(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) **World Intellectual Property Organization**
International Bureau

(43) **International Publication Date**
06 August 2020 (06.08.2020)

WIPO | PCT

(10) **International Publication Number**
WO 2020/156684 A1

(51) **International Patent Classification:**
G05D 1/02 (2006.01)

(21) **International Application Number:**
PCT/EP2019/052551

(22) **International Filing Date:**
01 February 2019 (01.02.2019)

(25) **Filing Language:** English

(26) **Publication Language:** English

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

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) **Title:** SELF MOVING DEVICE AND MAGNETIC BOUNDARY SYSTEM

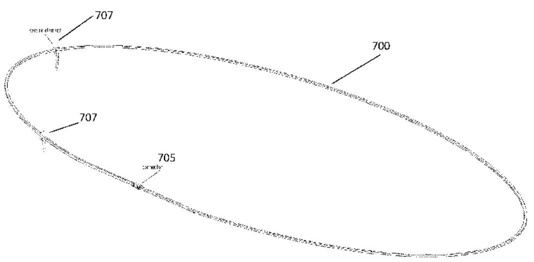

Figure 7

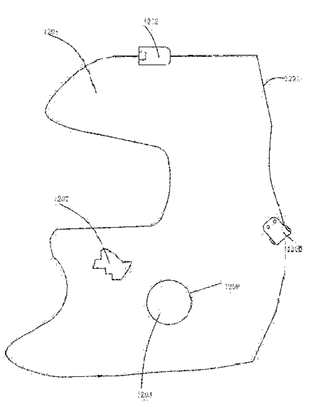

Figure 3B

(57) **Abstract:** A self moving device and control method are disclosed in which the self moving device comprises a magnetic field sensor for detecting a static magnetic field in the vicinity of the device. The method comprises instructing the device to retreat in response to detection of a first predetermined pattern of the magnetic field strength detected by the magnetic field sensor, verifying that the retreat instruction has been executed based on detected magnetic field strength, and generating an alert if the retreat instruction is not executed A magnetic boundary system comprises a magnetic strip having two ends and a connector, wherein: the magnetic strip provides a magnetic field having a polarity in a direction transverse to the length of the magnetic strip, the connector is designed to connect one end of the magnetic strip to the other end or to one end of a similar magnetic strip, and the strip and connector are designed such that the strip is prevented from rotating in the connector and the ends are accommodated such that the angle between the polarities is less than 180 degrees.

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SELF MOVING DEVICE AND MAGNETIC BOUNDARY SYSTEM

[0001] The invention is in the field of self moving devices, also commonly known as autonomous vehicles, such as but not limited to devices for performing domestic tasks for example robotic lawn mowers and vacuum cleaners. The invention also relates to methods of controlling self moving devices, systems for defining areas in which such devices may or may not operate and systems comprising one or more self moving devices.

Background

[0002] It is sometimes desirable to restrict an area in which a self moving device travels, for example by defining an area into which the device is prevented from entering or an area within which the device is confined. It is known to restrict the travel of a robotic lawn mower using a wire in which an electric field is induced in combination with an inductive sensor in the lawn mower. This has a number of drawbacks including the need to induce the magnetic field, which requires a device which consumes power and is cumbersome to rearrange to accommodate required changes in the defined area.

[0003] Some embodiments of the invention described below solve some of these problems. However the invention is not limited to solutions to these problems.

Summary

[0004] In some aspects the invention provides a self moving device comprising: a housing, a moving module mounted on the housing and drivable to cause the device to move, a magnetic field sensor for detecting a static magnetic field in the vicinity of the device, and a control module configured to control the moving module based on signals received from the sensor. The control module may be configured to: instruct the device to retreat in response to detection of a first predetermined pattern of magnetic field strength detected by the magnetic field sensor, verify that the retreat instruction has been executed based on detected magnetic field strength, and generate an alert if the retreat instruction is not executed.

[0005] In some aspects the invention provides a method of controlling the operation of a self moving device comprising a magnetic field sensor for detecting a static magnetic field in the vicinity of the device, the method comprising: instructing the device to retreat in response to detection of a first predetermined pattern of the magnetic field strength detected by the magnetic field sensor, verifying that the retreat instruction has been executed based on detected magnetic field strength, and generating an alert if the retreat instruction is not executed

[0006] In some aspects the invention provides a computer readable medium comprising instructions which, when implemented in a processor in a self-moving device, cause the processor to implement any of the methods described herein.

[0007] In some aspects the invention provides a magnetic boundary system comprising a magnetic strip having two ends and a connector, wherein: the magnetic strip provides a magnetic field having a polarity in a direction transverse to the length of the magnetic strip, the connector is designed to connect one end of the magnetic strip to the other end or to one end of a similar magnetic strip, and the strip and connector are designed such that the strip is prevented from rotating in the connector and the ends are accommodated such that the angle between the polarities is less than 180 degrees

[0008] In some aspects the invention provides a system comprising any of the self moving devices and any of the magnetic boundary systems described herein.

[0009] The term "static" is used herein with reference to a magnetic field to refer to a magnetic field having an intensity and direction that does not vary over time.

<u>Brief Description of the Drawings</u>

[0010] Embodiments of the invention will be described, by way of example only, with reference to the accompanying drawings, in which:

[0011] Figure 1 is a schematic diagram of a self moving device according to some embodiments of the invention, in the form of a lawn mower;

[0012] Figures 2(a) and 2(b) are schematic diagrams showing the mounting of a magnetic field sensor according to some embodiments of the invention;

[0013] Figure 3A is a plan view of a working area defined by a continuous conductive cable according to some embodiments of the invention;

[0014] Figure 3B is a plan view corresponding to figure 3A showing a magnetic strip installed around an area from which a device is to be excluded, according to some embodiments of the invention;

[0015] Figure 4A is a graph of field strength versus time in a first implementation according to some embodiments of the invention;

[0016] Figure 4B is a graph of magnetic field strength versus time in a second implementation according to some embodiments of the invention;

[0017] Figures 5(a) and 5(b) schematically illustrate respectively two strips of passive magnetic material joined such that their polarities are oriented at an angle of 180 degrees with respect to each other and the same two strips facing each other such that their polarities are aligned according to some embodiments of the invention;

[0018] Figure 6 schematically illustrates two strips of magnetic material arranged such that their polarities are oriented perpendicular to each other according to some embodiments of the invention;

[0019] Figure 7 shows a magnetic boundary system according to some embodiments of the invention;

[0020] Figure 8(a) shows a magnetic strip in a possible stored configuration and figure 8(b) shows the strip in cross section according to some embodiments of the invention;

[0021] Figure 9 schematically illustrates two strips of magnetic material arranged such that their polarities are oriented perpendicular to each other, ready for insertion into a connector according to some embodiments of the invention;

[0022] Figures 10(a) and 10(b) show two strips of magnetic material inserted into a connector according to some embodiments of the invention, with the connector in open and closed configurations;

[0023] Figure 11 is an enlarged perspective view of the connector of figure 10 prior to insertion of magnetic strips; and

[0024] Figure 12 is a flowchart illustrating a method according to some embodiments of the invention.

Detailed Description

[0025] Embodiments of the present invention are described below by way of example only. These examples represent the best ways of putting the invention into practice that are currently known to the applicant although they are not the only ways in which this could be achieved.

Self Moving Device

[0026] Figure 1 is a schematic diagram of a self moving device according to some embodiments of the invention in the form of an automatic mower 1. The automatic mower 1 includes a housing or 3 and a moving module 5. The moving module 5 may for example comprising one or more wheels driven by a driving motor (not shown) to actuate the automatic mower 1 to move forwards or backwards and/or to execute turns. Embodiments of the invention may comprise other kinds of moving module as known in the art as appropriate to the device propulsion system. Embodiments of the invention may include so called "floating chassis" devices, which have a chassis that can contact the ground and can be lifted by a lying obstacle on the ground. The mower further comprises a primary working module 7, for example including a cutting blade disc and driven by a cutting motor (not shown) to perform mowing. In use, a control module (not shown) which may be situated in a primary cavity 31 in the housing 3 controls the moving module 5 to actuate the automatic mower 1 to move, and controls the primary working module 7 to perform mowing. The moving module 5, the primary working module 7, and the control module are all mounted on the housing 3. The control module may comprise a processor and a memory and may be configured to perform various functions in use. For example, the processor may be programmed to cause the control module to control the primary working module 7 and/or the moving module 5, for example in response to signals from one or more sensors which may be in the form of sensing modules. The mower 1 of figure 1 comprises various cavities 32, 33, 34, 35, formed at various places in the housing 3, for accommodating other components not described further herein. A communication system or network may be provided to connect the control module to the moving module 5, the working module 7 and to one or more sensing modules. The communication system or network may comprise a CAN bus for example.

[0027] The mower 1 of figure 1 comprises a magnetic field sensor 13 for detecting static magnetic fields in the vicinity of the mower, shown in figure 1 as a separate module which may be mounted on the mower, for example on the housing or on the wheels. A self moving device according to some embodiments of the invention may comprise more than one magnetic field sensor 13. The magnetic field sensor 13 may be mounted at any suitable location on the mower 1, for example at a lower part of the device, such as inside or on the underside of the housing 3. With such a magnetic field sensor, a magnetic field external to a device may then be provided to limit the travel of the device, e.g. mower. For example the magnetic field may be provided by using a passive magnetic device, e.g. permanent magnet. The passive magnetic device may be in the form of a magnetic strip. Self-moving devices according to some embodiments of the invention may comprise more than one magnetic field detector. In the following, embodiments comprising one magnetic field detector are described by way of example and the invention is not limited to such embodiments.

[0028] The self moving device may be designed such that the magnetic field sensor 13 may operated with a clearance from the surface on which it is working, e.g. the ground. Embodiments of the invention are not limited to particular dimensions, the following suggesions for magnetic field sensor height are provided merely as examples. In general the distance between the magnetic field sensor 13 and the ground may vary for example depending on a task which the self moving device is to perform. For a lawn mower a distance of greater than 2cm, or possibly 6cm, is suitable, and possibly more than 9 cm, with the maximum distance being between 10cm and 15cm or possibly between 10cm and 20cm. It will be appreciated that a device may be designed with a magnetic field sensor at a predetermined distance from the lowermost point of the device, e.g. the lowest point of the wheels or, in the case of a floating chassis device the lowermost point of the chassis. Thus the minimum height of the sensor from the lowest point of the device is zero and a suitable maximum for a floating chassis or any other kind of device is the height of the self-moving device, which may be around 20cm. Where the chassis is not floating, e.g. fixed, and the sensor is mounted on the chassis, the sensor position may hinder the travel of the device. Here a suitable minimum height may be 2cm. A suitable range of height is 6-11cm.

[0029] Figures 2(a) and 2(b) are schematic diagrams showing a possible position of mounting of a magnetic field sensor on a self moving device such as a mower according to some embodiments of the invention. Figure 2(a) and figure 2(b) are partial perspective views of the automatic mower 1 from below. As shown in figure 2(a) and 2(b), in this embodiment, a position reserved on the housing 3 of the automatic mower for the magnetic field sensor 13, for example in the form of a module, is located at a lower part of the housing 3, to help the magnetic field sensor 13 to sense a magnetic field, for example from a magnetic strip, and to generate a corresponding signal which may indicate the strength or magnitude of a detected magnetic field. The magnetic field sensor may comprise a sensor such as a Hall sensor or a triaxial geomagnetism sensor , for example as described in US8712623. A self moving device according to some embodiments of the invention may comprise a filter for filtering signals detected by the magnetic field sensor, for example to eliminate noise such as background noise. A self moving device according to some embodiments of the invention may comprise more than one magnetic field sensor in which case noise may be eliminated without or with reduced use of a filter, for example by using a difference algorithm. The magnetic field sensor 13 may generate a signal at regular intervals which is transmitted to the control module, for example via a wired connection such as a CAN bus as mentioned elsewhere herein. The magnetic field sensor may be part of a sensing module including a processor which may process sensing signals before being transmitted to the control module.

[0030] The mounting position of the magnetic field sensor 13 may be such that there is no shielding by any metal object below the device, to prevent a signal from a magnetic field from being interfered with. For example the magnetic field sensor 13 may be protected by a cover having magnetic permeability substantially equal to 1. In this embodiment, the magnetic field sensor 13 not only is mounted on the lower part of the housing 3, but also is mounted towards the front of the housing 3, to help the magnetic field sensor to 13 detect, in a timely manner, a magnetic strip arranged in a direction along which the automatic mower 1 moves, and take an avoidance measure in a timely manner. In this embodiment, a cover plate 131 is disposed for a secondary cavity 33 in which the magnetic field sensor 13 is mounted, and before and after the magnetic field sensor 13 is mounted, the secondary cavity 33 may be covered by the cover plate 131, to prevent water vapour or dirt from entering the secondary cavity 33. It is advantageous for the magnetic field sensor to be positioned away from or shielded from any motor comprised in a self moving device, such as a motor for driving a moving or working module.

Magnetic Field Sensing

[0031] Some embodiments of the invention provide a self moving device comprising one or more sensing modules each comprising a sensor for sensing a static magnetic field, such as the magnetic field sensor 13 described with reference to figures 1 and 2. The ability, in a self moving device, to detect static magnetic fields may be additional to detection of varying magnetic fields using a boundary inductive sensor as described elsewhere herein and thus the device may comprise one or more inductive sensors. However, the detection of both static and varying magnetic fields is not essential in all embodiments of the invention.

[0032] The device may be configured to retreat from, for example turn away or reverse in response to detection of a first predetermined pattern of magnetic field strength, such as but not limited to a rise in static magnetic field strength above a predetermined field strength threshold. This may be achieved for example by suitable programming of a processor in a control module. The operation of a self moving device in this way is suitable for all kinds of self moving device, such as but not limited to devices for performing domestic tasks such as lawn mowers and robotic floor cleaners, and is not limited to the devices described herein. The sensing of a static magnetic field may be a function of a removable module or may be a permanent part of a device according to some embodiments of the invention. A "turn" may be executed in any manner known in the art. For example it may be executed "on the spot" for example by driving one wheel of a pair while the other remains stationary or rotates at a different speed, or it may be a multipoint turn in which the device first reverses. The turn may not be immediate but may instead take place after a predetermined time delay, for example to allow for signal processing and/or filtering. The term "turn" is generally used herein in connection with a device that has a defined front and rear and that is configured to turn so that the front is forward as the device retreats. Devices according to some embodiments of the invention may not have a defined front or rear and may retreat by travelling away with the opposite end forward relative to the direction in which it approached.

[0033] The control of the device based on magnetic field strength may be achieved through the use of a suitably programmed processor within a control module, in response to signals received from a sensing module, or may be partially achieved through the use of a processor comprised in a sensing module, such as a module comprising magnetic field sensor 13, which may for example also comprise a signal processor.

[0034] The use of permanent magnetic fields to control self moving devices within buildings is known, for example for the control of robots in factory environments, to define a track along which a device should move. By contrast, according to some embodiments of this invention, a static magnetic field may define a boundary from which the device, e.g. lawn mower or other outdoor working device, should turn away or otherwise retreat, for example using one or more passive magnetic devices. A passive magnetic device may be in the form of a strip of magnetic material.

[0035] A static or permanent magnetic field has the advantage that no signal generation is required and therefore it does not need to be connected to a power supply and/or signal generator. This leads to another advantage in that the magnetic field, e.g. magnetic material, may be easily repositioned, especially if the magnetic material comprises a flexible material, for example in the form of a flexible strip. However a strip of flexible magnetic material may be expensive relative to an electrically conductive cable. Therefore, whilst a passive magnetic device may be used according to some embodiments to define an outer boundary for a self moving device, according to some embodiments of the invention, a strip of magnetic material may be positioned around an area within a working area of the device from which the device is to be excluded. This may be for example a flower bed, or a less permanent feature such as an area of newly sown grass seed. The external perimeter of the working area may be defined by a method known in the art, such as an electrically conductive cable and a generator for generating a varying magnetic field in the conductive cable.

[0036] The use of a permanent magnetic field in addition to defining the external perimeter of the working area in a different way avoids some problems associated with the use of electrically conductive cable. Figure 3a shows a working area defined by a continuous conductive cable which may be used in some embodiments of the invention. In figure 3a a working area 1201 is defined by a continuous cable 1211, connected to a generator 1212. The cable 1211 extends around the external perimeter of the working area 1201 and extends into the working area as indicated by cable lengths 1211a, 1211b to surround an internal area 1203 from which the device 1205 is to be excluded. The device 1205 may be controlled to turn away or otherwise retreat from a magnetic field induced in the cable and will therefore depending on the positioning of the cable the device may not cross the cable lengths 1211a, 1211b, extending from the external perimeter of the working area 1201 to the internal area 1203. This may restrict the movement of the device in an undesirable way and may lead to inefficient coverage of the working area by the device 1205. Alternatively if the two cable lengths 1211a and 1211b are closely positioned, the magnetic field in those lengths may be cancelled as a result of the current flowing in opposite directions in the two cable lengths. This may require very precise positioning of the cable 1211. Either way, it may be desirable to use a different system for defining a working area, for example to accommodate temporary working areas, for example areas from which a self-moving device is to be temporarily excluded such as where grass seed is newly sown or areas in which it is to be temporarily retained.

[0037] Figure 3b is similar to figure 3a and shows the external perimeter of the working area defined by a continuous conductive cable 1211 with the internal area 1203 defined by a separate stationary magnetic closed loop 1209, for example in the form of a strip of magnetic material.

[0038] The use of a stationary magnetic field as opposed to an induced magnetic field may pose new problems for detection and controlling a device 1205 to turn or otherwise retreat. When an inductive sensor crosses an induced magnetic field, for example when crossing over a cable, the polarity of the field changes and therefore the exact crossing moment is known. This polarity reversal does not occur with a stationary magnetic field. Furthermore, especially in exterior environments, additional problems may be present in the form of other stationary magnetic fields in the working area, for example due to buried items of magnetic material.

[0039] Figures 3A and 3B also show an obstacle 1207 in the working area referred to elsewhere herein.

[0040] According to some embodiments of the invention, on initial powering on of the device 1205, a background level static magnetic field strength is determined. This may take place while the device 1205 is stationary, or it may take place during a first calibration operation in which the device1205 is controlled to move over a part of the working area. The background static magnetic field strength may be used to determine a new "zero" from which a threshold may be determined. In other words, a predetermined threshold at which the device may be caused to retreat may be determined to be above the background magnetic field level.

[0041] It will be appreciated that in a situation where two boundaries are provided between which the device is to travel, the distance between the two boundaries should be greater than the width of the self moving device. For example, where a passive magnetic device is used to define an inner boundary as shown for example in figure 3B, the distance of the passive magnetic device from the outer boundary should be greater than the width of the self moving device.

[0042] According to some embodiments of the invention, the device 1205 may be further controlled to avoid it crossing into an area bounded wholly or partially by a static magnetic field. This may be desirable to ensure that the device does not travel outside an area in which it is to be confined or to ensure that the device does not travel into an area from which it is to be excluded, and thus may act as an additional "failsafe". An additional failsafe mechanism solves the general technical problem of improving the reliability of a device in not traveling where it should not. It may also solve at least one more specific problem, for example differentiating a passive magnetic device such as a strip from a background source such as buried magnetic material, or providing specific location information relative to a boundary, for example whether the device is inside or outside the boundary.

[0043] In the specific case of lawnmowers for example, it may be a requirement that the mower cannot operate outside a working area, and therefore the mower must know whether it is inside or outside of a working area which is defined by a boundary, and stop working if it is outside the working area. The same may apply regardless of the technology used to define the working area and therefore it is desirable to verify that a self moving device has retreated from the boundary, either by reversing or by executing a turn or both.

[0044] Notably according to some embodiments of the invention, this additional failsafe may be based on the detection of magnetic field strength, rather than for example using different sensing technology. A failure to retreat, e.g. to successfully execute a retreat instruction, may occur for example in a situation in which the device is prevented from executing a turn as instructed by the control module in response to detection of a predetermined pattern of magnetic field strength such as a rise above a predetermined threshold or a peak in magnetic field strength. There may be various causes for this including but not limited to a mechanical failure in the device turning mechanism. The further control may be achieved for example by analysing the magnetic field strength as the device 1205 moves to verify that it is moving away from the area, for example to verify that a retreat e.g. turn instruction has been successfully executed. This is useful not only as a failsafe but also in determining the location of the device to provide information to augment location information provided by one or more other movement or location sensors on the device such as a gyroscope. Such location information may not for example verify that a device has performed a retreat manoeuvre, e.g. turn, if it reverses by a small distance before turning. For example, the control module may be configured to verify that the retreat, e.g. turn, has been executed based on detected magnetic field strength and to generate an alert if the retreat is not executed. The alert may be in the form of a stop instruction, for example from the control module to the moving module, as a result of which the device stops moving. The verification may involve detecting one or more events, or predetermined patterns in magnetic field variation, associated with the device approaching and retreating from the area respectively. The event(s) or pattern(s) may be predetermined patterns in the variation of detected magnetic field strength as the device moves. For example, the device 1205 may be configured to detect a first predetermined pattern associated with the device approaching the area and a second predetermined pattern associated with the device retreating from the area. The detection of the first predetermined pattern may trigger the device to retreat, e.g. trigger a retreat instruction by the control module. If the second predetermined pattern is not detected, this could be indicative of an error or other fault in the detection of the static magnetic field, an obstacle preventing the device from turning or otherwise retreating or some other problem. In such a situation the device 1205 may be configured to stop to avoid it continuing into the excluded area. The non-detection of the second predetermined pattern may be indicated for example by the time between detection of the first and second predetermined pattern exceeding a predetermined threshold, and an alert may be generated which may lead to the device 1205 stopping.

[0045] The first and second predetermined patterns may be detected by analysis of variations in magnetic field strength as the device 1205 moves forward and then retreats, for example by performing a turn or other retreat manoeuvre. The analysis may be carried out at the sensing module or at a control module. The device may be agnostic to the area from which it is excluded. This is in contrast for example to devices which are pre-programmed to follow a particular path. The first and second patterns may be associated with the device 1205 respectively approaching and retreating. The patterns may be independent of the source of the magnetic field.

[0046] Two examples of first and second patterns are described with reference to figures 4A and 4B.

[0047] Figure 4A shows variation of magnetic field strength with time as a device approaches and retreats from a static magnetic field, such as might occur for example if the device does not cross a magnetic strip. As the device approaches the static magnetic field, such as might be present in a strip of magnetic material, the strength of the magnetic field as detected by a static magnetic field sensor, e.g. Hall sensor, increases from a background or noise level n to a threshold th at time t1. The increase in detected field strength above the threshold level may be a first predetermined pattern. The device may be controlled to begin to retreat as soon as the first predetermined pattern is detected. At this point the device may not be touching the magnetic material and the magnetic field strength may continue to increase, for example if the robot executes a turning manoeuvre or slows down in a forward direction before retreating, to a peak before decreasing as the device retreats to below the threshold at time t2. Thus according to some embodiments of the invention a first predetermined event or pattern may be the magnetic field strength rising above the predetermined threshold and the second predetermined event or pattern may be the magnetic field strength falling below the same or a different predetermined threshold. The thresholds for the first and second predetermined patterns do not need to be exactly the same.

[0048] The rate of increase of the magnetic field and the time interval between t1 and t2 will depend on a number of factors including the speed of travel of the device and the angle at which the magnetic field is approached by the device. The device may be controlled to slow down as the magnetic field strength increases from the background level between times t0 and t1, and to speed up after time t2 as the magnetic field strength decreases. Therefore each of the first and second predetermined patterns may be further defined by a minimum or maximum rate of change of magnetic field strength.

[0049] In some configurations of device and magnetic field or boundary, the device may be controlled to cross the magnetic boundary, or at least for the magnetic field sensor to cross the boundary, before completing a turn or other retreat manoeuvre, in which case the magnetic field strength may begin to decrease before the retreat manoeuvre has been completed. The "crossing" may simply result in the device straddling the boundary rather than crossing it completely. Either way this may result in the magnetic field strength detected by the magnetic field sensor 13 decreasing from a maximum as the device continues towards or into an area from which it is prohibited. This may require positioning of magnetic material at a minimum distance away from the area from which the device is to be excluded for example to ensure that the device does not enter an area before a retreat manoeuvre is complete. In general a boundary wire or other means defining a boundary may be positioned at a distance from an area boundary. In the case where the device is designed to cross the boundary, this distance may need to be larger than in a case where the device is designed not to cross the boundary. The change in magnetic field strength is illustrated graphically in figure 4B, where the magnetic field strength increases from the background level n at t9, crosses the predetermined threshold th at t1, and increases to a peak or maximum at t2, and decreases to a minimum at t3 (which may be above or below th). The decrease may be the result of the device overrunning, for example due to continued momentum, after receiving an instruction to retreat. Alternatively according to some embodiments of the invention the control module may be configured to instruct the device to retreat after detecting that the static magnetic field strength has begun to decrease so that it returns towards the boundary. The detected magnetic field strength then increases to a second peak or maximum at t4, decreases past the predetermined threshold at t5 and returns to the background level at t6. In this example, the first and second predetermined patterns associated with the device approaching and retreating may be peaks in the magnetic field strength. The predetermined patterns may be the same or they may be different. For example they may be predetermined to have different ranges of rate of change in one or both of increase and decrease of detected field strength.

[0050] The embodiment of the invention demonstrated in figure 4B is useful to avoid erroneous operation caused by anomalies in the background magnetic field, such as might be caused by buried magnetic items in the working area. A buried magnetic item might produce a single peak in magnetic field strength as a device approached and retreated from it. The detection of two peaks as shown in figure 4B enables a device to behave differently when encountering a large buried magnetic object from when encountering a magnetic strip defining a boundary. As with the embodiment of figure 4A, an alert may be generated if the time between two events or detected predetermined patterns in field strength variation, exceeds a predetermined time, and this may result in the mower stopping, possibly to be manually repositioned while the cause of the error is investigated. In the case of figure 4B the predetermined patterns are peaks in the variation of magnetic field strength. The embodiment of figure 4B is one example in which first and second predetermined patterns may be the same or substantially the same, for example differing only in the time at which they occur. In other words, the second predetermined pattern may be a second occurrence of the first predetermined pattern. The use of the same first and second patterns is not limited to the detection of peaks in field strength.

[0051] It will be appreciated that with some embodiments of the invention, whether or not the self moving device is intended to cross the boundary, it may be necessary to position the passive magnetic device at a minimum distance from the area from which the device is to be excluded.

[0052] There is thus described in the foregoing a method of controlling the operation of a self moving device, illustrated in more detail in figure 12. The method of figure 12 may be implemented in a processor in a control module or a sensor module or may be shared between one or more processors. The method may be a subroutine of a larger process. The method commences with initialisation at operation 1200 following which at operation 1202 a magnetic field threshold may be determined, if not already predetermined, for example with reference to a background magnetic field as described elsewhere herein. At operation 1204, signals indicating magnetic field strength are received and analysed to determine whether a first predetermined pattern of magnetic field variation is present. At operation 1206 it is determined whether the predetermined pattern is present and if not the the flow returns to operation 1204 where the reception and analysis of signals continues. If the first predetermined pattern is detected, a turn is instructed at operation 1208 and a timer is started at operation 1212. Then at operation 1213 further signals are received from the sensor indicating field strength and analyzed to determine whether a second predetermined pattern of magnetic field variation is present. These are used at operations 1214 and 1215 to determine whether the turn took place, for example according to the methods described elsewhere herein. For example according to some embodiments of the invention, operation 1214 may comprise analyzing signals receive d from the sensor to determine variations in magnetic field strength over time, as the device moves, to identify a second predetermined magnetic field strength patter. If the pattern is identified, the method returns to operation 1204 to receive and analyze further signals from the sensor. If the second predetermined pattern is not identified within a predetermined time monitored at operation 1215, it is determined that the turn did not take place an alert is generated at operation 1216. The method then stops at operation 1218. The reason for the failure to turn may be investigated in ways not described further herein. Operations 1212, 1213 and 1214 show one example of verification that a turn has taken place. Other methods of turn or retreat verification are possible.

Magnetic Boundary System

[0053] The magnetic boundary such as the closed loop 1209 shown in figures 3A and 3B may be formed from a continuous length of magnetic material, which may for example be cut either to a predetermined length by a supplier or to a desired length by a user. The positioning of the boundary may involve problems with the fixing of the cut or free ends of the magnetic material, and therefore in some aspects the present invention provides a magnetic boundary system comprising a magnetic strip having two ends and a connector for connecting the two ends of the magnetic strip to each other (or for connecting one end of one strip to one end of a similar strip). Of course any number of connectors may be provided in a system according to the invention and either one strip to be cut or any number of strips may be provided. The strip may be flexible. This may enable it to be positioned in a variety of shapes to define an area within which a device may be confined to travel or from which the device may be excluded. The invention in some aspects also provides a system comprising a self moving vehicle as described herein and a magnetic boundary system.

[0054] A magnetic strip may have a magnetic field, or polarity, in a direction transverse to the length of the strip, which may be substantially uniform for the whole length of the strip. In that case, in order to join the ends of the strip with the magnetic field in alignment, the natural forces of magnetic repulsion need to be overcome. Since opposite poles attract, the two ends of the strip will attract each other so that they tend to join such that the magnetic field directions in the two ends are reversed with respect to each other. In other words, the natural tendency of the two ends is to join such that the polarities of the magnetic fields in each of the ends are oriented at an angle of 180 degrees with respect to each other. The result is that the magnetic field at the region where the ends join is to some extent cancelled and a "blind zone" is created where the two ends meet, where the magnetic field may not be sufficiently strong to be detected by a sensor on a moving device. This is illustrated in figure 5(a).

[0055] Figures 5 (a) and 5(b) show two magnetic strips 501, 502 each having a magnetic field with a polarity indicated by a north (N) to south (S) arrow, oriented transverse to the length of the strip, in this case perpendicular to the length of the strip. The two magnetic strips 501, 502, may be the opposing ends of a continuous strip. In figure 5(a) the two strips are joined by mutual attraction, such that the magnetic fields in each of the ends are oriented at an angle of 180 degrees with respect to each other, and a "blind" zone is formed, indicated schematically by the dotted rectangle 503, where the magnetic field detectable by a sensor is null or greatly reduced. Figure 5(b) shows the two strips facing each other with the magnetic field aligned. This is more difficult to achieve in practice but does not result in a "blind" zone.

[0056] According to some embodiments of the invention, the strip is designed so that its orientation relative to another similar strip or the orientation of the end of one strip with respect to the other can be determined. This may be achieved for example by the strip having a non circular cross section. It may be square for example. The strip may be designed so that the orientation of the magnetic field can be identified, for example visually without the need for additional equipment. This can be achieved in various ways including by visual marking on the strip and/or the strip having a non circular cross section. The connector is designed to accommodate the ends of the magnetic strip so as to prevent the polarities in the respective ends from being oppositely oriented, e.g. to prevent the polarity of one end being oriented at an angle of 180 degrees with respect to each other. The ends may be accommodated end to end (in other words ends facing each other). In order to achieve this, the strip and connector may be designed such that the strip is prevented from rotating in the connector, and the ends are accommodated such that the angle between the polarities is less than 180 degrees, for example by the strip having a non circular cross section, and the connector having suitably shaped slots to receive the strip ends in a particular orientation. In some embodiments, the ends of the strip may be held in the connector with the magnetic fields in the respective ends either aligned with each other or inclined to each other at an angle of less than 90 degrees. Therefore the undesired effect of the fields being reversed with respect to each other, e.g. at an angle of 180 degrees, may be mitigated.

[0057] An example orientation is shown schematically in figure 6 where the two strips or ends 501, 502 are positioned with the magnetic fields oriented perpendicular to each other. This achieves a compromise between the two situations of figures 5(a) and 5(b). A connector may be designed to hold the two strips in this or any other orientation between 0 and 90 degrees. It is not essential for the two ends to abut and a small gap may be acceptable depending on the operating parameters of the system. For example a 1-2 cm gap may be acceptable in a lawn mower system.

[0058] In principle the two strips, or the two ends 501 and 502 may be positioned such that they overlap and are thereby attracted to each other. Here a connector is still desirable in order to ensure that the two ends are not easily knocked apart in use. In the following, an embodiment of connector is described in which the respective fields are oriented at 90 degrees with respect to each other. This perpendicular, or substantially perpendicular, orientation is useful, especially when the surface of the passive magnetic device is not marked, to ensure that the user does not inadvertently connect the ends in the manner shown in FIG. 5A. It will be appreciated that the user may not notice or even be able to see a twist in a strip as it is laid and therefore may easily wrongly connect the ends. Therefore according to some embodiments of the invention, a connector may be designed such that the user is not able to connect the ends as shown in FIG. 5A.

[0059] Figure 7 shows a magnetic boundary system according to some embodiments of the invention comprising a magnetic strip 700 forming a magnetic closed loop, suitable for forming the closed loop 1209 described elsewhere herein. In use the longitudinal direction of the strip may be parallel to the surface on which a device, e.g. mower, travels. The system of figure 7 also comprises a connector 705 shown in a position connecting together the two ends of the strip 700. The system of figure 7 also comprises a plurality of pegs 707 for securing the strip 700 to the ground. Any kind of securing element other than a peg may be used in addition to or alternatively to the pegs 700 in a system according to some embodiments of the invention.

[0060] Figure 8(a) illustrates the magnetic strip 700 in a possible stored configuration in which the strip forms a spiral. Figure 8(b) illustrates a possible cross section of the magnetic strip. In general according to some embodiments of the invention the magnetic strip cross section may have an elongate cross section and therefore have a height and width with the height being greater than the width. This is an example of a strip designed such that the orientation of the magnetic field may be identified since the polarity may have a particular orientation relative to the height dimension, for example substantially parallel or substantially perpendicular to the height dimension. According to some embodiments of the invention, for example where the core cross section is rectangular, the shape of the cross section alone may not be sufficient to identify the direction of the polarity but it may be used to determine the orientation. In figure 8(b) the strip cross section is shown to be rectangular.

An oval cross section is also possible for example. It will be appreciated that with such a cross section the strip will be most flexible about an axis parallel to the height dimension, and therefore the strip will typically be positioned for use with the height mainly vertical, or perpendicular to the ground, except where it may be tilted for insertion into a connector.

[0061] The strip may comprise a core 700(a) of magnetic material. The strip may be flexible. Any suitable magnetic material known to those skilled in the art may be used. A suitable magnetic material is ferrite. A flexible core may be composed of ferrite magnetic power and rubber. The actual dimensions of the core may vary depending on several factors including the design of the device, particularly the height of the sensor from the ground which may be in the region 0-10 cm in some examples, the material of the strip, and other factors. An example of a suitable size for some situations is 4mm x 7mm.

[0062] According to some embodiments of the invention, instead of or in addition to a cross section with a height greater than the width, the strip may be marked to indicate the orientation and/or direction of the magnetic field, e.g. the polarity. The marking may be continuous along the length of the strip and may comprise for example different patterns or colours, for example on a protective cover, to denote the respective poles, as shown in figures 5 and 6. The connector may then be provided with suitable marking to indicate the intended orientation of the strip in the connector. As shown in the embodiment of figures 5 and 6, different surfaces of a passive magnetic strip may be marked to indicate the opposing poles of the magnetic field.

[0063] According to some embodiments of the invention, the passive magnetic device, e.g. magnetic strip, is provided with a protective cover, which may for example extend along the whole length of the strip so that the cover and the core may be cut to a desired length together. The rectangular strip in figure 8(b) has a cover 700(b). The cover 700(b) may be made from rubber and/or plastic material. It may be a waterproof and/or heat insulating material. The cover should be permeable to the passive magnetism, for example the magnetic permeability of the cover may be substantially equal to 1 in some embodiments of the invention, which is similar to the permeability of air. A filler material, not shown, may be disposed under the protective cover 700(b) to strengthen the magnetic strip, especially in the processing of the magnetic strip.

[0064] According to some embodiments of the invention, the connector 705 is designed to accommodate the ends of a magnetic strip end to end (in other words ends facing each other) so as to prevent the polarities in the respective ends from being oppositely oriented. In one embodiment the connector has first and second slots for receiving respective ends of a magnetic strip. The slots may be shaped to prevent rotation of the magnetic strip once it has been inserted into the slot.

[0065] According to some embodiments of the invention, two ends 501 and 502 may be accommodated end to end with their polarities oriented at 90 degrees with respect to each other, as shown in figure 6. A specific example of such an arrangement is shown in figure 9. Here the magnetic strip has an elongate, specifically rectangular, cross section, and the two ends are oriented with the height dimensions perpendicular to each other. It will be appreciated from figure 9 that it is not essential for the direction of the field polarity to be identifiable from the design of the passive magnetic device, e.g. strip. It is sufficient to know that the polarity to have a particular orientation with respect to the cross section to be able to position the two ends with the polarities inclined. An orientation of 180 degrees and hence a "blind" zone may be avoided simply by ensuring that the ends cannot be positioned in a parallel orientation in the connector.

[0066] Figure 10(a) shows the connector 705 of figure 7 in an open configuration with the two ends 501 and 502 of a magnetic strip inserted in perpendicular orientations. Figure 10(b) is a view similar to figure 10(a) with the connector in a closed configuration. The connector 705 is described in more detail with respect to figure 11.

[0067] The connector 700 shown in figure 11 is in the form of a shell in which two ends of a magnetic strip (the same strip or two different strips) are enclosed in use with the remainder of the strip extending from an aperture formed in the shell in the closed state. The apertures have the same elongate, for example rectangular, shape and are oriented perpendicular to each other. Within the shell, receiving portions for each of the two magnetic strip ends are formed. In the embodiment of figure 11 the receiving portions are in the form of slots into which the ends may be inserted. The shell comprises two portions 1101 and 1102 joined by a hinge connection which may in some embodiments may be integrally formed in one piece. Shell portion 1101 has respective cut outs 1103, 1104 on opposing faces 1105 and 1106 of the connector which together with corresponding cut outs 1107, 1108 in shell portion 1102 form the apertures from which the remainder of a strip extends in use. Within the shell, walls are provided to define respective slots for retaining the ends of the strip in a particular orientation, in particular for preventing the strip from rotating in use. The connector shown in figure 11 is designed to receive a rectangular strip and therefore comprises a first pair of walls 1121, 1122 defining a slot having a spacing corresponding to the width dimension of the magnetic strip and second pair of walls 1123, 1124 defining a slot having a spacing corresponding to the height dimension of the magnetic strip. In the example of figure 11 the pairs of walls are formed in the same shell portion 1101 but it is equally possible for one pair of walls to be formed in each of the shell portions 1101, 1102. For at least one pair of walls, e.g. walls 1123, 1124, an additional protrusion may be provided in the opposite shell portion to further prevent rotation of the magnetic strip end. In the embodiment of figure 11 this additional protrusion comprises additional walls 1131, 1132 in the shell portion 1102 extending transverse to the length of the strip in use. One shell portion has integrally formed tabs 1141, 1142 along one edge each defining a recess into which a protrusion 1143, 1144 may be received on closure of the connector to secure the two shell halves together.

[0068] Some operations of the methods described herein may be performed by software in machine readable form e.g. in the form of a computer program comprising computer program code. A computer readable medium may be in transitory or tangible (or non-transitory) form such as storage media include disks, thumb drives, memory cards etc.. The software can be suitable for execution on a parallel processor or a serial processor such that the method steps may be carried out in any suitable order, or simultaneously.

[0069] The described methods according to some embodiments of the invention may be implemented in any form of a computing and/or electronic system. Such a system may comprise one or more processors as mentioned elsewhere herein which may be microprocessors, controllers or any other suitable type of processors for processing computer executable instructions to control the operation of a device.

[0070] It will be understood that the benefits and advantages described above may relate to one embodiment or may relate to several embodiments. The embodiments are not limited to those that solve any or all of the stated problems or those that have any or all of the stated benefits and advantages.

[0071] The term 'comprising' is used herein to mean including the method steps or elements identified, but that such steps or elements do not comprise an exclusive list and a method or apparatus may contain additional steps or elements.

[0072] The term "substantially" applied herein to a parameter such as an angle is intended to include "exactly" as well as variations from the exact parameter within manufacturing tolerances.

[0073] Further, to the extent that the term "includes" is used in either the detailed description or the claims, such term is intended to be inclusive in a manner similar to the term "comprising" as "comprising" is interpreted when employed as a transitional word in a claim.

[0074] While the methods are described herein as being a series of acts that are performed in a particular sequence, it is to be understood and appreciated that the methods are not limited by the order of the sequence. For example, some acts can occur in a different order than what is described herein. In addition, an act can occur concurrently with another act. Further, in some instances, not all acts may be required to implement a method described herein.

[0075] The order of the steps of the methods described herein is exemplary, but the steps may be carried out in any suitable order, or simultaneously where appropriate. Additionally, steps may be added or substituted in, or individual steps may be deleted from any of the methods without departing from the scope of the subject matter described herein. Aspects of any of the examples described above may be combined with aspects of any of the other examples described to form further examples.

[0076] It will be understood that the above description of a preferred embodiment is given by way of example only and that various modifications may be made by those skilled in the art. What has been described above includes examples of one or more embodiments. It is, of course, not possible to describe every conceivable modification and alteration of the above devices or methods for purposes of describing the aforementioned aspects, but one of ordinary skill in the art can recognize that many further modifications and permutations of various aspects are possible. Accordingly, the described aspects are intended to embrace all such alterations, modifications, and variations that fall within the scope of the appended claims.

Claims:

1. A self moving device comprising:

a housing,

a moving module mounted on the housing and drivable to cause the device to move,

a magnetic field sensor for detecting a static magnetic field in the vicinity of the device,

a control module configured to control the moving module based on signals received from the sensor, wherein the control module is configured to:

instruct the device to retreat in response to detection of a first predetermined pattern of magnetic field strength detected by the magnetic field sensor,

verify that the retreat instruction has been executed based on detected magnetic field strength, and generate an alert if the retreat instruction is not executed.

2. A self moving device as claimed in claim 1 wherein the first predetermined pattern comprises a rise in detected magnetic field strength above a predetermined threshold.

3. A self moving device as claimed in claim 1 wherein the first predetermined pattern comprises a peak in detected magnetic field strength.

4. A self moving device as claimed in claim 1, 2 or 3, configured to detect a second predetermined pattern of magnetic field strength associated with the device retreating, and to generate the alert after the expiry of a predetermined time following detection of the first predetermined pattern before detection of the second predetermined pattern.

5. A self moving device as claimed in claim 4 wherein the second predetermined pattern comprises the magnetic field strength falling below the predetermined threshold.

6. A self moving device as claimed in claim 4 wherein the second predetermined pattern comprises a peak in the strength of the magnetic field.

7. A self moving device as claimed in any preceding claim wherein the alert comprises a stop signal to cause the device to stop moving.

8. A self moving device as claimed in any preceding claim wherein the device comprises a lawn mower.

9. A self moving device as claimed in any preceding claim wherein the magnetic field sensor is located at a lower part of the housing.

10. A self moving device as claimed in any preceding claim wherein the magnetic field sensor is located towards the front of the device.

11. A self moving device as claimed in any preceding claim additionally comprising one or more inductive sensors for sensing an induced magnetic field in the vicinity of the self moving device.

12. A self moving device as claimed in claim 11 wherein a static magnetic field sensor is mounted beneath the housing facing the ground and an inductive sensor is mounted at the front of the housing facing the forward direction of travel.

13. A method of controlling the operation of a self moving device comprising a magnetic field sensor for detecting a static magnetic field in the vicinity of the device, the method comprising:
instructing the device to retreat in response to detection of a first predetermined pattern of the magnetic field strength detected by the magnetic field sensor,
verifying that the retreat instruction has been executed based on detected magnetic field strength, and
generating an alert if the retreat instruction is not executed.

14. A method device as claimed in claim 13 wherein the first predetermined pattern comprises a rise in detected magnetic field strength above a predetermined threshold.

15. A method as claimed in claim 14 wherein the first predetermined pattern comprises a peak in detected magnetic field strength.

16. The method of claim 13, 14 or 15 comprising:
detecting a second predetermined pattern of magnetic field strength associated with the device retreating, and
generating the alert if the time between detecting said first and second patterns exceeds a predetermined time threshold.

17. The method of claim 16 wherein the second predetermined pattern comprises the magnetic field strength falling below the predetermined threshold.

18. The method of claim 16 wherein the second predetermined pattern comprises a peak in the strength of the magnetic field.

19. The method of any of claims 13 to 18 wherein the alert comprises a stop signal to cause the device to stop moving.

20. The method of any of claims 13 to 19 comprising determining a background magnetic field level and determining the predetermined threshold to be above the background magnetic field level.

21. A computer readable medium comprising instructions which, when implemented in a processor in a self-moving device, cause the processor to implement the method of any of claims 13 to 20.

22. A magnetic boundary system comprising a magnetic strip having two ends and a connector, wherein:
the magnetic strip provides a magnetic field having a polarity in a direction transverse to the length of the magnetic strip,
the connector is designed to connect one end of the magnetic strip to the other end or to one end of a similar magnetic strip, and
the strip and connector are designed such that the strip is prevented from rotating in the connector and the ends are accommodated such that the angle between the polarities is less than 180 degrees.

23. A magnetic boundary system as claimed in claim 22 wherein the ends are accommodated such that the angle between the polarities is less than 90 degrees.

24. A magnetic boundary system as claimed in claim 22 or 23 wherein the connector is designed to accommodate the ends such that the magnetic fields are perpendicular to each other.

25. A magnetic boundary system as claimed in claim 22, 23 or 24 wherein the strip is designed to indicate the orientation of the magnetic field.

26. A magnetic boundary system as claimed in claim 25 wherein the magnetic field orientation is identified using a pattern or colour on at least the surface of the magnetic strip.

27. A magnetic boundary system as claimed in claim 26 wherein the connector is designed to indicate the intended orientation of the strip ends in the connector.

28. A magnetic boundary system as claimed in any of claims 22 to 27 wherein the strip is designed to indicate the orientation of the magnetic field by having a non circular cross section.

29. A magnetic boundary system as claimed in claim 28 wherein the magnetic strip has an elongate cross section.

30. A magnetic boundary system as claimed in claim 29 wherein the polarity of the magnetic field is parallel to the height of the strip.

31. A magnetic boundary system as claimed in claim 28 or 29 wherein the magnetic strip cross section has a height and width and the height is greater than the width.

32. A magnetic boundary system as claimed in claim 28, 29 or 30 wherein the magnetic strip cross section is rectangular or oval.

33. A magnetic boundary system as claimed in any of claims 22 to 32 wherein the magnetic strip is flexible along its length.

34. A magnetic boundary system as claimed in any of claims 22 to 33 wherein the connector comprises first and second slots for receiving respective ends of a magnetic strip.

35. A magnetic boundary system as claimed in claim 34 wherein the slots are shaped to prevent rotation of the magnetic strip once it has been inserted into the slot.

36. A magnetic boundary system as claimed in any of claims 22 to 35 wherein the connector comprises a shell designed to enclose two ends of a magnetic strip in use with the remainder of the strip extending from an aperture formed in the shell in the closed state.

37. A magnetic boundary system as claimed in claim 36 wherein the apertures are formed in opposing ends of the shell.

38. A magnetic boundary system as claimed in claim 36 or claim 37 wherein the apertures have the same elongate shape and are oriented perpendicular to each other.

39. A magnetic boundary system as claimed in any of claims 22 to 38 comprising at least one further magnetic strip providing a magnetic field having a polarity in a direction transverse to the length of the magnetic strip and designed to indicate the orientation of the magnetic field, and
at least one further connector designed to connect one end of the magnetic strip to the other end or to one end of a similar magnetic strip, wherein
each strip and connector are designed such that the strip is prevented from rotating in the connector and the ends are accommodated such that the angle between the polarities is less than 180 degrees.

40. A system comprising a self moving device as claimed in any of claims 1 to 12 and a magnetic boundary system as claimed in any of claims 22 to 39.

41. A system as claimed in any of claims 22 to 40 further comprising an electrically conductive cable to be positioned around a working area of the device and a generator for generating a varying magnetic field in the conductive cable.

42. A system as claimed in any of claims 22 to 41 wherein the or each magnetic strip comprises a protective cover extending along the length of the strip.

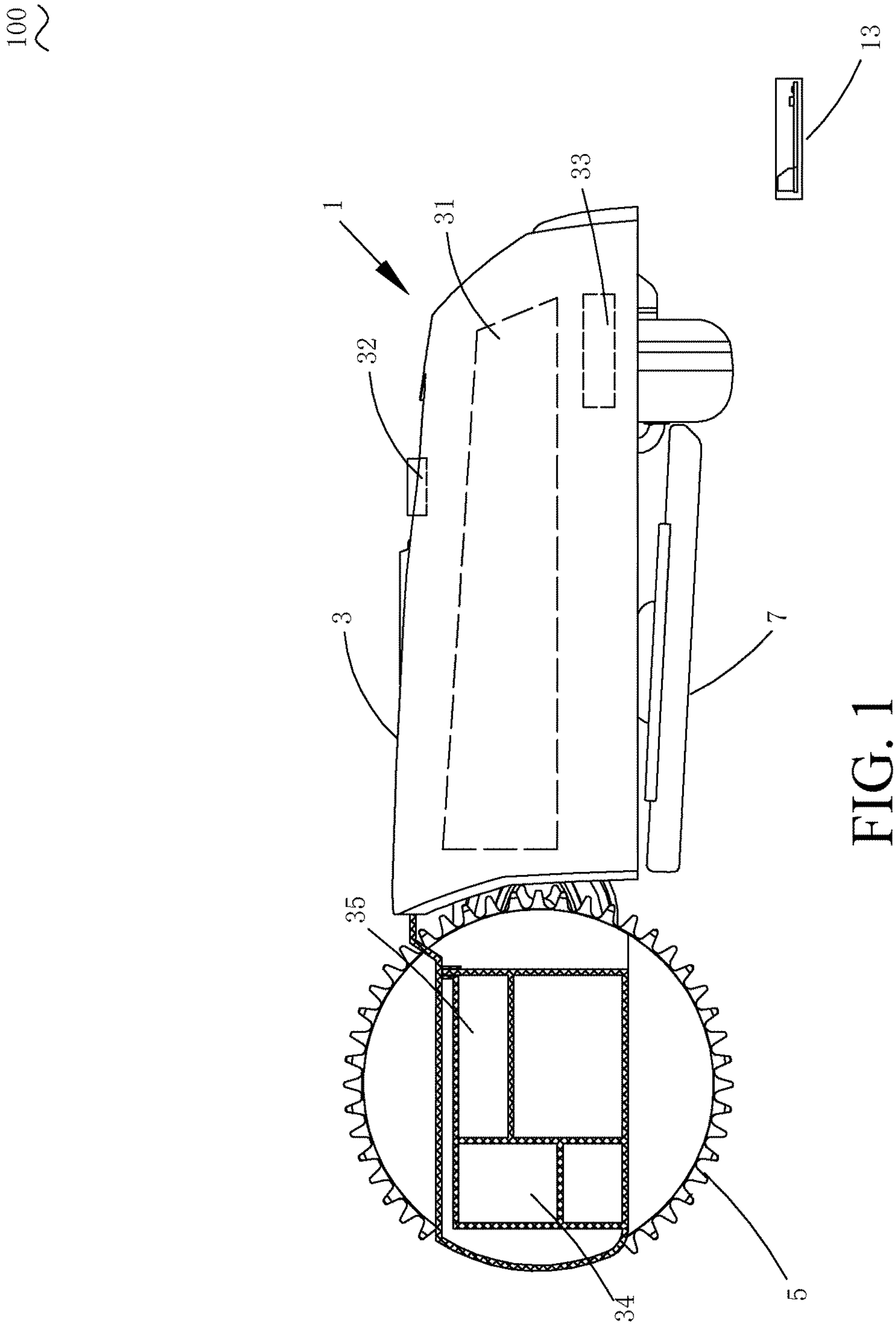
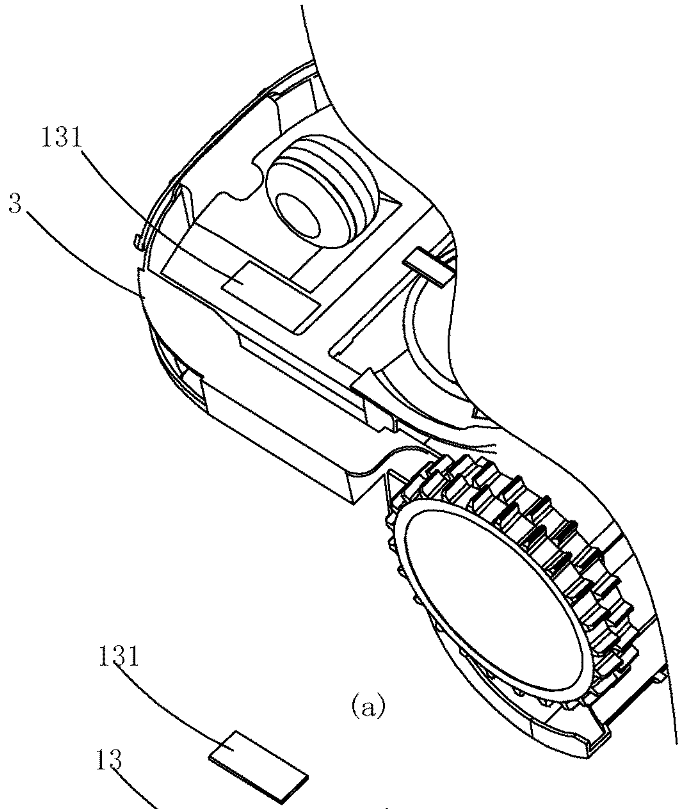


FIG. 1



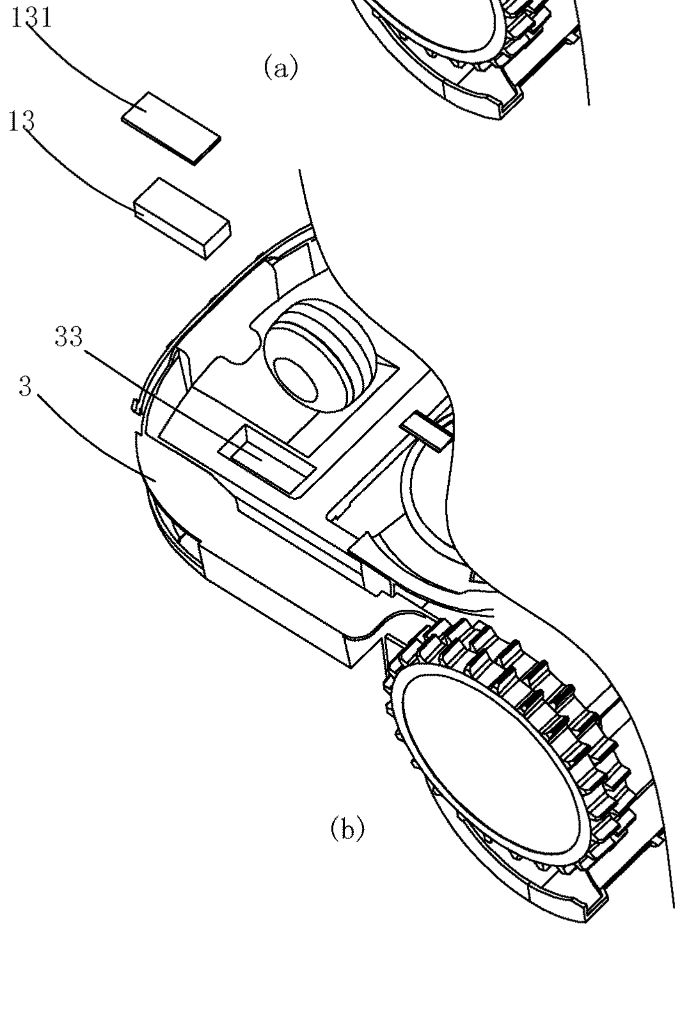


Figure 2

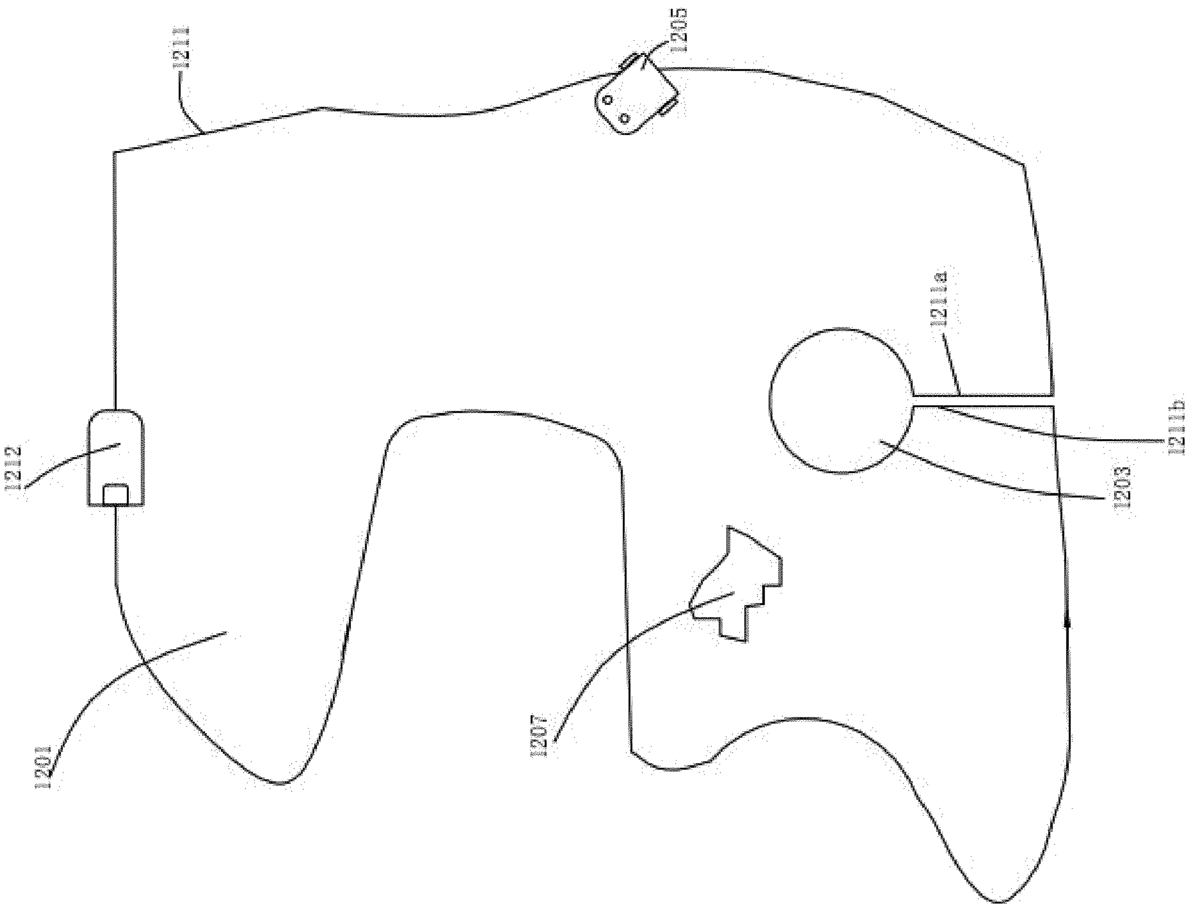


Figure 3A

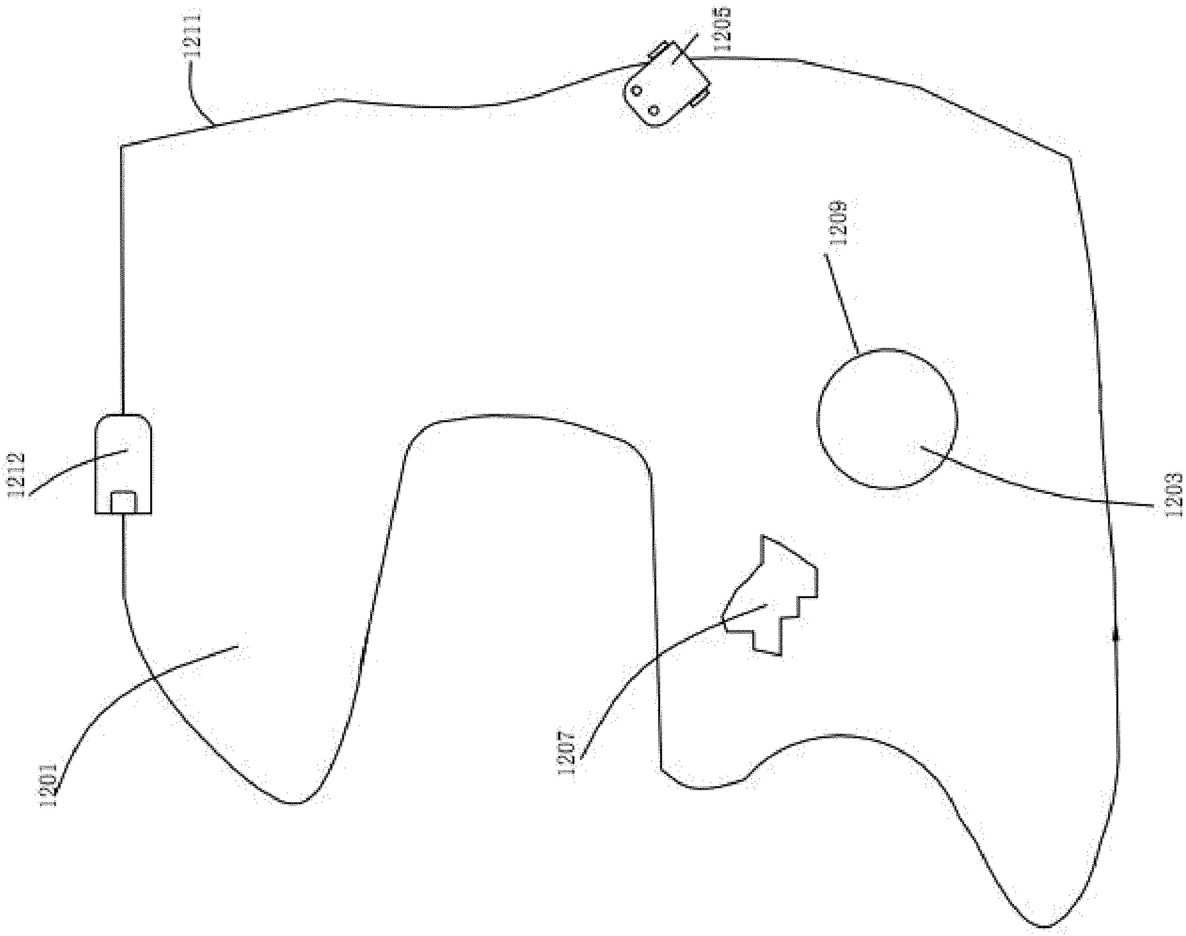


Figure 3B

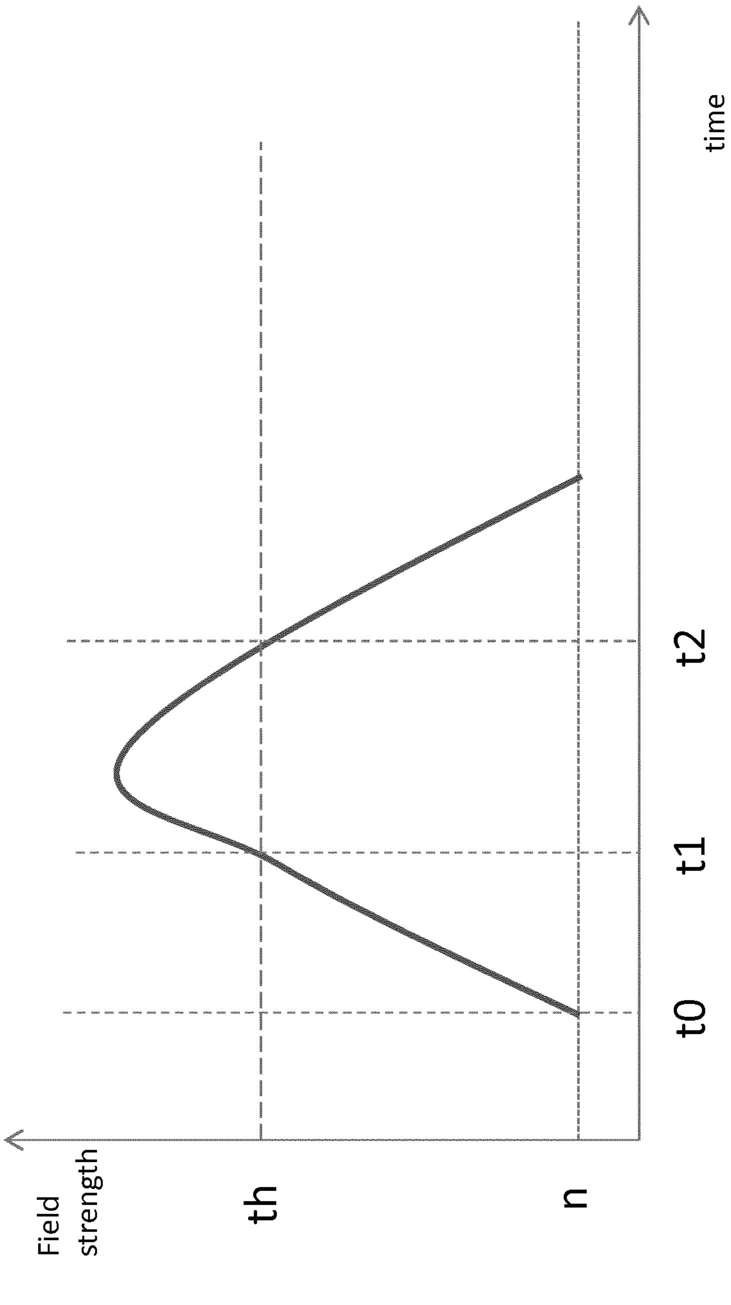


Figure 4A

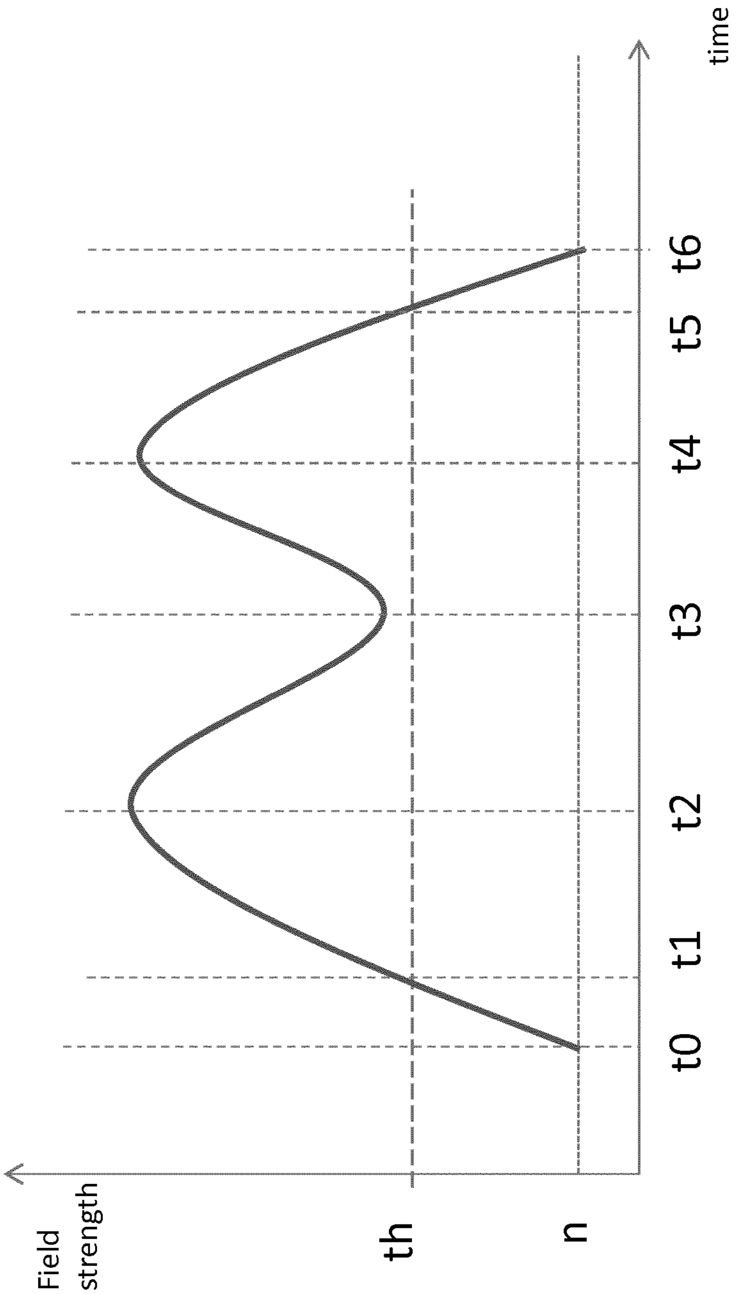


Figure 4B

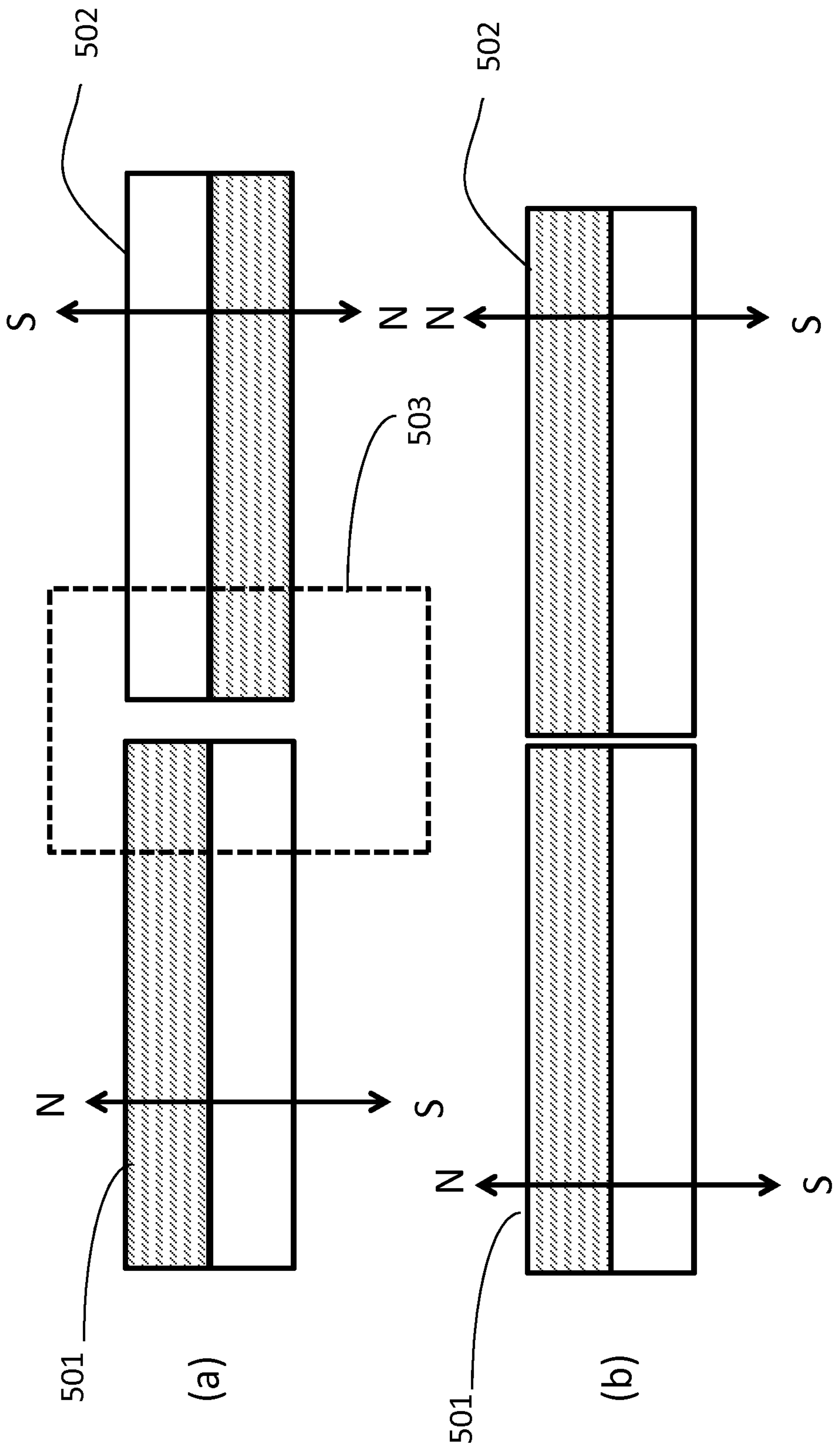


Figure 5

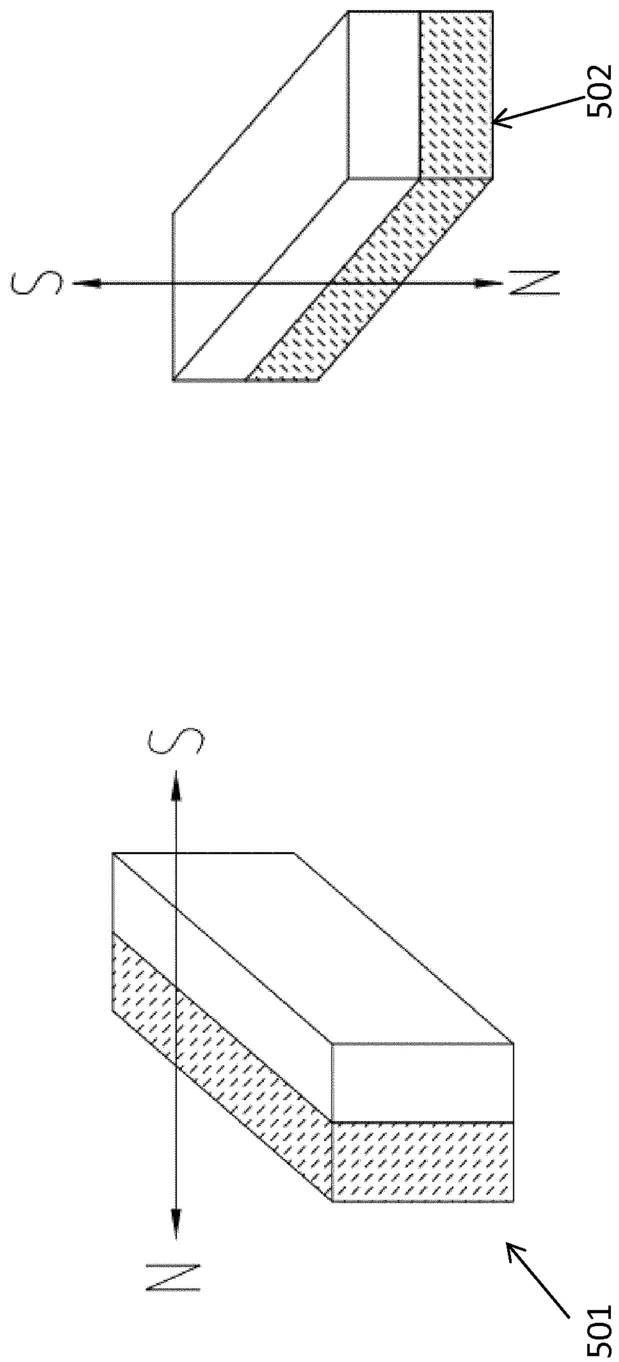


Figure 6

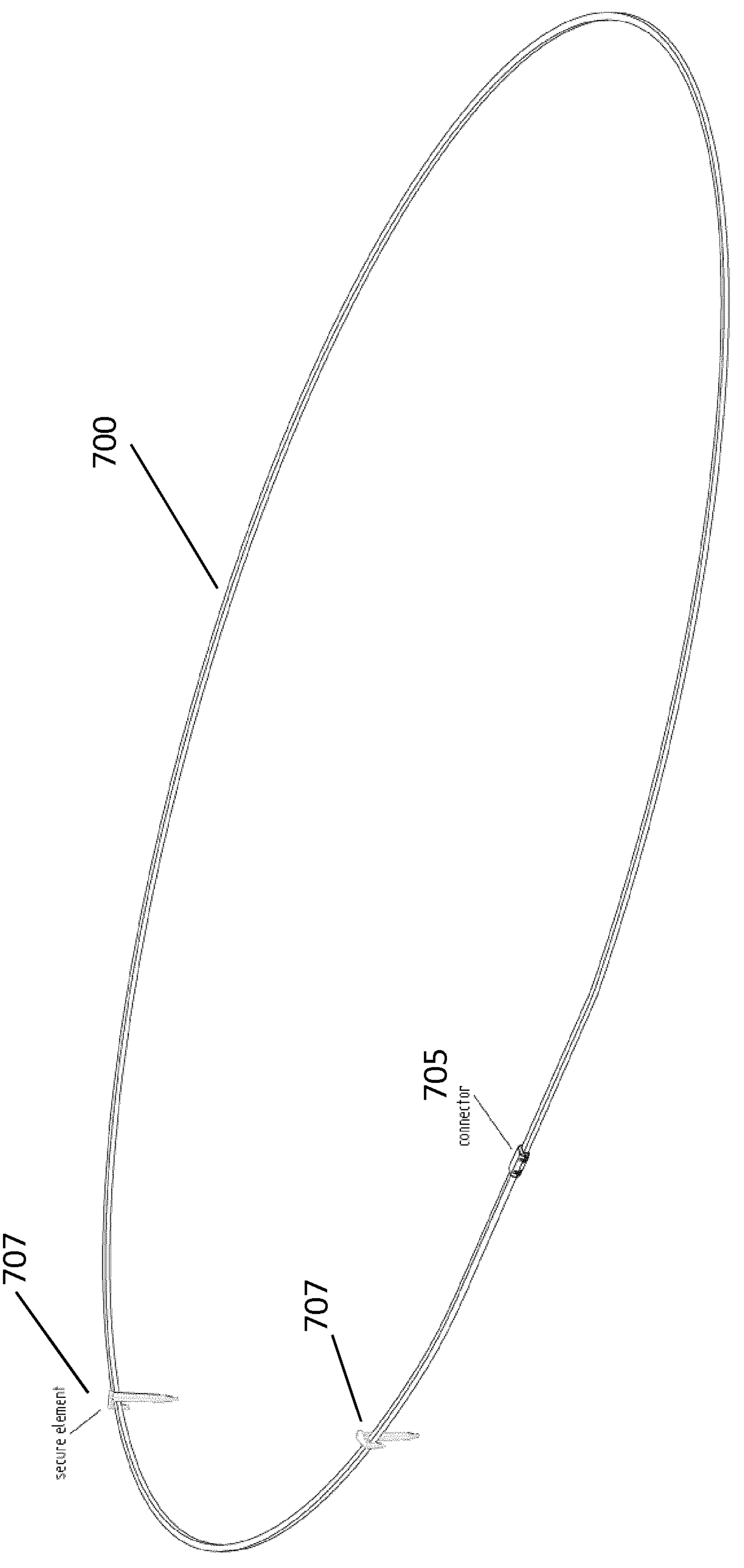


Figure 7

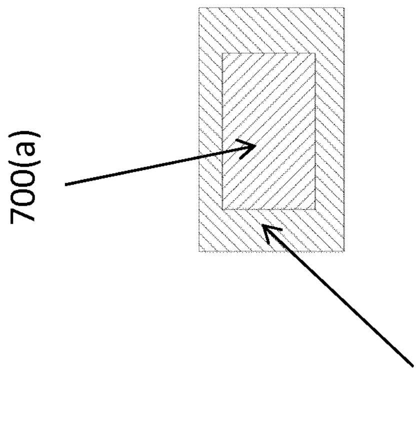


Figure 8(b)

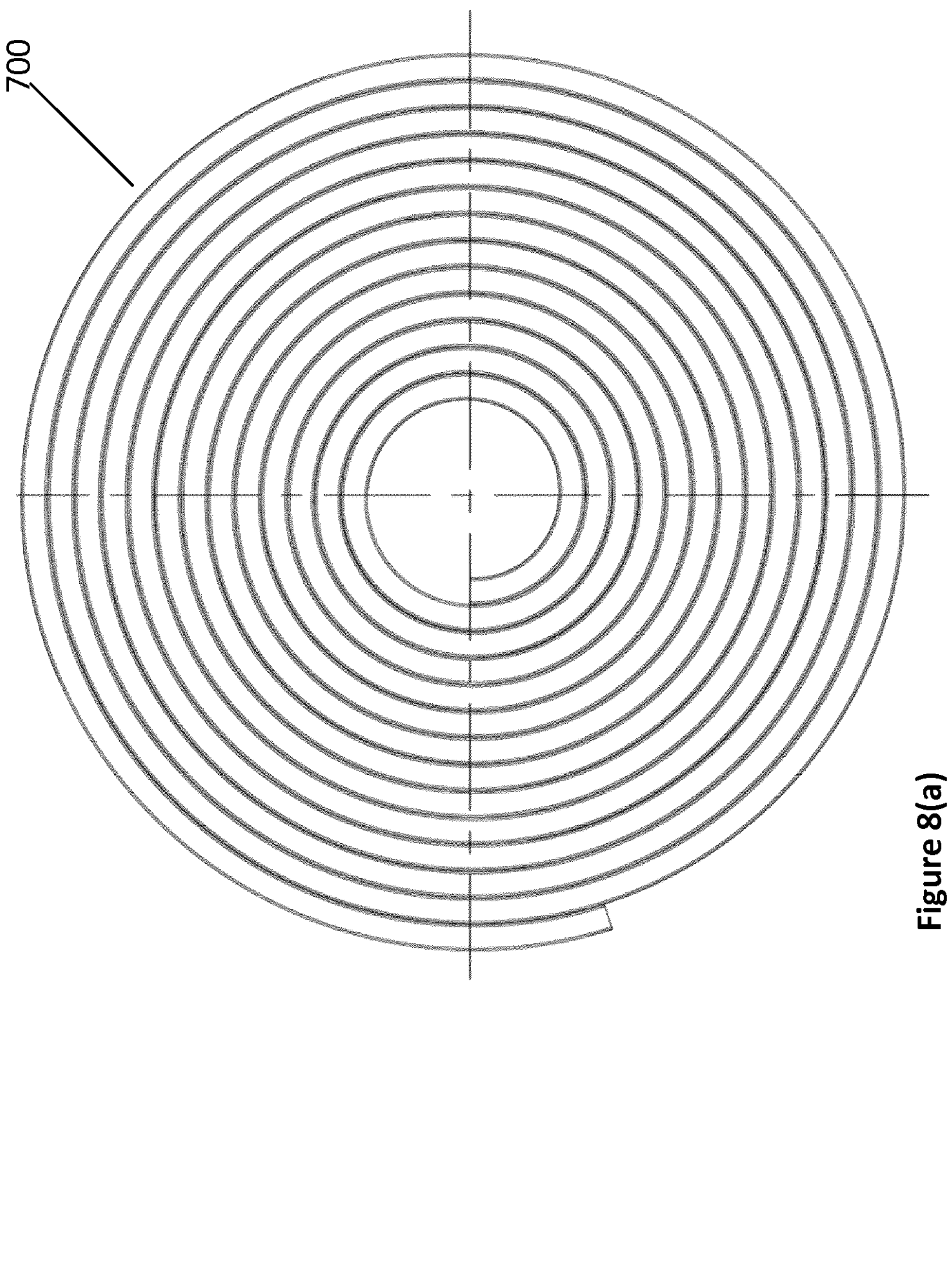


Figure 8(a)

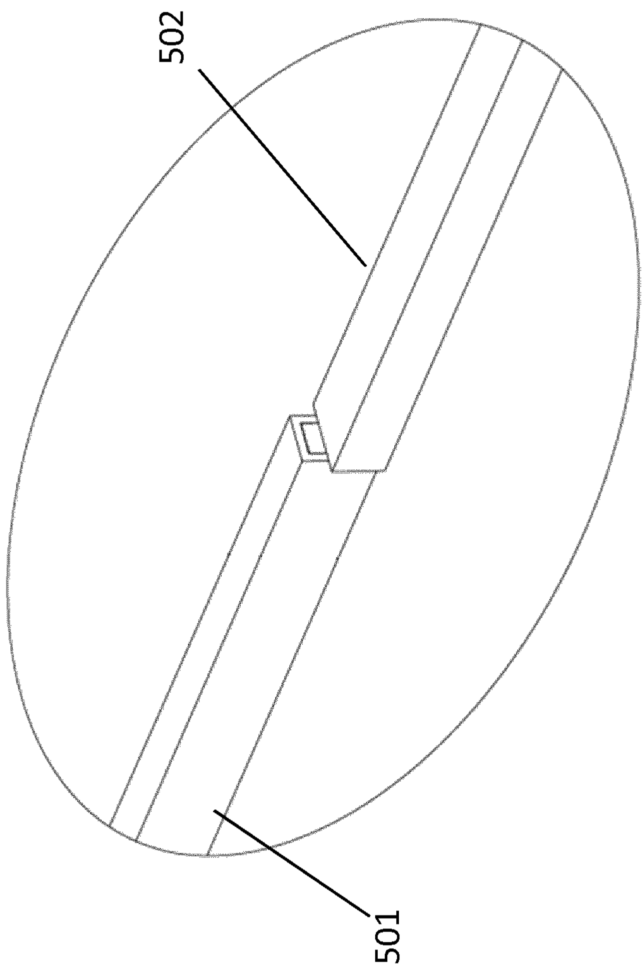


Figure 9

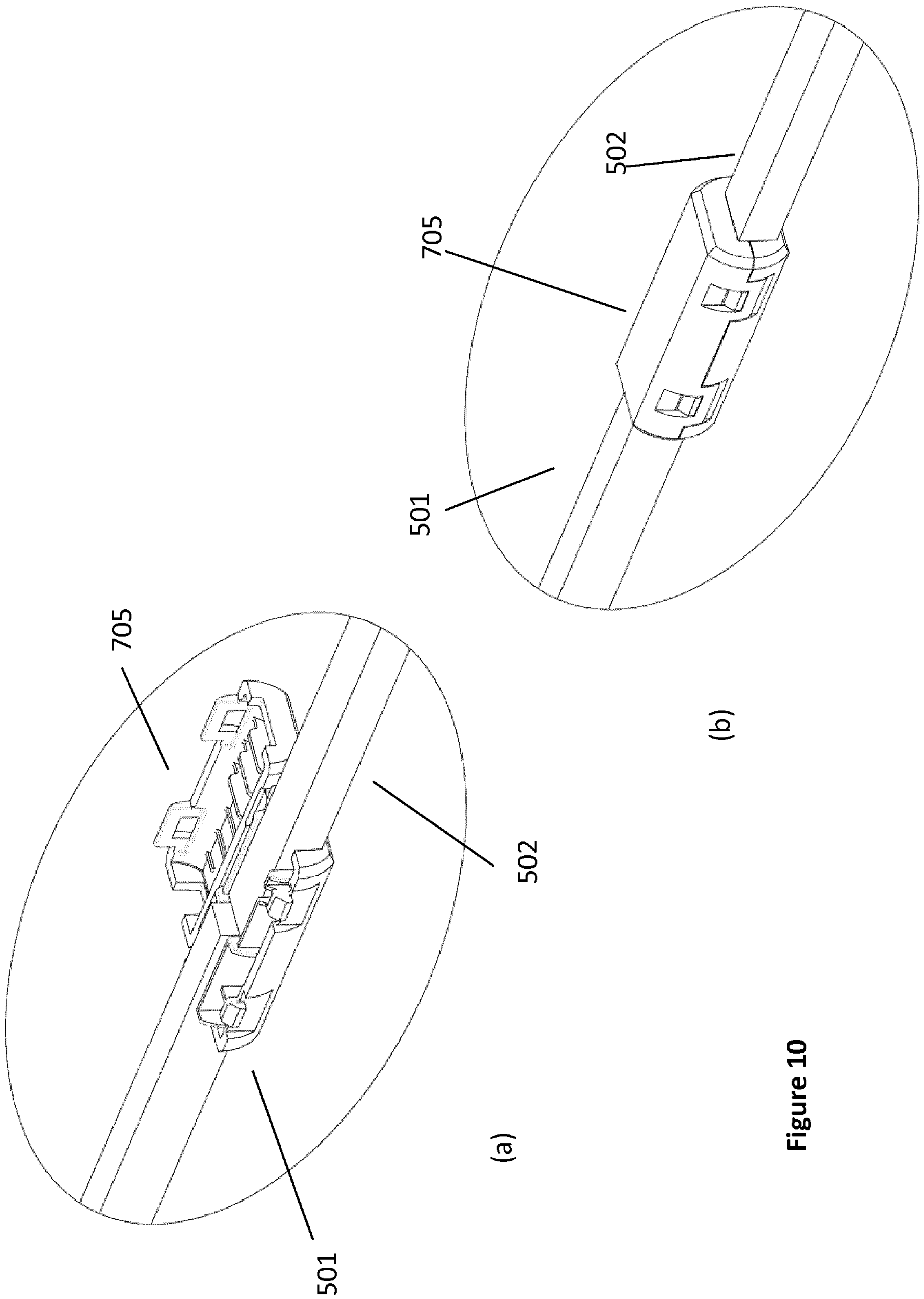


Figure 10

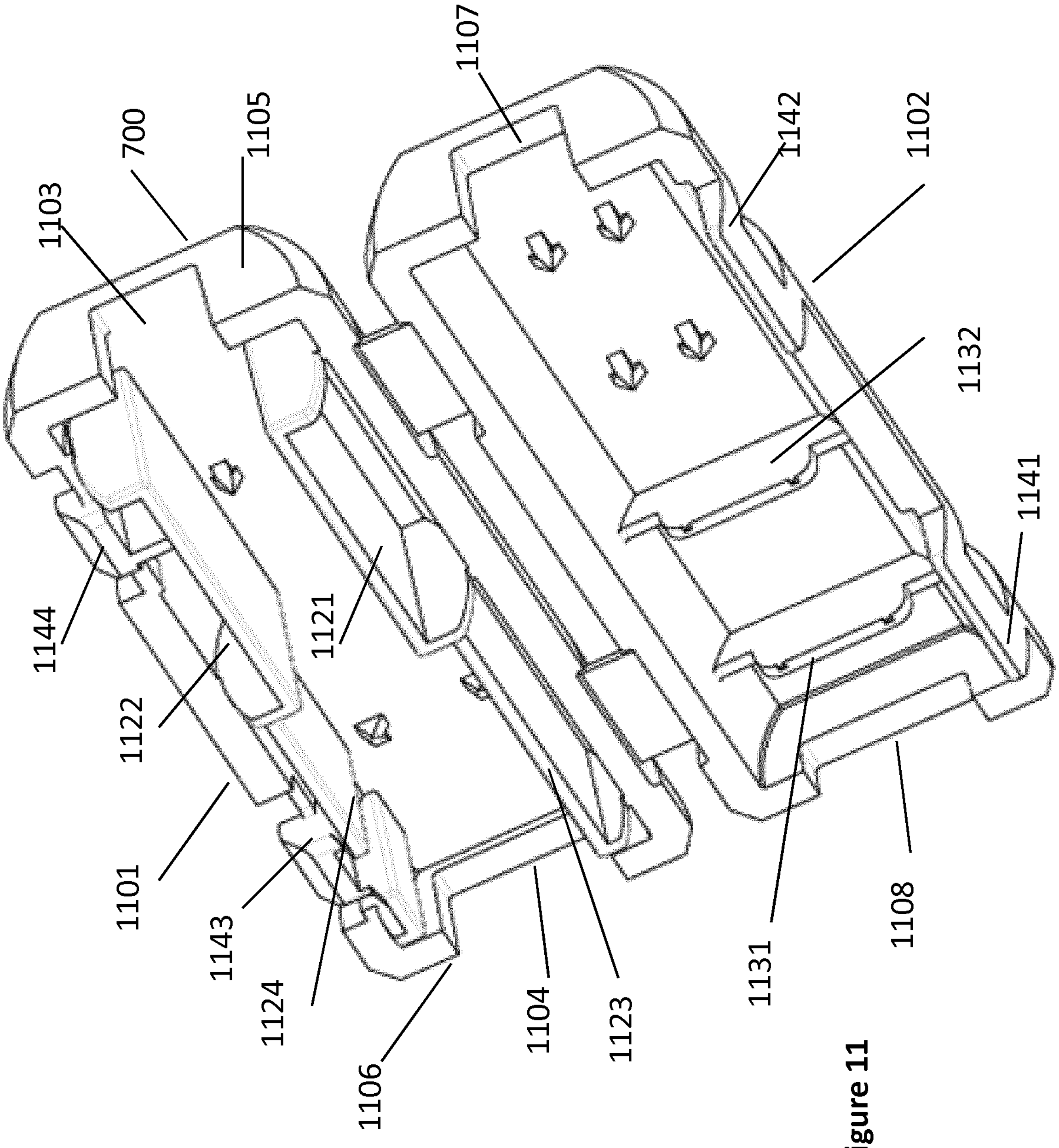

1107
700
1105
1103
1142
1102
1132
1141
1144
1121
1122
1101
1143
1124
1106
1104
1123
1131
1108

Figure 11

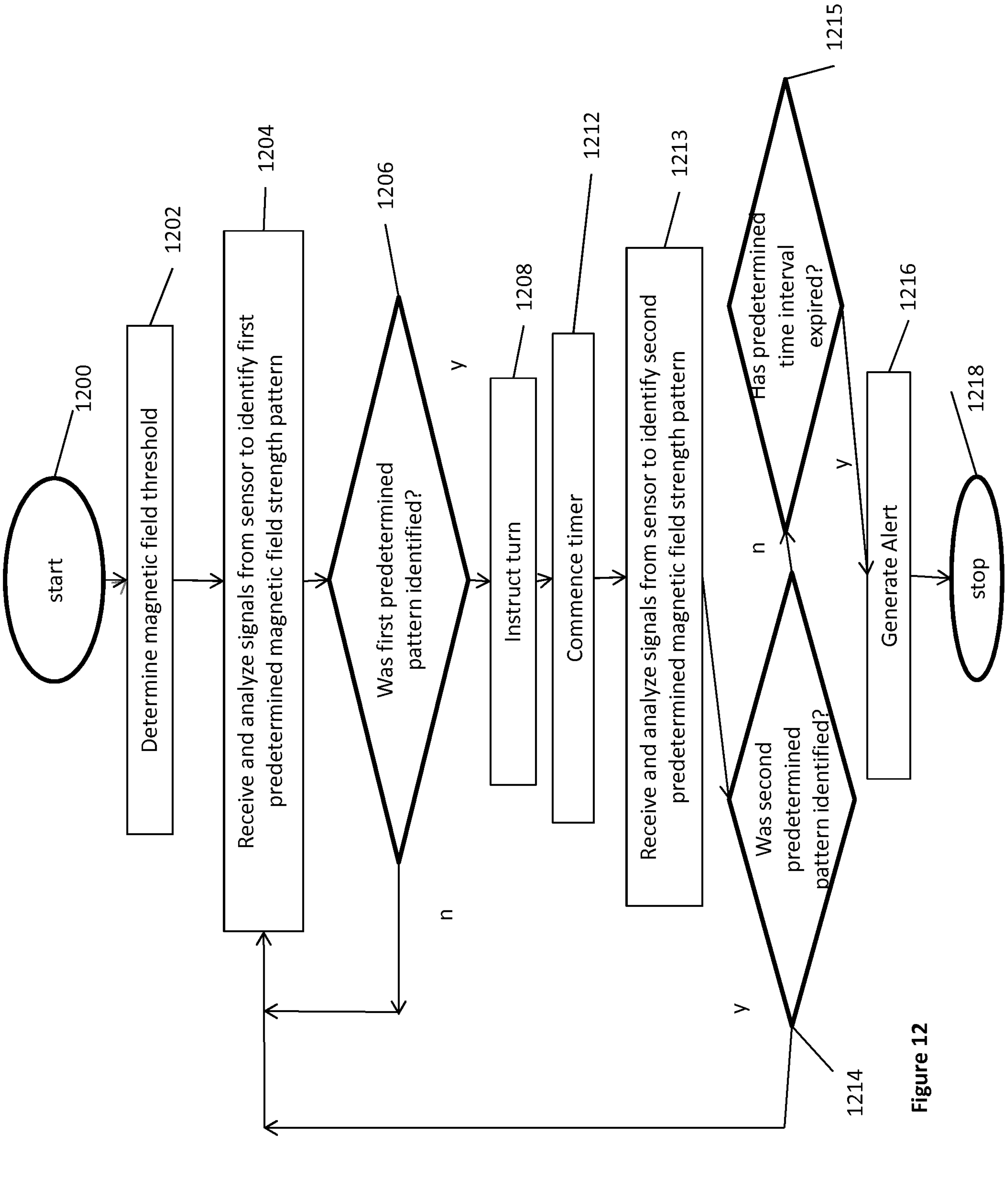

start
1200
Determine magnetic field threshold
1202
Receive and analyze signals from sensor to identify first predetermined magnetic field strength pattern
1204
Was first predetermined pattern identified?
1206
y
n
Instruct turn
1208
Commence timer
1212
Receive and analyze signals from sensor to identify second predetermined magnetic field strength pattern
1213
Was second predetermined pattern identified?
1214
y
n
Has predetermined time interval expired?
1215
y
Generate Alert
1216
stop
1218

Figure 12

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/052551

A. CLASSIFICATION OF SUBJECT MATTER
INV. G05D1/02
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G05D

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2014/054099 A1 (HO YU-LUN [TW] ET AL) 27 February 2014 (2014-02-27) paragraphs [0016], [0017], [0024]; figures 1,2,4	1-21, 40-42 30-39
X Y	CN 107 544 484 A (GUANGZHOU ROBOTZERO SOFTWARE TECH CO LTD) 5 January 2018 (2018-01-05) figure 2	22-29, 32,33, 40,42 30-39
A	US 8 712 623 B2 (SATO KAZUHISA [JP]; YAMAMURA MAKOTO [JP] ET AL.) 29 April 2014 (2014-04-29) cited in the application	1-42

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

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Date of the actual completion of the international search: 7 October 2019

Date of mailing of the international search report: 16/10/2019

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2019/052551

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 2014054099	A1	27-02-2014	NONE			
CN 107544484	A	05-01-2018	NONE			
US 8712623	B2	29-04-2014	EP	2437130	A1	04-04-2012
			JP	5712097	B2	07-05-2015
			JP	2012094123	A	17-05-2012
			US	2012083962	A1	05-04-2012