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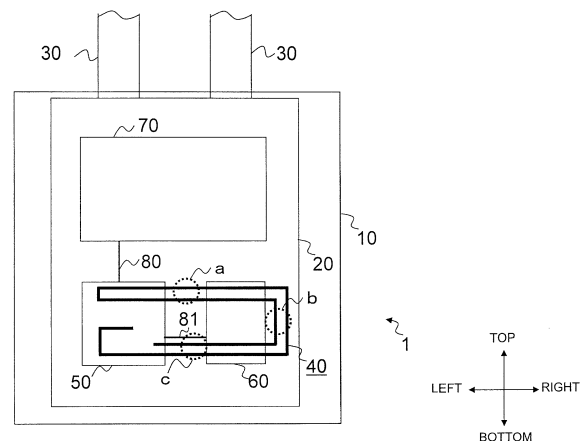
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(54) **Flow amount measurement apparatus and wireless device for use in flow amount measurement apparatus**

(57) There is provided a flow amount measurement apparatus and the like whose transmission output is reduced relative to conventional techniques even when the wireless transmission output power is increased. The flow amount measurement apparatus includes: a housing accommodating a sensor for outputting a detected value concerning a flow amount of a substance for measurement; a first circuit board having thereon a first circuit for acquiring data concerning a flow amount of the substance for measurement based on the detected value; a second circuit board having thereon a second circuit, the second circuit being electrically connected to the first circuit board and modulating a high-frequency signal with the data concerning the flow amount; and a radiation conductor being connected to the second circuit board, and radiating the high-frequency signal as a radio wave. The radiation conductor includes a lead having at least one pair of a first linear portion and a second linear portion which are parallel and opposing each other, the high-frequency signal being sent in mutually opposite directions in the first linear portion and the second linear portion.

FIG.3



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, and a wireless device for use in a flow amount measurement apparatus.

[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 with an internal wireless adapter slave unit, for example. In this wireless adapter slave unit described in Patent Document 1, a substratemounted type planar antenna is internalized. In a substratemounted type planar antenna, a ground conductor plate and a shorting conductor of a radiation conductor portion are connected via the wiring pattern of a printed circuit board. This ground conductor plate is utilized as the ground for the radiation conductor portion.

[CITATION LIST]

[PATENT LITERATURE]

[0004] [Patent Document 1] Japanese Laid-Open Patent Publication No. 10-313212

[SUMMARY OF INVENTION]

[TECHNICAL PROBLEM]

[0005] In the case where the region for installing an antenna is small, a loop-shaped antenna is used in order to attain improved antenna characteristics despite the small antenna region. When a loop-shaped antenna is used, an electromagnetic wave is excited in the center of the loop-shaped antenna, so that a high-frequency current will flow on an RF substrate to which the antenna is connected. This is not a problem when the wireless transmission output power is small, because the high-frequency current flowing on the RF substrate will be small. However, there is a problem when amplifying a predetermined signal by using a high-frequency power amplifier (amplifier) for increasing the wireless transmission output power. Since a large high-frequency current will flow on the

substrate, this excited high-frequency current will affect the transmission power amplifier, thereby deteriorating the transmission output.

[0006] Thus, it has been difficult to reconcile both an improved antenna radiation power and an increased transmission power.

[0007] The present invention has been made in order to solve the above problem, and an objective thereof is to reconcile both an improved antenna radiation power and an increased transmission power with a good balance.

[SOLUTION TO PROBLEM]

[0008] A flow amount measurement apparatus according to an illustrative embodiment of the present invention comprises: a housing accommodating a sensor for outputting a detected value concerning a flow amount of a substance for measurement; a first circuit board having thereon a first circuit for acquiring data concerning the flow amount of the substance for measurement based on the detected value; a second circuit board having thereon a second circuit, the second circuit being electrically connected to the first circuit board and modulating a high-frequency signal with the data concerning the flow amount; and a radiation conductor being connected to the second circuit board, and radiating the high-frequency signal as a radio wave, the radiation conductor including a lead having at least one pair of a first linear portion and a second linear portion which are parallel and opposing each other, the high-frequency signal being sent in mutually opposite directions in the first linear portion and the second linear portion.

[0009] The second circuit board may include a high-frequency power amplifier for amplifying the high-frequency signal; and the first linear portion and second linear portion may be disposed so that an electromagnetic wave which is radiated from the first linear portion and second linear portion and transmitted through the high-frequency power amplifier has an electromagnetic field intensity equal to or less than a predetermined value.

[0010] The radio wave radiated from the radiation conductor may have a previously defined intensity; and the predetermined value may be determined so as to fall within a range satisfying the intensity of the radio wave.

[0011] The radiation conductor may include a plurality of pairs of first linear portions and second linear portions.

[0012] The radiation conductor may be a folded dipole antenna.

[0013] A case accommodating the first circuit board, the second circuit board, and the radiation conductor may be further comprised, the case being made of an electrically non-conductive material, wherein the housing may be made of an electrically conductive material.

[0014] The radiation conductor may include a first electrically conducting member extending along a first direction, and a second electrically conducting member extending along a second direction different from the first

direction; and the first electrically conducting member and the second electrically conducting member may be electrically connected but separable.

[0015] The first electrically conducting member may extend along a horizontal direction, the horizontal direction being a direction on a plane parallel to the second circuit board; and the second electrically conducting member may extend along a vertical direction, the vertical direction being a direction perpendicular to the plane parallel to the second circuit board.

[0016] A connecting portion for connecting the second circuit board and the radiation conductor may be further comprised, wherein, as the radiation conductor is inserted into the connecting portion along a direction parallel to the second circuit board, the connecting portion electrically may connect the second circuit board and the radiation conductor.

[0017] A wireless device according to an illustrative embodiment of the present invention is a wireless device to be attached to a flow amount measurement apparatus including a sensor for outputting a detected value concerning a flow amount of a substance for measurement; and a first circuit board having thereon a first circuit for acquiring data concerning a flow amount of the substance for measurement based on the detected value, the wireless device outputting the data concerning the flow amount as a radio wave of a high-frequency signal, the wireless device comprising: a second circuit board having thereon a second circuit for modulating a high-frequency signal with the data concerning the flow amount acquired by the first circuit board; and a radiation conductor for radiating the high-frequency signal as a radio wave, the radiation conductor being connected to the second circuit board, the radiation conductor including a lead having at least one pair of a first linear portion and a second linear portion which are parallel and opposing each other, the high-frequency signal being sent in mutually opposite directions in the first linear portion and the second linear portion.

[ADVANTAGEOUS EFFECTS OF INVENTION]

[0018] The present invention attains an effect of being able to provide a flow amount measurement apparatus which has the above-described construction, and which, even when the wireless transmission output power is high, does not allow its wireless transmission output power to be deteriorated as compared to conventional techniques.

[0019] 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]

[0020]

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

[FIG. 2] A side view showing a flow amount measurement apparatus according to illustrative Embodiment 1 of the present invention.

[FIG. 3] A schematic diagram showing the internal construction of the flow amount measurement apparatus according to illustrative Embodiment 1 of the present invention as seen through from the front.

[FIG. 4] A schematic diagram showing the internal construction of the flow amount measurement apparatus according to illustrative Embodiment 1 of the present invention as seen through a side face.

[FIG. 5] A schematic diagram showing the three-dimensional construction of a lower case portion of a flow amount measurement apparatus according to illustrative Embodiment 2 of the present invention.

[FIG. 6] A schematic assembly diagram showing a part-by-part exploded view of the construction of the lower case portion of the flow amount measurement apparatus of the present invention according to illustrative Embodiment 2 of the present invention.

[FIG. 7] A schematic diagram showing the lower case portion of the flow amount measurement apparatus according to illustrative Embodiment 2 of the present invention, as cut in a side face direction.

[FIG. 8] A perspective view generally showing a connection structure according to illustrative Embodiment 3 of the present invention.

[FIG. 9] A cross-sectional view showing an exemplary connection structure according to illustrative Embodiment 3 of the present invention.

[FIG. 10] A schematic illustration showing an exemplary method of assembling a connecting portion into a case, according to illustrative Embodiment 3 of the present invention.

[DESCRIPTION OF EMBODIMENTS]

[0021] A flow amount measurement apparatus according to an embodiment of the present invention includes: a housing accommodating a sensor for outputting a detected value concerning a flow amount of a substance for measurement; a first circuit board (e.g., a measurement circuit board) having thereon a first circuit for acquiring data concerning the flow amount of the substance for measurement based on the detected value; a second circuit board (e.g., a wireless communications circuit board) having thereon a second circuit, the second circuit being electrically connected to the first circuit board and modulating a high-frequency signal with the data concerning the flow amount; and a radiation conductor being connected to the second circuit board, and radiating the high-frequency signal as a radio wave. The radiation conductor includes a lead having at least one pair of a first linear portion and a second linear portion which are parallel and opposing each other, the high-frequency signal

being sent in mutually opposite directions in the first linear portion and the second linear portion.

[0022] Hereinafter, an illustrative embodiment of a flow amount measurement apparatus according to the present invention will be specifically described with reference to the drawings.

[0023] Hereinafter, identical or corresponding elements will be denoted by the same reference numeral throughout the figures, and any redundant description thereof will be omitted.

[0024] 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)

[0025] 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.

[0026] 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.

[0027] 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.

[0028] The housing 10 is made of an electrically conductive material. Examples of the electrically conductive material include metals such as aluminum and stainless steels, and electrically conductive resins.

[0029] 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.

[0030] 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.

[0031] 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.

[0032] 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.

[0033] 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, and leads 80 and 81. 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, and the interconnects 80 and 81. 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 constituent element below that may pertain to the wireless device 25 (including the description of the Embodiments set forth below) should also be relied on as description concerning the wireless device 25.

[0034] 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.

[0035] 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 the data 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.

[0036] On the wireless communications circuit board **50**, an integrated circuit including a high-frequency power amplifier and a feeding circuit is further incorporated. The high-frequency power amplifier amplifies a high-frequency signal which has been modulated by the transmission circuit. The feeding circuit is electrically connected to the radiation conductor **40** for supplying to the radiation conductor **40** the high-frequency signal which has been modulated by the transmission circuit and amplified by the high-frequency power amplifier. The lead **80** allows the integrated circuit on the wireless communications circuit board **50** including the feeding circuit to be electrically connected to the integrated circuit of the measurement circuit board **70**. 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 issuing a high-frequency signal representing the measurement data.

[0037] 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 500MHz, and more specifically to a signal of about 169MHz. Moreover, the description of the embodiments of the present invention contemplates that the high-frequency power amplifier has an output of about 1 W (watt). This value is higher than the output of a mobile phone (0.5 to 0.8 W).

[0038] 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, power which is supplied from the battery **60** is electrically coupled to the wireless communications circuit board **50** through the lead **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**.

[0039] 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

[0040] (high-frequency signal) and pass it to the reception circuit, which then demodulates it. The radiation conductor **40** includes an electrically conducting member **41**, an electrically conducting member **42**, and a metal member **43**. The electrically conducting member **42** and the metal member **43** are disposed vertical with respect to the wireless communications circuit board **50**. Moreover, the metal member **43** is supported by the electrically conducting member **41** and the electrically conducting member **42**, and is disposed substantially horizontal with respect to the wireless communications circuit board **50**. The electrically conducting member **41** and the electrically conducting member **42** are electrically connected to the metal member **43**, and also electrically connected to the wireless communications circuit board **50**.

[0041] 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**.

[0042] Next, the radiation conductor **40** will be described. The radiation conductor **40** has the structure of a folded dipole antenna. The ground (GND; the same will always apply below) end of the radiation conductor **40** of this folded dipole antenna structure is connected to GND of the wireless communications circuit board **50**.

[0043] GND of the wireless communications circuit board **50** is electrically connected to the housing **10**. By connecting the GND end of the radiation conductor **40** at a portion which is close to this electrical connection to the housing **10**, maximum effects can be obtained.

[0044] The reason for adopting the aforementioned construction will be described. In a meter unit for use as a generic gas meter, a water meter, or an electricity meter, a very large size cannot be adopted for the case which accommodates a wireless unit that is attached on the meter unit. Therefore, a $\lambda/4$ ($\lambda = 1$ wavelength) monopole is used as the antenna. With this antenna, a high-frequency current which is excited from the antenna will also flow on the wireless communications circuit board. Thus, as the power amplifier mounted on the wireless communications circuit board has an increased transmission output, the wireless communications circuit board will have an increased transmission output, and this high transmission output will also cause an electromagnetic wave which is excited in the antenna to increase in intensity. Then, an electromagnetic wave which is radiated from this antenna will cause a high-frequency current to flow on the wireless communications circuit board. As a result, the power amplification characteristics of the power amplifier will be deteriorated, resulting in a deterioration in the transmission power which is radiated from the antenna.

[0045] In fact, the inventors have conducted an experiment by using a monopole antenna under the conditions of a relatively large power amplifier output of 1 W (watt) and a relatively low frequency of 169 MHz. The inventors have thus confirmed that, when a non-folded monopole antenna and a power amplifier are disposed at reduced distance due to physical constraints within the housing,

the electromagnetic wave which is radiated from the radiation conductor will concentrate on the power amplifier that is provided on the wireless communications circuit board, and the power amplification characteristics of the power amplifier will be deteriorated under the influence of the excited high-frequency current.

[0046] Therefore, the inventors have conducted studies on antenna constructions. As a result, the inventors have arrived at constructing an antenna which includes a lead having at least one pair of a first linear portion and a second linear portion which are parallel and opposing each other, such that a high-frequency signal is sent in mutually opposite directions in the first linear portion and the second linear portion. It has been found that this, alleviates or substantially eliminates the aforementioned problems.

[0047] For example, when a folded dipole antenna whose antenna length is elongated to about $\lambda/2$ is used as the antenna, the geometric area of a loop shape which is constructed of the antenna element can be reduced. This enables an adjustment such that an electromagnetic wave which is excited from the antenna element will not pass on the wireless communications circuit board in concentration.

[0048] The aforementioned first linear portion and second linear portion are adjusted so that an electromagnetic wave which is radiated from the first linear portion and second linear portion and transmitted through the power amplifier provided on the wireless communications circuit board has an electromagnetic field intensity which is equal to or less than a predetermined value. It is meant by "equal to or less than predetermined" that the aforementioned electromagnetic field intensity may be equal to or less than the predetermined value, and does not need to be zero so long as it is within a range where the required specifications for communications (radio wave intensity) are satisfied, although its value is preferably as small as possible (e.g., zero).

[0049] As a specific method of adjustment, for example, the interval between the first linear portion and the second linear portion may be adjusted to ensure that the intensity of an electromagnetic field which is radiated from the first linear portion and second linear portion is equal to or less than predetermined (e.g., zero) at the power amplifier. By providing pairs of aforementioned first linear portions and second linear portions at a plurality of places on the folded dipole antenna, it becomes possible to disperse the influence of the electromagnetic wave on the power amplifier. FIG. 3 shows three pairs of first linear portions and second linear portions (pairs a, b, and c). This allows to reduce the high-frequency current which is excited on the wireless communications circuit board by the electromagnetic wave radiated from the antenna. By reducing the influence on the high-output power amplifier, it becomes possible to reduce power deteriorations in the transmission output. Ultimately, lowering of the intensity of the radio wave radiated from the antenna of the radiation conductor **40** can be prevented.

[0050] The above-described construction is more suitable under the conditions of a relatively large power amplifier output of 1 W (watt) and a relatively low frequency of 169 MHz, which is contemplated in the present specification.

[0051] Note that folded dipole antennas are used in mobile phones and the like. This is to ensure that as little current will flow in the case as possible. Since a mobile phone is used in a person's hand, the current flowing through the case of the mobile phone will vary depending on how the mobile phone is held, and on differences in the hand (size, fat, and bones). As the current flowing through the case changes, the antenna characteristics may change. A folded dipole antenna is suitable for preventing such changes in antenna characteristics.

[0052] On the other hand, a folded dipole antenna is generally not adopted for a meter unit for use as a generic gas meter, a water meter, or an electricity meter which performs wireless communications. The reason is that such a meter unit is to stay installed, and therefore the current through the case usually does not change.

[0053] Furthermore, the radiation conductor **40** for radiating a radio wave of a relatively low frequency such as about 169 MHz, which is contemplated in the present specification, usually does not need to be so long as to require a folded shape. Moreover, it is appropriate to adopt a folded dipole antenna in cases where a relatively broad bandwidth is needed at high frequencies. However, under use at relatively low frequencies as mentioned above, it is difficult to ensure a broad bandwidth in the first place. Therefore, especially under the conditions that are contemplated in the present specification, there is no advantage in utilizing a folded dipole antenna.

[0054] Moreover, adopting a folded shape results in a complicated shape, thus increasing molding difficulties. Also, the required material will be approximately doubled, thereby increasing the cost. Although it is technically possible to form a folded-shape antenna out of a single metal lead, it will not permit mass production using a die, so that processing via human hands will be required. The cost for such processing will translate to production cost.

[0055] Considering the various circumstances above, it is usually inconceivable for those skilled in the art to utilize a folded dipole antenna.

[0056] Although the radiation conductor **40** as a linear antenna is used in all of the above Embodiments, the radiation conductor **40** may be composed of other plate-like conducting elements. Examples of linear conducting elements include loop antennas, meander line antennas, etc.

[0057] Although a linear conducting element is used as the radiation conductor **40** in all of the above Embodiments, the radiation conductor **40** may be composed of other conducting elements. For example, a planar conducting element such as a planar inverted F antenna, a linear inverted L antenna, or a planar dipole antenna may be used as the radiation conductor **40**.

(Embodiment 2)

[0058] In this Embodiment, the construction of the radiation conductor **40** and a method of connection between the radiation conductor **40** and the wireless communications circuit board **50** will be described.

[0059] Conventionally, a planar antenna which is stress-resistant, e.g., a single plate, is not likely to deform even if the component part (antenna element) constituting the antenna is stressed upon incorporation into the case. For example, an antenna for communications purposes has a relatively high transmission frequency (i.e., has a relatively short wavelength), so that its antenna length may be short, thus making for a stress-resistant design.

[0060] However, when reasons such as low transmission frequency (long wavelength) or the like make it necessary for a relatively long antenna element to be accommodated within the same volume, the antenna element shape will inevitably become complicated, thus resulting in low resistance against stress and more liability to deform. Therefore, the stress acting on the antenna element upon incorporation into the case may deform the antenna element and deteriorate its wireless characteristics, so that a stable wireless performance cannot be obtained.

[0061] When forming an antenna within a limited volume, the antenna characteristics will be deteriorated unless it is distanced from the circuit board. Therefore, as a common antenna element shape, an antenna element is often formed which extends along the vertical direction from the circuit board, and then follows parallel along the circuit board once in a space which is distant from the circuit board. This unstable three-dimensional shape increases the difficulty of antenna incorporation, and serves as a cause for more stress and deformation of the antenna element.

[0062] Accordingly, in this Embodiment, there is provided a small-sized flow amount measurement apparatus which attains more stable wireless characteristics by reducing the risk of deformation of the antenna element composing the radiation conductor.

[0063] FIG. 5 shows the three-dimensional construction of a lower case portion of the flow amount measurement apparatus **1**, and FIG. 6 shows a part-by-part exploded view of the construction of the lower case portion of the flow amount measurement apparatus **1**. FIG. 7 shows a schematic diagram of the lower case portion of the flow amount measurement apparatus in FIG. 1 as cut in a side face direction.

[0064] The radiation conductor **40** according to this Embodiment is shaped as a thin bar or plate-like, and made of an electrically conductive material such as copper or iron. The radiation conductor **40** is composed of a combination of a plurality of members. Now, in view of the manner in which the radiation conductor **40** will be incorporated, directions are defined as follows. Specifically, any direction on a plane which is parallel to the

wireless communications circuit board **50** and/or the measurement circuit board **70** is defined as the horizontal direction, and a direction perpendicular to that plane is defined as the vertical direction.

[0065] The radiation conductor **40** according to this Embodiment includes an electrically conducting member extending along the horizontal direction and electrically conducting members extending along the vertical direction. FIG. 5 shows a metal member **43** as an electrically conducting member extending along the horizontal direction, and electrically conducting members **41** and **42** and screws **44** and **45** as electrically conducting members extending along the vertical direction.

[0066] Examples of the electrically conductive material include, for example, metals such as aluminum and stainless steels, and electrically conductive resins. As an example, in a manner of spacers, the electrically conducting members **41** and **42** may have at their lower ends a mechanism for allowing them to be fixed to other materials, e.g., a screw. In this Embodiment, the lower face of the columnar portion of the electrically conducting member **41** abuts with an output section (feeding terminal) of the wireless communications circuit board **50**, so that, while maintaining an electrically connected state, the screw portion at the tip end of the electrically conducting member **41** is fixed to the case **20** having a screw receptacle. In this Embodiment, a feed point of the radiation conductor **40** is the point where the electrically conducting members **41** and **42** abut with the output section (feeding terminal) of the wireless communications circuit board **50**.

[0067] As a more generalized explanation, the radiation conductor **40** according to this Embodiment at least includes: a first electrically conducting member extending in a first direction from the feed point; and a second electrically conducting member extending in a second direction different from the first direction. The first electrically conducting member and the second electrically conducting member are detachable from each other; upon incorporation, for example, the first electrically conducting member may first be attached to the substrate, and thereafter the second electrically conducting member may be attached to the first electrically conducting member. The radiation conductor **40** according to this Embodiment is not an integrally-molded radiation conductor that extends in different directions, and therefore hardly undergoes any deformation due to the stress upon incorporation. Moreover, since the respective electrically conducting members can be produced separately and independently, any complicated bending processing or the like is not needed, and its production is easy. For example, the second electrically conducting member can be produced through punching.

[0068] Hereinafter, the construction of the radiation conductor **40** during incorporation and after incorporation, illustrated in FIG. 5 and the like, will be specifically described.

[0069] The lower face of the columnar portion of the electrically conducting member **42** abuts with GND of the

wireless communications circuit board **50**, and while maintaining electrical connection, the screw portion at the tip end of the electrically conducting member **42** is fixed to the case **20** having a screw receptacle.

[0070] Moreover, in order to cope with the stress upon incorporation and the self-weight of the radiation conductor **40**, it is desirable for the electrically conducting members **41** and **42** to have a shape that can withstand stress, e.g., desirably a cylinder or prism shape with a diameter of 5 mm or more.

[0071] Next, the screws **44** and **45** penetrate the radiation conductor **40**, and are respectively fixed to the electrically conducting members **41** and **42** for electrical connection. As a result, a circuit of electrical connection is established from the output section (feeding terminal) of the wireless communications circuit board **50** to GND of the wireless communications circuit board **50**, via the electrically conducting member **41**, the screw **44**, the radiation conductor **40**, the screw **45**, and the electrically conducting member **42**.

[0072] A construction may also be adopted where electrical connection is directly made with the wireless communications circuit board **50** through the radiation conductor **40** and the electrically conducting member **41** or **42**, via the electrically conductive screws **44** and **45**. So long as similar modes of electrical connection can be established, the means of connection may be any, e.g., welding or solder connection, without being limited to screw-based connection as illustrated in this Embodiment.

[0073] Conventionally, an antenna element would extend in a plurality of directions, thus having a three-dimensional structure; therefore, the antenna element is likely to receive stress upon antenna incorporation, thus resulting in a high risk of characteristics deterioration due to deformation of the antenna element.

[0074] However, this Embodiment adopts a construction where the radiation conductor **40** is divided into the electrically conducting members **41** and **42**, which serve as antenna elements along the first direction (e.g., the vertical direction) with respect to the case plane, and the metal member **43**, which serves as an antenna element along the second direction (e.g., the horizontal direction), such that the respective component parts can be independently fixed. Not only does this reduce difficulty of assembly, but this also allows to incorporate the antenna element without undue stress acting on each component part, whereby deteriorations in the antenna wireless characteristics can be prevented.

[0075] Moreover, by switching from the aforementioned three-dimensional antenna element construction to the construction which is divided into a planar antenna and electrically conducting members which are in the form of support pillars, the number of steps in antenna element production is reduced (bending processing is eliminated) to enable lower cost, together with effects such as ease of accommodation and storage of the members and decrease in the risk of antenna element deformation during transportation.

mation during transportation.

[0076] Since this Embodiment adopts a loop antenna, the two ends of the radiation conductor **40** are connected to the output section and GND of the wireless communications circuit board **50**, respectively. However, in the case where other types of antennas are used, the output section (feeding terminal) of the wireless communications circuit board **50** may only be connected to one end at the feed point, while the other end may be left open.

[0077] Thus, in this Embodiment, the flow amount measurement apparatus 1 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; an electrically conducting member electrically connected to the radiation conductor; a circuit board having a feeding circuit for supplying to the electrically conducting member and the radiation conductor a high-frequency power to form the high-frequency signal, via the electrically conducting member; a measurement circuit board electrically connected to the circuit board; a battery also electrically connected to the circuit board; and a case being made of an electrically non-conductive material and accommodating the radiation conductor and the circuit board. As a result, it is possible to incorporate an antenna element without allowing undue stress to act on the component parts, thus preventing deteriorations in the wireless characteristics of the antenna.

(Embodiment 3)

[0078] In this Embodiment, still another method of connection between the radiation conductor **40** and the wireless communications circuit board **50** will be described. FIG. 8 to FIG. 10 illustrate related constructions in describing this Embodiment.

[0079] FIG. 8 is a perspective view showing a schematic structure in relation with the method of connection between the radiation conductor **40** and the wireless communications circuit board **50** according to the present invention. As shown in FIG. 8, the radiation conductor **40** and the wireless communications circuit board **50** are connected via a connecting portion **101**.

[0080] The radiation conductor **40** is inserted into the connecting portion **101** along a direction which is parallel to the wireless communications circuit board **50**. In FIG. 8, an arrow indicates the direction along which the radiation conductor **40** is inserted into the connecting portion **101**. As a result, the connecting portion **101** electrically connects the wireless communications circuit board **50** and the radiation conductor **40**.

[0081] With the construction of this Embodiment, since the radiation conductor **40** is inserted along a direction which is parallel to the wireless communications circuit board **50**, the stress on the substrate upon connecting the radiation conductor **40** is alleviated, thus reducing warpage of the substrate. As a result, breaking of the

substrate, breaking of the mounted component parts, solder breaking, or the like can be prevented.

[0082] Next, the internal structure of the connecting portion **101** will be described.

[0083] FIG. **9** is a cross-sectional view showing an exemplary connection structure at the connecting portion **101**. Specifically, the connecting portion **101** is composed of two metal plates **102a** and **102b** having a spring mechanism. In this Embodiment, the metal plate **102a** is provided at the upper portion of the connecting portion **101**, whereas the metal plate **102b** is provided at the lower portion. Thus, the connecting portion **101** allows the tip end of the inserted radiation conductor **40** to be sandwiched between the two metal plates **102a** and **102b**. At this time, the metal plate **102a** confers an elastic force in the lower direction in the figure, whereas the metal plate **102b** confers an elastic force in the upper direction in the figure. As a result, the connecting portion **101** physically fixes the radiation conductor **40**. In other words, in this Embodiment, the connecting portion **101** fixes the radiation conductor **40** via fitting. Then, the radiation conductor **40** is electrically connected to the wireless communications circuit board **50** via the metal plates **102a** and **102b**. Although this Embodiment illustrates an example where fitting is achieved by utilizing elastic force, fitting may also be achieved by anything other than elastic force so long as electrical conduction is attained and physical fixation is enabled.

[0084] Thus, while facilitating attachment/release between the component part and the connecting portion, stress on the substrate upon attachment/release can be alleviated, and warpage of the substrate, breaking of the substrate, breaking of the mounted component parts, solder breaking, or the like can be prevented.

[0085] In the connecting portion **101** according to the present embodiment, the two metal plates **102a** and **102b** having a spring mechanism are disposed on the wireless communications circuit board **50** to fix the radiation conductor **40** being inserted along a direction which is parallel to the wireless communications circuit board **50**. Therefore, depending on the size and shape of the radiation conductor **40**, the metal plates **102a** and **102b** may be elongated along a direction which is parallel to the wireless communications circuit board **50**; they do not need to be elongated along the vertical direction.

[0086] Thus, with the construction of this Embodiment, while maintaining the height between the radiation conductor **40** and the wireless communications circuit board **50**, it is possible to reduce the height of the case accommodating the wireless communications circuit board **50**, the radiation conductor **40**, the connecting portion **101**, and the like. As a result, limitations as to where to install the case can be relaxed.

[0087] Or conversely, the case size may be maintained, and the connecting portion **101** may be provided so that the radiation conductor **40** and the wireless communications circuit board **50** are more distant, whereby sensitivity of the radiation conductor **40** can be improved.

[0088] Moreover, in accordance with the size, etc., of the radiation conductor **40**, the connecting portion **101** according to this Embodiment can be made larger along a direction conforming to a direction which is parallel to the wireless communications circuit board **50**. Specifically, in a construction as shown in FIG. **9**, the surface area of the face at which the metal plate **102b** is grounded to the wireless communications circuit board **50** is increased. Therefore, even if a force that causes the radiation conductor **40** to swing is applied, the connecting portion **101** can be prevented from peeling off the wireless communications circuit board **50**.

[0089] Note that the aforementioned problematic peeling of the connecting portion **101** off the wireless communications circuit board **50** will have more significance as the frequency used for communications (wireless communications frequency) becomes lower. The reason is that the antenna size is in proportion to the wavelength of the wireless communications frequency. In other words, as the wireless communications frequency lowers, the wavelength increases, so that the antenna size will also increase. Therefore, the problematic peeling of the connecting portion **101** off the wireless communications circuit board **50** is more serious in the field of flow amount measurement apparatuses having a wireless transmission function (so-called smart meters) according to the present disclosure, where a lower wireless communications frequency (about 169 MHz) is used than the wireless communications frequency which is used in the fields of mobile applications (about 1 to 5 GHz).

[0090] Next, a method of assembly by which the wireless communications circuit board **50** and the radiation conductor **40** is accommodated into the case will be described with reference to FIG. **10**. FIG. **10** is a schematic illustration showing an exemplary method of assembly into the case **20**. In this manner, an apparatus that includes the electrical circuit of the present invention, as described in Embodiment 1 or Embodiment 2, is constructed.

[0091] Moreover, in FIG. **10**, the case **20** has a small window **102** which can be opened or closed when assembling the wireless communications circuit board **50** and the radiation conductor **40** composing an electrical circuit, or during maintenance, e.g., battery exchange. Thus, the connecting portion **101** is placed at a position for allowing the radiation conductor **40** to be attached or released through the small window **102**.

[0092] For example, when assembling the wireless communications circuit board **50** and the radiation conductor **40**, a worker or the like may open the small window **102** and insert the tip end of the radiation conductor **40** into the connecting portion **101** along a direction which is parallel to the wireless communications circuit board **50**, thus fixing the radiation conductor **40**. This work is also conducted as necessary during maintenance such as battery exchange.

[0093] With this construction, attachment/release of the component parts and the connecting portion can be

easily performed through the small window, without detaching the case **20** or disassembling the case **20**. Also, stress on the substrate upon attachment/release can be alleviated, and warpage of the substrate, breaking of the substrate, breaking of the mounted component parts, solder breaking, or the like can be prevented.

[0094] In particular, a great improvement in workability is obtained in the case where the connecting portion **101** is placed by the edge of the small window **102**. As a result, workability can be improved while facilitating attachment/release between the component part and the connecting portion.

[0095] Although the above illustrates an antenna as an example to be connected to the connecting portion on the substrate, similar effects are also provided when connecting any component part other than an antenna to the connecting portion.

[0096] In the description of the above Embodiments, a parallel direction and a vertical direction are defined, and the direction of insertion into the connecting portion **101** is described to be "along a direction which is parallel to the "wireless communications circuit board **50**. However, such description does not intend strictly horizontal, vertical, or parallel, and some deviation may be allowed. For example, the direction of insertion of the radiation conductor **40** into the connecting portion **101** does not need to be completely parallel, but also encompasses substantially parallel directions, thus to take into account the placement of component parts on the substrate or accommodation into the case. Similarly, the horizontal direction and the vertical direction may also encompass substantially horizontal directions and substantially vertical directions.

[0097] In other words, in order to reduce the stress associated with the antenna or the like being inserted along the vertical direction with respect to the substrate (i.e., with an angle of 90 degrees from the substrate), the antenna or the like may be inserted in a direction such that the angle from the substrate is smaller than 90 degrees. The stress on the substrate will become the smallest along the horizontal direction with respect to the substrate (i.e., with an angle of 0 degrees from the substrate).

[0098] Thus, by adopting a connecting portion construction such that an antenna or the like is inserted in a direction with an angle less than 90 degrees from the substrate, a connection direction can be realized which takes into account the location of the component parts on the substrate or accommodation into the case, while alleviating stress on the substrate upon insertion. Thus, the efficiency of work during maintenance or the like can be improved.

[0099] Note that the constructions and the methods of connection between the radiation conductor **40** and the wireless communications circuit board **50** described in Embodiments 1 to 3 may be adopted in combinations as necessary.

[0100] 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]

[0101] Thus, a flow amount measurement apparatus according to the present invention is useful for the reconciliation of an improved antenna radiation efficiency and an improved transmission output in a small-sized flow amount measurement apparatus which is intended to provide improved antenna characteristics over conventional techniques.

[REFERENCE SIGNS LIST]

[0102]

1	flow amount measurement apparatus
10	housing
20	case
21	sensor
22	display section
30	conduit
40	radiation conductor
41, 42	electrically conducting member
43	metal member
44, 45	screw (for connection)
50	wireless communications circuit board (circuit board)
60	battery
70	measurement circuit board (circuit board)
80, 81	lead (for connection)
101	connecting portion
102	small window

Claims

1. A flow amount measurement apparatus comprising:

a housing accommodating a sensor for outputting a detected value concerning a flow amount of a substance for measurement;

a first circuit board having thereon a first circuit for acquiring data concerning the flow amount of the substance for measurement based on the detected value;

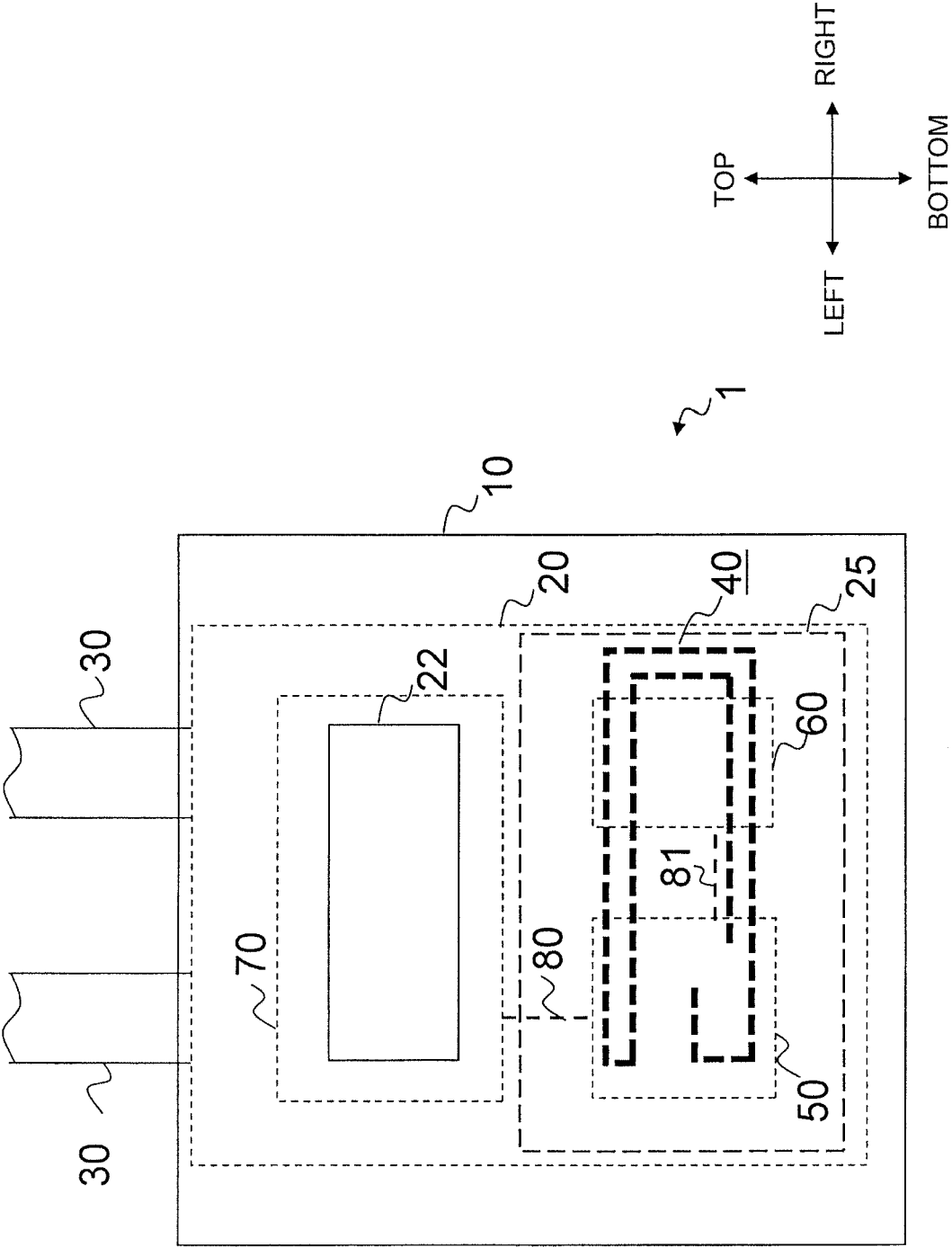
a second circuit board having thereon a second circuit, the second circuit being electrically connected to the first circuit board and modulating a high-frequency signal with the data concerning the flow amount ; and

a radiation conductor being connected to the second circuit board, and radiating the high-frequency signal as a radio wave,

- the radiation conductor including a lead having at least one pair of a first linear portion and a second linear portion which are parallel and opposing each other, the high-frequency signal being sent in mutually opposite directions in the first linear portion and the second linear portion.
2. The flow amount measurement apparatus of claim 1, wherein,
the second circuit board includes a high-frequency power amplifier for amplifying the high-frequency signal; and
the first linear portion and second linear portion are disposed so that an electromagnetic wave which is radiated from the first linear portion and second linear portion and transmitted through the high-frequency power amplifier has an electromagnetic field intensity equal to or less than a predetermined value.
 3. The flow amount measurement apparatus of claim 2, wherein,
the radio wave radiated from the radiation conductor has a previously defined intensity; and
the predetermined value is determined so as to fall within a range satisfying the intensity of the radio wave.
 4. The flow amount measurement apparatus of claim 1, wherein the radiation conductor includes a plurality of pairs of first linear portions and second linear portions.
 5. The flow amount measurement apparatus of claim 1, wherein the radiation conductor is a folded dipole antenna.
 6. The flow amount measurement apparatus of claim 1, further comprising a case accommodating the first circuit board, the second circuit board, and the radiation conductor, the case being made of an electrically non-conductive material, wherein the housing is made of an electrically conductive material.
 7. The flow amount measurement apparatus of claim 1, wherein,
the radiation conductor includes
a first electrically conducting member extending along a first direction, and
a second electrically conducting member extending along a second direction different from the first direction; and
the first electrically conducting member and the second electrically conducting member are electrically connected but separable.
 8. The flow amount measurement apparatus of claim 7, wherein,
- the first electrically conducting member extends along a horizontal direction, the horizontal direction being a direction on a plane parallel to the second circuit board; and
the second electrically conducting member extends along a vertical direction, the vertical direction being a direction perpendicular to the plane parallel to the second circuit board.
9. The flow amount measurement apparatus of claim 1, further comprising a connecting portion for connecting the second circuit board and the radiation conductor, wherein,
as the radiation conductor is inserted into the connecting portion along a direction parallel to the second circuit board, the connecting portion electrically connects the second circuit board and the radiation conductor.
 10. A wireless device to be attached to a flow amount measurement apparatus including
a sensor for outputting a detected value concerning a flow amount of a substance for measurement; and
a first circuit board having thereon a first circuit for acquiring data concerning a flow amount of the substance for measurement based on the detected value, the wireless device outputting the data concerning the flow amount as a radio wave of a high-frequency signal,
the wireless device comprising:

a second circuit board having thereon a second circuit for modulating a high-frequency signal with the data concerning the flow amount acquired by the first circuit board; and
a radiation conductor being connected to the second circuit board, and radiating the high-frequency signal as a radio wave,
the radiation conductor including a lead having at least one pair of a first linear portion and a second linear portion which are parallel and opposing each other, the high-frequency signal being sent in mutually opposite directions in the first linear portion and the second linear portion.

FIG. 1



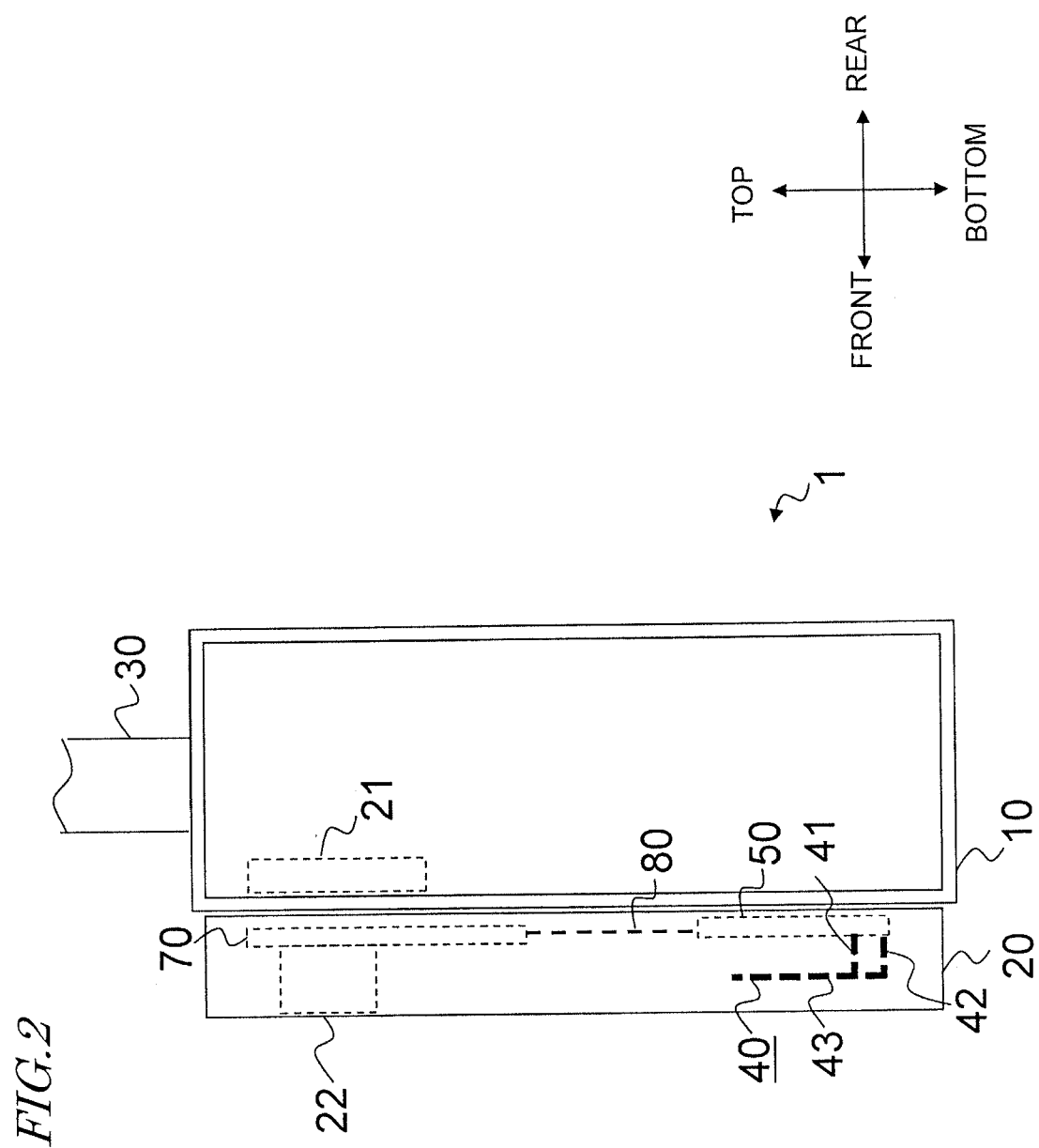


FIG. 3

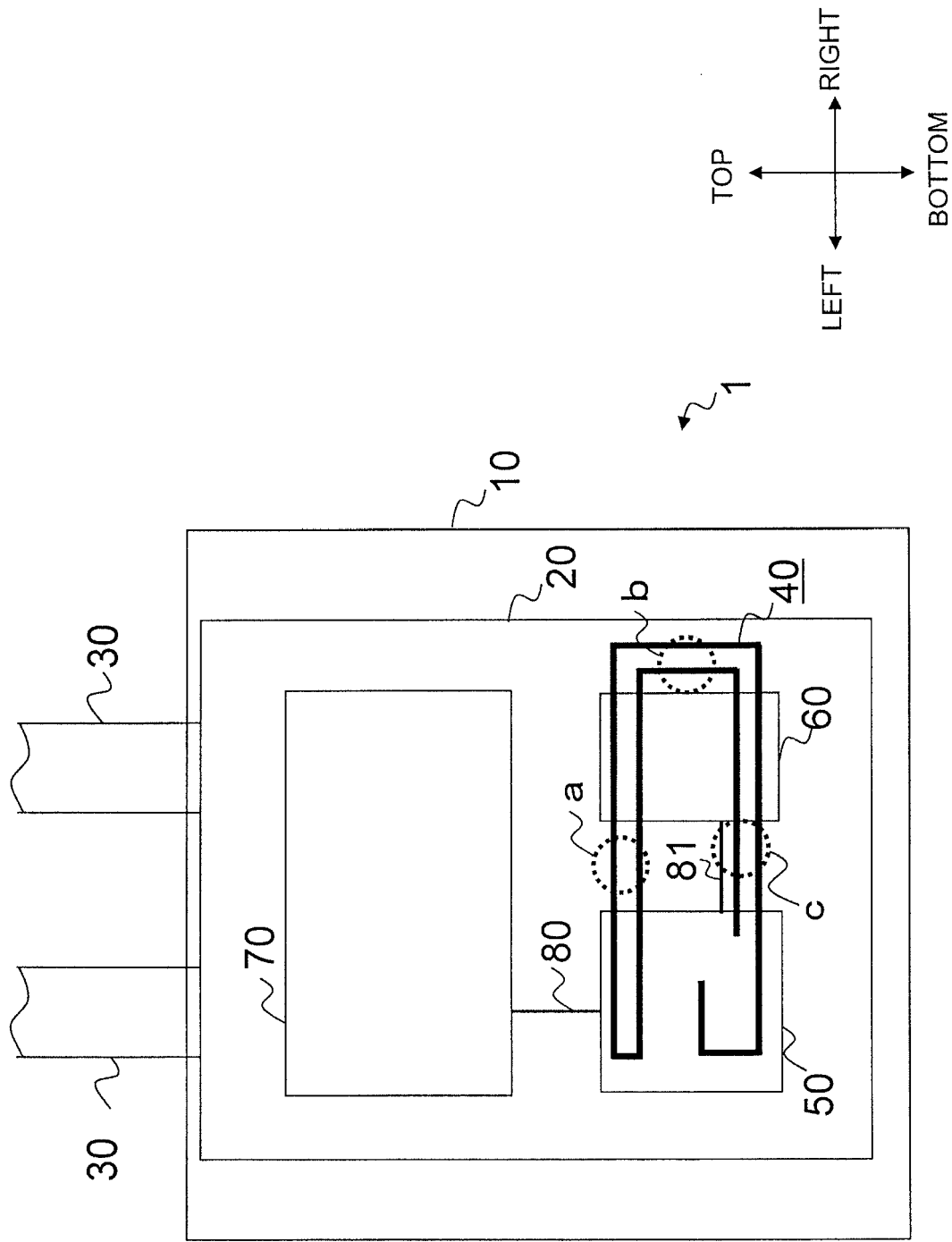


FIG. 4

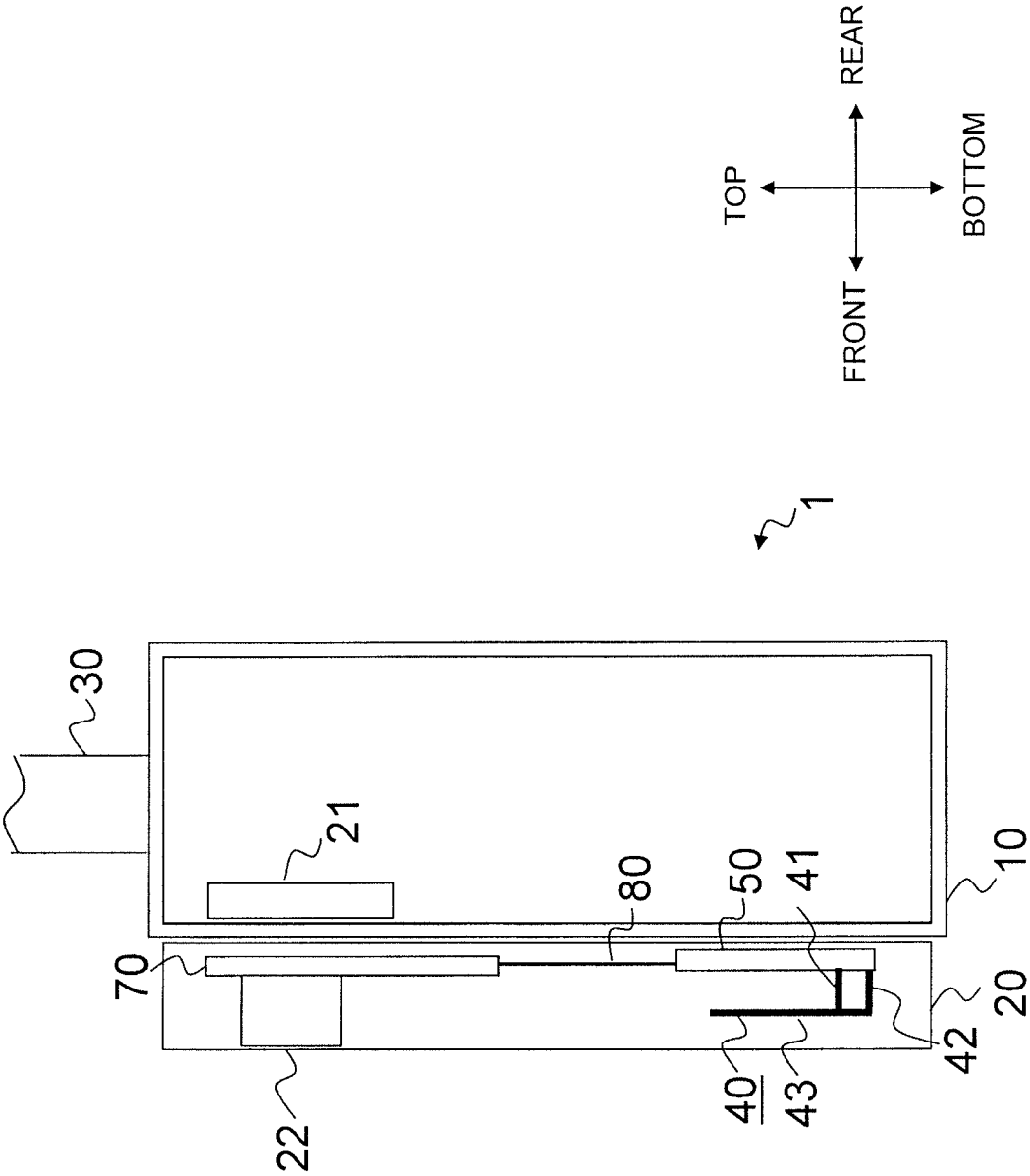


FIG.5

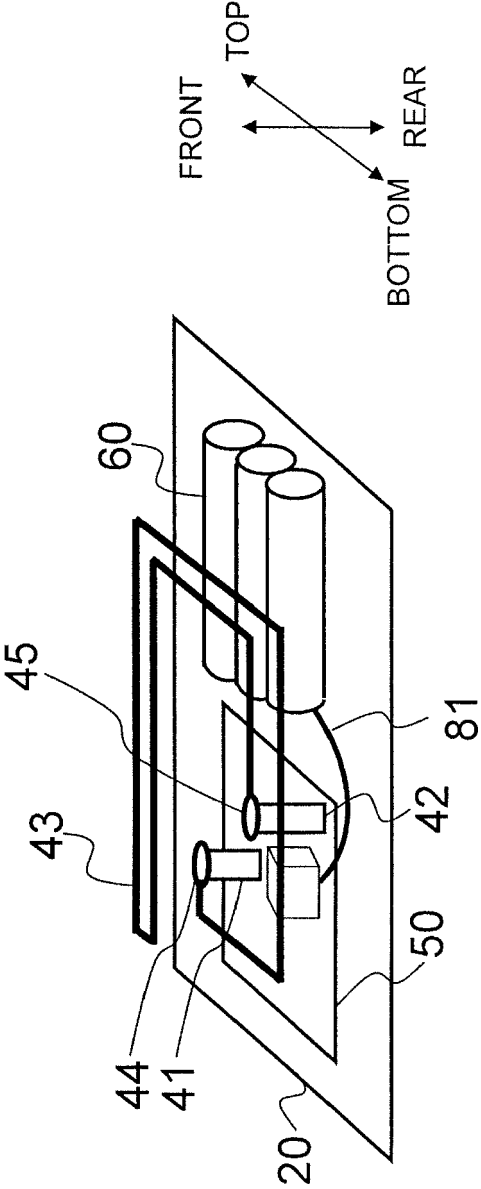


FIG.6

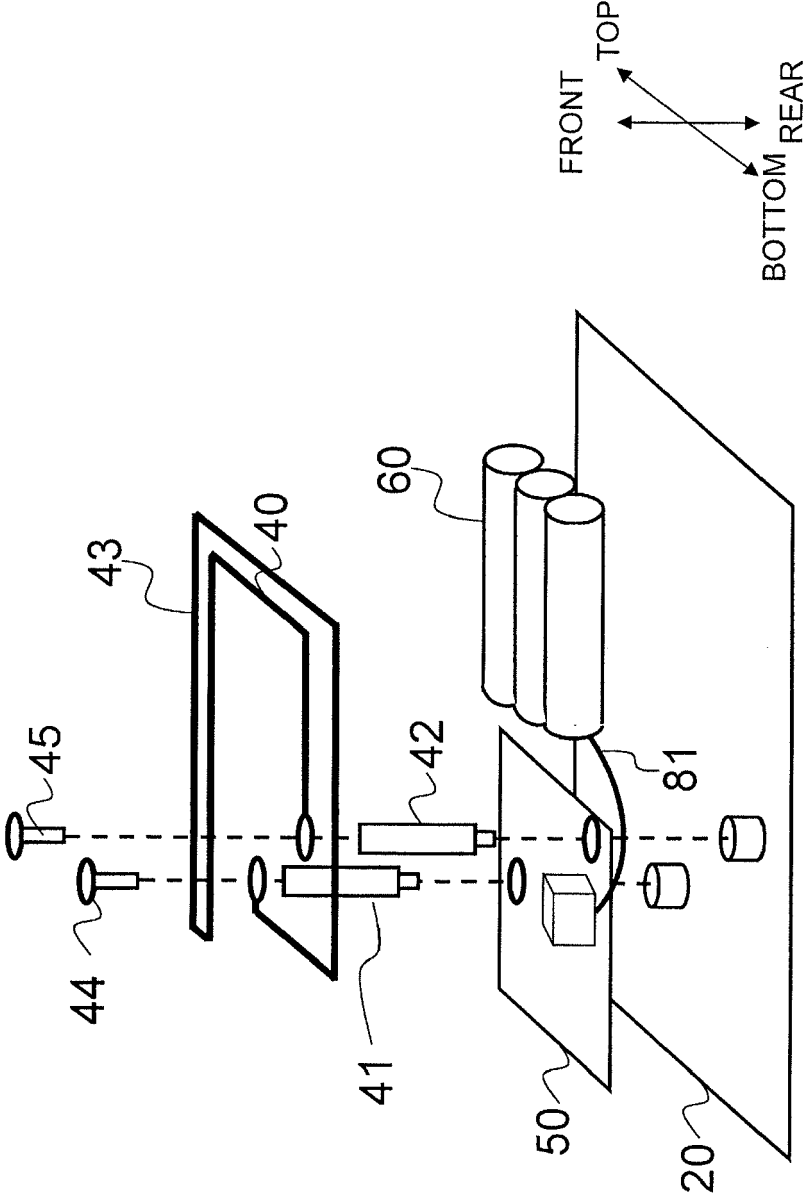
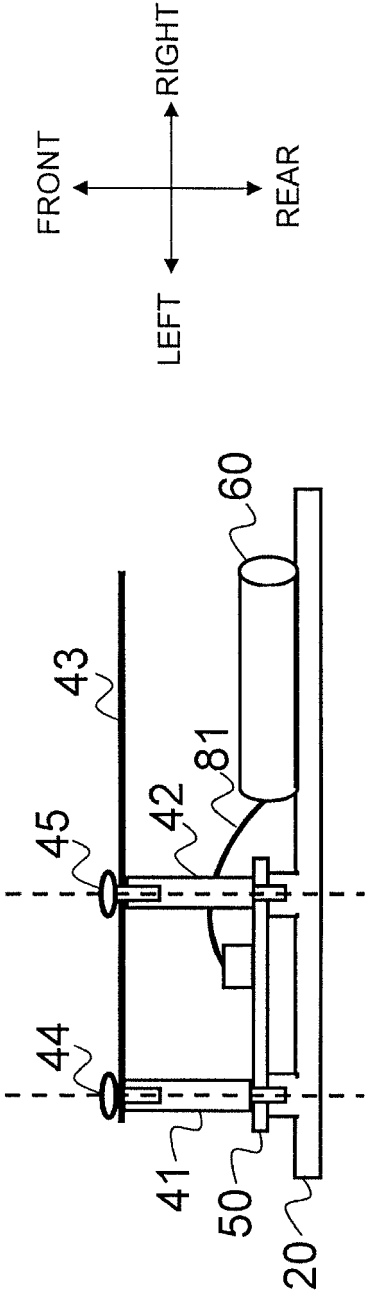
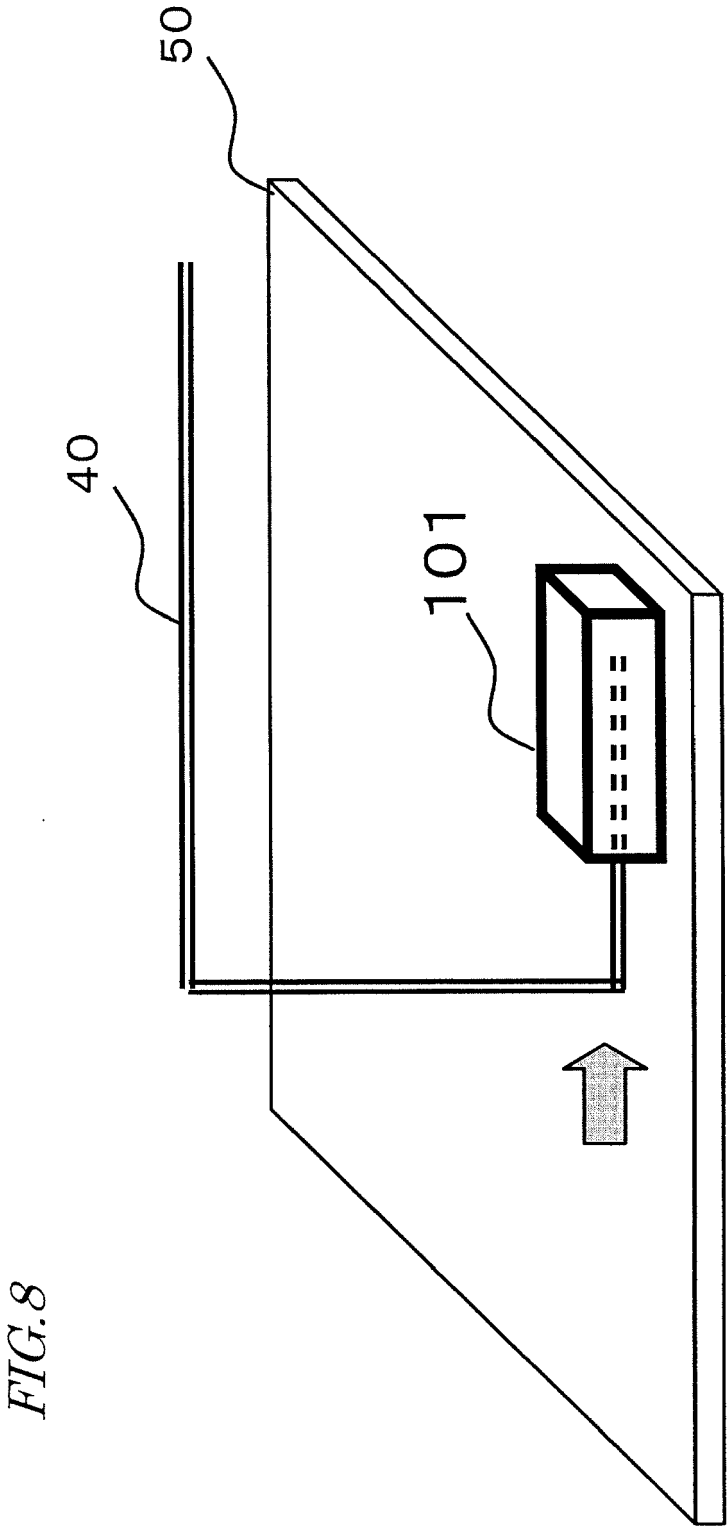
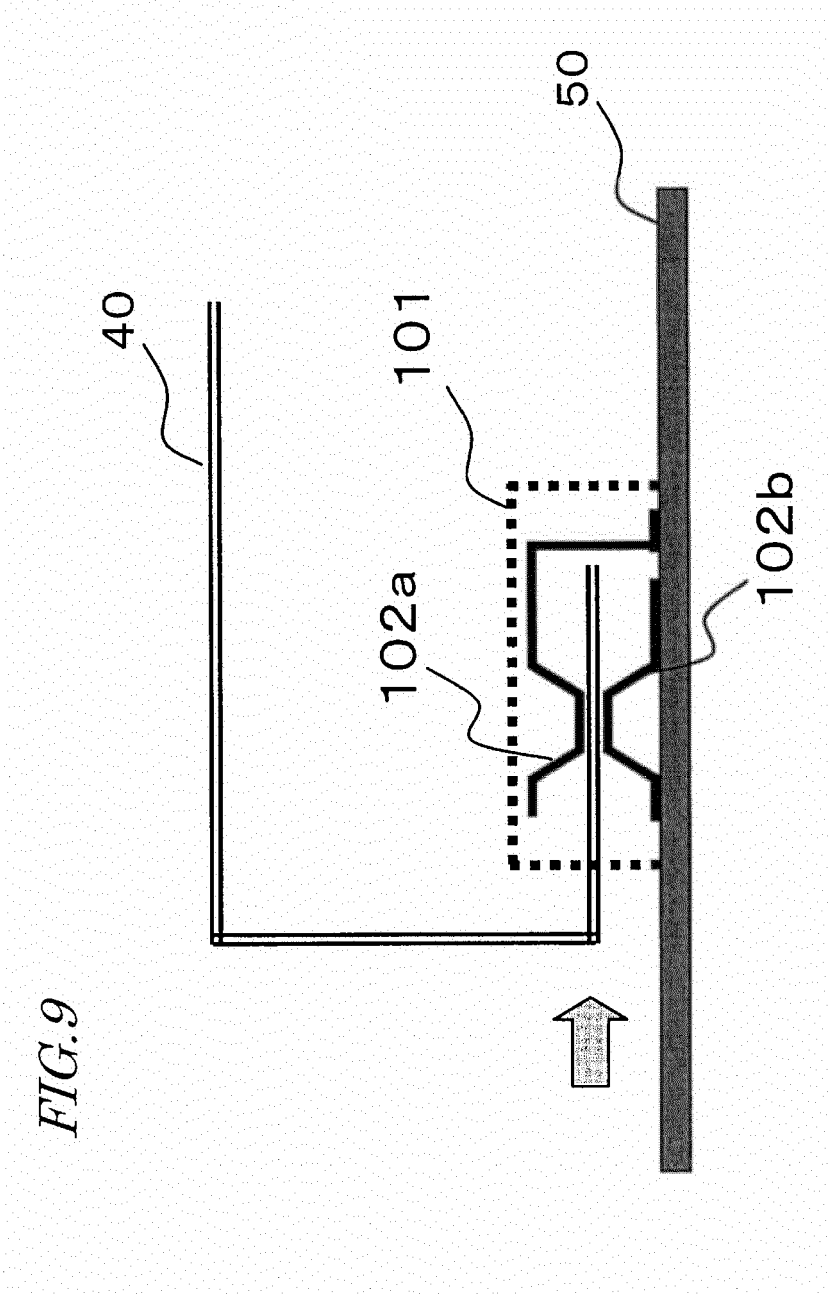
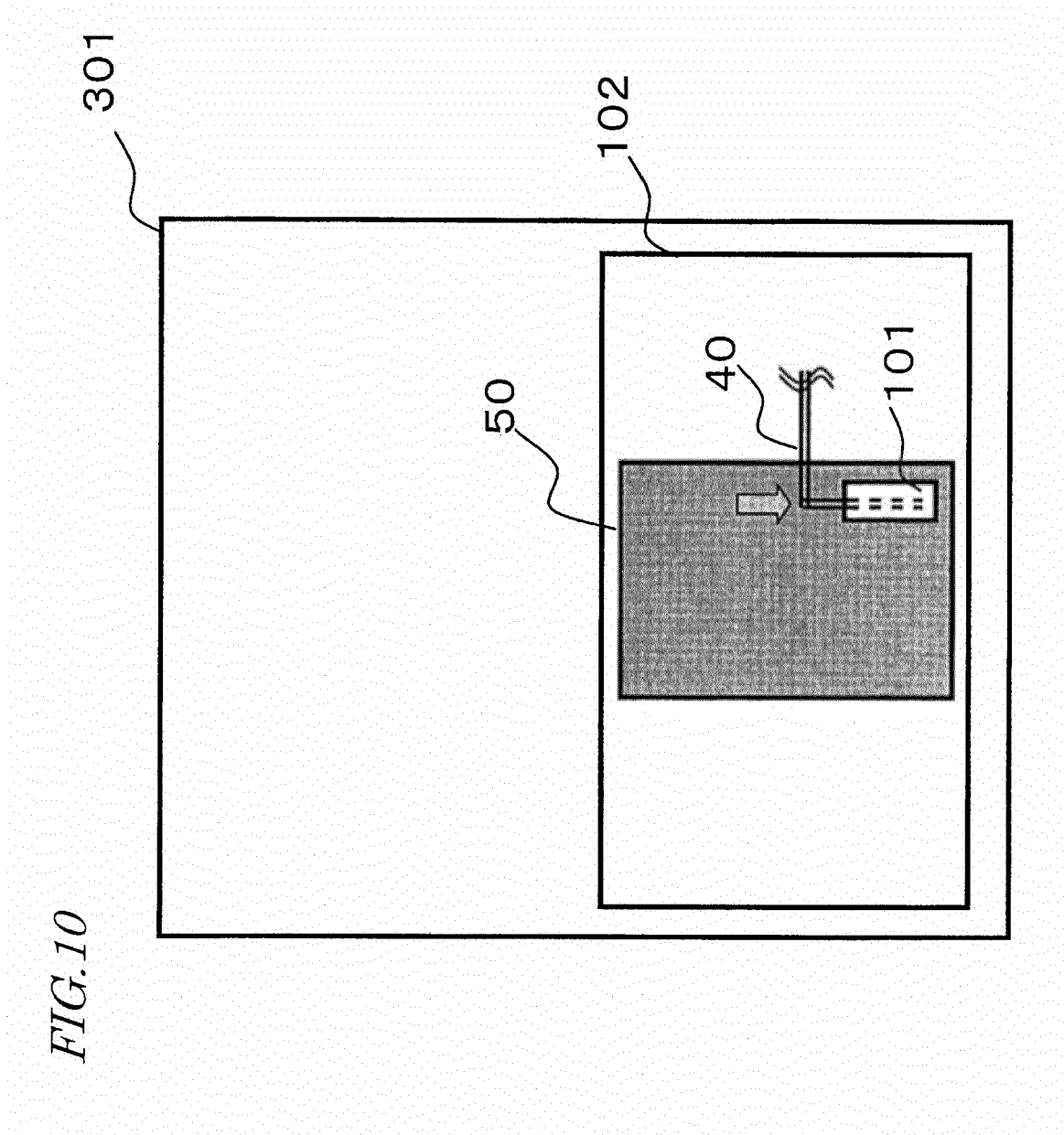


FIG. 7











EUROPEAN SEARCH REPORT

 Application Number
EP 14 16 8459

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			H01Q
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Place of search The Hague		Date of completion of the search 13 October 2014	Examiner Hüschelrath, Jens
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