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(54) SWITCHABLE PERMANENT MAGNETIC DEVICE

SCHALTBARE MAGNETISCHE ANORDNUNG

DISPOSITIF MAGNETIQUE COMMUTABLE

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(73) Proprietor: **The Aussie Kids Toy Company Pty. Limited**
Port Macquarie, NSW 2444 (AU)

(72) Inventors:
- **UNDERWOOD, Perry John**
  Lake Cathie, NSW 2445 (AU)
- **KOCIJAN, Franz**
  Pappinbara, NSW 2446 (AU)

(74) Representative: **Ertl, Nicholas Justin**
Elkington and Fife LLP
Prospect House
8 Pembroke Road
Sevenoaks
Kent TN13 1XR (GB)

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Description

Field of the invention

[0001] The present invention relates to a magnetic device. In particular, the present invention relates to a switchable permanent magnet device.

Background of the invention

[0002] Permanent magnets consist of a ferromagnetic material that has been suitably magnetized. Permanent magnets provide a magnetic field without requiring an electric current. Permanent magnets are attracted to and can be firmly affixed ferromagnetic materials. However, permanent magnets suffer from the drawback that their energy output is fixed and they cannot be employed if a variation in magnetic field strength is required.

[0003] Due to the above-mentioned drawback with permanent magnets, it has been customary to control magnetic fields by using electric currents or electromagnets. The strength and orientation of the magnetic fields of electromagnets can be controlled successfully by controlling the strength and direction of the electric current. However, this introduces the necessity of having to provide a constantly available source of electric current and associated wiring. This can cause complexity and potential hazards.

[0004] A number of attempts have also been made to arrange permanent magnets to enable variations to be achieved in magnetic field strength. A number of different approaches have been tried to produce practical solutions. However, these approaches resulted in bulky constructions, complicated constructions, or devices that were expensive to manufacture. The prior art devices also paid little attention to achieving a good holding force between the devices and substrates under conditions where an incomplete external magnetic circuit existed, for example, where there were gaps between the magnet and the keeper, or where the keeper or substrate had a low permeability, such as thin ferrous sheet metal. To achieve good holding forces in the prior art devices, it was necessary that perfect contact between the magnet and the substrate be achieved and that the substrate be of substantial volume to enable a sufficient magnetic flux to be established. This, of course, could be difficult to achieve in practice.

[0005] United States patent no 3121193 (Engelstead) describes a permanent magnet-type work holding device especially a chuck that is adapted for use in turning operations. The device of Engelstead consists of arrays of permanent magnets, which magnets are of generally rectangular configuration. In order to adjust the field strength an array of pole pieces was moved away from and out of alignment with another array of pole pieces.

[0006] United States patent no 4251791 (Yanagisawa) describes a magnetic base which is switchable between an engaged position and releasable from a substance by an operation of a single rotating permanent magnet disposed notably in a magnetic circuit block. The rotary magnet in Yanagisawa is rotated by90 to switch between the exited and the unexcited states.

[0007] This device relies upon using passive external magnetic members of substantial mass (12 and 14 of Figure 1 of Yanagisawa) having a rotatable magnet (20) positioned therein.

[0008] United Kingdom patent application no 2130797 relates to a permanent magnet chuck capable of switching from an excited state to an unexcited state by changing the relative positional relationship between fixed permanent magnets and movable permanent magnets. The movable permanent magnets move laterally with respect to the fixed magnets in order to vary the magnetic filed.

[0009] Patent document DE 11 21 242 B discloses a switchable magnetic device that uses two, diametrically polarised permanent magnet discs, one of which is held stationary within a non-ferromagnetic outer housing whilst the other magnet, which is stacked on top of the stationary magnet, is held rotatable about the height axis of the device. An upper, fixed, ferromagnetic disc provides a passive shunting member to allow the device to function. It is believed that use of high powered NdFeB permanent magnets in such device, without the presence of pole elements located at the periphery of the magnet discs and in magnetic circuit therewith, will not lead to proper magnetic field cancellation (i.e. substantially no external magnetic field in the tumed-off state of the device.

[0010] German patent document DE 43 28 171 A1 discloses a magnetic grab for lifting toroidal cores (for eg electric motors). For this purpose, the device incorporates two ferro-magnetic pole pieces of substantial mass and axial length, which in cross-section are half-cylindrical, separated by an air-gap of constant width. The lower ends of the complementary pole pieces are shaped in cross-section such as to be adapted for the specific purpose of being insertable into and magnetically lifting a torus-like body, i.e. have a conically converging lower end. Two permanent dipole magnets which are not further characterised in the DE document are received in a chamber defined at an upper end of the pole elements, whereby rotation of the upper one of the magnets with respect to the lower dipole which is arranged stationarily between the pole shoes causes the magnetic fields of the magnets to be either paralleled (resulting in flux transfer from the magnets, to one pole element to a work piece attached to the device, to the other pole element and back through the magnets, or compensated when the dipoles attain an antiparallel pole orientation.

SUMMARY OF THE INVENTION

[0011] It is an object of the present invention to provide a switchable magnetic device having improved properties, in particular minimised loss of magnetic energy in a turned-on state when in use.

[0012] The present invention provides a switchable magnetic device comprising a first permanent magnet, a second permanent magnet, a housing having two, magnetically separated passive ferro-magnetic pole elements, said first and second permanent magnets being mounted within the housing and between the pole elements in stacked manner such as to be rotatable relative to each other about an axis of the device, and actuation means for causing relative rotation of the first and second permanent magnets, wherein said device presents a relatively strong external magnetic field when said first and second permanent magnets are positioned relative to each other such that north and south poles of the first magnet are in substantial alignment with respective north and south poles of the second magnet, and the device presents a relatively weak external magnetic field when the first and second magnets are positioned relative to each other such that the north pole of the first magnet is in substantial alignment with the south pole of the second magnet and vice versa, characterised in that said first and second permanent magnets are cylindrically shaped and diametrically polarised, and in that said two passive pole elements (a) are pole pieces of low magnetic reluctance material, (b) have a dimension along the stacking direction of the first and second permanent magnets chosen to provide a minimised low magnetic reluctance path within the pole pieces along the device axis, said dimension being preferably about the same as that of the stacked permanent magnets, and (c) encircle the permanent magnets with a wall thickness shaped to either maximise the external magnetic field in an activated state of the device or provide an external magnetic field strength that is about uniform around the perimeter of the pole pieces in an activated state of the device.

[0013] Preferred embodiments are defined in dependent claims. Preferably, the first and second magnets are substantially disc-shaped, and are mounted in the housing such that a face of the first magnet is opposed to a face of the second magnet.

[0014] It is preferred that one magnet is fixedly mounted in the housing and that the other magnet is able to rotate in the housing.

[0015] The housing does comprise a pair of passive ferro-magnetic elements which encircle the magnets but are magnetically separated, for example, by an air gap or by magnetically high reluctance material(s). The housing most suitably defines a chamber in which the first and second magnets are positioned. The chamber may have open ends or, more preferably, is a closed chamber.

[0016] Chamber closing members are suitably used to close the chamber.

[0017] In another embodiment, the housing could be made as a unitary construction or from a single piece of material. In this embodiment, it is preferred that there be two portions of the housing having reduced cross sectional area such that the housing acts as two passive poles, and alternatively, portions of the housing may be treated such that the portions become nonmagnetic to thereby result in the housing acting as two passive poles.

[0018] The housing is preferably made from a material having a low magnetic reluctance. Soft steel, iron or permalloys are examples of suitable materials for the housing.

[0019] The strength of the external magnetic field can be influenced by shaping the pair of passive poles. In one embodiment, the pole elements have a wall thickness shaped to maximise the external magnetic field in an activated state of the device such that they reflect the magnetic field strength around the perimeter of the first and second permanent magnets. In another embodiment, the pole elements have a wall thickness that is constant along the perimeter of the permanent magnets whereby the magnetic field strength is about uniform around the perimeter of the pole pieces in an activated state of the device.

[0020] As noted, the first and second magnets are essentially cylindrical in shape and the height of the cylinder is preferably less than the diameter of the cylinder. It will be appreciated that the first and second magnets need not be exactly cylindrical and that slight variations from a circular cross-section also fall within the scope of the present invention. The height of the magnets may vary over a wide range, and the ratio of diameter to height may also vary over a wide range.

[0021] The first and second magnets are also diametrically magnetised. By that, it is meant that the north pole region is separated by a diameter of the cylindrical surface of the magnet from the south pole region. The north pole region and south pole region both exist on the upper and lower substantially circular faces of the magnet and extend through the length or height of the magnet.

[0022] As mentioned earlier, it is preferred that one magnet is fixed in the housing and one magnet can rotate in the housing. It is especially preferred that the rotatable magnet can rotate about the centre point of its essentially circular faces. In this fashion, the requirement for large clearances between the inner walls of the housing and the rotatable magnet are avoided. In this embodiment, the shape of the body of rotation of the rotatable magnet is the same shape as the magnet itself (i.e. substantially circular in top or plan view) and thus the magnet can rotate and yet retain its positioning relative to the walls of the housing.

[0023] The actuation means for causing relative rotation of the magnets preferably comprises a handle or knob being in connection with one of the magnets. The handle or knob may be connected to the one magnet by one or more intermediate members.

[0024] The handle or knob may be rotated manually, electrically, pneumatically, hydraulically, by the action of expansion of a bimetallic strip, or indeed by any other suitable method.

[0025] The handle may comprise a torque sensitive lever that does not allow a torque in excess of a predetermined amount to be applied to the one magnet. In this regard, when there is no external load applied to the device, it is difficult to switch device between active and inactive states. Use of a torque sensitive lever as part of the actuation means can result in it being impossible to switch the device between the active and inactive states if no sufficient external magnetic circuit is present.

[0026] As mentioned above, the housing has two passive poles, and it is also preferred that one magnet is fixed in the housing. In this particularly preferred embodiment, the one magnet is fixed in place such that the pole pieces are permanently energised.

[0027] The permanent magnets in the present invention may be of any suitable type. The most preferred at present are rare earth magnets because they can have a strong magnetic field. Such magnets also have a high coercivity, which means that they resist becoming demagnetised. It is envisaged that permanent magnet technology will continue to develop and it is likely that more powerful magnets will become available in the future that will be suitable for use in the present invention.

[0028] The first and second magnets may be essentially identical to each other. Alternatively, the first and second magnets may have different magnetic properties. The magnets may have the same or different physical dimensions to each other. Varying the magnetic properties or the physical dimensions of the first and second magnets can be used in some embodiments of the invention to vary magnetic switching properties.

[0029] The present invention may be used as a switchable magnetic holding device. For example, the device may be used to clasp onto surfaces, especially metal surfaces. In some embodiments, the surface to which the device is affixed is located adjacent or underneath a lower surface of the lower magnet. In other embodiments, the surface to which the device is affixed is located adjacent or beside the side surfaces of the magnets.

[0030] Alternatively, the device may be used in applications where mainly use of magnetic field is required or desirable. For example, triggering magnetic sensors, for example, in mines, particle deflection, etc.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] In order to more fully understand the present invention, a preferred embodiment of the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of an essentially cylindrically-shaped magnet for use in the present invention;

Figure 2 shows a device in accordance with the present invention apart and in-line for assembly;

Figures 3 and 4 show schematic; cross-sectional side views of the device in accordance with the present invention to demonstrate the principle of the present invention;

Figure 5 shows the relationship between the angle of rotation and the external magnetic field in a device in accordance with the present invention; and

Figure 6 shows an end view of a device in accordance with the present invention, particularly showing one potential suitable shape for the pole pieces.

Detailed description of the embodiments

[0032] The magnet 1 as shown in Figure 1 may be described as a cylindrically-shaped magnet. The magnet is diametrically magnetised. By that, is meant that the notional division between the north pole and the south pole of the magnet is achieved by a vertical plane that passes along a diameter 2 of an upper face 3 of the disc magnet 1.

[0033] The disc magnet 1 shown in Figure 1 is preferably a rare-earth type magnet, for example, the magnet 1 may be a neodymium-iron-boron magnet. The present invention also contemplates the use of any other permanent magnet material.

[0034] Turning to Figure 2, the device includes a first magnet 10 and a second magnet 11. Both magnets 10, 11 are essentially disc shaped magnets and are similar to magnet 1 as shown in Figure 1. Magnets 10, 11 are housed in a housing that is made from pole pieces 12, 13. Pole pieces 12, 13 are preferably made from a material that is ferromagnetic with low magnetic reluctance. The pole pieces 12, 13 are arranged such that they fixedly hold lower magnets 10 in a fixed position. Upper magnet 11, however, is able to be rotated within the housing formed by pole pieces 12, 13.

[0035] In order to facilitate rotation of upper magnet 11, the magnet 11 is formed with notches or grooves 14, 15 along its vertical side walls. These notches or grooves 14, 15 receive the downwardly depending arms 16, 17 of bar 18. Bar 18 is received inside a groove 19 formed on boss 20. Boss 20 is connected to a short bar 21 that, in turn, is fixedly connected to a handle or lever 22. By this means, rotation of handle or lever 22 causes rotation of second magnet 11. It will be appreciated that second magnet 11 rotates essentially about its centre point.

[0036] The device further includes a top cover that is fixedly secured to the housing formed by pole pieces 12 and 13. Cover seals the top of the housing formed by pole pieces 12, 13. It will be noted that boss 20 extends through an opening in top cover and that sealing member 24 assists in forming a water tight and dust proof seal around that opening.

[0037] In one embodiment of the device shown in Figure 2, the lower surface of lower magnet 10 formed part of the lower surface of the device. In this embodiment, the lowest surface of the lower magnet 10 is positioned such that it lies essentially adjacent to the lower surfaces of respective pole pieces 12, 13.

[0038] In another embodiment, the lower surface of the device is provided by a lower cover (not shown).

[0039] In either embodiment, it is preferred that the device is essentially sealed, such that it is substantially waterproof and dustproof. This enables the device to be used in harsh environments, such as dusty environments, wet environments, or even fully submerged.

[0040] The principle of operation of the device in accordance with the present invention is shown in Figures 3 and 4. In Figures 3 and 4, first magnet 10 and second magnet 11 are mounted such that first magnet 10 is below second magnet 11. The first and second magnets 10, 11 are mounted such that they are in face to face juxtaposition. First magnet 10 is fixedly mounted, whilst second magnet 11 is mounted for rotation about axis of rotation 24.

[0041] In Figure 3, the second magnet 11 has been positioned such that its north pole substantially overlies the south pole of first magnet 10. Similarly, it follows that the south pole of second magnet 11 substantially overlies the north pole of first magnet 10. In this arrangement, the first and second magnets act as an internal active magnetic shunt and as a result the external magnetic field strength from the device is quite low.

[0042] Rotating the upper magnet 11 180° about its axis of rotation brings the magnets into the alignment as shown in Figure 4. In this alignment, the respective north and south poles of the upper magnet 11 substantially overlie respective north and south poles of lower magnet 10. In this alignment, the external magnet field from the device is quite strong and the device can be firmly attached to ferromagnetic surfaces. The passive poles are important in assisting the magnetic functionality shown in Figures 3 and 4.

[0043] Figure 5 shows the analogue relationship between the angle of rotation and the variation of the external magnetic field. The exact characteristics of the curve depend on the way the disc magnets are magnetised in their physical shape as well as the shape of the poles (12, 13). Variation of the ratio of the magnetic energy products of the magnetic discs 10, 11 can achieve further modification of the curve in figure 5 to suit particular applications.

[0044] Further increases in external magnetic field strengths can be accomplished by shaping the wall thickness of the pole pieces 12, 13 in such a way that they reflect the variation of the magnetic field strength around the perimeter of the permanently magnetised discs 10, 11.

[0045] Figure 6 indicates the design of the pole pieces 12, 13 shaped in accordance with the variation of the field strength H around the perimeter of the magnetic discs 10, 11. The application of the inverse square law of magnetic fields achieves good results but specific materials and applications they influence the optimal shape. In particular, the wall thickness of the poles may be varied as follows:

(a) oval poles, where the wall thickness is a mathematical function of the field strength of the perimeter of the magnets;

(b) oval poles, where the wall thickness is a mathematical function of the distribution of the magnetic mass of magnets 10 and 11;

(c) round pole pieces, where the wall thickness is constant and the magnetic field strength is lower but uniform around the perimeter.

[0046] The shape of the outer casing of the housing shown in figure 6, being an oval-shape, maximises the external field strength and assists in holding the device in place in incomplete magnetic circuits. Incomplete magnetic circuits are met in practice when there is an air gap between the bottom of the device and the surface to which it is to be attached, or were there is a non-magnetic material interposed between the surface to which the device is designed to be attached and the bottom of the device.

[0047] It is another feature of preferred embodiments of the present invention that the poles are of the shortest possible length. The poles form part of the magnetic circuit (along with the magnets). The poles have an inherent magnetic resistance ("reluctance") which results in loss of magnetic energy. Thus, the present invention, in minimising the length of the poles, minimises loss of magnetic energy and hence maximises the external field strength.

[0048] It has also been found that the required torque to shift the upper magnet 11 to the "on" position decreases markedly with the increase of magnetic flux through the external circuit. An added feature is therefore a torque sensitive lever which will only allow the device to be switched to the "on" position if an appropriate external magnetic circuit is present.

[0049] The present invention utilises an "active" shunting technique wherein the magnetic circuit is switched from a strong external field to a weak external field by performing a magnetic short circuit using the magnets themselves. The passive poles can be reduced to a minimum of mass which, in turn, is a prerequisite for retaining the highest possible magnetic force. This should be contrasted with "passive" shunting, as disclosed in the Yanagisawa reference cited earlier, in which passive ferromagnetic external poles establish a magnetic short circuit between the poles of the permanent magnet. A strong permanent magnet requires relatively large amounts of passive material to perform this shunting.

[0050] The present invention, in its preferred embodiments, also has the advantage of having very low friction between the magnets and around the magnets and between the magnets and the poles. This is a result of the symmetrical pull between the cylindrical magnets and the poles and the walls of the housing, resulting in a zero net attraction.

[0051] The preferred embodiments of the present invention also make greater use of the area under the B-H curve. The use of shorter pole lengths also reduces the reluctance of the poles, thereby minimising magnetic losses through the poles.

[0052] It is a further advantage of preferred embodiments of the present invention that the bulk of the field lines are directed through the pole pieces to the workpiece or surface.

[0053] The switchable magnetic device of the present invention provides a compact and rugged device capable of many uses. The use of diametrically polarised, essentially cylindrically shaped magnets allows the device to be compact and it also enables the magnets to be rotated relative to each other without the necessity of having larger void spaces within the internal chamber for the magnets to be moved into. The shape of the external pole pieces enables the external magnetic fields to be maximised. The device is simple to use and can provide a strong holding force to hold objects firmly in place.

[0054] Those skilled in the art will appreciate that the present invention may be susceptible to variations and to modifications other than those specifically described.

[0055] It is to be understand that present invention encompasses all such variations and modifications that fall within its scope as defined in the claims.

Claims

1. A switchable magnetic device comprising a housing, a first permanent magnet (10), and a second permanent magnet (11), the housing having two magnetically separated passive ferromagnetic pole elements (12, 13), between which the first and second permanent magnets (10, 11) are mounted in stacked manner such as to be rotatable relative to each other about an axis of the device, the device further comprising actuation means (22) for causing relative rotation of the first and second permanent magnets (10, 11), wherein said device presents a relatively strong external magnetic field when said first and second permanent magnets (10, 11) are positioned relative to each other such that north and south poles of the first magnet (10) are in substantial alignment with respective north and south poles of the second magnet (11), and the device presents a relatively weak external magnetic field when the first and second magnets (10, 11) are positioned relative to each other such that the north pole of the first magnet (10) is in substantial alignment with the south pole of the second magnet (11) and vice versa, **characterised in that** said first and second permanent magnets (10, 11) are essentially cylindrically shaped and diametrically polarised, and **in that** said two passive pole elements (12, 13) (a) are pole pieces of low magnetic reluctance material, (b) have a dimension along the stacking direction of the first and second permanent magnets (10, 11) chosen to provide a minimised low magnetic reluctance path within the pole pieces (12, 13) along the device axis, and (c) encircle the permanent magnets (10, 11) with a wall thickness shaped to either maximise the external magnetic field in an activated state of the device or provide an external magnetic field strength that is about uniform around the perimeter of the pole pieces (12, 13) in an activated state of the device.

2. A device as claimed in claim 1, wherein the first and second magnets (10, 11) are substantially disc-shaped.

3. A device as claimed in any one of claims 1 or 2, wherein one magnet (10) is fixedly mounted in the housing between the pole elements (12, 13) and the other magnet (11) is able to rotate within the housing.

4. A device as claimed in claim 3, wherein the other magnet (11) is arranged for rotation through180° to vary the device from a state having the relatively strong external magnetic field to a state having the relatively weak external magnetic field.

5. A device as claimed in any one of claims 1 to 4, wherein the housing is made as a unitary construction or from a single piece of material, and wherein two portions of the housing have a reduced cross sectional area whereby the remaining portions of the housing embody and provide the two passive pole pieces.

6. A device as claimed in any one of claims 1 to 4, wherein the housing is made as a unitary construction or from a single piece of material, and wherein two portions of the housing are treated such that the two portions are non-magnetic and the remaining portions of the housing embody and provide the two passive pole pieces.

7. A device as claimed in any one of the preceding claims, wherein the housing defines a chamber in which the first and second magnets are mounted, the chamber either having one or two open ends along the axis of the device

8. A device as defined in claim 7, wherein the chamber has one or more chamber closing members arranged such as to close one or both of the open ends of the chamber.

9. A device according to claim 8, wherein a lowermost (10) of the magnets provides one of the chamber closing members and closes the lower end of the chamber.

10. A device as claimed in any one of the preceding claims, wherein the housing is made from soft steel, iron or a permalloy.

11. A device as claimed in any one of claims 1 to 10, wherein the wall thickness of the pole pieces is a

mathematical function of the field strength along the perimeter of the dipole permanent magnets (10, 11) whereby the housing has an oval cross sectional shape.

12. A device as claimed in any one of claims 1 to 10, wherein the wall thickness of the pole pieces (12, 13) is a mathematical function of the distribution of the magnetic mass of the dipole permanent magnets (10, 11) along their perimeter whereby the housing has an oval cross sectional shape.

13. A device as claimed in any one of claims 1 to 10, wherein the two passive pole pieces (12, 13) encircle the permanent magnets (10, 11) with a wall thickness that is constant along the perimeter of the dipole permanent magnets whereby the magnetic field strength is about uniform around the perimeter of the pole pieces in an activated state of the device.

14. A device as claimed in any one of the preceding claims, wherein the actuation means comprises a handle or knob (22) connected to the rotatable one (11) of the magnets.

15. A device as claimed in claim 14, wherein the handle (22) comprises a torque sensitive lever arranged to not allow application of a torque in excess of a predetermined value on to the rotatable one of the magnets whereby in absence of an appropriate external magnetic circuit said device can not be switched into a position in which said device presents a relatively strong external magnetic field.

16. A device as claimed in claim 14 or 15, in which the handle (22) or knob is actuated manually, electrically, pneumatically, hydraulically or by the action of expansion of a bimetallic strip.

17. A device as claimed in any one of the preceding claims wherein the first and second magnets (10, 11) comprise rare earth type magnets.

18. A device as claimed in any one of the preceding claims, wherein the dimension of the pole pieces (12, 13) along the stacking direction of the first and second permanent magnets is about the same as that of the stacked permanent magnets (10, 11).

Patentansprüche

1. Schaltbare Magnetvorrichtung umfassend ein Gehäuse, einen ersten Dauermagneten (10) sowie einen zweiten Dauermagneten (11), wobei das Gehäuse zwei magnetisch voneinander getrennte passive ferromagnetische Polelemente (12, 13) umfasst, zwischen denen die ersten und zweiten Dauermagneten (10, 11) derart in einer übereinander liegenden Art und Weise befestigt sind, dass sie relativ zueinander um eine Achse der Vorrichtung drehbar sind, wobei die Vorrichtung ferner eine Betätigungseinrichtung (22) umfasst, um eine relative Drehung der ersten und zweiten Dauermagneten (10, 11) zu verursachen, wobei die Vorrichtung ein relativ starkes äußeres magnetisches Feld aufweist, wenn die ersten und zweiten Dauermagneten (10, 11) derart zueinander angeordnet sind, dass die Nord- und Südpole des ersten Magneten (10) im Wesentlichen mit den jeweiligen Nord- und Südpolen des zweiten Magneten (11) ausgerichtet sind, und die Vorrichtung ein relativ schwaches äußeres magnetisches Feld aufweist, wenn die ersten und zweiten Magneten (10, 11) derart zueinander angeordnet sind, dass der Nordpol des ersten Magneten (10) im Wesentlichen mit dem Südpol des zweiten Magneten (11) ausgerichtet ist, und umgekehrt,
dadurch gekennzeichnet,
dass die ersten und zweiten Dauermagneten (10, 11) im Wesentlichen zylindrisch geformt und diametral polarisiert sind, und dass die beiden passiven Polelemente (12, 13)

(a) Polteile aus Material mit geringer magnetischer Reluktanz sind,
(b) eine Abmessung entlang der Stapelrichtung der ersten und zweiten Dauermagneten (10, 11) haben, die derart ausgewählt ist, dass innerhalb der Polteile (12, 13) ein minimaler Weg mit geringer magnetischer Reluktanz entlang der Achse der Vorrichtung zur Verfügung gestellt wird, und
(c) die Dauermagneten (10, 11) mit einer Wanddicke, die derart geformt ist, dass entweder das äußere magnetische Feld in einem aktivierten Zustand der Vorrichtung maximiert wird, oder eine äußere Magnetfeldstärke zur Verfügung gestellt wird, die in einem aktivierten Zustand der Vorrichtung etwa gleichmäßig um den Umfang der Polteile (12, 13) ist, umgeben.

2. Vorrichtung gemäß Anspruch 1, wobei die ersten und zweiten Magnete (10, 11) im Wesentlichen scheibenförmig sind.

3. Vorrichtung gemäß einem der Ansprüche 1 oder 2, wobei ein Magnet (10) fest zwischen den Polelementen (12, 13) in dem Gehäuse befestigt ist und sich der andere Magnet (11) innerhalb des Gehäuses drehen kann.

4. Vorrichtung gemäß Anspruch 3, wobei der andere Magnet (11) derart zur Rotation um 180° angeordnet ist, um die Vorrichtung von einem Zustand mit dem relativ starken äußeren magnetischen Feld zu einem Zustand mit dem relativ schwachen äußeren magnetischen Feld zu wechseln.

5. Vorrichtung gemäß einem der Ansprüche 1 bis 4, wobei das Gehäuse als einheitlicher Aufbau oder aus einem einzigen Stück Material gebildet ist, und wobei zwei Abschnitte des Gehäuses eine geringere Querschnittsfläche aufweisen, wobei die verbleibenden Abschnitte des Gehäuses die zwei passiven Polteile enthalten und zur Verfügung stellen.

6. Vorrichtung gemäß einem der Ansprüche 1 bis 4, wobei das Gehäuse als einheitlicher Aufbauoder aus einem einzigen Stück Material gebildet ist, und wobei zwei Abschnitte des Gehäuses derart behandelt sind, dass die zwei Abschnitte nicht magnetisch sind und die verbleibenden Abschnitte des Gehäuses die zwei passiven Polteile enthalten und zur Verfügung stellen.

7. Vorrichtung gemäß einem der vorangehenden Ansprüche, wobei das Gehäuse eine Kammer definiert, in der die ersten und zweiten Magneten befestigt sind, wobei die Kammer entweder eine oder zwei offene Enden entlang der Achse der Vorrichtung aufweist.

8. Vorrichtung gemäß Anspruch 7, wobei die Kammer eine oder mehrere Kammerschüeßelemente aufweist, die derart angeordnet sind, dass eine oder beide Enden der Kammer geschlossen werden.

9. Vorrichtung gemäß Anspruch 8, wobei der unterste (10) der Magneten eines der Kammerschließelemente zur Verfügung stellt und das untere Ende der Kammer schließt.

10. Vorrichtung gemäß einem der vorangehenden Ansprüche, wobei das Gehäuse aus Weichstahl, Eisen oder Permalloy hergestellt ist.

11. Vorrichtung gemäß einem der Ansprüche 1 bis 10, wobei die Wanddicke der Polteile eine mathematische Funktion der Feldstärke entlang dem Umfang der Dipol-Dauermagneten (10, 11) ist, wobei das Gehäuse eine ovale Querschnittsform aufweist.

12. Vorrichtung gemäß einem der Ansprüche 1 bis 10, wobei die Wanddicke der Polteile (12, 13) eine mathematische Funktion der Verteilung der magnetischen Masse der Dipol-Dauermagneten (10, 11) entlang ihrem Umfang ist, wobei das Gehäuse eine ovale Querschnittsform aufweist.

13. Vorrichtung gemäß einem der Ansprüche 1 bis 10, wobei die zwei passiven Polteile (12, 13) die Dauermagneten (10, 11) mit einer Wanddicke umgeben, die entlang dem Umfang der Dipol-Dauermagneten konstant ist, wobei die magnetische Feldstärke in einem aktivierten Zustand der Vorrichtung um den Umfang der Polteile ungefähr gleichmäßig ist.

14. Vorrichtung gemäß einem der vorangehenden Ansprüche, wobei die Betätigungseinrichtung einen Griff oder Knopf (22) umfasst, der mit dem drehbaren (11) der Magnete verbunden ist.

15. Vorrichtung gemäß Anspruch 14, wobei der Griff (22) einen drehmomentempfindlichen Hebel umfasst, der derart angeordnet ist, dass die Anwendung eines Drehmomentes, der einen vorbestimmten Wert übersteigt, auf den drehbaren der Magnete nicht erlaubt ist, wobei die Vorrichtung in Abwesenheit eines geeigneten äußeren magnetischen Kreises nicht in eine Position geschalten werden kann, in der die Vorrichtung ein relativ starkes äußeres magnetisches Feld aufweist.

16. Vorrichtung gemäß Anspruch 14 oder 15, bei weicher der Griff (22) oder Knopf manuell, elektrisch, pneumatisch, hydraulisch oder durch die Wirkung einer Ausdehnung eines Bimetallstreifens betätigt wird.

17. Vorrichtung gemäß einem der vorangehenden Ansprüche, wobei die ersten und zweiten Magnete (10, 11) Magnete von Seltenerd-Typ umfassen.

18. Vorrichtung gemäß einem der vorangehenden Ansprüche, wobei die Abmessungen der Polteile (12, 13) entlang der Stapelrichtung der ersten und zweiten Dauermagneten in etwa denjenigen der gestapelten Dauermagneten (10, 11) entsprechen.

Revendications

1. Dispositif magnétique commutable comprenant un boîtier, un premier aimant permanent (10) et un second aimant permanent (11), le boîtier présentant deux éléments polaires ferromagnétiques passifs séparés magnétiquement (12, 13) entre lesquels le premier et le second aimant magnétique (10, 11) sont montés de façon empilée de manière à être en rotation l'un par rapport à l'autre autour d'un axe du dispositif, ce dernier comprenant en outre un organe d'actionnement (22) pour causer une rotation relative des premier et second aimants (10, 11), dans lequel ledit dispositif présente un champ magnétique externe relativement intense lorsque lesdits premier et second aimants permanents (10, 11) sont positionnés l'un par rapport à l'autre de manière à ce que les pôles nord et sud du premier aimant (10) soient sensiblement dans l'alignement des pôles nord et sud respectifs du second aimant (11) et le dispositif présente un champ magnétique externe relativement faible lorsque les premiers et second aimants

(10, 11) sont positionnés l'un par rapport à l'autre de manière à ce que le pôle nord du premier aimant (10) soit sensiblement dans l'alignement du pôle sud du second aimant (11) et vice-versa, **caractérisé en ce que** lesdits premier et second aimants (10, 11) sont essentiellement de forme cylindrique et diamétricalement polarisés et **en ce que** deux éléments polaires passifs (12, 13) (a) sont des pièces polaires faites d'un matériau de faible réluctance magnétique, (b) ont une dimension le long du sens d'empilage des premier et second aimants magnétiques (10, 11) choisie pour procurer un chemin de faible réluctance magnétique minimisée au sein des pièces polaires (12, 13) le long de l'axe du dispositif, et (c) encordent les aimants permanents (10, 11) d'une épaisseur de paroi formée pour soit maximiser le champ magnétique externe en un état activé du dispositif, soit procurer une intensité de champ magnétique externe qui est plus ou moins uniforme autour du périmètre des pièces polaires (12, 13) dans un état activé du dispositif.

2. Dispositif selon la revendication 1, dans lequel les premier et second aimants (10, 11) ont sensiblement la forme d'un disque.

3. Dispositif selon l'une quelconque des revendications 1 ou 2, dans lequel un aimant (10) est monté de manière fixe dans le boîtier entre les éléments polaires (12, 13) et l'autre aimant (11) peut tourner à l'intérieur du boîtier.

4. Dispositif selon la revendication 3, dans lequel l'autre aimant (11) est agencé en vue d'une rotation à 180° pour varier le dispositif d'un état possédant le champ magnétique externe relativement intense en un état possédant le champ magnétique externe relativement faible.

5. Dispositif selon l'une quelconque des revendications 1 à 4, dans lequel le boîtier est fait d'une construction unitaire ou d'une pièce de matériau unique et dans lequel deux parties du boîtier ont une surface de coupe transversale réduite, tandis que les parties restantes du boîtier constituent et procurent les deux pièces polaires passives.

6. Dispositif selon l'une quelconque des revendications 1 à 4, dans lequel le boîtier est fait d'une construction unitaire ou d'une pièce de matériau unique et dans lequel deux parties du boîtier sont traitées de sorte à ce que les deux parties soient non magnétiques et les parties restantes du boîtier constituent et procurent les deux pièces polaires passives.

7. Dispositif selon l'une quelconque des revendications précédentes, dans lequel le boîtier définit une chambre dans laquelle sont montés les premier et deuxième aimants, la chambre possédant soit une, soit deux extrémités ouvertes le long de l'axe du dispositif.

8. Dispositif tel que défini à la revendication 7, dans lequel la chambre possède un ou plusieurs organes de fermeture de la chambre disposés de manière à fermer une ou les deux des extrémités ouvertes de la chambre.

9. Dispositif selon la revendication 8, dans lequel un aimant inférieur (10) des aimants procure l'un des organes de fermeture de la chambre et ferme l'extrémité inférieure de la chambre.

10. Dispositif selon l'une quelconque des revendications précédentes, dans lequel le boîtier est fait d'acier doux, de fer ou de permalloy.

11. Dispositif selon l'une quelconque des revendications 1 à 10, dans lequel l'épaisseur de la paroi des pièces polaires est une fonction mathématique de l'intensité du champ le long du périmètre des aimants permanents dipolaires (10, 11), de sorte que le boîtier présente une coupe transversale ovale.

12. Dispositif selon l'une quelconque des revendications 1 à 10, dans lequel l'épaisseur de paroi des pièces polaires (12, 13) est une fonction mathématique de la distribution de la masse magnétique des aimants permanents dipolaires (10, 11) le long de leur périmètre, de sorte que le boîtier présente une coupe transversale ovale.

13. Dispositif selon l'une quelconque des revendications 1 à 10, dans lequel les deux pièces polaires passives (12, 13) encerclent les aimants permanents (10, 11) avec une épaisseur de paroi qui est constante le long du périmètre des aimants permanents dipolaires, de sorte que l'intensité du champ magnétique est plus ou moins uniforme autour du périmètre des pièces polaires dans un état activé du dispositif.

14. Dispositif selon l'une quelconque des revendications précédentes, dans lequel l'organe d'actionnement comprend une poignée ou un bouton (22) connecté (e) à celui qui est rotatif (11) des aimants.

15. Dispositif selon la revendication 14, dans lequel la poignée (22) comprend un levier sensible au couple de rotation agencé pour ne pas permettre l'application d'un couple de rotation excédant une valeur prédéterminée sur celui qui est rotatif des aimants, de sorte qu'en l'absence d'un circuit magnétique externe approprié, ledit dispositif ne peut pas être commuté en une position dans laquelle ledit dispositif présente un champ magnétique externe relativement intense.

16. Dispositif selon la revendication 14 ou 15, dans lequel la poignée (22) ou le bouton est actionné(e) manuellement, électriquement, pneumatiquement, hydrauliquement ou par l'action de l'expansion d'une bande bimétallique.

17. Dispositif selon l'une des revendications précédentes, dans lequel les premier et second aimants (10, 11) comprennent des aimants à type des terres rares.

18. Dispositif selon l'une quelconque des revendications précédentes, dans lequel la dimension des pièces polaires (12, 13) le long du sens d'empilage du premier et du second aimant est environ la même que celle des aimants permanents empilés (10, 11).

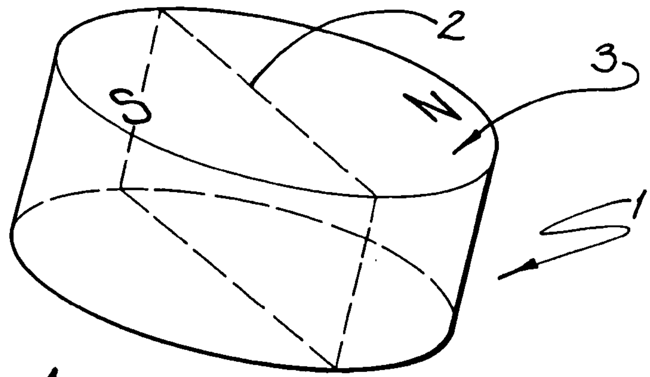

FIG. 1

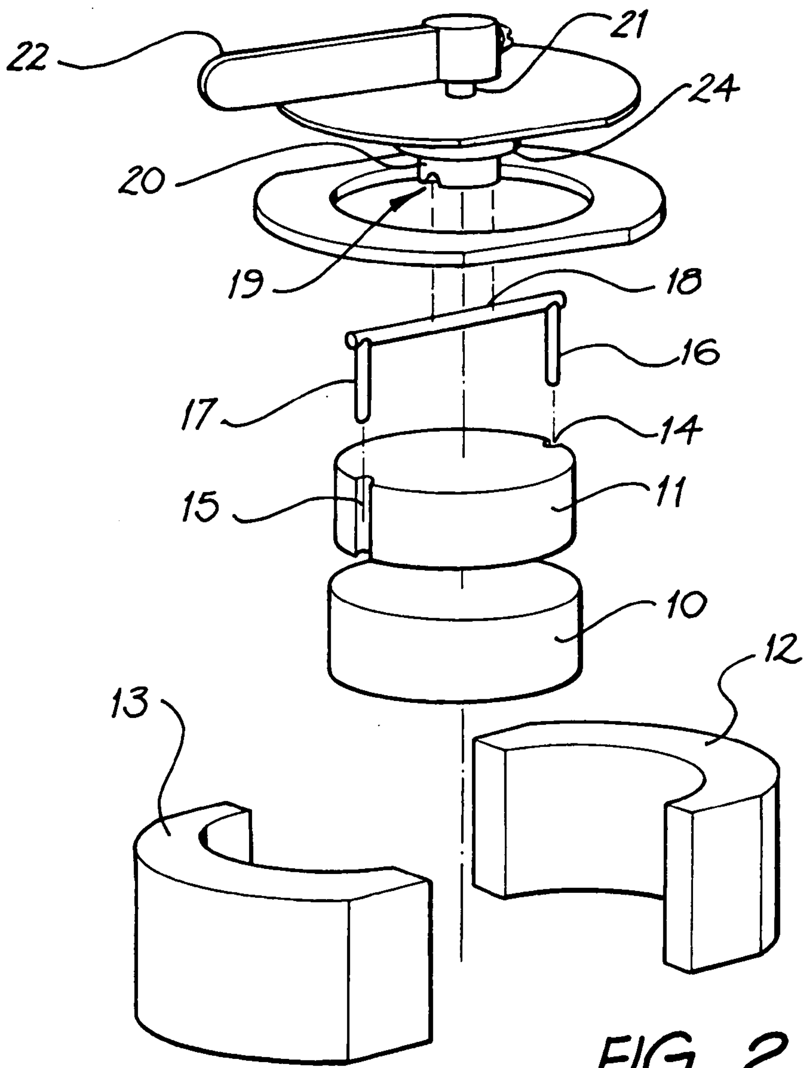

FIG. 2

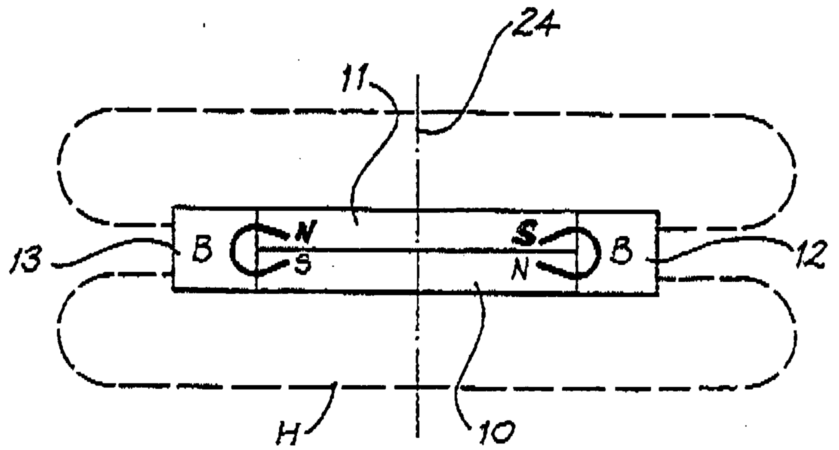

FIG. 3

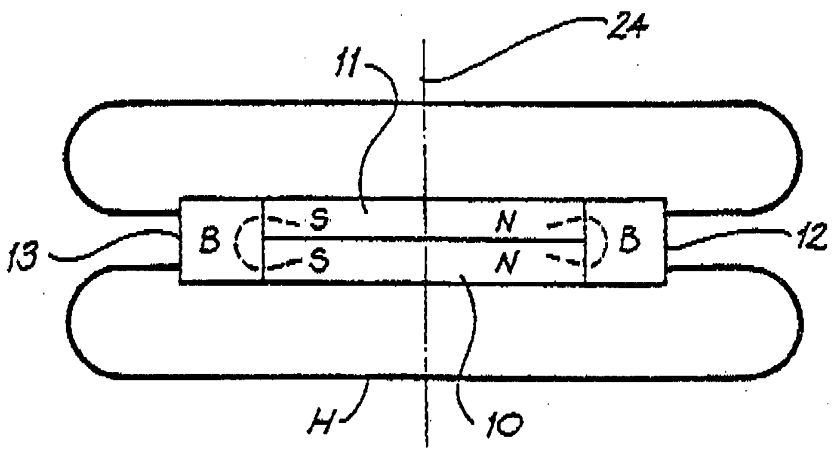

FIG. 4

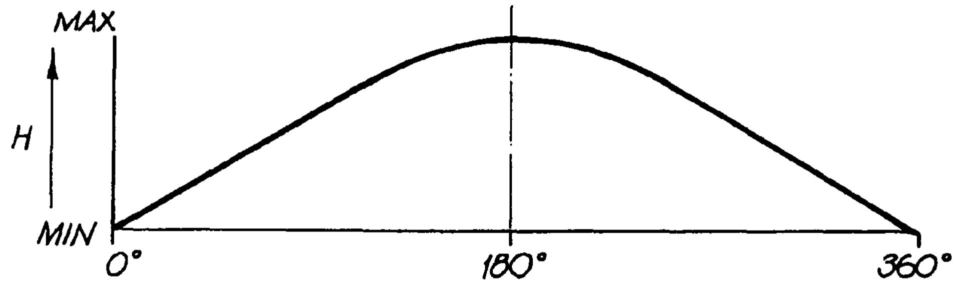

FIG. 5

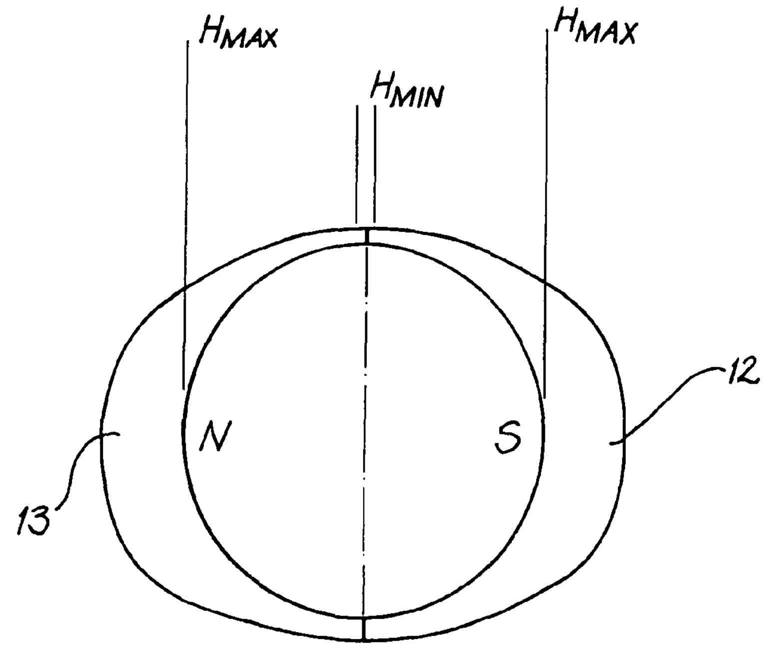

FIG. 6

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