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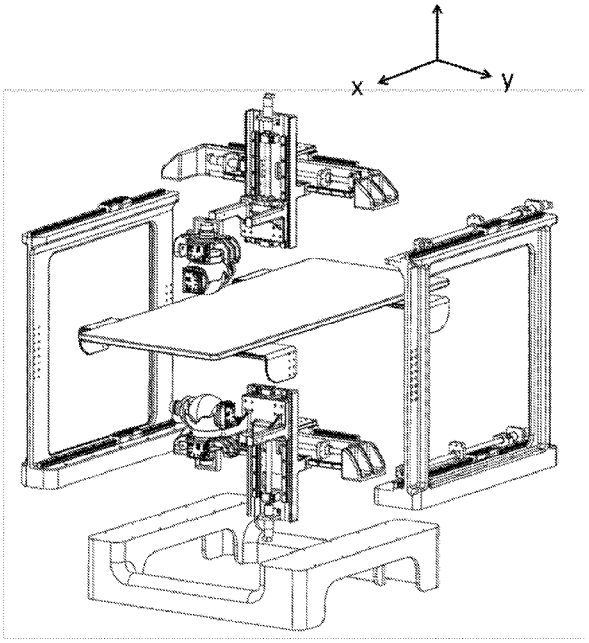


FIG. 4

(57) Abstract: A system to control a movement of a magnetic capsule using an external magnet control system is provided. The external magnet control system includes more than one external magnetic ball(1,2), and at least one external magnetic ball(1,2) can be moved freely in five degrees of the freedom.

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SYSTEM and METHOAD FOR USING A CAPSULE DEVICE

CROSS-REFERENCE

[0001] This application is related to the co-pending application 15274771, filed on September 23, 2016.

TECHNICAL FIELD OF THE DISCLOSURE

[0002] This patent application relates to the art of capsule devices to be used in medical related applications, and more particularly, to systems to use two external magnetic generating means to navigate a magnetic capsule through a patient's GI track and methods of using the same.

BACKGROUND OF THE DISCLOSURE

[0003] The magnetic controllable capsule endoscope has been widely used commercially in the stomach examination and proved to be very successful. However, the same magnetically controlled capsule endoscope is not currently used to be placed inside the small bowel and colon to perform a routine examination.

[0004] To date, there are three types of external magnetic field generation systems to guide a magnetic capsule endoscope while traveling in a patient's GI track. They are electromagnetic coils, electromagnet and permanent magnet. In order to meet the requirement of providing sufficient driving force, by external magnetic field or external magnetic gradient to move a typical magnetic capsule endoscope throughout a patient's small bowel, the power consumption for electromagnetic coils and electromagnet systems is very large, and the heat dissipation can make these systems even more bulkier and eventually very expensive to build and operate. Additionally, for electromagnetic coils and electromagnet systems, the electromagnetic compatibility (EMC) is also a big challenge, and potential safety issue relating to the electromagnetic field also post some concern.

[0005] Comparing to electromagnetic coils, the permanent magnet is a much more clean and efficient way to generate large magnetic field or field gradient. However, the control algorithm of the permanent magnet is much more complex than the electromagnetic coils. The electromagnet has a little bit more flexibility then the permanent magnet, since its strength can be adjust by the current. However, for the control of the movement of the magnetic capsule, the electromagnet has the same order of the complexity of the permanent magnetic field. And to achieve the same magnetic field or field gradient, the electromagnet will occupy 2~3 times larger space than the permanent magnet. As for the permanent magnet, the sphere shape is the most efficient for the remote field or field gradient generation.

[0006] Therefore magnetic control system to navigate a capsule through a small bowel is needed, the said system should employ an external permanent magnet dipole and easy to use.

SUMMARY OF THE INVENTION

[0007] The present invention discloses a system and method that can be used to examine a patient's GI track.

[0008] It is one object of the present invention to invent a system that can use permanent magnet to control the movement of a magnetic capsule place in situ.

[0009] It is another object of the present invention that the magnetic capsule can move in 3 dimensional freely, having 5 degrees of the freedom.

[0010] It is another object of the present invention that the magnetic capsule can move adjust orientation by the external magnet.

[0011] In one aspect of the present invention, a system for controlling movement of a magnetic capsule in a human GI track, is described. The system comprises

a magnetic dipole for placement in a human GI track, an external magnet control system, having more than five degrees of freedom, that can apply external translational and or rotational magnetic field force to the magnetic capsule; and
the magnetic dipole is enclosed in a capsule, having a length, wherein the magnetic dipole is parallel to the length of the capsule. Further, the system includes more than one external magnetic balls, and at least one external magnetic ball can moved freely in five degrees of the freedom.

[0012] In a second aspect of the present invention, a mechanical control of the system is described. The system comprises two magnetic balls, each is controlled by an individual movement control assembly, which can be operated either simultaneously or separately.

[0013] The system comprises a first external magnetic control assembly and a second external magnetic control assembly.

[0014] Each external magnetic control assembly comprises a magnetic field generation means, two horizontal translation means, one vertical translation means, horizontal rotating means and vertical rotation means.

[0015] In a third aspect of the present invention, an apparatus for medical examination is described. The medical apparatus for examining a patient's GI track, comprises a base, situated on a ground; a pair of vertical supporting frame assembly, two spherical shaped external magnets, each magnet attached to a movement control assembly, wherein both magnets are used to navigate a magnetic capsule placed inside the patient along their progressive pathway.

[0016] In a fourth aspect of the present invention, a method for controlling movement of a magnetic capsule in a human GI track is disclosed. Said method comprise

Preparing a patient laying down on the examination bed, when capsule is inside the patient;

Aligning two magnetic balls vertical and both have a horizontal magnetization;

Positioning the two magnetic balls so that a distance the centers of the two magnetic balls are more than 50 cm in the vertical direction;

moving two magnetic balls simultaneously in a XY plane;

measuring the resulted combined magnetic field by magnetic sensors inside the capsules;

calculating a position and orientation of the magnetic capsule by two three dimensional magnetic sensors and one three dimensional acceleration sensor inside the capsules, the position and orientation of the capsule;

adjusting the vertical and horizontal position of the two magnetic balls so that the capsule is in a middle position of two balls;

moving the two magnetic balls to adjust their magnetic directions so that the magnetic capsule can image an open space of colon; and moving the two magnetic balls to be ahead of the capsule's moving direction; and

moving the magnetic capsule forward by rotating the two magnetic balls' to change their magnetization direction.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] Exemplary embodiments of the disclosure will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings in which:

[0018] FIG. 1 shows a schematic illustration of a magnetic capsule system in accordance with aspect of the present invention;

[0019] FIG. 2 shows a perspective view of an exemplar external magnetic control system in accordance with aspects of the present invention; wherein the bed is extended outside of the supporting frames;

[0020] FIG. 3 shows a perspective view of an exemplar system in accordance with aspects of the present invention; wherein the bed is placed inside of the supporting frames;

[0021] FIG. 4 shows an exploded perspective view of an exemplar system in accordance with aspects of the present invention; wherein the bed is placed inside of the

supporting frames and assemblies are not placed together to better illustrate the system structure;

[0022] FIG. 5 shows an exploded perspective view of an exemplar system in accordance with aspects of the present invention, wherein the platform or bed is removed so that the structural components can be clearly displayed and labeled;

[0023] FIG. 6 is a cross sectional view of the external magnetic system, when viewing from the back of the external magnetic control system;

[0024] FIG. 7 is a left side view of the system of Figure 6;

[0025] FIG. 8 is a top view of the system of Figure 6;

[0026] FIG. 9 is an illustration of a magnetic capsule in the accordance with the aspect of the present invention;

[0027] FIG. 10 is a schematic diagram to illustrate that capsule can move horizontally along an XY plane, wherein the capsule magnetization direction is the same as the forward movement direction;

[0028] FIG. 11 is a schematic diagram to illustrate that a capsule can move vertically away from the XY plane in the z direction, wherein the capsule magnetization direction is the opposite to the forward movement direction;

[0029] FIG. 12 is a force and magnetic field relative distribution chart when the positions of the two magnets and magnetic capsule are as listed in FIG.11;

[0030] FIG. 13 is a schematic illustration of another operation condition wherein the magnetizations of the two magnets are opposite to the magnet capsule;

[0031] FIG. 14 is a force and magnetic field relative distribution chart when the positions of the two magnets and magnetic capsule are as listed in FIG.13;

[0032] FIG. 15 is schematic illustration of another operation condition wherein two magnetic balls are aligned vertically, their magnetizations of both balls are same and the magnetization directions are mirror image to each other along the middle plane between them;

[0033] FIG. 16 is schematic illustration of another operation condition wherein two magnetic balls are aligned vertically, their magnetizations of both balls are same and the magnetization directions are mirror image to each other along the middle plane between them, and wherein the magnetic capsule is dragged forward;

[0034] FIG. 17 is schematic illustration of another operation condition wherein two magnetic balls are aligned vertically, their magnetizations of both balls are same and the magnetization directions are mirror image to each other along the middle plane between them, and wherein the magnetic capsule is dragged forward;

[0035] FIG.18 is an initial position and orientation of the magnetic capsule and external magnetic balls in a process to change a magnetic capsule through the adjustment in the external magnetic system;

[0036] FIG.19 is a finished position and orientation of the magnetic capsule and external magnetic balls in a process to change a magnetic capsule through the adjustment in the external magnetic system;

[0037] FIG. 20 is another finished position and orientation of the magnetic capsule and external magnetic balls in an alternative process to change a magnetic capsule through the adjustment in the external magnetic system;

[0038] FIGs.21-24 are schematic illustration of how to rotate a magnetic capsule in xz plane;

[0039] FIG. 25 is a top view of a schematic illustration of how to rotate a magnetic capsule in xy plane;

[0040] FIG. 26 shows a side view of a schematic diagram to how to spin a magnetic capsule in xy plane;

[0041] FIGs. 27 and 28 show side views of a schematic diagram to illustrate how to adjust the position of the magnetic balls to move the magnetic capsule vertically; and

[0042] FIG.29 is a process flow diagram to show how the system is used.

DETAILED DESCRIPTION OF SELECTED EXAMPLES

[0043] Hereinafter, selected examples of a magnetic capsule system to be placed in a target location and its external control system, and methods of using the same will be described in detail with reference to the accompanying drawings. For simplicity purpose, the magnetic capsule and its external system is explained in the context of biomedical applications, i.e. the target location is an in vivo location, for example a location inside a digestive tract. For simplicity purpose, the medical device disclosed herein is designed to

be placed in vivo. One of the non-invasive methods of delivery is by swallow into a digestive tract. Therefore the medical device disclose herein is referred as a capsule, which should not be construed as a limitation for its shape, dimension or size. The capsule device disclosed herein and methods of using the same can be implemented for many other applications as long as there is a movement of the magnetic capsule in the target location needs to be controlled externally from one location to another location.

[0044] In the scope of the present invention, xyz coordinate system is used to define a position or direction. Figure 3 shows xyz axis direction with respect to the orientation of the medical system in the scope of the present invention. It is for illustration purposes only. It should not be construed as a limitation. For example, according to Figure 3, in referring to figure 2, x direction is the direction the bed moves, which is from back to forward; y direction is the direction from one supporting frame to another opposing supporting frame, which is from left to right, and z direction is the direction to move the magnets closer and away to the patient, which is the up down direction. Horizontal rotation means a rotation around z axis, along xy plane, for example rotation from left to right, when viewing from the front of the apparatus. Vertical rotation means a rotation around y axis, along yz plane, for example, rotation from top to bottom, when viewing from the front of the apparatus.

[0045] Elements in the figures are

1. Motor 1
2. Z- axis upper assembly 1
3. Y-axis upper horizontal assembly
4. Motor 3
5. Magnetic ball 1
6. Right supporting frame assembly
7. Right sliding rail for the bed
8. Magnetic ball 2
9. Y-axis lower horizontal assembly
10. Motor 8

11. Z-axis uplift assembly 2
12. Motor 6
13. Base
14. Motor 2
15. Motor 4
16. Motor 5
17. Left supporting frame assembly
18. Bed
19. Left sliding rail for the bed
20. Motor 9
21. Motor 10
22. Motor 7

[0046] Details of the elements and their functions are:

1.Motor 1:

provide power to move the upper magnetic ball up in Z direction

2. Z- axis upper assembly 1

movement control parts for the upper magnetic ball along Z-axis are all placed on Z-axis upper assembly

3. Y-axis upper horizontal assembly

movement control parts for the upper magnetic ball along Y-axis are all placed on Y-axis upper assembly

4. Motor 3

provide power to move the upper magnetic ball up in x direction

5. Magnetic ball 1

the magnetic ball above the bed

6. Right supporting frame assembly

supporting frame on the right and parts attached to it

7. Right sliding rail for the bed

sliding rail for the bed on the right side

8. Magnetic ball 2

the magnetic ball below the bed

9. Y-axis lower horizontal assembly

movement control parts for the lower magnetic ball along Y-axis are all placed on Y-axis lower assembly

10. Motor 8

provide power to move the lower magnetic ball in x direction

11. Z-axis uplift assembly 2

movement control parts for the lower magnetic ball along z-axis are all placed on z-axis lower assembly

12. Motor 6

provide power to move the lower magnetic ball in z direction

13. Base

apparatus base, placed on the ground

14. Motor 2

provide power to move the upper magnetic ball in y direction

15. Motor 4

provide power to turn the upper magnetic ball along the horizontal plane, rotate around the z direction

16. Motor 5

provide power to turn the upper magnetic ball along the vertical plane, rotate around the z direction

17. Left supporting frame assembly

Left apparatus supporting frame

18. Bed

Bed to provide support to a patient and carry the patient into/out of the examination area

19. Left sliding rail for the bed

sliding rail for the bed on the left

20. Motor 9

provide power to rotate the lower magnetic ball along the vertical plane, rotate around the z direction

21. Motor 10

provide power to rotate the lower magnetic ball along the horizontal plane, rotate around the z direction

22. Motor 7

provide power to move the lower magnetic ball in the y direction

[0047] The present invention discloses a system uses to examine GI track of a patient, especially small bowl. The system uses magnetic capsule. The magnetic capsule comprises a permanent magnet, which respond to an external magnetic control system. The present invention discloses a system utilizes more than one external magnet to control the movement of the magnetic capsule.

Two magnets

[0048] Referring to Figure 1, the magnetic capsule of the present invention is meant to be used for a patient's GI track examination, in particular for small bowl. The magnetic capsule further comprises an imaging means, which can examine the interior of the GI track of the patient. In the present invention, the magnet capsule moves in the small bowl because of the combined magnetic field generated by both external magnets.

[0049] In the present invention, the magnetic capsule can be of any shape. One exemplary magnetic capsule is schematically illustrated in Figure 9, the capsule has a length L. A permanent magnetic dipole is enclosed in the housing. In one example, the length of the capsule is parallel to the magnetization direction (N->S) of the capsule. In another example, the length of the capsule is perpendicular to the magnetization direction (N->S) of the capsule. In the operation embodiments depicted in figures of the present invention, the magnetization direction (N->S) of the capsule is parallel to the length of the magnetic capsule. Herein, length is directed to describe a longest dimension of the capsule. Because it is desired to have the longest dimension of the capsule parallel to the interior wall of the small bowel to reduce discomfort.

[0050] In the present invention, it is disclosed a system comprises two magnetic generation means. Each magnetic generation means comprises an external magnetic

control assembly. The external magnetic control assembly provides power to move the magnetic generation means' position and magnetization direction with respect to the patient, in order to provide optimal magnetic field guidance to the magnet capsule.

[0051] In one embodiment of the present invention, two magnetic generation means each has a permanent magnetic dipole. In example, the two magnetic generation means have equal amount of magnetic dipoles. In the scope of the present invention, equal amount means, one magnetic dipole is at 95%-105% of the other magnetic dipole.

[0052] In one embodiment of the present invention, two magnetic generation means each is spherical shaped. In one example, both magnetic balls have the same diameter. Each magnetic ball has a weight center and a magnetization center. In one example, the magnetization center for both spherical shaped magnetic generation means is always aligned in one of the three coordinates (x, y, z) direction. In another example, the weight center and magnetization center coincide with each other. In another example, the weight center for both spherical shaped magnetic generation means is always aligned in two of the three coordinates (x, y, z) direction. For instance, referring to figures 4-8, the two magnetic balls are the in the same xy position and only differs in the vertical z direction.

[0053] The purpose of the present invention is to provide a better external magnetic control to the magnetic capsule during small bowel examination. Therefore more than one magnet is used to provide a distributed external magnetic field, which is not able to achieve use one single magnet and one magnetic field. The two magnet are always on and off at the same time during the patient examination period.

[0054] Therefore it is desired to place the patient in between the two external magnets. After the magnetic capsule has been introduced into the patient, the patient is ready for GI track examination, the patient is invited to enter the medical apparatus.

[0055] In one embodiment of the present invention, the two magnetic generations means are placed above and below the patient, when the patient lies down on a platform or bed in the medical examination system.

[0056] In another embodiment of the present invention, the two magnetic generations means are placed in the front or behind the patient, when the patient stands in the space of the medical examination system. In still another embodiment of the present invention, the two magnetic generations means are placed on the left and right of the patient, when the patient stands in the space of the medical examination system. In all the above embodiments, for safety and other reasons, the magnetic ball is positioned at least 5-25cm away from a surface of the patient.

[0057] In the scope of the present invention, in the embodiment of two magnetic generations means are placed above and below the patient, when the patient lies down on a platform or bed in the medical examination system, referring to figure 3 and 4, the x direction is a front-back direction; y direction is the left-right direction; and z direction is vertical up-down direction; horizontal rotation is rotation along yz plane, rotation around y axis; and vertical spinning is rotation along xy plane, rotation around z axis.

[0058] In the embodiment of two magnetic generations means are placed in front of and behind the patient, when the patient stands in the middle of the open medical examination area with the semi-enclosed system, the x direction is a front-back direction; z direction is the left-right direction; and y direction is vertical up-down direction; horizontal rotation is rotation along yz plane, rotation around z axis; and vertical spinning is rotation along xz plane, rotation around y axis.

[0059] In the scope of the present invention, any system that can generate a magnetic field can be used as magnetic generation means. In one embodiment, any materials that have permanent magnetic dipole can be used as external magnetic means. The materials are of the external magnetic balls are selected from Fe, Co or Ir and any alloy from them. In one example, the two magnetic balls are made of the same magnetic materials.

[0060] In the scope of the present invention, the external magnets can be of any shape. The spherical shape is preferred because spherical shaped magnetic is known to generate a less complicated magnetic field. The two external magnets can be at different sizes according to the scope of the present invention.

[0061] In a preferred example, the two external magnets are made of the same material composition; it is preferred to provide the two external magnets with same sizes, so that the operations are more intuitive and easy to operate. When two external magnets provide the magnetic fields at the similar strength, the operator can easily make the magnet closer or further away from the patient in order to make the associated magnetic field stronger or weaker.

[0062] The two external magnets are the same size means one external magnet is having a size or volume at about 95%-105% of the other external magnet.

[0063] In a preferred example, the two external magnets are made of the same material composition; it is preferred to provide the two external magnets with same weight, so that the operations are more intuitive and easy to operate.

[0064] The two external magnets are the same weight means one external magnet is having a size or volume at about 95%-105% of the other external magnet.

[0065] In the event that the two external magnets have different weight, or size, which can be taken into the consideration when setting up the operation system and movement protocols. For example, if one magnet is bigger than the other, the bigger magnet can be positioned at a distance farther away from the patient than the smaller magnet.

[0066] In generally, the magnets are made of Aluminum, Iron Boron alloy.

[0067] By doing so, the magnets can be moved gently and smoothly to guide the movement of the magnetic capsule so that the examination can be finished within a

reasonable amount of the time, the amount date to be collected are enough for the doctors to evaluate and yet the patient does not suffer much discomfort due the movement magnetic capsule.

Two magnetic movement control assembly

[0068] Each external magnet is attached to an external magnet movement control assembly. Each external magnet movement control assembly has motors and arms that moves the magnet in more than 3 degrees of freedoms.

[0069] Each magnetic control assembly can be operated individually. Each magnetic generation means can move along x direction, y direction, z direction, and further rotate horizontally and vertically. In another words, each magnetic generation means can move in 5 degrees of freedom. The each external control assembly can provide power for movement individually in the five degrees of freedom.

[0070] Referring to figures 5-8, each magnetic generation means have five motors to provide the power for movement in each degree of freedom. Totally, there are 10 motors. Each motor is connected to a driver, which can be controlled directly.

[0071] In one embodiment of the present invention, the two magnetic generation means moving along the same direction can be controlled simultaneously. In one example, the two magnets moves horizontally in either x, y direction simultaneously.

[0072] In accordance with the aspect of the present invention, in one embodiment, the system for navigating a magnetic capsule inside a patient, comprises more than one magnetic field generation means and more than one external movement control assemblies. In the present invention, the system comprises a first magnetic field generation means, positioned on a first side of the patient, configured to provide a first magnetic field to move the magnetic capsule; and a first external movement control assembly, comprise

a first horizontal translation means, which can move the first magnetic field generation means along an x-axis direction;
a second horizontal translation means, which can move the first magnetic field generation means along an y-axis direction;
a first vertical movement means, which can move the first magnetic field generation means along a z-axis direction;
a first rotation means, which can turn the first magnetic dipole along or parallel to a xy plane defined by the x-axis and y-axis, or rotate around the z-axis direction;
a second rotation means which can turn the first magnetic dipole around the x-axis direction;
wherein the can each adjust the position and orientation of the first magnetic field generation means individually.

[0073] The system further includes a second external magnetic control assembly, directed to control the movement of the second magnetic field generation means, which is positioned on a second side of the patient, configured to provide a second magnetic field to move the magnetic capsule.

[0074] The second external magnetic control assembly comprises, in one example, a third horizontal translation means which can move the second magnetic field generation means along the x-axis direction.

[0075] In another example, the second external magnetic control assembly further comprises, a fourth horizontal translation means which can move the second magnetic field generation means along the y-axis direction.

[0076] In another example, the second external magnetic control assembly further comprises, a second vertical movement means which can move the first magnetic field generation means along the z-axis direction.

[0077] In another example, the second external magnetic control assembly further comprises, a third rotation means which can turn the second magnetic dipole along or parallel to the xy plane defined by the x-axis and y-axis, or rotate around the z-axis direction.

[0078] In another example, the second external magnetic control assembly further comprises, a fourth rotation means which can turn the second magnetic dipole around the x-axis direction.

[0079] In the second external magnetic control assembly, wherein each translation means and rotation means can adjust the position and orientation of the first magnetic field generation means individually.

[0080] Further, the first and external magnetic control assembly can operate sequentially or simultaneously including at least one movement means.

[0081] In one embodiment, the first and second magnets are above and below the patient having a magnetic capsule inside patient's GI track. In one example, the first horizontal translation means for the first magnetic field generation means and the third horizontal translation means for the second magnetic field generation means can be moved together.

[0082] In another example of the same embodiment, the second horizontal translation means for the first magnetic field generation means and the fourth horizontal translation means for the second magnetic field generation means can be moved together.

[0083] In another example of the same embodiment the first vertical translation means for the first magnetic field generation means and the second vertical translation means for the second magnetic field generation means can be moved together.

[0084] In still another example of the same embodiment the first rotation means for the first magnetic field generation means and the third rotation means for the second magnetic field generation means can be moved together.

[0085] In yet another example of the same embodiment, the second rotation means for the first magnetic field generation means and the fourth rotation means for the second magnetic field generation means can be moved together.

[0086] When the patient is under examination, in one embodiment of the same embodiment the magnetic dipole direction of the first and second magnetic field generation means are parallel to each other (Figures 13-14). In one example, NS direction of the first and second magnetic field generation means are parallel to each other but opposite to the magnetic dipole direction of the magnetic capsule when the patient is under examination.

[0087] In another embodiment, he two magnetic dipole directions of the first and second magnetic field generation means are perpendicular to the magnetic dipole direction of the magnetic capsule (Figures 10 and 11). In one example, NS direction of the first and second magnetic field generation means are parallel to each other but opposite to the magnetic dipole direction of the magnetic capsule when the patient is under examination.

bed

[0088] The system further comprises a supporting platform and the patient lies on the platform during examination. The height of the supporting platform from ground is adjustable.

[0100] The position of the supporting platform along x direction, in the z direction defines a center line of the system, because the two magnetic balls are intended to provide combined magnetic fields centered around the patient and the magnetic capsule there within. The center line may be the same as the proposed travel pathway of the magnetic capsule. In one example, the first and second magnetic field generation means

are mirror images to each other across the center line. In a preferred example, the magnetic centers of the first and second magnetic field generation means are mirror images to each other, in another words they are in the same x direction.

[0101] Referring to figures 3 and 4, the platform can move in the y direction in and out from the examination area.

Mechanical parts of the assembly

Base

[0102] The present invention discloses a medical apparatus, comprising a base, situated on the ground. Referring to figures 3 and 4, the base is square or rectangular shaped, with two of the supporting members raised above the ground and two of supporting members laid on the ground. The two members raised above the ground further comprise a top area as a supporting surface for the vertical supporting frame assemblies.

A pair of supporting frame assemblies

[0103] The medical apparatus further comprises a pair of vertical supporting frame assembly, a left vertical supporting frame assembly and a right vertical supporting frame assembly. The pair of the arranged crosswise to each other, each vertical supporting frame assembly comprising a first horizontal member and a second horizontal member, a first vertical member and a second vertical member, the second horizontal member is connected to the base on the ground. The base has a width, which is the distance between the two members that provides a top seating surface, and is also the length of two members which sit on the ground.

[0104] In each vertical supporting frame assembly, the first horizontal member is an upper horizontal member and the second horizontal member is a seating horizontal member. The seating horizontal member rests on the top supporting surface of the base.

[0105] Referring to Figures 2-4, there are holes are at pre-determined positions of the both the first and second vertical member, configured to allow the bed to be place at different height from the ground for different patient.

[0106] Referring to figures 2-3, the first vertical member of each supporting frame assembly is a front vertical member, and the second vertical member of each supporting frame assembly is a back vertical member.

[0107] Further, both the upper horizontal members and the lower horizontal members are fixed with sliding rails, which allows x-axis assemblies to travel between the front vertical member to the back vertical member and stop anywhere in between.

[0108] In one embodiment of the present invention, the medical apparatus comprises two external magnetic control systems. The two magnetic external magnetic control systems are positioned above and below the bed of the medical apparatus. The external magnetic control system positioned above the bed comprises an upper magnetic ball and upper magnetic control assembly. The external magnetic control system positioned below the bed comprises a lower magnetic ball and a lower magnetic control assembly. Referring to figures 3 and 4, the upper magnetic control assembly crosses over the bed and is mounted on two opposing upper horizontal members of the pair of vertical supporting frames. The lower magnetic control assembly crosses over an open area or hollow bottom of the base and to be placed on two opposing lower horizontal members or seating members of the pair of vertical supporting frames.

x-axis movement assembly

[0109] Referring to figures 3-5, a horizontal arm of the x-axis movement control assembly is mounted on the opposing horizontal members of the two vertical supporting assemblies. The movement control assembly can move between the distance from the front vertical member to the back vertical member of the vertical supporting assembly, and the magnetic balls travels within the same distance in the x direction. In one example, the x axis movement assembly can moves between 0-50 cm.

y-axis movement assembly

[0110] Further, the arm of the horizontal arm of the x-axis movement control assembly comprises a sliding rail in the y direction. The sliding rail is positioned on either front surface or back surface of the horizontal arm of the x-axis movement. The y axis movement control assembly is mounted onto the arm of the sliding track, moves between the upper horizontal member of the left vertical supporting assembly and the upper horizontal member of the right vertical supporting assembly, and when the y axis movement control assembly moves, the external magnetic ball move with it. . In one example, the y axis movement assembly can moves between 0-30 cm.

z-axis movement assembly

[0111] Additionally, y-axis movement assembly further comprises a vertical arm, perpendicular to the arm of the horizontal arm of the x-axis movement control assembly, attached to the horizontal arm of the x-axis movement control assembly through the sliding rails on the horizontal arm of the x-axis movement control assembly. The vertical arm provides a pair of sliding rails near its left edge and right edge, so that z-axis assembly can moves along the pair of sliding rails up and down to bring the magnetic ball away or closer to the patient. The vertical arm has a bottom edge, and the bottom edge of the vertical arm is at least 5cm away from the surface of the bed. The top edge of the vertical arm is about 20cm-30 cm from the bottom edge of the vertical arm. The z axis assembly moves between the top edge and bottom edge of the vertical member in order to adjust the vertical position of the magnetic ball. . In one example, the z-axis movement assembly can moves between 0-20 cm.

Horizontal rotation/spin

[0112] One x-axis lever extends away from the vertical arm, attached to a first layer helmet-like cover. The first layer of helmet cover is centered around a z-axis rotation arm, hanging down from the x-axis lever. The first layer helmet-like cover extends downwardly, leaving the magnetic ball un-covered substantially. The z-axis rotation arm bring rotation with the corresponding motor bring rotation close wise or counter clock

wise rotation along xy plane to the magnetic ball. The first layer helmet-like cover of the horizontal rotation assembly comprise two ears.

Vertical rotation

[0113] A second layer of helmet is placed under the first layer of helmet-like cover. The second layer of helmet covers less than 50% of the surface the magnetic ball. A motor and a x-axis rotation axis is position on the front to back or left to right sides of the magnetic ball. The a-axis rotation axis and the corresponding motor provide rotation power to the magnetic ball, so that it can rotation around x axis and along yz plane.

[0114] In another aspect of the present invention, a method to examine a patient's GI track using the external magnetic control system described above, is disclosed. The method comprises

preparing a patient laying down on the examination bed, when capsule is inside the patient;

aligning two magnetic balls vertical and moving two magnetic balls simultaneously in a XY plane.

[0115] In one embodiment of the aspect of the present invention, the method further comprises arranging the two magnetic balls so that both have a horizontal magnetization direction. In one example, the horizontal magnetization direction of the two magnetic balls are the same. In one example, the horizontal magnetization direction of the two magnetic balls are the opposite to each other.

[0116] In another embodiment of the aspect of the present invention, the method Positioning the two magnetic balls so that a distance between the centers of the two magnetic balls are more than a desired vertical distance in the z direction. In one example, the desired vertical distance is more than 15cm. In another example, the desired vertical distance is more than 30 cm. In still another example, vertical distance is more than 40 cm.

[0117] Once the examination procedure is started, the location of the capsule under the combined external magnetic field is detected through sensors in the magnetic capsule.

[0118] The method, further comprises measuring the resulted combined magnetic field by magnetic sensors inside the capsules; calculating a position and orientation of the magnetic capsule by two three dimensional magnetic sensors and one three dimensional acceleration sensor inside the capsules, the position and orientation of the capsule.

[0119] After the determining the position and orientation of the magnetic capsule, the method of using further comprising

adjusting the vertical and horizontal position of the two magnetic balls so that the capsule is in a middle position of two balls;

moving the two magnetic balls to adjust their magnetic directions so that the magnetic capsule can image an open space of colon; and moving the two magnetic balls to be ahead of the capsule's moving direction; and

moving the magnetic capsule forward by rotating the two magnetic balls' to change their magnetization direction.

[0120] In one example of the present invention, the method of using including a step of dragging the magnetic capsule backwards, the method comprising

[0121] Providing a two magnetic balls aligned in a vertical direction;

providing both magnetization direction of the magnetic balls parallel to each other;

providing the NS magnetization direction opposite to each other, wherein the upper magnet has NS direction pointing down and the lower magnet has NS direction point up; and

moving the magnetic capsule backward.

[0122] In another example of the present invention, the method further comprises moving the two magnetic balls close to each other at the same pace to about 5cm-10cm from the surface of the patient's body.

[0123] In another example of the present invention, the method further comprises moving capsules toward a center line between the centers of the upper and lower magnetic ball.

[0124] In another example of the present invention, the method further comprises adjusting a tilt angel of the magnetic capsule endoscope when the tilt angle is between 45-135 degrees.

[0125] In another example of the present invention, the method further comprises horizontally rotating the two magnetic balls together to adjust the pasture or orientation of the magnetic capsule so that the two magnetization direction of the magnetic balls are perpendicular to each other.

[0126] In another example of the present invention, the method further comprises vertically rotating of the two magnetic balls together to adjust the pasture or orientation of the magnetic capsule.

[0127] Any reference in this specification to "one embodiment," "an embodiment," "example embodiment," etc., means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the invention. The appearances of such phrases in various places in the specification are not necessarily all referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with any embodiment, it is submitted that it is within the purview of one skilled in the art to affect such feature, structure, or characteristic in connection with other ones of the embodiments. Furthermore, for ease of understanding, certain method procedures may have been delineated as separate procedures; however, these separately delineated procedures

should not be construed as necessarily order dependent in their performance. That is, some procedures may be able to be performed in an alternative ordering, simultaneously, etc. In addition, exemplary diagrams illustrate various methods in accordance with embodiments of the present disclosure. Such exemplary method embodiments are described herein using and can be applied to corresponding apparatus embodiments, however, the method embodiments are not intended to be limited thereby.

[0128] Although few embodiments of the present invention have been illustrated and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the invention. The foregoing embodiments are therefore to be considered in all respects illustrative rather than limiting on the invention described herein. Scope of the invention is thus indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are intended to be embraced therein. As used in this disclosure, the term "preferably" is non-exclusive and means "preferably, but not limited to." Terms in the claims should be given their broadest interpretation consistent with the general inventive concept as set forth in this description. For example, the terms "coupled" and "connect" (and derivations thereof) are used to connote both direct and indirect connections/couplings. As another example, "having" and "including", derivatives thereof and similar transitional terms or phrases are used synonymously with "comprising" (i.e., all are considered "open ended" terms) – only the phrases "consisting of" and "consisting essentially of" should be considered as "close ended". Claims are not intended to be interpreted under 112 sixth paragraph unless the phrase "means for" and an associated function appear in a claim and the claim fails to recite sufficient structure to perform such function.

Claims

We claim:

1. A system for controlling movement of a magnetic capsule in a human GI track, comprising;
   a magnetic dipole for placement in a human GI track, the magnetic dipole is enclosed in a capsule, having a length, wherein the magnetic dipole is parallel to the length of the capsule, wherein the length is a longest dimension of the capsule;
   an external magnet control system, having more than five degree of freedom, that can apply external translational and or rotational magnetic field force to the magnetic capsule endoscope; and
   a control system for moving the external magnet to manipulate the object along the variable axis in a desired direction of movement.

2. The system of claim 1, wherein the external magnetic control system have two magnetic generation means having permanent magnetic dipole.

3. The system of claim 1, wherein the two magnetic generation means in the external magnetic control system are two magnetic balls.

4. The system of claim 1, wherein the two magnetic generation means having equal magnetic dipoles.

5. The system of claim 2, wherein the two magnetic generation means in external magnetic control system are placed on opposing sides of the magnetic capsule.

6. The system of claim 5, wherein the two magnetic generation means in external magnetic control system are placed above and below the magnetic capsule.

7. The system of claim 3, wherein one magnetic generation means in external magnetic control system are placed above the magnetic capsule with an adjustable vertical distance from a center of the magnetic means to the length of the capsule at 5-20 cm.

8. The system of claim 3, wherein each magnetic generation means in external magnetic control system can be moved laterally in 20 cm.

9. The system of claim 1, wherein two magnetic generation means are made of the same materials.

10. The system of claim 1, wherein two magnetic generation means have equal sizes.

11. A magnetic capsule system to examine a GI track of a patient:

a first external magnetic control system, comprising

a first magnetic field generation means, positioned on a first side of the patient, configured to provide a first magnetic field to move the magnetic capsule;

and a first external magnetic movement control assembly, comprising

a first horizontal translation means which can move the first magnetic field generation means along an x-axis direction;

a second horizontal translation means which can move the first magnetic field generation means along an y-axis direction;

a first vertical movement means which can move the first magnetic field generation means along a z-axis direction;

a first rotation means which can turn the first magnetic dipole along or parallel to a xy plane defined by the x-axis and y-axis, or rotate around the z-axis direction;
a second rotation means which can turn the first magnetic dipole around the x-axis direction;
wherein the can each adjust the position and orientation of the first magnetic field generation means individually.

a second external magnetic control assembly, comprising
a second magnetic field generation means, positioned on a second side of the patient, configured to provide a second magnetic field to move the magnetic capsule;
a third horizontal translation means which can move the second magnetic field generation means along the x-axis direction;
a fourth horizontal translation means which can move the second magnetic field generation means along the y-axis direction;
a second vertical movement means which can move the first magnetic field generation means along the z-axis direction;
a third rotation means which can turn the second magnetic dipole along or parallel to the xy plane defined by the x-axis and y-axis, or rotate around the z-axis direction;
a fourth rotation means which can turn the second magnetic dipole around the x-axis direction;
wherein the can each adjust the position and orientation of the first magnetic field generation means individually; and
wherein the first and external magnetic control assembly can operate sequentially or simultaneously to each adjust at least one movement means of the first and second magnetic dipole to provide a combined magnetic field change experienced by the magnetic capsule, which result a change in either position or orientation of the capsule inside the patient.

12. The magnetic capsule system of claim 11, wherein a first magnetic field generation means is above the patient and the second magnetic field generation means is under the patient.

13. The magnetic capsule system of claim 11, wherein a first magnetic field generation means is positioned in front of the patient and the second magnetic field generation means positioned is behind the patient.

14. The magnetic capsule system of claim 11, wherein
the first horizontal translation means for the first magnetic field generation means and the third horizontal translation means for the second magnetic field generation means can be moved together.

15. The magnetic capsule system of claim 11, wherein
the second horizontal translation means for the first magnetic field generation means and the fourth horizontal translation means for the second magnetic field generation means can be moved together.

16. The magnetic capsule system of claim 11, wherein
the first vertical translation means for the first magnetic field generation means and the second vertical translation means for the second magnetic field generation means can be moved together.

17. The magnetic capsule system of claim 11, wherein
the first rotation means for the first magnetic field generation means and the third rotation means for the second magnetic field generation means can be moved together.

18. The magnetic capsule system of claim 11, wherein

the second rotation means for the first magnetic field generation means and the fourth rotation means for the second magnetic field generation means can be moved together.

19. The magnetic capsule system of claim 11, wherein
the magnetic dipole directions of the first and second magnetic field generation means are parallel to each other when the patient is under examination.

20. The magnetic capsule system of claim 19, wherein
the magnetic dipole directions of the first and second magnetic field generation means are perpendicular to the magnetic dipole direction of the magnetic capsule.

21. The magnetic capsule system of claim 11, wherein the two magnetic field generation means are position at an equal distance to the magnetic capsule.

22. The magnetic capsule system of claim 21, wherein the distance is between 5-15 cm.

23. The magnetic capsule system of claim 11, wherein
the magnetic dipole directions of the first and second magnetic field generation means are parallel to the magnetic dipole direction of the magnetic capsule when the patient is under examination.

24. The magnetic capsule system of claim 23, wherein
NS direction of the first and second magnetic field generation means are parallel to each other but opposite to the magnetic dipole direction of the magnetic capsule when the patient is under examination.

25. The magnetic capsule system of claim 11, wherein
the first horizontal translation means for the first magnetic field generation means and the third horizontal translation means for the second magnetic field generation means can be moved to the same direction when a patient is under examination.

26. The magnetic capsule system of claim 11, further comprise a center line which is a proposed travel pathway of the magnetic capsule and the magnetization direction of the first and second magnetic field generation means are mirror image to each other across the center line.

27. The magnetic capsule system of claim 11, further comprise a supporting platform and the patient lies on the platform during examination.

28. The magnetic capsule system of claim 11, wherein the platform moves along the y direction in and out from the examination area.

29. The magnetic capsule system of claim 11, wherein the platform can move in the x direction.

30. A method for controlling movement of a magnetic capsule in a human GI track, wherein said method comprising:

1) Preparing a patient laying down on the examination bed, when capsule is inside the patient;

2) Aligning two magnetic balls vertical and both have a horizontal magnetization;

3) Positioning the two magnetic balls so that a distance the centers of the two magnetic balls are more than 50 cm in the vertical direction;

4) moving two magnetic balls simultaneously in a XY plane;

5) measuring the resulted combined magnetic field by magnetic sensors inside the capsules;

6) calculating a position and orientation of the magnetic capsule by two three dimensional magnetic sensors and one three dimensional acceleration sensor inside the capsules, the position and orientation of the capsule;

7) adjusting the vertical and horizontal position of the two magnetic balls so that the capsule is in a middle position of two balls;

8) moving the two magnetic balls to adjust their magnetic directions so that the magnetic capsule can image an open space of colon; and moving the two magnetic balls to be ahead of the capsule's moving direction; and

9) moving the magnetic capsule forward by rotating the two magnetic balls' to change their magnetization direction.

31. The method of claim 30, further comprising

moving the capsule backward and rotate the two magnetic balls so that magnetic direction of the two magnetic balls are perpendicular to the magnetic direction of the magnetic capsule, while the magnetic direction of the two magnetic balls pointing to each other.

32. The method of claim 30, further comprising

moving the two magnetic balls close to each other at the same pace to about 5cm-10cm from the surface of the patient's body.

33. The method of claim 30, further comprising

moving capsules toward center line between the magnetic balls' centers.

34. The method of claim 30, further comprising

adjusting a tilt angel of the magnetic capsule endoscope when the tilt angle is between 45-135 degrees.

35.The method of claim 30, further comprising

horizontally rotating the two magnetic ball together to adjust the pasture or orientation of the magnetic capsule.

36.The method of claim 30, further comprising

vertically spinning the two magnetic ball together to adjust the pasture or orientation of the magnetic capsule.

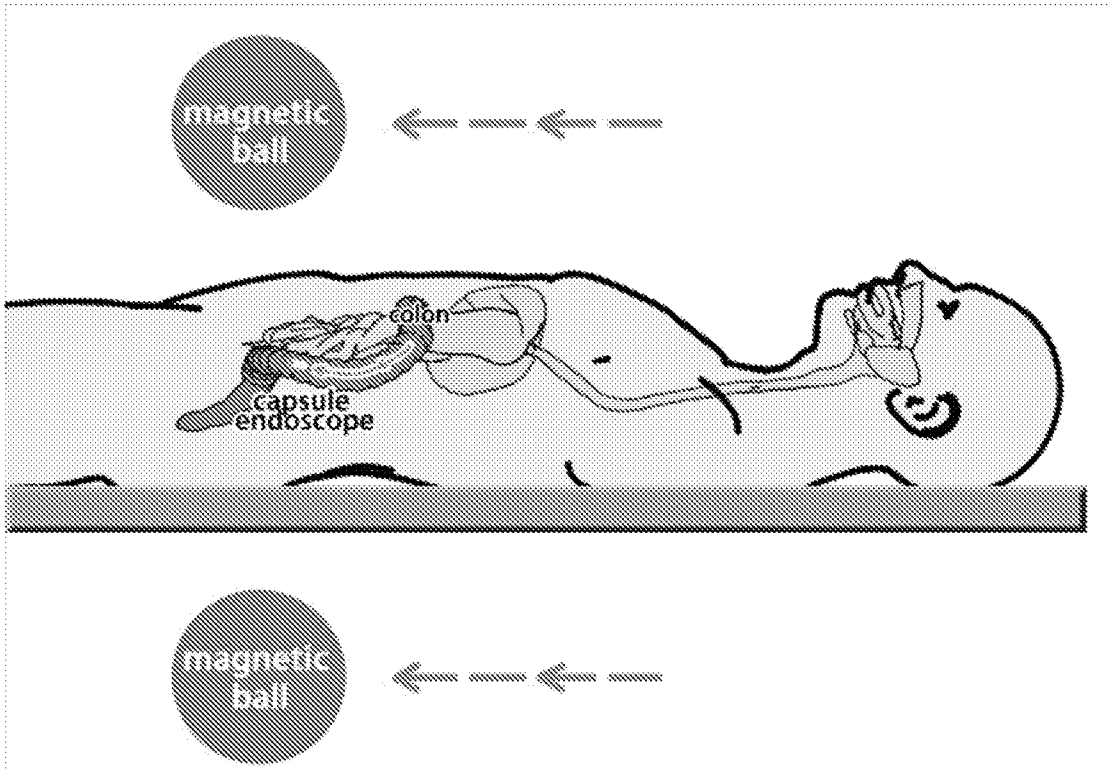
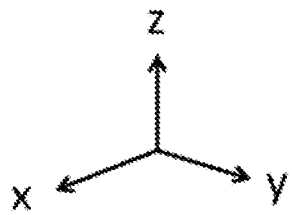


FIG. 1



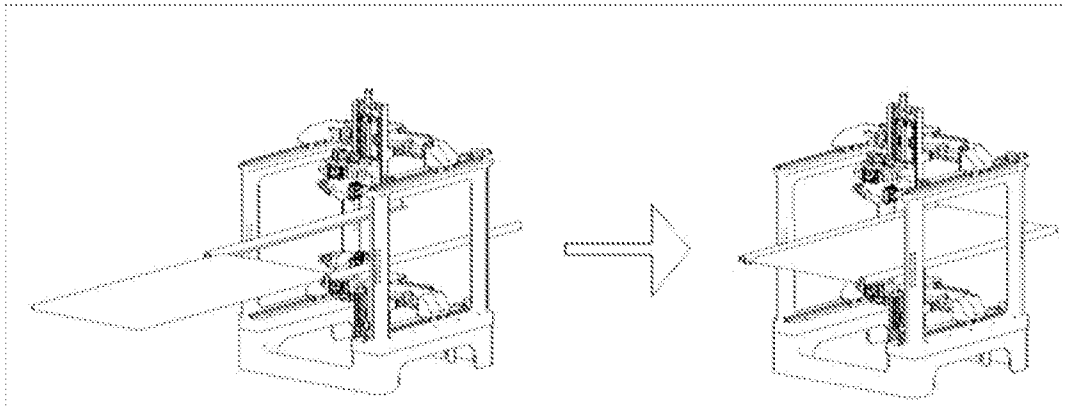


FIG. 2

FIG. 3

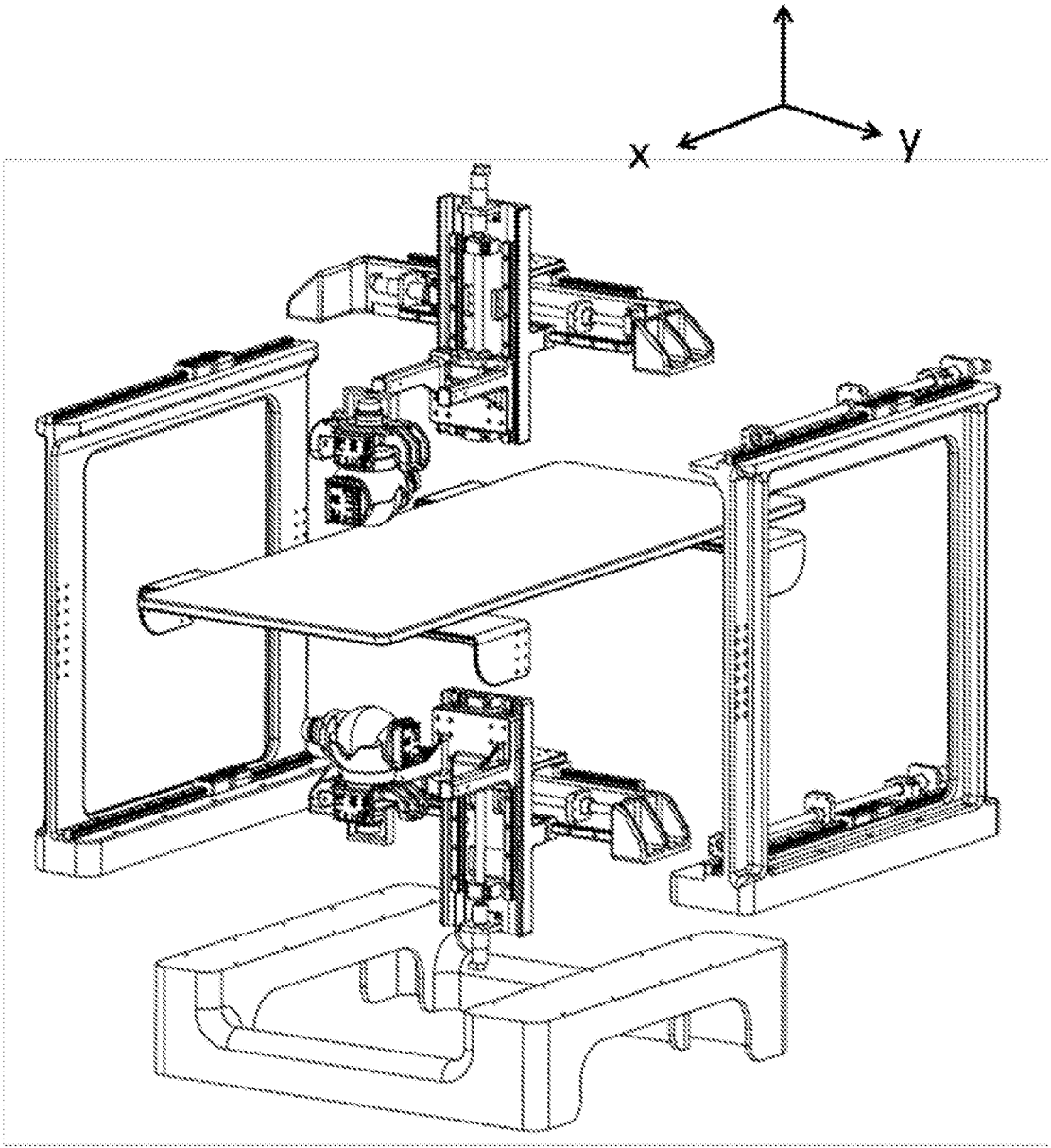


FIG. 4

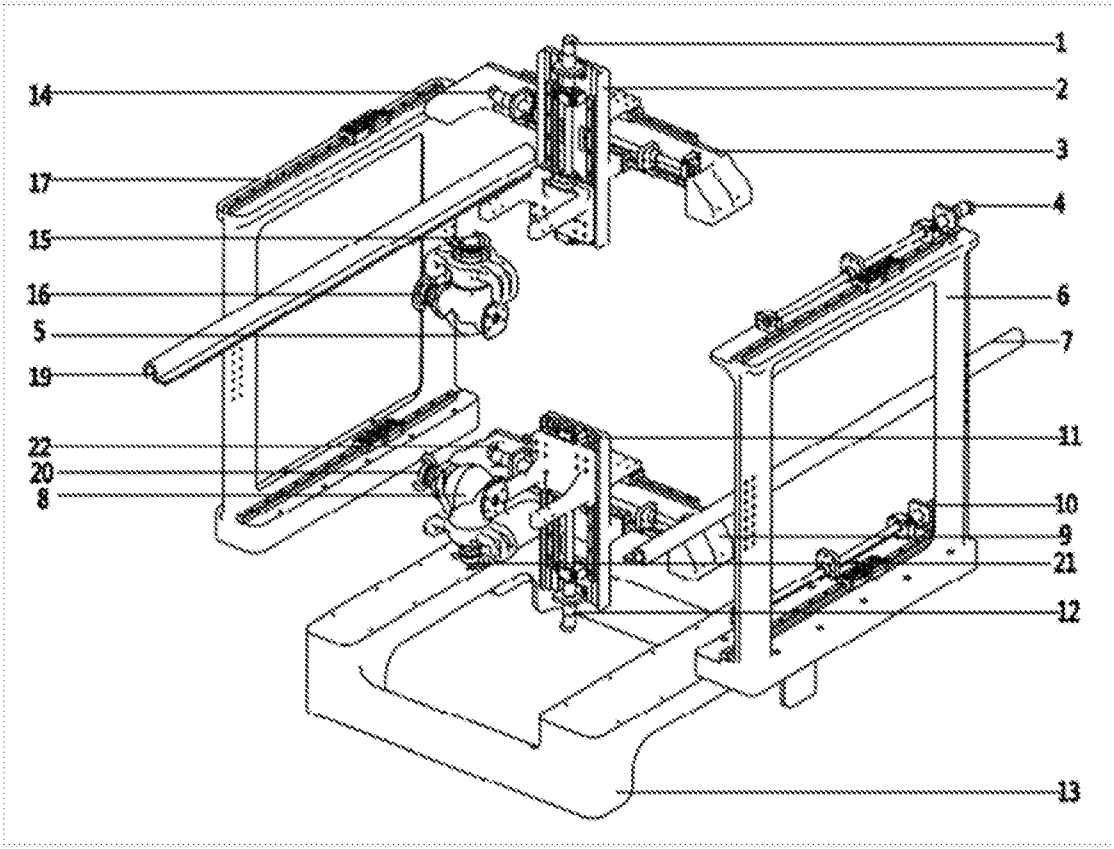


FIG. 5

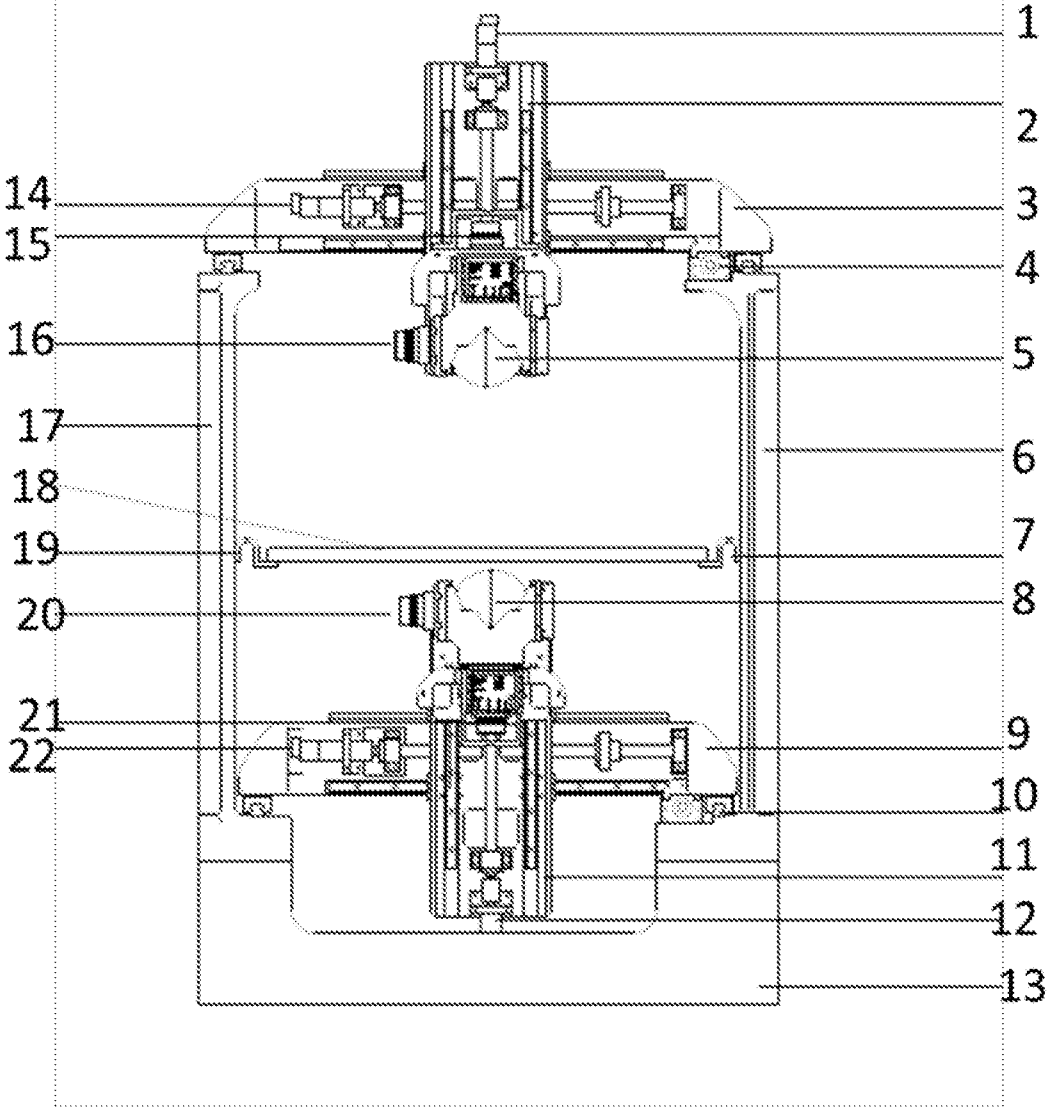


FIG. 6

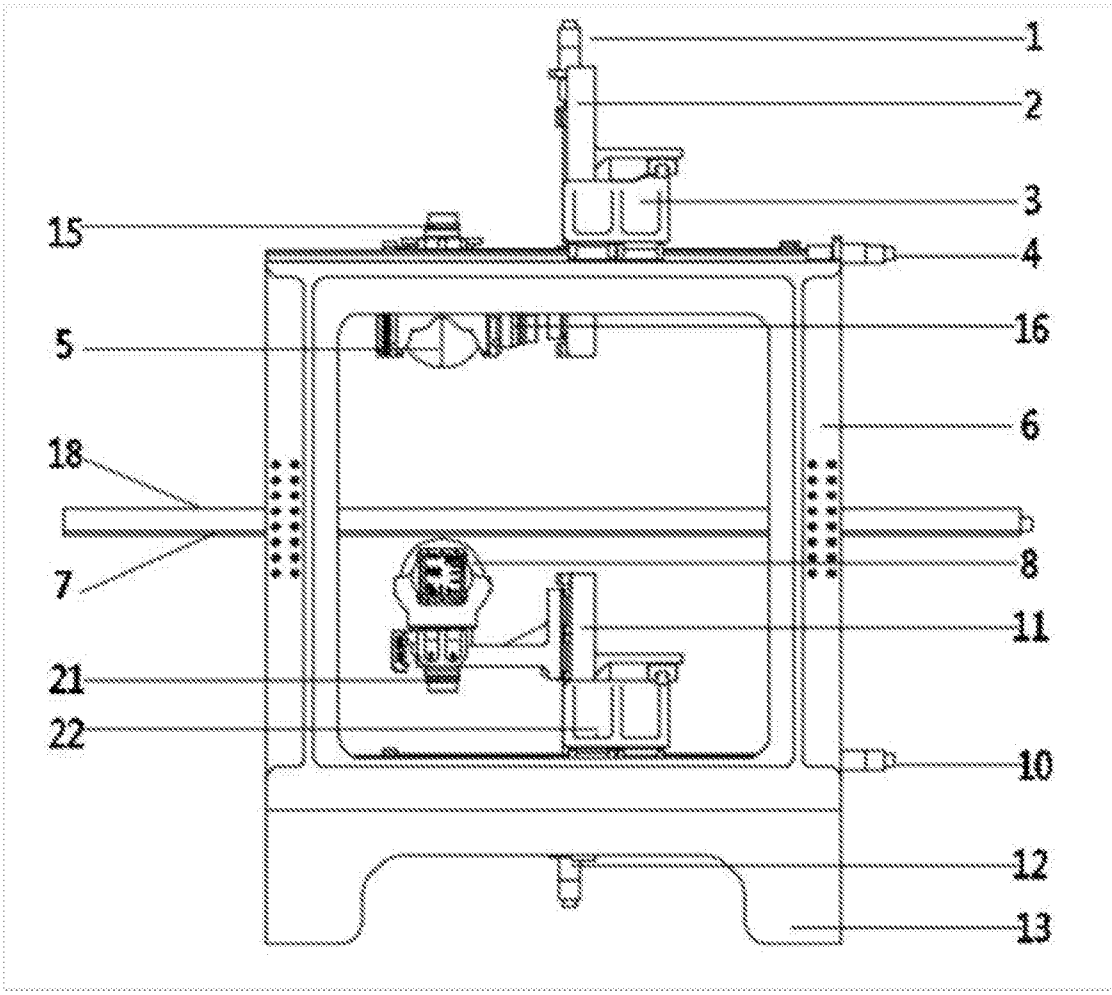


FIG. 7

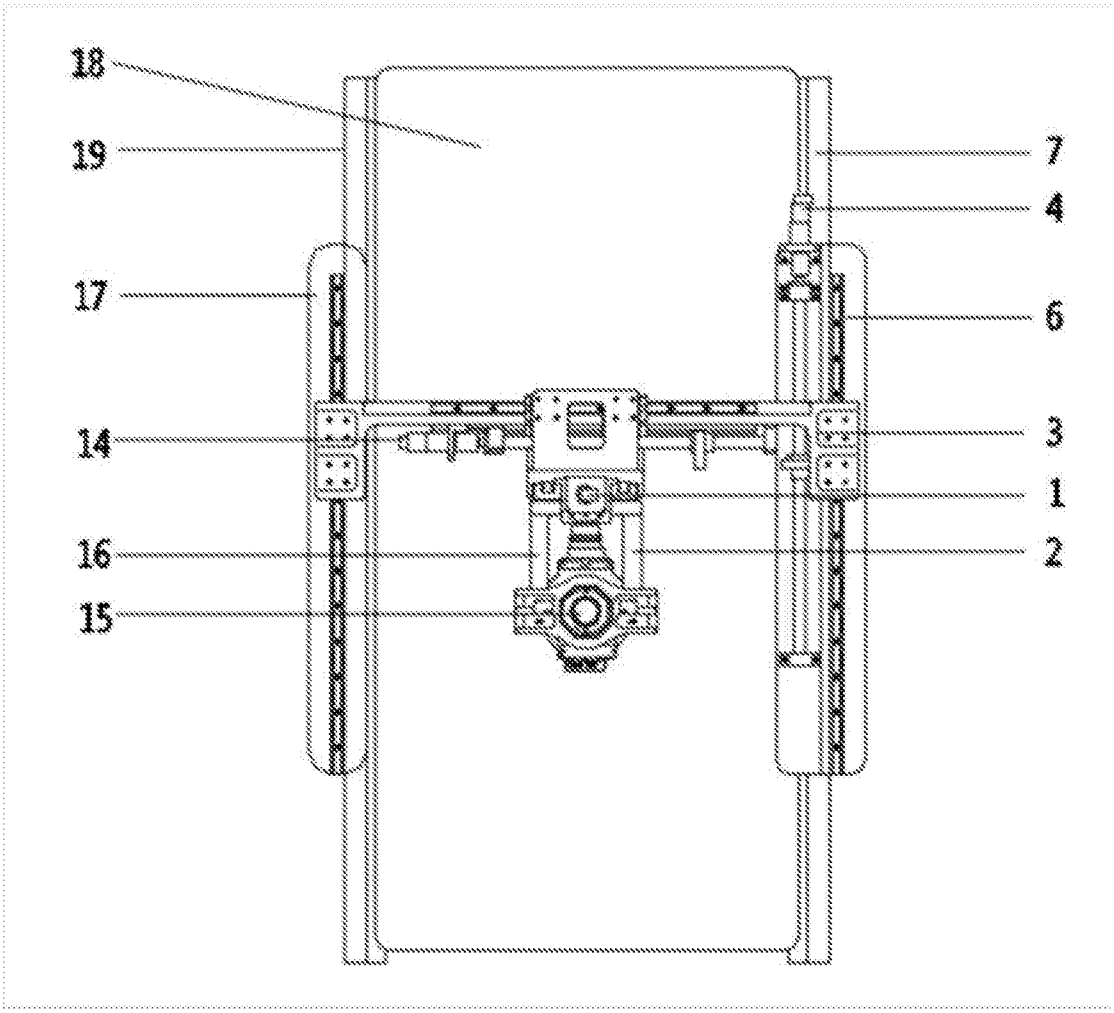


FIG. 8

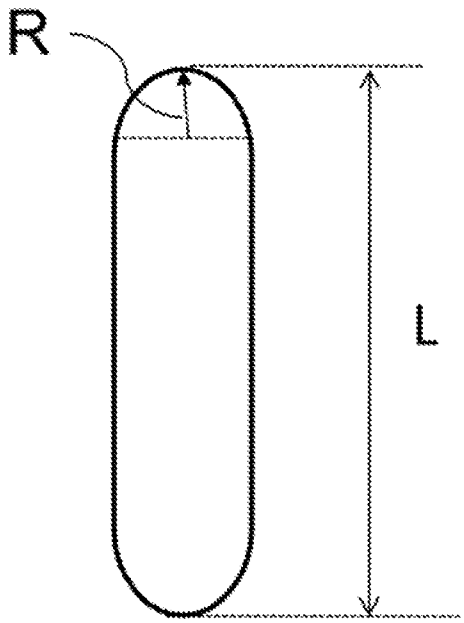


FIG. 9

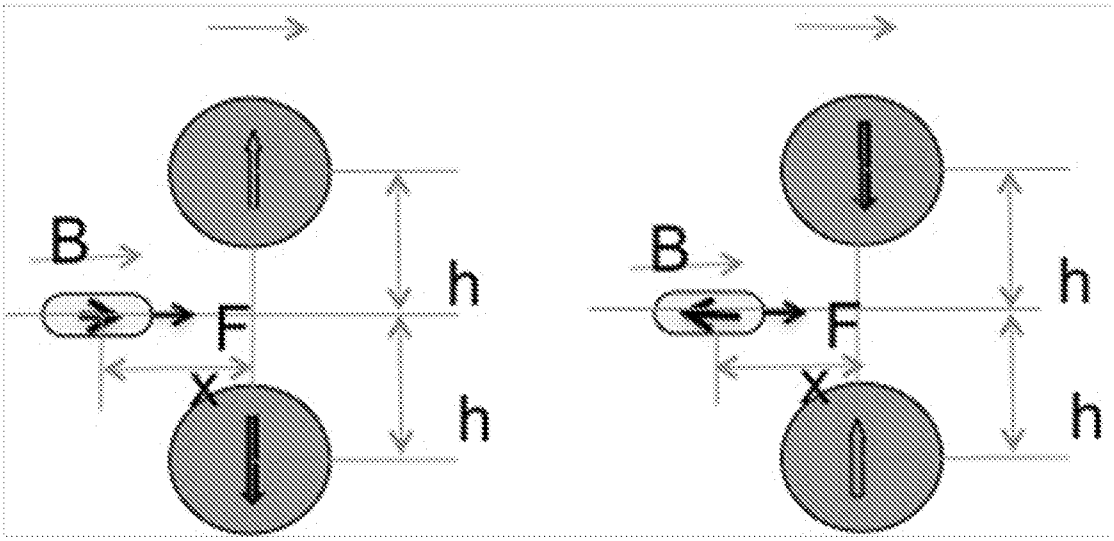
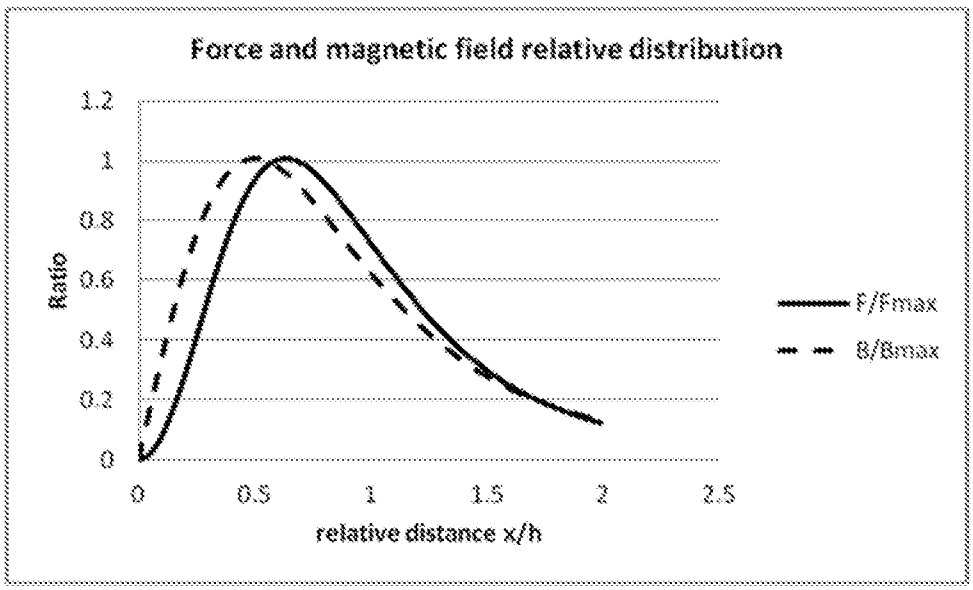


FIG. 10

FIG. 11

FIG. 12



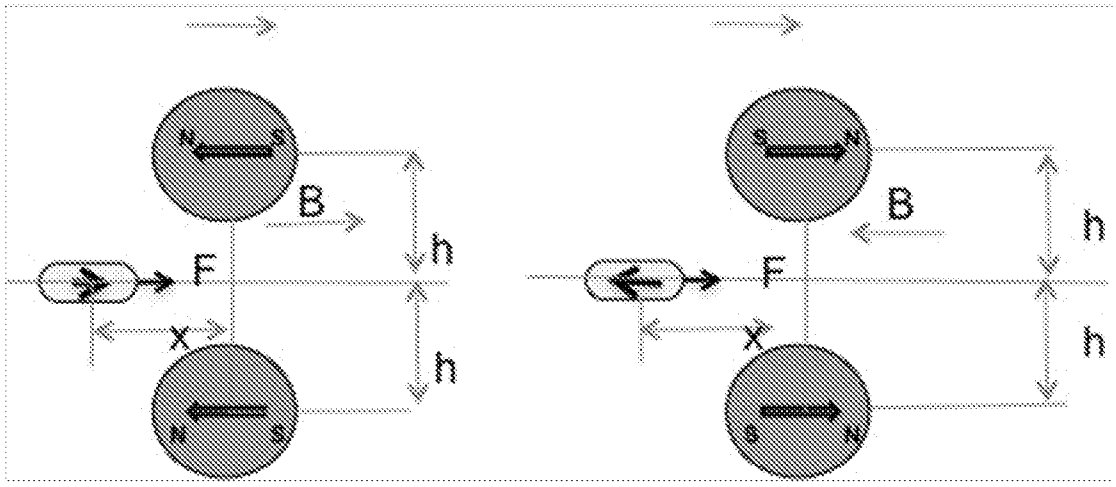


FIG. 13

FIG. 14

FIG. 15

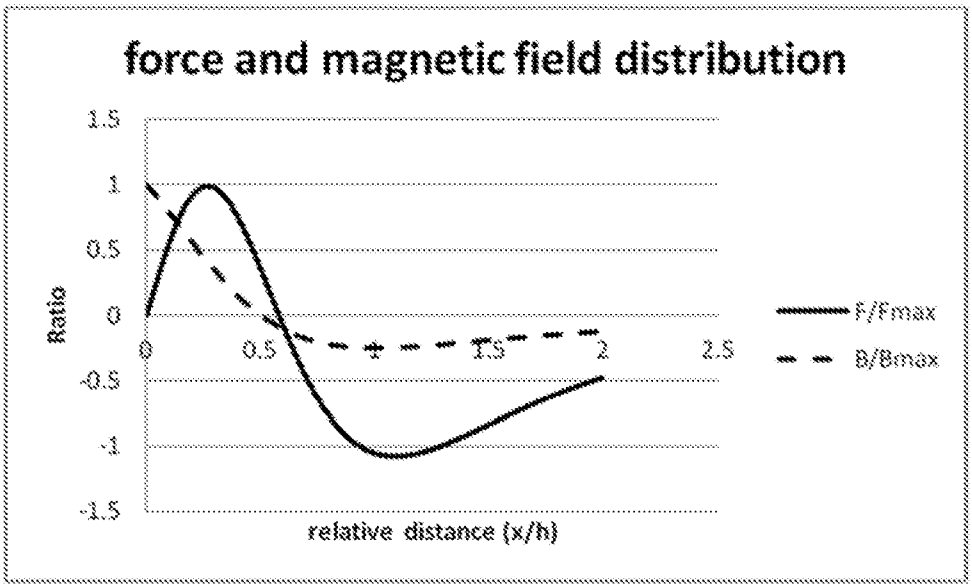


FIG. 16

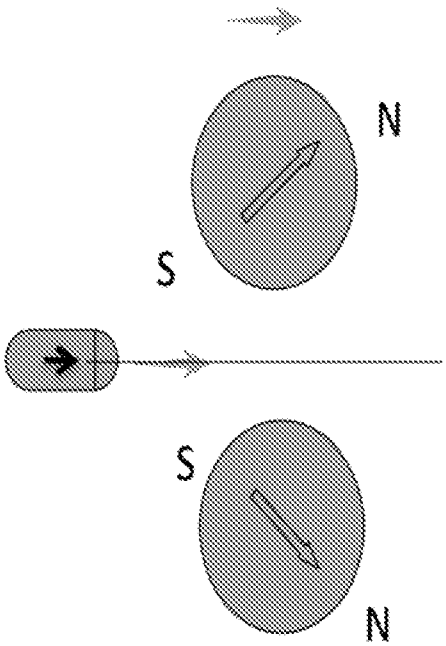
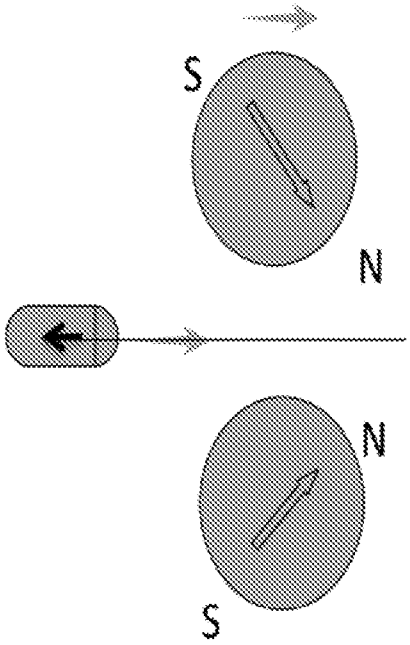


FIG. 17



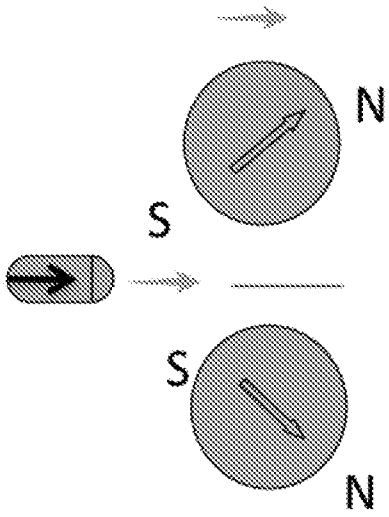


FIG. 18

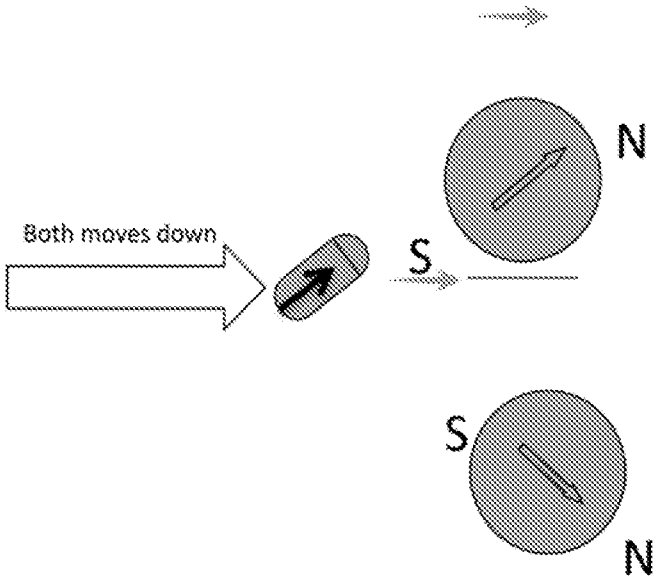


FIG. 19

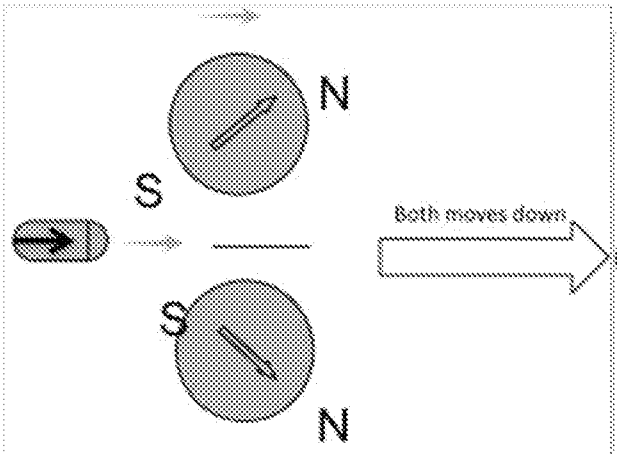


FIG. 18

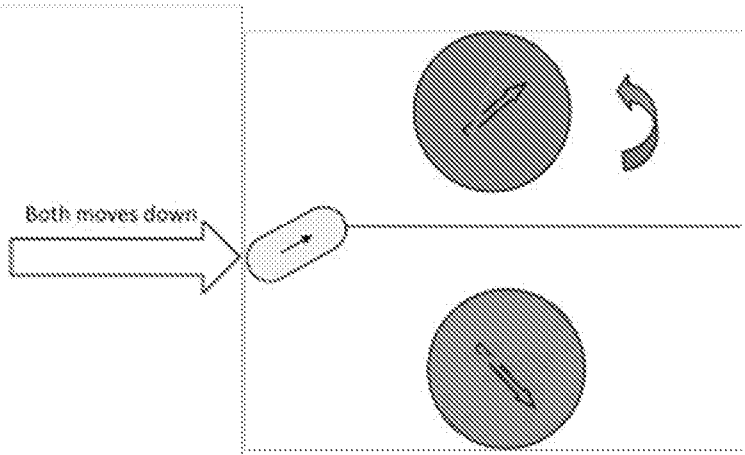


FIG. 20

FIG. 21 FIG. 22 FIG. 23 FIG. 24

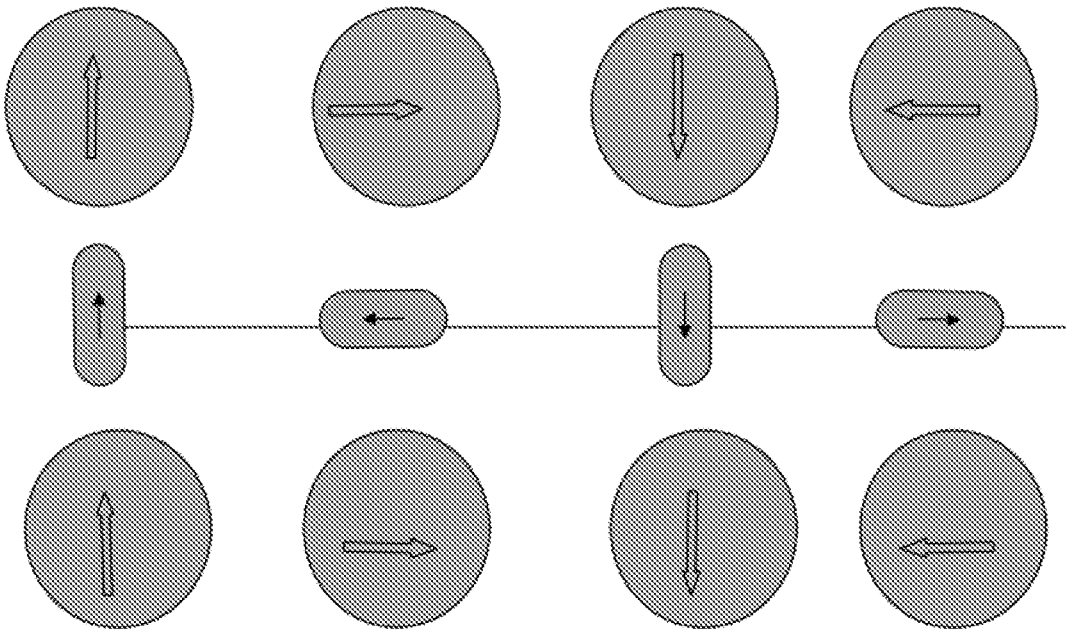
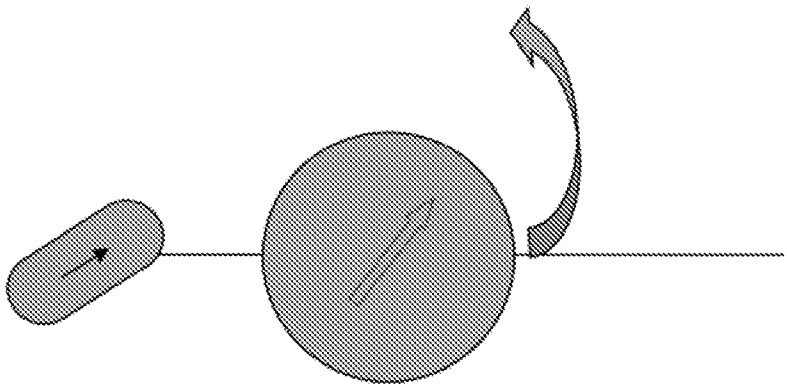


FIG. 25



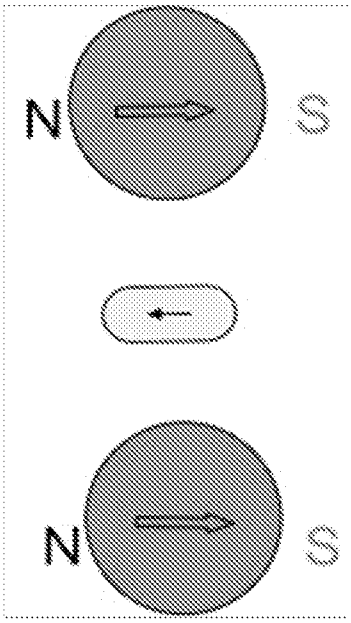


FIG. 26

FIG. 27

FIG. 28

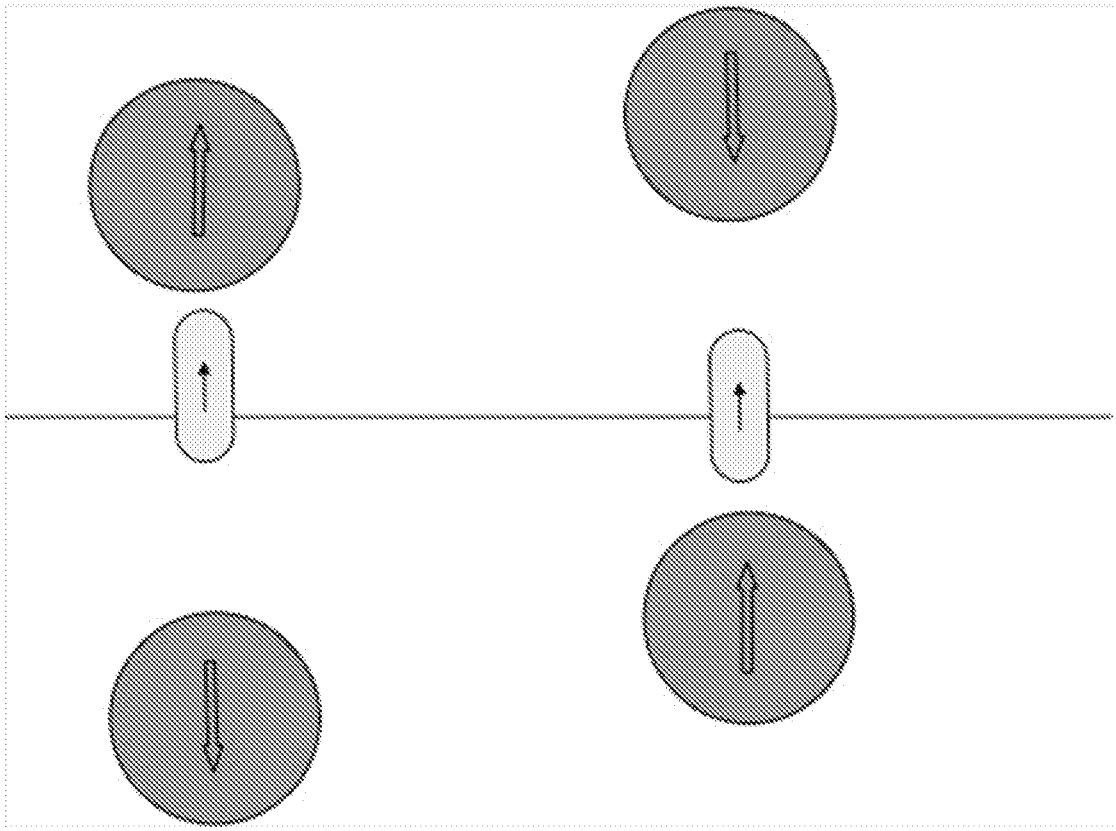
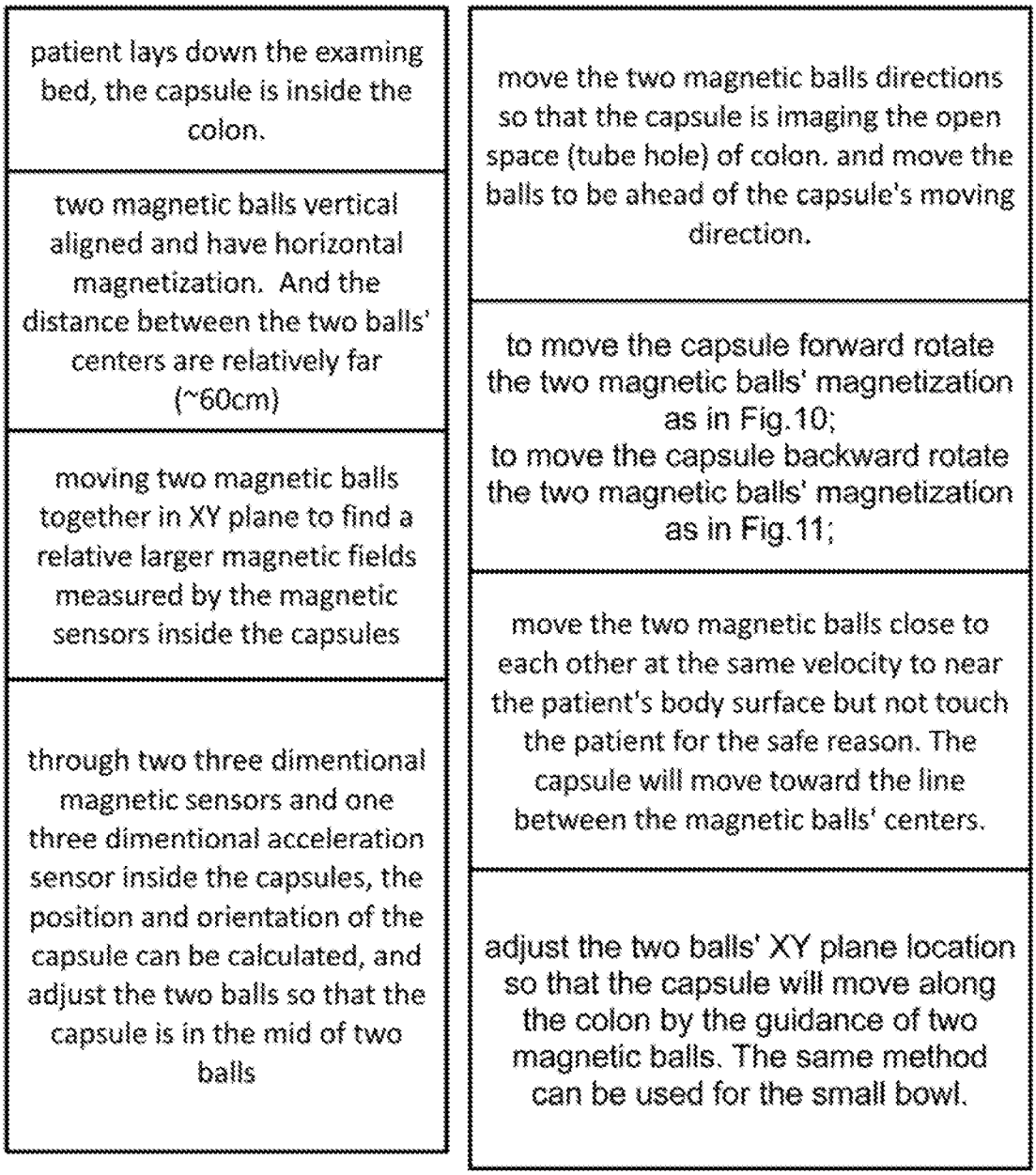


FIG. 29


patient lays down the examing bed, the capsule is inside the colon.
two magnetic balls vertical aligned and have horizontal magnetization. And the distance between the two balls' centers are relatively far (~60cm)
moving two magnetic balls together in XY plane to find a relative larger magnetic fields measured by the magnetic sensors inside the capsules
through two three dimentional magnetic sensors and one three dimentional acceleration sensor inside the capsules, the position and orientation of the capsule can be calculated, and adjust the two balls so that the capsule is in the mid of two balls
move the two magnetic balls directions so that the capsule is imaging the open space (tube hole) of colon. and move the balls to be ahead of the capsule's moving direction.
to move the capsule forward rotate the two magnetic balls' magnetization as in Fig.10;
to move the capsule backward rotate the two magnetic balls' magnetization as in Fig.11;
move the two magnetic balls close to each other at the same velocity to near the patient's body surface but not touch the patient for the safe reason. The capsule will move toward the line between the magnetic balls' centers.
adjust the two balls' XY plane location so that the capsule will move along the colon by the guidance of two magnetic balls. The same method can be used for the small bowl.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2017/103062

A. CLASSIFICATION OF SUBJECT MATTER

A61B 1/00(2006.01)i; A61B 5/06(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A61B1/-,A61B5/-

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)

CNPAT;CNKI;EPODOC;WPI:ankon medical technologies, sphere?,spherical, ball?, magnet, magnetic,permanent, capsule, control+, endoscope,endoscopy,endoscopic

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 103222842 A (ANKON PHOTOELECTRIC TECHNOLOGY WUHAN CO., LT.) 31 July 2013 (2013-07-31) description paragraphs [0006]-[0047], figures 1-11	1-36
Y	WO 2006005075 A2 (BELSON, AMIR) 12 January 2006 (2006-01-12) description pages 13-26, figures 1-14	1-36
A	CN 102176855 A (OLYMPUS MEDICAL SYSTEMS CORP.) 07 September 2011 (2011-09-07) the whole document	1-36
A	US 2011184235 A1 (NOVINEON HEALTHCARE TECHNOLOGY PARTNERS GMBH) 28 July 2011 (2011-07-28) the whole document	1-36
A	CN 105411505 A (SHANGHAI ANHAN MEDICAL TECHNOLOGY CO., LT.) 23 March 2016 (2016-03-23) the whole document	1-36
A	CN 104490394 A (SHANGHAI ANHAN MEDICAL TECHNOLOGY CO., LT.) 08 April 2015 (2015-04-08) the whole document	1-36

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
29 November 2017	**28 December 2017**

Name and mailing address of the ISA/CN	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2017/103062

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 101849814 A (UNIV. SHANGHAI SCIENCE & TECHNOLOG) 06 October 2010 (2010-10-06) the whole document	1-36
A	CN 105852783 A (CHONGQING JINSHAN SCIENCE AND TECH. GROUP CO., LT.) 17 August 2016 (2016-08-17) the whole document	1-36

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2017/103062

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	103222842	A	31 July 2013	CN	103222842	B	09 September 2015
				JP	6111375	B2	05 April 2017
				US	2015018614	A1	15 January 2015
				EP	2987447	A1	24 February 2016
				WO	2014169504	A1	23 October 2014
				US	2015018615	A1	15 January 2015
				JP	2016515444	A	30 May 2016
WO	2006005075	A2	12 January 2006	US	2011060189	A1	10 March 2011
CN	102176855	A	07 September 2011	JP	WO2010047357	A1	22 March 2012
				US	8449454	B2	28 May 2013
				EP	2338402	A1	29 June 2011
				WO	2010047357	A1	29 April 2010
				CN	102176855	B	18 September 2013
				US	2010268026	A1	21 October 2010
				JP	4625146	B2	02 February 2011
US	2011184235	A1	28 July 2011	US	8771175	B2	08 July 2014
				JP	5942163	B2	29 June 2016
				BR	PI1100715	A2	24 July 2012
				JP	2011147785	A	04 August 2011
				EP	2347699	A1	27 July 2011
CN	105411505	A	23 March 2016		None		
CN	104490394	A	08 April 2015		None		
CN	101849814	A	06 October 2010	CN	101849814	B	12 December 2012
CN	105852783	A	17 August 2016		None		