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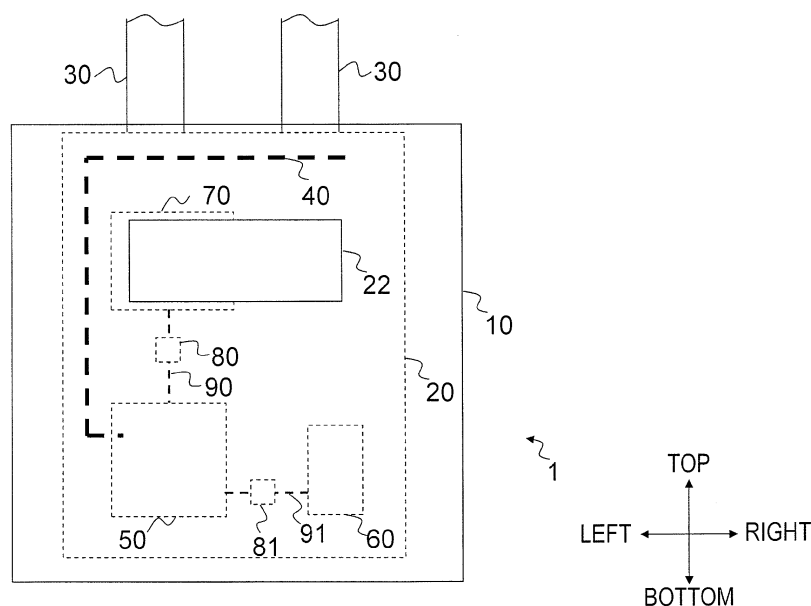
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(54) **Flow amount measurement apparatus and wireless device for use in flow amount measurement apparatus**

(57) A small-sized flow amount measurement apparatus or the like which suppresses harmonics over the conventional level. The flow amount measurement apparatus includes: a housing configured to accommodate a sensor for detecting a flow amount of a substance for measurement; a radiation conductor electrically connected to a feeding circuit on a first circuit board to radiate a

high-frequency signal as a radio wave; an electrically conducting member electrically connected to the feeding circuit; and a high-frequency isolation circuit being interposed between the feeding circuit and the electrically conducting member and electrically isolating the feeding circuit from the electrically conducting member with respect to the high-frequency signal.

FIG. 1



Description

[TECHNICAL FIELD]

[0001] The present invention relates to a flow amount measurement apparatus, and more particularly to a flow amount measurement apparatus for measuring the flow amount of a substance for measurement.

[BACKGROUND ART]

[0002] In the recent years, automatic meter reading systems which measure used amounts of gas, electricity, tap water, or the like with a flow amount measurement apparatus that is installed in a premises such as a house have come into use, this measurement data being collected via wireless communications. In such automatic meter reading systems, flow amount measurement apparatuses in small size are required from the standpoint of installment ease, etc.

[0003] As such a flow amount measurement apparatus, Patent Document 1 proposes a gas meter having a wireless adapter slave unit attached on its surface, for example. Since wireless equipment is internalized, it must be designed according to a predetermined wireless standard. One problem with such wireless designs is how to suppress harmonics.

[0004] Patent Document 2 proposes a method for solving this problem. Specifically, in constructing a band-pass filter by connecting resonant circuits via transmission lines in order to obtain a broad passband, Patent Document 2 reduces spurious response associated with serial resonance of the transmission lines. As a result, a band-pass filter having low spurious characteristics across a broad band is obtained.

[CITATION LIST]

[PATENT LITERATURE]

[0005]

[Patent Document 1] Japanese Laid-Open Patent Publication No. 10-313212

[Patent Document 2] Japanese Laid-Open Patent Publication No. 2009-278347

[SUMMARY OF INVENTION]

[TECHNICAL PROBLEM]

[0006] However, the approach of the conventional technique, where harmonics are suppressed by using a filter in the output line, may not be able to provide an adequate solution depending on the frequency. For example, when the transmission frequency is low, the frequency interval between the desired signal and any harmonic will be narrow, which presents a technological dif-

ficulty in designing a filter that sufficient attenuates only the harmonics while minimizing passage losses in the transmission frequency band. In the case of using a communications method with a low transmission frequency, selective suppression of the harmonics presents a major challenge.

[0007] The present invention has been made in order to solve the aforementioned problems, and an objective thereof is to provide a small-sized flow amount measurement apparatus which provides better suppression of harmonics associated with wireless communications.

[SOLUTION TO PROBLEM]

[0008] A flow amount measurement apparatus according to an exemplary embodiment of the present invention includes: a housing configured to accommodate a sensor for detecting a flow amount of a substance for measurement; a radiation conductor electrically connected to a feeding circuit on a first circuit board to radiate a high-frequency signal as a radio wave; an electrically conducting member electrically connected to the feeding circuit; and a high-frequency isolation circuit being interposed between the feeding circuit and the electrically conducting member and electrically isolating the feeding circuit from the electrically conducting member with respect to the high-frequency signal.

[0009] The high-frequency isolation circuit may include a parallel resonant circuit whose impedance increases in resonance with the high-frequency signal and a harmonic signal thereof.

[0010] The high-frequency isolation circuit may include a filter circuit configured to attenuate the high-frequency signal and the harmonic signal thereof.

[0011] The high-frequency signal may be a signal having a frequency of 500MHz or less.

[0012] The high-frequency signal may further be a signal having a frequency from 100 to 500 MHz.

[0013] The high-frequency signal may be a signal having a frequency of 169MHz.

[0014] The high-frequency isolation circuit may attenuate a 3rd harmonic of the high-frequency signal.

[0015] The high-frequency isolation circuit may further attenuate a 5th harmonic of the high-frequency signal.

[0016] The electrically conducting member may be an integrated circuit on a second circuit board distinct from the first circuit board.

[0017] The electrically conducting member may be a battery for supplying power to the feeding circuit.

[0018] The housing may be made of an electrically conductive material, and the flow amount measurement apparatus may further include a connection member electrically connecting a second circuit board distinct from the first circuit board to the housing.

[0019] A wireless device according to an illustrative embodiment of the present invention is a wireless device attached to a flow amount measurement apparatus to output data of a flow amount measured by the flow

amount measurement apparatus as a radio wave of a high-frequency signal, the wireless device comprising: a radiation conductor electrically connected to a feeding circuit on a first circuit board to radiate a high-frequency signal as a radio wave; an electrically conducting member electrically connected to the feeding circuit; and a high-frequency isolation circuit being interposed between the feeding circuit and the electrically conducting member and electrically isolating the feeding circuit from the electrically conducting member with respect to the high-frequency signal.

[0020] These general and specific aspects may be implemented using a system, a method, and a computer program, and any combination of systems, methods, and computer programs.

[ADVANTAGEOUS EFFECTS OF INVENTION]

[0021] The present invention attains the effect of being able to provide a small-sized flow amount measurement apparatus having the above-described construction, with suppressed harmonics.

[0022] The aforementioned and other objectives, features, and advantages of the present invention will be apparent from the following detailed description of preferable embodiments, with reference to the accompanying figures.

[BRIEF DESCRIPTION OF DRAWINGS]

[0023]

[FIG. 1] A front view showing a flow amount measurement apparatus according to an illustrative embodiment of the present invention.

[FIG. 2] A side view showing a flow amount measurement apparatus according to an illustrative embodiment of the present invention.

[FIG. 3] A schematic diagram showing the internal construction of a flow amount measurement apparatus according to an illustrative embodiment of the present invention as seen through from the front.

[FIG. 4] A schematic diagram showing the internal construction of a flow amount measurement apparatus according to an illustrative embodiment of the present invention as seen through a side face.

[FIG. 5] A diagram showing a parallel resonant circuit as an example construction of high-frequency isolation circuits **80** and **81**.

[FIG. 6] A diagram showing the construction of a flow amount measurement apparatus **2** having a radiation conductor **41** which extends over to above a battery **60**.

[FIG. 7] A schematic diagram showing the internal construction of a flow amount measurement apparatus **3** according to an illustrative embodiment of the present invention as seen through a side face.

[FIG. 8] A schematic diagram showing the internal

construction of a flow amount measurement apparatus **4** according to an illustrative embodiment of the present invention as seen through from the front.

[FIG. 9] A schematic diagram showing the internal construction of the flow amount measurement apparatus **4** according to an illustrative embodiment of the present invention as seen through a side face.

[FIG. 10] A schematic diagram showing the internal construction of a flow amount measurement apparatus **5** according to an illustrative embodiment of the present invention as seen through from the front.

[DESCRIPTION OF EMBODIMENTS]

[0024] The findings forming the basis of the present invention are as follows.

[0025] The conventional techniques would be valid when utilizing relatively high transmission frequencies. For example, given the frequency which is used for mobile phones (800 MHz), it has been easy to suppress the 3rd harmonic (2.4 GHz) and the 5th harmonic (4 GHz), which have relatively large presence as noises. The reason is that the frequency bands of these harmonics are very distant from the desired 800 MHz, and also that not such extensive noise reduction is needed. Such a band-pass filter is relatively easy to design.

[0026] However, these have been inadequate when using a relatively low transmission frequency (e.g., a frequency from 100 to 500 MHz, lower than the aforementioned 800 MHz). To be more specific, in wireless communications where a frequency of 169 MHz is used for the desired signal, the 3rd harmonic (508 MHz) and the 5th harmonic (847 MHz), which have relatively large presence, cannot be considered as sufficiently distant from the desired signal. Furthermore, there is a possibility that a wireless standard or regulation may come into force stipulating that the 3rd harmonic and the 5th harmonic must be strongly suppressed. Under such additional conditions, a band-pass filter having very steep cut-off characteristics will be needed in order to pass signals in a narrow band which includes the frequency of the desired signal, while cutting off signals in any other frequency band. Realizing such a band-pass filter may present technological and/or cost problems.

[0027] Note that the aforementioned 169 MHz is an example. As the frequency of the desired signal becomes increasingly lower than 800 MHz, its harmonics will become closer to the desired signal, thus causing the aforementioned problem. For example, when the frequency of the desired signal is in a range of 500 MHz or less (or at least in a range from 100 to 500 MHz), its harmonics cannot be considered as sufficiently distant from the desired signal, possibly resulting in the aforementioned problem.

[0028] Through their research, the inventors have developed a wireless communications device which sufficiently attenuates nothing but the harmonics while minimizing passage losses in the transmission frequency

band, even in the case where the frequency intervals between the desired signal and the harmonics are relatively narrow. The wireless communications device is applicable to a small-sized flow amount measurement apparatus.

[0029] The present invention relates to a flow amount measurement apparatus. The flow amount measurement apparatus includes: a housing being made of an electrically conductive material and accommodating a sensor for detecting a flow amount of a substance for measurement; a radiation conductor for radiating a radio wave of a high-frequency signal; a circuit board on which is incorporated a feeding circuit being electrically connected to the radiation conductor and supplying to the radiation conductor a high-frequency power to form the high-frequency signal; an electrically conducting member electrically connected to the feeding circuit; and a high-frequency isolation circuit being interposed between the feeding circuit and the electrically conducting member and electrically isolating the feeding circuit from the electrically conducting member with respect to the high-frequency signal and a harmonic signal thereof.

[0030] In the flow amount measurement apparatus, the high-frequency isolation circuit may include a parallel resonant circuit whose impedance increases in resonance with the high-frequency signal, and/or a filter for attenuating the high-frequency signal.

[0031] In the flow amount measurement apparatus, the high-frequency isolation circuit may include a photocoupler for electrically insulating the feeding circuit from the electrically conducting member.

[0032] Hereinafter, embodiments of the present invention will be specifically described with reference to the figures.

[0033] Hereinafter, identical or corresponding elements will be denoted by the same reference numeral throughout the figures, and any redundant description thereof will be omitted.

[0034] For convenience of description, "front", "rear", "top", "bottom", "right", "left" are defined as shown in each figure. That is, the direction in which a case **20** is located relative to a housing **10** is defined as "front", and the opposite of this is defined as "rear". Then, "right" and "left" are defined regarding the front. Furthermore, the upper and lower directions along the vertical direction are defined as "top" and "bottom", respectively.

(Embodiment 1)

[0035] FIG. 1 is a front view showing a flow amount measurement apparatus **1** according to Embodiment 1. FIG. 2 is a side view showing the flow amount measurement apparatus **1**. FIG. 3 is a schematic diagram showing the internal construction of the flow amount measurement apparatus **1** as seen through from the front. FIG. 4 is a schematic diagram showing the internal construction of the flow amount measurement apparatus **1** as seen through from the side.

[0036] For example, the flow amount measurement apparatus **1** is an apparatus which sends data that is detected by a sensor **21** to a computer of a supplier of gas, electricity, tap water, or the like, via wireless communications.

[0037] The flow amount measurement apparatus **1** includes a housing **10** which accommodates the sensor **21** for measuring a flow amount of a fluid, as well as a case **20** which accommodates the construction for controlling the operation of the sensor **21** and sending data that has been detected by the sensor **21** to the exterior.

[0038] The housing **10** is made of an electrically conductive material, for example. Examples of the electrically conductive material include metals such as aluminum and stainless steels, and electrically conductive resins.

[0039] The housing **10** substantially has a rectangular solid shape, with two conduits **30** being connected to its upper face for allowing a substance for measurement to flow in or flow out. The sensor **21** is accommodated in the housing **10**. The flow amount of the substance for measurement which has flowed into the housing **10** through the flow-in conduit **30** is detected by the sensor **21**, and thereafter the substance for measurement flows out to the exterior through the flow-out conduit **30**. Examples of the substance for measurement include gas, tap water, and electricity.

[0040] The case **20**, which is made of an electrically non-conductive material, is provided on the frontal wall face of the housing **10**. Examples of the electrically non-conductive material include electrically insulative resins, e.g., polypropylene and ABS.

[0041] The case **20** has a rectangular solid shape with a smaller thickness dimension, i.e., along the front-rear direction, than its top-bottom dimension and right-left dimension. The case **20** is fixed to the housing **10** with nuts or the like.

[0042] A display section **22** is provided on the front face of the case **20**. On the display section **22**, the flow amount of the substance for measurement which has been detected by the sensor **21** and the like are to be displayed.

[0043] In this interior space, the case **20** accommodates a radiation conductor **40**, a wireless communications circuit board **50**, a measurement circuit board **70**, a battery **60**, high-frequency isolation circuits **80** and **81**, and interconnects **90** and **91**. All construction within the case **20** except the measurement circuit board **70** may be regarded as a wireless device **25** that is detachable from the flow amount measurement apparatus **1**. In other words, such a wireless device **25** accommodates the following: the radiation conductor **40**, the wireless communications circuit board **50**, the measurement circuit board **70**, the battery **60**, the high-frequency isolation circuits **80** and **81**, and the interconnects **90** and **91**. When the wireless device **25** is attached to the flow amount measurement apparatus **1**, a wireless function is introduced in the flow amount measurement apparatus **1**. The following description will not make particular mention of the wireless device **25**. However, the description of any con-

stituent element below that may pertain to the wireless device **25** (including the description of Embodiment 2 and variants) should also be cited as description concerning the wireless device **25**.

[0044] The measurement circuit board **70** includes an integrated circuit in which a program is implemented. The integrated circuit includes a signal generation circuit which generates a signal to be transmitted based on a detected signal from the sensor **21**. As this integrated circuit operates in accordance with the program, the flow amount of the substance for measurement such as gas or tap water is acquired based on the detected value from the sensor **21**. There is no particular limitation as to the method of acquiring the measurement value. For example, when the target of measurement is a gas, any known method e.g., a membrane type or an ultrasonic type, may be adopted. A program which is necessary for calculating the measurement value based on this adopted measurement method may be implemented in the integrated circuit.

[0045] A transmission circuit, a reception circuit, a matching circuit, and the like are incorporated on the wireless communications circuit board **50**. The transmission circuit is a circuit for modulating the data for transmission into a high-frequency signal, and sending it via wireless communications. The reception circuit is a circuit for demodulating the signal received through wireless communications to acquire it as data. The matching circuit is a circuit which establishes matching between the radiation conductor **40** and the transmission circuit and reception circuit.

[0046] On the wireless communications circuit board **50**, an integrated circuit including a feeding circuit is further incorporated. The feeding circuit is a circuit which is electrically connected to the radiation conductor **40** for supplying to the radiation conductor **40** the high-frequency signal that has been modulated by the transmission circuit. The interconnect **90** allows the integrated circuit including the feeding circuit to be electrically connected to the integrated circuit of the measurement circuit board **70**, via the high-frequency isolation circuit **80**. Then, the integrated circuit incorporated on the wireless communications circuit board **50** provides a potential for the radiation conductor **40** in accordance with the measurement data from the integrated circuit on the measurement circuit board **70**, thereby transmitting a high-frequency signal representing the measurement data.

[0047] In the description of the embodiments of the present invention, the "high-frequency signal" to be sent or received by utilizing the radiation conductor **40** refers to a signal from 100 to 500 MHz, and more specifically to a signal of 169 MHz. In the present specification, a high-frequency signal to be sent or received may be referred to as a "desired signal" (desired wave).

[0048] The battery **60** is a power source which supplies power to the electronic parts and the like which are mounted on the wireless communications circuit board **50**. Among others, the battery **60** is electrically connected

to the wireless communications circuit board **50** through the interconnect **91**, via the high-frequency isolation circuit **81**. Thus, power which is supplied from the battery **60** is converted into a high-frequency power through the feeding circuit on the wireless communications circuit board **50**, and supplied to the radiation conductor **40**.

[0049] The radiation conductor **40** may radiate the high-frequency signal having been modulated by the transmission circuit as a radio wave, or receive an external radio wave (high-frequency signal) and pass it to the reception circuit, which then demodulates it. The radiation conductor **40** according to the present embodiment has a thin bar shape, and is made of an electrically conductive material such as copper. The length of the radiation conductor **40** is set to $\lambda/4$ or $\lambda/2$, where λ is the wavelength of the high-frequency signal constituting a radio signal. At a feed point, the base end of the radiation conductor **40** is connected to an output section (feeding terminal) of the wireless communications circuit board **50**. The radiation conductor **40** is bent so as to spread within the interior space of the case **20**, such that the radiation conductor **40** is as far away from the housing **10** as possible and that portions of the radiation conductor **40** are not close to one another as much as possible.

[0050] In the flow amount measurement apparatus **1** of the above construction, the substance for measurement flows through the conduit **30**, and the sensor **21** detects the flow amount of the substance for measurement. Based on the detected value from the sensor **21**, the integrated circuit on the measurement circuit board **70** measures the flow amount of the substance for measurement. In accordance with the measurement value from the integrated circuit on the measurement circuit board **70**, the integrated circuit on the wireless communications circuit board **50** generates a high-frequency signal, and supplies this to the radiation conductor **40**. An electric field is created between the radiation conductor **40** and the housing **10** (and the conduit **30**) that serves as ground, this electric field changing in accordance with the high-frequency signal provided. The change in the electric field is the radio wave which is radiated from the radiation conductor **40**.

[0051] The flow amount measurement apparatus **1** includes electrically conducting members as well as the high-frequency isolation circuits **80** and **81**. An electrically conducting member is any member that is accommodated in the case **20** and is electrically connected with the wireless communications circuit board **50**. Examples of electrically conducting members include the battery **60**, circuits other than the feeding circuit, and circuit boards such as the measurement circuit board **70** and a valve control circuit board.

[0052] The high-frequency isolation circuits **80** and **81** are circuits for electrically insulating (isolating) integrated circuit (feeding circuit) from the electrically conducting members, with respect to the high-frequency signal that is supplied from the wireless communications circuit board **50** to the radiation conductor **40**. As each high-

frequency isolation circuit, a parallel resonant circuit whose impedance increases in resonance with a transmission frequency which is radiated from the radiation conductor **40** as well as harmonic signals thereof, and/or a filter circuit which attenuates this frequency is used.

[0053] For example, FIG. 5 shows a parallel resonant circuit as an example construction of the high-frequency isolation circuits **80** and **81**. This parallel resonant circuit is composed of LC circuits **101** and **102** being connected in series. In the LC circuit **101**, a coil **101a** and a capacitor **101b** are connected in parallel. In the LC circuit **102**, a coil **102a** and a capacitor **102b** are connected in parallel.

[0054] In the present embodiment, the LC circuit **101** attenuates the 3rd harmonic of the desired signal, whereas the LC circuit **102** attenuates the 5th harmonic of the desired signal. In wireless communications where a frequency of 169 MHz is used for the desired signal, the 3rd harmonic is 508 MHz, and the 5th harmonic is 847 MHz. Note that the circuit construction shown in the figure may be used to attenuate the frequency of the desired signal (169 MHz), or a further parallel resonant circuit as shown in FIG. 5 may be provided in order to attenuate the frequency of the desired signal.

[0055] The inductance of the coil **101a** and the electrostatic capacitance of the capacitor **101b** in the LC circuit **101**, and the inductance of the coil **102a** and the electrostatic capacitance of the capacitor **102b** in the LC circuit **102**, are to be determined in accordance with the frequency of the desired signal.

[0056] Although the present embodiment illustrates that the 3rd harmonic and the 5th harmonic are attenuated, this is an example. Depending on the frequency to be attenuated, only a certain harmonic may be attenuated, or a plurality of harmonics including the 3rd and 5th harmonics may be attenuated. With the example construction of FIG. 5, those skilled in the art would be able to determine the inductance and electrostatic capacitance in each LC circuit and the number of LC circuits to be connected in series, once the frequency or frequencies to be attenuate are identified.

[0057] The high-frequency isolation circuits **80** and **81** are interposed between the wireless communications circuit board **50** and the aforementioned electrically conducting members. Specifically, the high-frequency isolation circuits **80** and **81** are designed so as to have an increased impedance with respect to the transmission frequency used and its harmonics, and to provide electrical separation at those frequencies.

[0058] Consequently, even if a secondary emission occurs due to an intensive input signal which is radiated from the radiation conductor **40** such that a signal having an input signal component is induced in any electrically conducting member, the high-frequency isolation circuits **80** and **81** provide electrical separation at the relevant frequency or frequencies, so that the input signal component return to the wireless communications circuit board **50**. As a result, the harmonic levels of the transmission signal that is generated from the radiation con-

ductor **40** can be suppressed.

[0059] While it is commonplace to provide high-frequency isolation circuits around circuits which perform communications, the present embodiment provides the high-frequency isolation circuits **80** and **81** also for elements which do not perform wireless communications, e.g., the battery **60** and the measurement circuit board **70**. This is to take into account a secondary emission that is caused in the metal case of the battery **60**, which in itself is an electrically conducting member, by the radio waves radiated from the radiation conductor **40**. Such construction is particularly effective in the case where the radiation conductor **41** needs to extend for reasons such as the wavelength of the desired signal.

[0060] For example, FIG. 6 shows the construction of a flow amount measurement apparatus **2** having a radiation conductor **41** which extends over to above a battery **60**. The radiation conductor **41** is longer than the radiation conductor **40** in FIG. 3. Since the radiation conductor **41** is located above the battery **60**, the radio wave radiated from the radiation conductor **41** causes a stronger secondary emission at the metal case of the battery **60**. However, noise emission can be reduced by providing the high-frequency isolation circuit **81** to cut off the harmonics.

[0061] Other than the battery **60** and the measurement circuit board **70**, such a high-frequency isolation circuit may be interposed if any problematic electrically conducting member exists for the radiation conductor **40** such that a signal having an input signal component may be induced therein and possibly return to the wireless communications circuit board **50**.

[0062] Another effect attained by the above construction is that the wireless communications circuit board **50**, which is electrically separated at the relevant frequency or frequencies by the high-frequency isolation circuits from any electrically conducting member that is connected via the high-frequency isolation circuits, remarkably reduces the influences of any impedance change in electrically conducting members on the antenna matching of the radiation conductor **40**. This permits a design free from the influences of manufacturing variations (variations in the impedance of the substrate or battery and in the interconnect length), and allows for efficient development and stable manufacturing with a reduced production yield.

(Embodiment 2)

[0063] When the radiation conductor **40** has a large wireless output, a signal which is radiated from the radiation conductor **40** and being radiated onto the wireless communications circuit board **50** and the measurement circuit board **70** causes harmonic noise (spurious noise) to be radiated from the wireless communications circuit board **50** and the measurement circuit board **70**, thereby failing to satisfy standards concerning noise emission.

[0064] Accordingly, the present embodiment illus-

trates a construction which reconciles improvement in antenna gain characteristics and reduction in harmonic noise emission, even under a particularly large wireless output.

[0065] Note that the wireless output being large encompasses the case where the output power is about 1 watt, for example.

[0066] FIG. 7 is a schematic diagram showing the internal construction of a flow amount measurement apparatus 3 according to Embodiment 2 as seen through from the side. Among the constituent elements shown in FIG. 7, those which are identical to the constituent elements that have been described in FIG. 1 to FIG. 4 will be denoted by the same numerals, and their descriptions will be cited.

[0067] Embodiment 2 relates to a flow amount measurement apparatus which, in addition to the construction which has been described in Embodiment 1, includes a connection cable 100 for the measurement circuit board which electrically connects the housing 10 to the measurement circuit board 70, and a connection cable 110 for the wireless communications circuit board which electrically connects the housing 10 to the wireless communications circuit board 50. More specifically, the present embodiment relates to a flow amount measurement apparatus which includes the high-frequency isolation circuit according to Embodiment 1 plus the cables (electrical conductors) for electrically connecting the housing to the circuit boards.

[0068] The connection cable 100 for the measurement circuit board has one end connected to the ground of the measurement circuit board 70 and another end connected to the housing 10. In order to allow the other end of the connection cable 100 for the measurement circuit board to be connected to the housing 10, an aperture is provided in the case 20, and a protrusion is provided on the housing 10. Then, the housing 10 and the case 20 are fixed so that the protrusion penetrates the aperture, and that the other end of the connection cable 100 for the measurement circuit board is in contact with the protrusion. Sealing is provided around the aperture so that the interior of the case 20 is closed.

[0069] The connection cable 100 for the measurement circuit board is made of an electrically conductive material such as copper, aluminum, or iron.

[0070] As the position to connect the connection cable 100 for the measurement circuit board to the measurement circuit board 70, a position is preferably selected which is as distant from the radiation conductor 40 on the substrate as possible and which is considered to provide a high grounding effect. For example, a position which is considered to provide a high grounding effect may be, when given a ground pattern on the measurement circuit board 70 which is divided by circuit elements and the like into a plurality of divisions, a position within one division that has as broad a geometric area as possible. A "ground pattern" means, among interconnects of a copper foil on the measurement circuit board 70, for

example, any interconnect that is set to the ground. On the other hand, "as broad a geometric area as possible" may be any relatively broad geometric area among a plurality of divisions having various geometric areas, and in one instance may be the broadest geometric area. Maximum effects can be obtained by connecting the connection cable 100 for the measurement circuit board at such positions on the measurement circuit board 70.

[0071] Any meter other than an electricity meter, e.g., a gas meter or a water meter, is driven by a battery (such as the battery 60), and thus usually there is no need to electrically connect the measurement circuit board 70 to the housing 10. However, when the measurement circuit board 70 is adjacent to the radiation conductor 40, the measurement circuit board 70 may operate as an antenna to generate spurious noises. This will increase the noise generation level, such that standards concerning the noise generation level may no longer be satisfied.

[0072] However, by electrically connecting the measurement circuit board 70 to the housing 10 as in the present embodiment, the measurement circuit board 70 is prevented from operating as an antenna, thus making it possible to reduce the undesired signals which are generated as noises from the interior of the case 20. Undesired signals of the highest level in this case are, usually, the 3rd harmonic and 5th harmonic of the desired signal.

[0073] Note that such undesired signals would not be problematic in mobile phones, which similarly conduct wireless communications. The reason is that the radio wave frequency of a mobile phone is in the 800 MHz band at the lowest, so that the 3rd harmonic (2.4 GHz) and the 5th harmonic (4 GHz) thereof are distant in frequency band from 800 MHz, and thus is subject to only lenient requirements of communications standards concerning noise removal.

[0074] Note that a gas meter itself, as one flow amount measurement apparatus that is contemplated in the present specification, does not inherently have a wired communications function. Even if GND of the meter controller substrate is electrically connected to the case, surge voltage from lightning will never make its way onto any communications signal lines that are on the substrate; thus, the controller substrate will not be destroyed by extrinsic noises such as lightning surge.

[0075] The connection cable 110 for the wireless communications circuit board has one end connected to the ground of the wireless communications circuit board 50 and another end connected to the housing 10. The technique of connecting the other end of the connection cable 110 for the wireless communications circuit board to the housing 10 may be similar to the technique of connecting the other end of the connection cable 100 for the measurement circuit board to the housing 10, or, alternatively, the other end of the connection cable 100 for the measurement circuit board may be connected to a screw that penetrates through the housing 10 and the case 20 for fixing the housing 10 and the case 20.

[0076] Although there is more than one screw that fix

the housing **10** and the case **20**, the screw that is the closest to the wireless communications circuit board **50** (i.e., a screw located in a lower portion of the case **20** in the present embodiment) is desirably used for the connection. The connection cable **110** for the wireless communications circuit board is made of an electrically conductive material such as copper, aluminum, or iron, for example.

[0077] Although FIG. 7 illustrates the radiation conductor **40** as an inverted L antenna, the radiation conductor **40** may be composed of other linear conducting elements. Examples of linear conducting elements include loop antennas and meander line antennas.

[0078] Moreover, the radiation conductor **40** may not be a linear conducting element. For example, a planar conducting element such as a planar inverted L antenna, a linear inverted L antenna, or a planar dipole antenna, may be used as the radiation conductor **40**. Moreover, a metal foil on a circuit board may be used for the connection cable **110** for the wireless communications circuit board and the radiation conductor **40**.

[0079] In all above embodiments, the connection cable **110** for the wireless communications circuit board and a screw are used as connecting portions that electrically connect the wireless communications circuit board **50** to the housing **10**. However, this construction is only an example. It suffices if the connecting portion functions to electrically connect the wireless communications circuit board **50** to the housing **10**, and those skilled in the art will be able to adopt various specific constructions that realizes such a function. For example, a resin case of the same outer shape as that of the case **20** may be adopted. In this case, a face of the resin case that borders on the housing **10** has an aperture. A projection of the metal case **201** is fitted in this aperture of the resin case. Then, the connection cable **100** for the measurement circuit board is electrically connected to this projection of the metal housing, while the opposite end of the connection cable **100** of the measurement circuit board is electrically connected to the ground of the wireless communications circuit board **50**. At this time, sealing is provided around the aperture so that the interior of the resin case is closed.

[0080] Coupling of the radiation conductor **40** to the output section of the wireless communications circuit board **50** and coupling of the ground of the wireless communications circuit board **50** to the connection cable **110** for the wireless communications circuit board are achieved with solder. However, the method of coupling is not limited thereto, so long as these are electrically coupled. For example, they may be coupled via a screw, a connector, or the like.

[0081] In all of the above embodiments, an ultrasonic type gas meter (USM) may be used as the flow amount measurement apparatus. In this case, the housing **10** has a small size. Therefore, the effective length of the antenna can be increased by varying the shape of the housing **10**, thereby improving the antenna gain. Alter-

natively, the housing **10** being small makes it possible to secure a large distance between the radiation conductor **40** and the housing **10** (ground), whereby a gain improvement can be expected.

[0082] Thus, a flow amount measurement apparatus according to the present invention is useful for reconciling a high radiated radio wave intensity and a reduced undesired signal level, in a small-sized flow amount measurement apparatus which is designed for improved antenna characteristics over the conventional techniques.

[0083] The present embodiment illustrates a flow amount measurement apparatus including the high-frequency isolation circuits **80** and **81** and further electrical conductors connecting the substrates to the housing. However, even without the high-frequency isolation circuits **80** and **81**, it is possible to reconcile a high radiated radio wave intensity and a reduced undesired signal level.

[0084] For example, FIG. 8 is a schematic diagram showing the internal construction of a flow amount measurement apparatus **4** lacking high-frequency isolation circuits, as seen through from the front. FIG. 9 is a schematic diagram showing the internal construction of the flow amount measurement apparatus **4** as seen through from the side.

[0085] Moreover, by shaping the radiation conductor **40** so as to be distant from the measurement circuit board **70** as much as possible, the harmonic noises radiated from the measurement circuit board **70** can be alleviated. For example, FIG. 10 is a schematic diagram showing the construction of a flow amount measurement apparatus **5** according to a variant of the present embodiment. In the flow amount measurement apparatus **5**, the radiation conductor **40** is worked into a shape that avoids the measurement circuit board **70**. Note that, in addition to being distant from the measurement circuit board **70**, it is also preferable for the radiation conductor **40** to be formed so that portions of the radiation conductor **40** are not close to one another.

[0086] The above description should be interpreted as illustrative only, and is rather provided in order to teach those skilled in the art of the best aspects in which to carry out the present invention. Substantial modifications in the specific structure and/or functions thereof would be possible without departing from the spirit of the invention.

[INDUSTRIAL APPLICABILITY]

[0087] Thus, a flow amount measurement apparatus according to the present invention is useful as a small-sized flow amount measurement apparatus having a means for suppressing harmonics as compared to the conventional techniques.

[REFERENCE SIGNS LIST]

[0088]

- 1 - 5 flow amount measurement apparatus
- 10 housing
- 20 case
- 21 sensor
- 22 display section
- 30 conduit
- 40 radiation conductor
- 50 wireless communications circuit board (circuit board)
- 60 battery
- 70 measurement circuit board (circuit board)
- 80, 81 high-frequency isolation circuit
- 90, 91 interconnect (lead)

Claims

1. A flow amount measurement apparatus comprising:

a housing configured to accommodate a sensor for detecting a flow amount of a substance for measurement;
 a radiation conductor electrically connected to a feeding circuit on a first circuit board to radiate a high-frequency signal as a radio wave;
 an electrically conducting member electrically connected to the feeding circuit; and
 a high-frequency isolation circuit being interposed between the feeding circuit and the electrically conducting member and electrically isolating the feeding circuit from the electrically conducting member with respect to the high-frequency signal.

2. The flow amount measurement apparatus of claim 1, wherein the high-frequency isolation circuit includes a parallel resonant circuit whose impedance increases in resonance with the high-frequency signal and a harmonic signal thereof.

3. The flow amount measurement apparatus of claim 2, wherein the high-frequency isolation circuit includes a filter circuit configured to attenuate the high-frequency signal and the harmonic signal thereof.

4. The flow amount measurement apparatus of any of claims 1 to 3, wherein the high-frequency signal is a signal having a frequency of 500 MHz or less.

5. The flow amount measurement apparatus of claim 4, wherein the high-frequency signal is a signal having a frequency from 100 to 500 MHz.

6. The flow amount measurement apparatus of claim 5, wherein the high-frequency signal is a signal having a frequency of 169MHz.

7. The flow amount measurement apparatus of claim

5 or 6, wherein the high-frequency isolation circuit attenuates a 3rd harmonic of the high-frequency signal.

8. The flow amount measurement apparatus of claim 7, wherein the high-frequency isolation circuit further attenuates a 5th harmonic of the high-frequency signal.

9. The flow amount measurement apparatus of any of claims 1 to 8, wherein the electrically conducting member is an integrated circuit on a second circuit board distinct from the first circuit board.

10. The flow amount measurement apparatus of any of claims 1 to 8, wherein the electrically conducting member is a battery for supplying power to the feeding circuit.

11. The flow amount measurement apparatus of any of claims 1 to 10, wherein,
 the housing is made of an electrically conductive material, the flow amount measurement apparatus comprising
 a connection member electrically connecting a second circuit board distinct from the first circuit board to the housing.

12. A wireless device attached to a flow amount measurement apparatus to output data of a flow amount measured by the flow amount measurement apparatus as a radio wave of a high-frequency signal, the wireless device comprising:

a radiation conductor electrically connected to a feeding circuit on a first circuit board to radiate a high-frequency signal as a radio wave;
 an electrically conducting member electrically connected to the feeding circuit; and
 a high-frequency isolation circuit being interposed between the feeding circuit and the electrically conducting member and electrically isolating the feeding circuit from the electrically conducting member with respect to the high-frequency signal.

FIG. 1

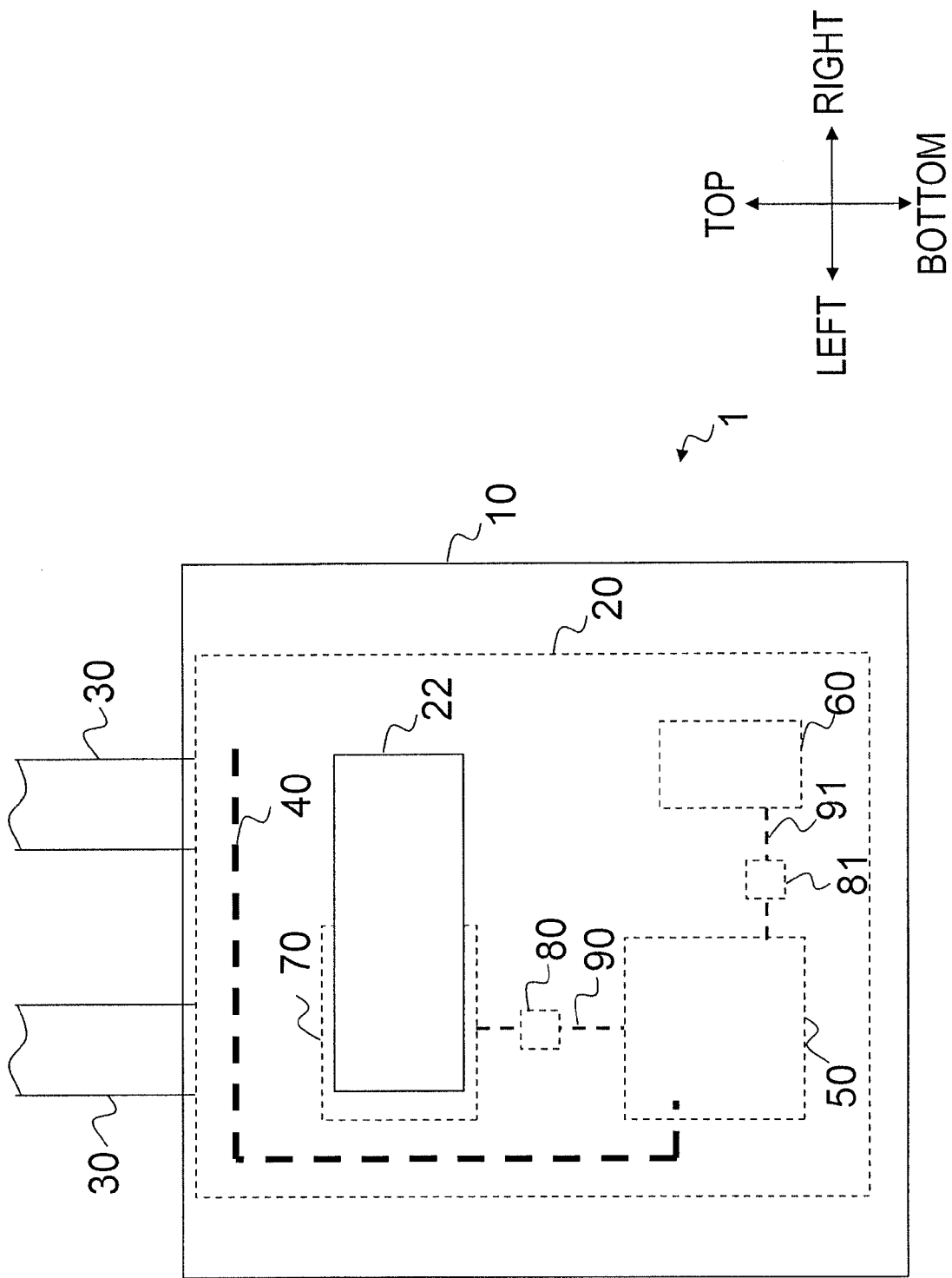
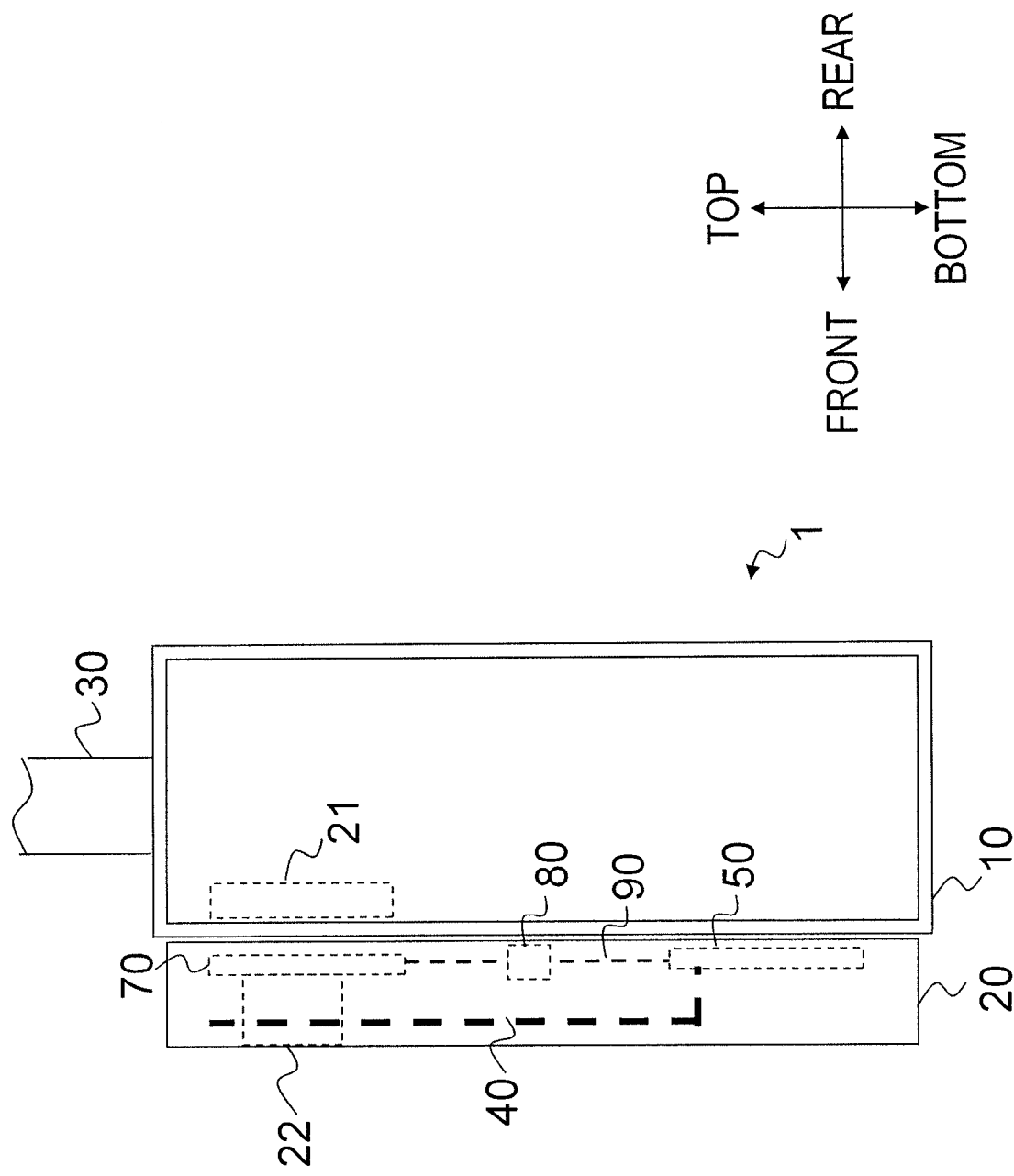


FIG. 2



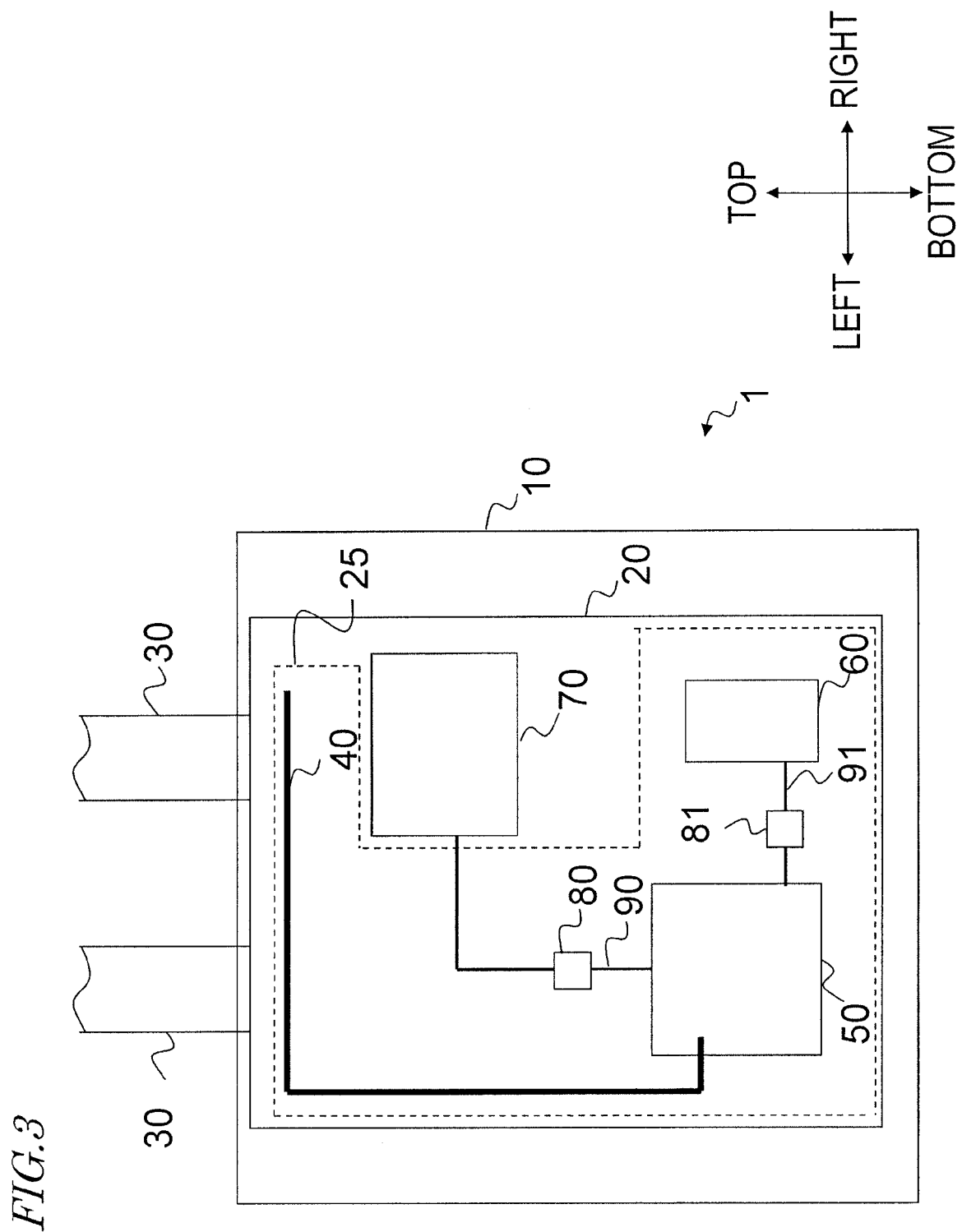


FIG. 4

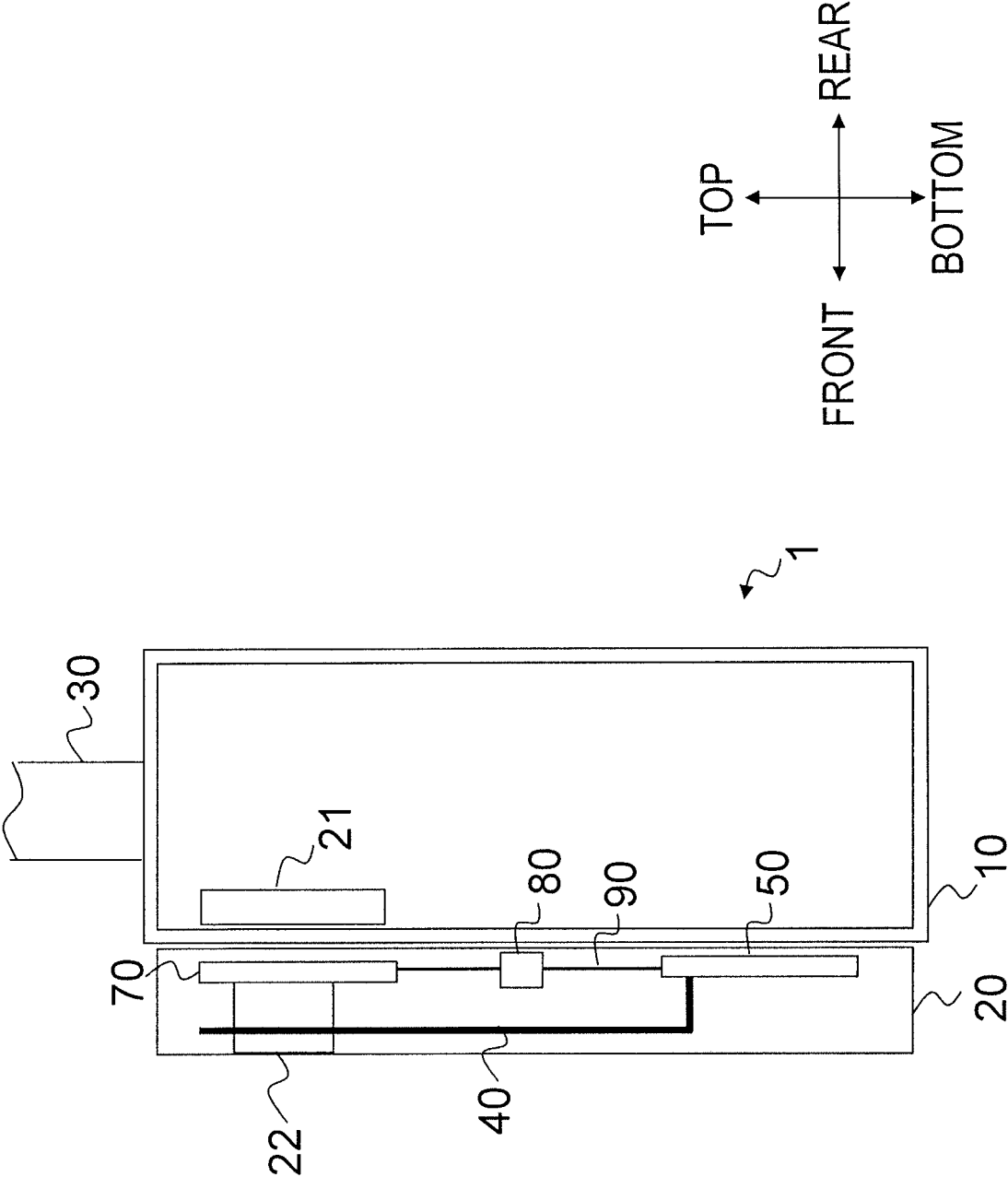


FIG. 5

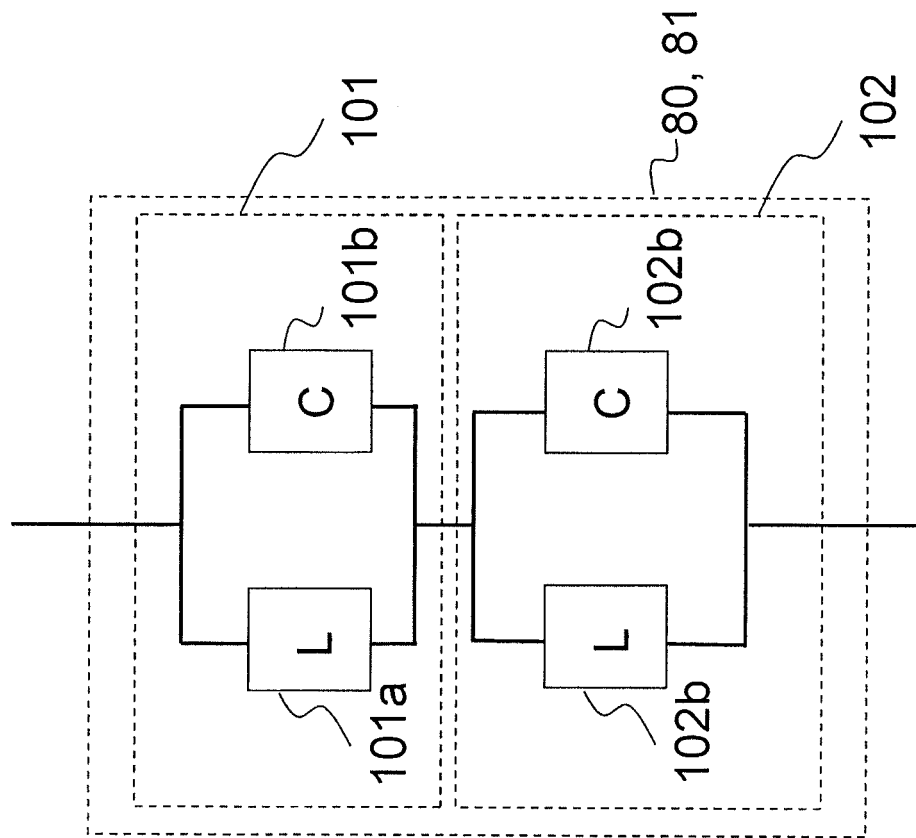


FIG. 6

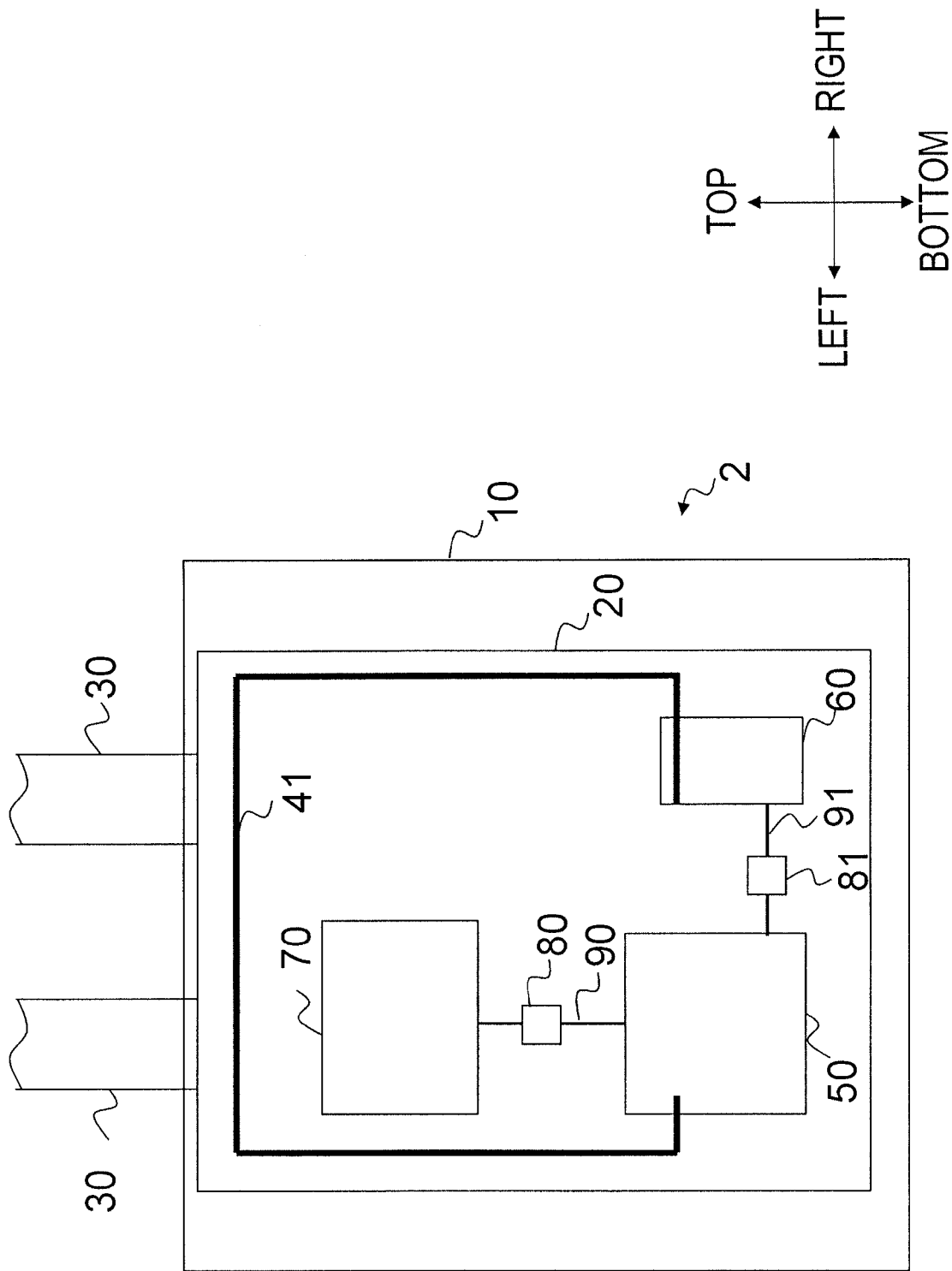


FIG. 7

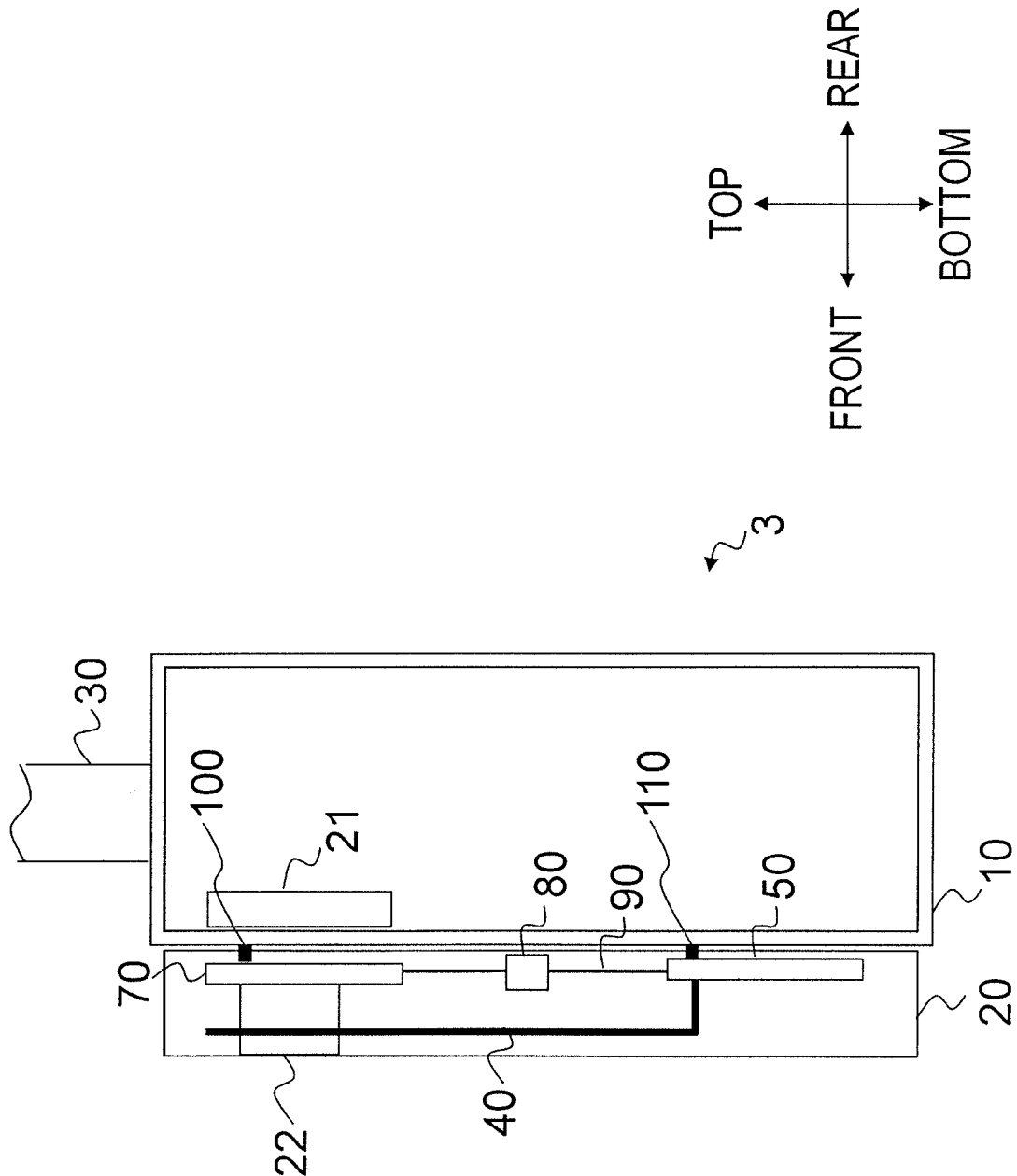


FIG. 8

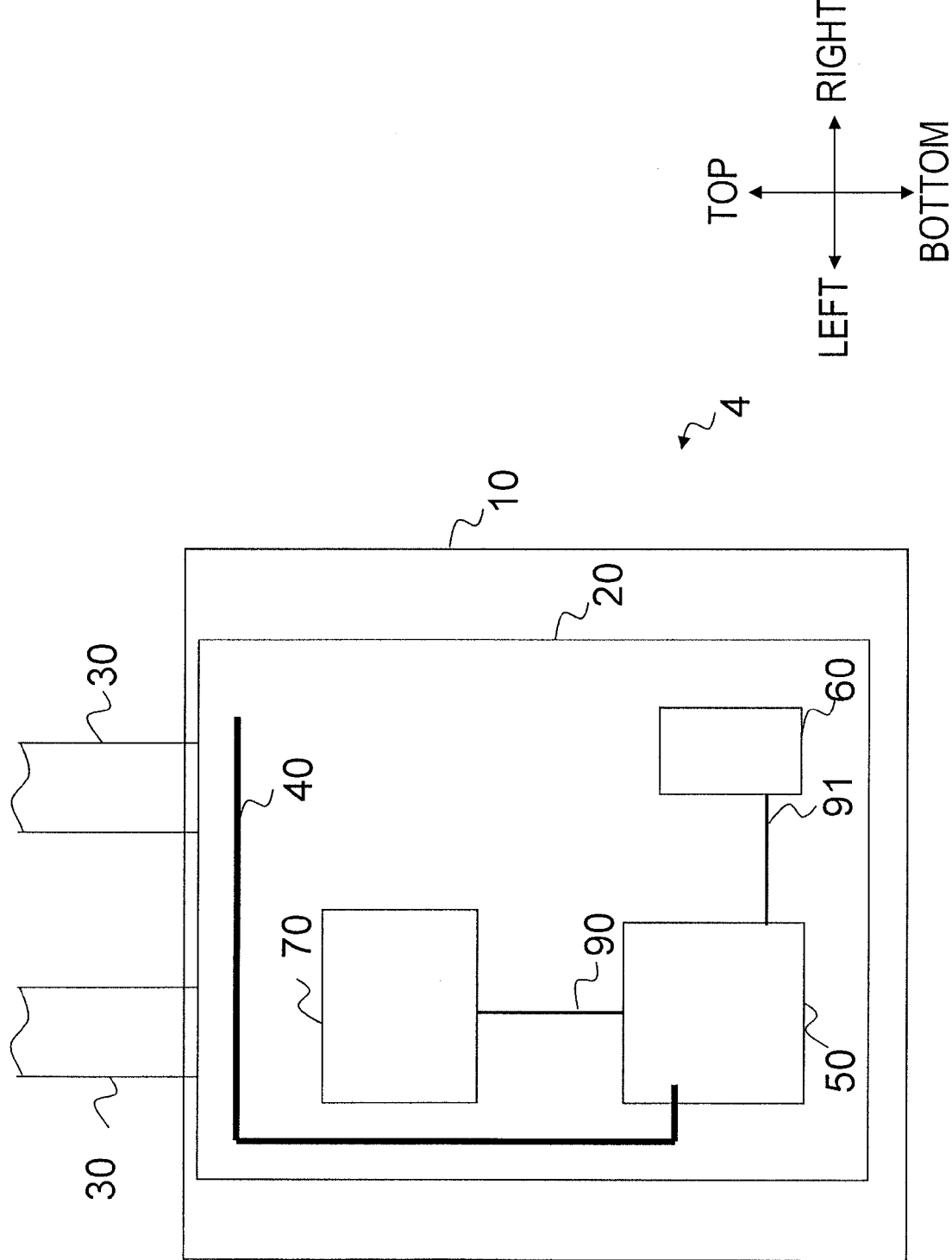


FIG. 9

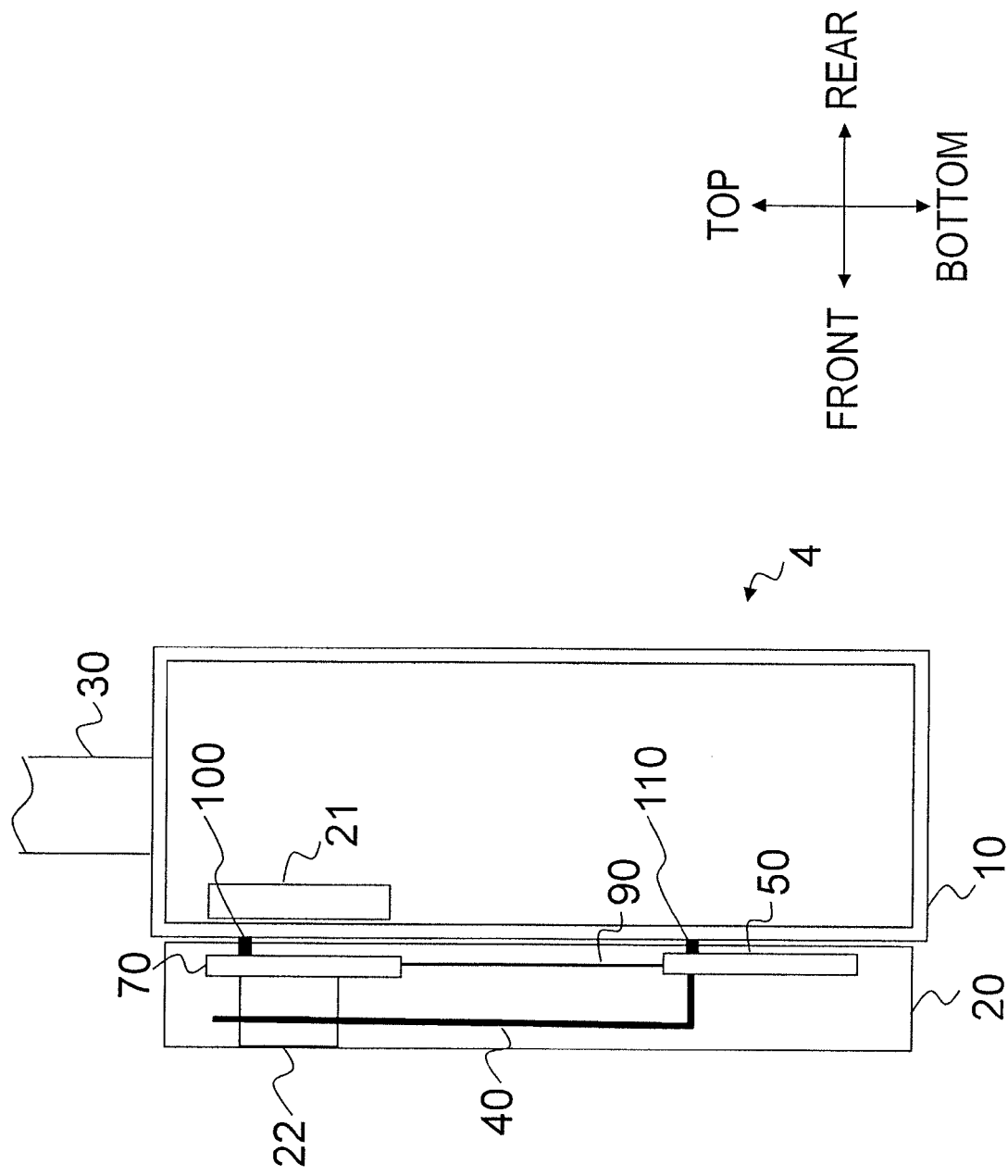
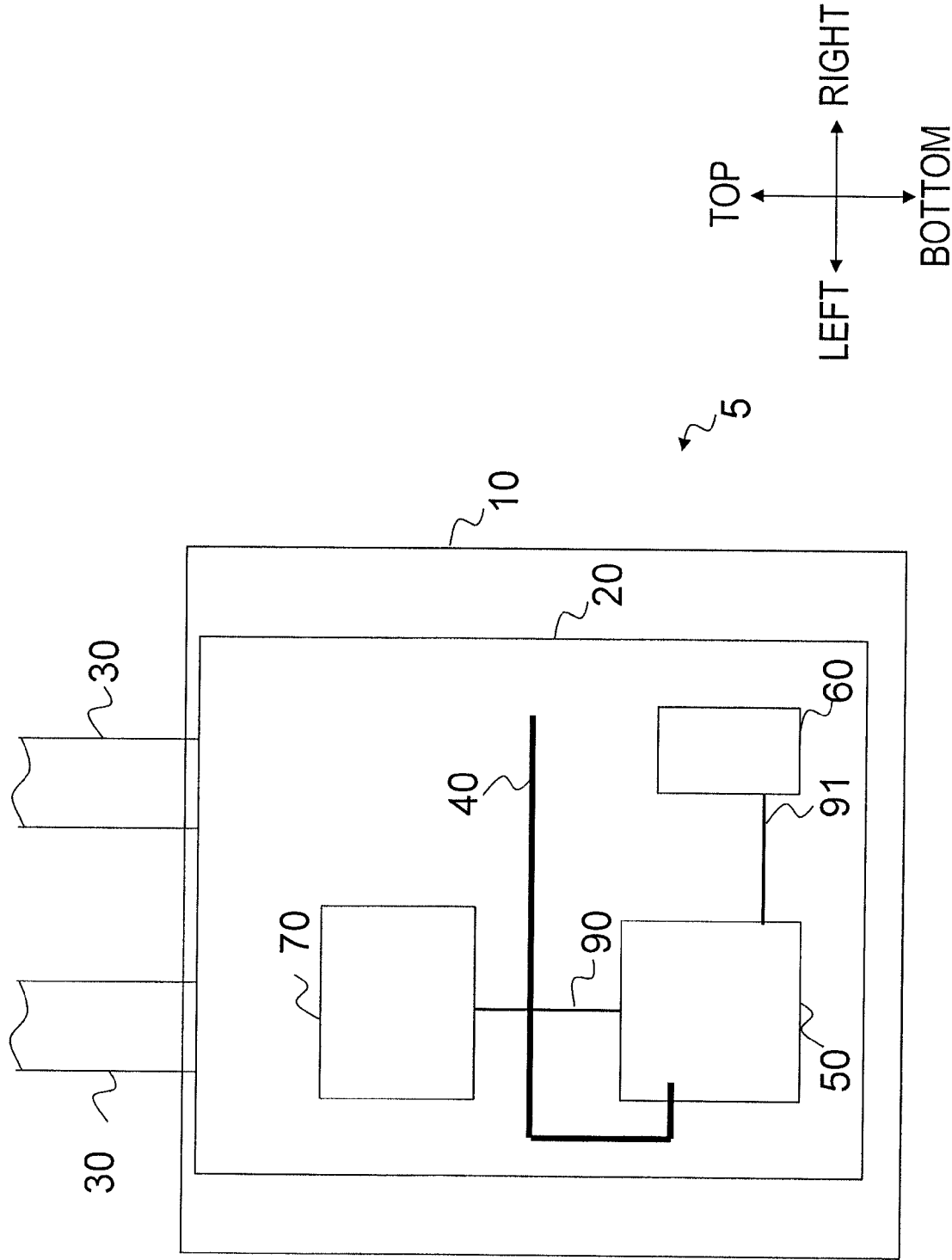


FIG.10





EUROPEAN SEARCH REPORT

Application Number
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Place of search The Hague		Date of completion of the search 3 October 2014	Examiner Hüschelrath, Jens
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