B17/00(2006.01)i, G08B23/00(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)
Int.Cl. G10K9/12, G08B17/00, G08B23/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2017
Registered utility model specifications of Japan	1996-2017
Published registered utility model applications of Japan	1994-2017

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 2010-49606 A (HOCHIKI CORPORATION) 04 March 2010, paragraphs [0012]-[0077], fig. 1-11 (Family: none)	1, 2, 15, 16 3-5, 8, 9, 13, 14 6, 7, 10-12
Y	JP 2005-524185 A (EDWARDS SYSTEMS TECHNOLOGY, INC.) 11 August 2005, paragraphs [0030]-[0033], fig. 2, 3 & US 2003/0210153 A1, paragraphs [0032]-[0035], fig. 2, 3	3-5, 8, 9, 13, 14
Y	JP 2010-49605 A (HOCHIKI CORPORATION) 04 March 2010, paragraphs [0021]-[0082], fig. 1-13 (Family: none)	5, 8, 9, 13, 14

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"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
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"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
28 November 2017 (28.11.2017)	12 December 2017 (12.12.2017)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2010049604 A **[0004]**