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[11] **4,329,673**

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[54] **SWITCHABLE PERMANENT MAGNET HOLDING DEVICE**

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.**[3] **H01F 7/20**

[52] **U.S. Cl.** **335/288;** 335/302

[58] **Field of Search** 335/285, 288, 295, 302

[56] **References Cited**

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[57] **ABSTRACT**

A switchable permanent magnet holding device in which a permanent magnet rotatably disposed within a bore in a magnetic circuit block is rotated, so that the magnetism acting surfaces of the magnetic circuit block are brought into an exciting state for retaining a magnetic substance thereon and into a non-exciting state for releasing the magnetic substance therefrom. The permanent magnet is pressed against a stopper for impeding rotation thereof, due to a gyromagnetic force acting across the permanent magnet and the magnetic circuit block when the permanent magnet is rotated to a position in which the magnetism acting surfaces of the block become exciting.

5 Claims, 4 Drawing Figures

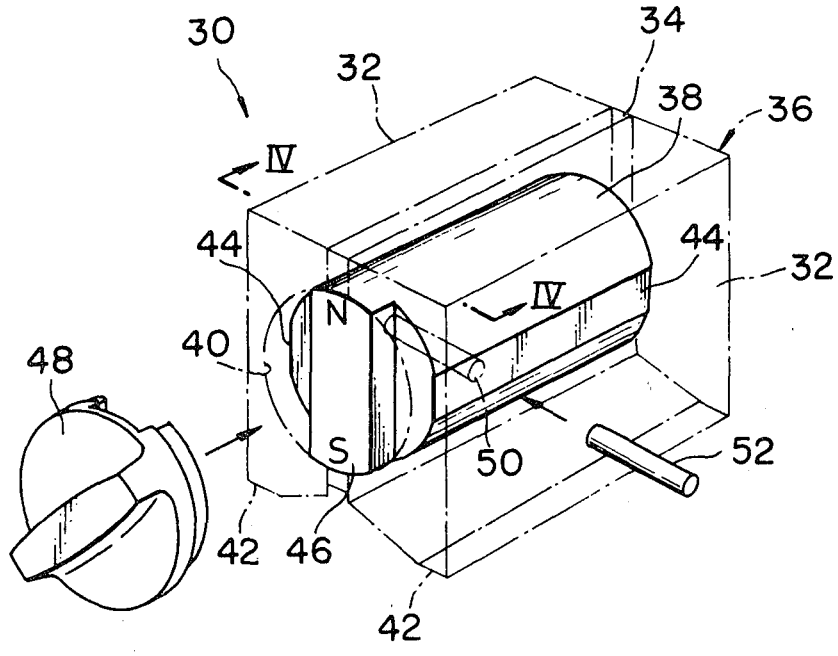


FIG. 1 PRIOR ART

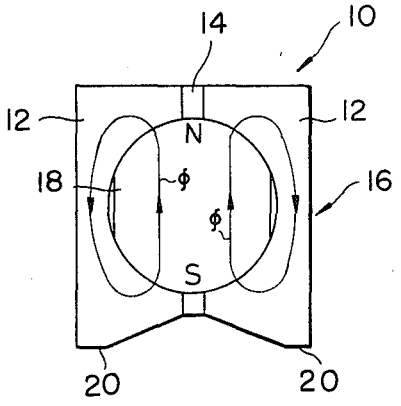


FIG. 2

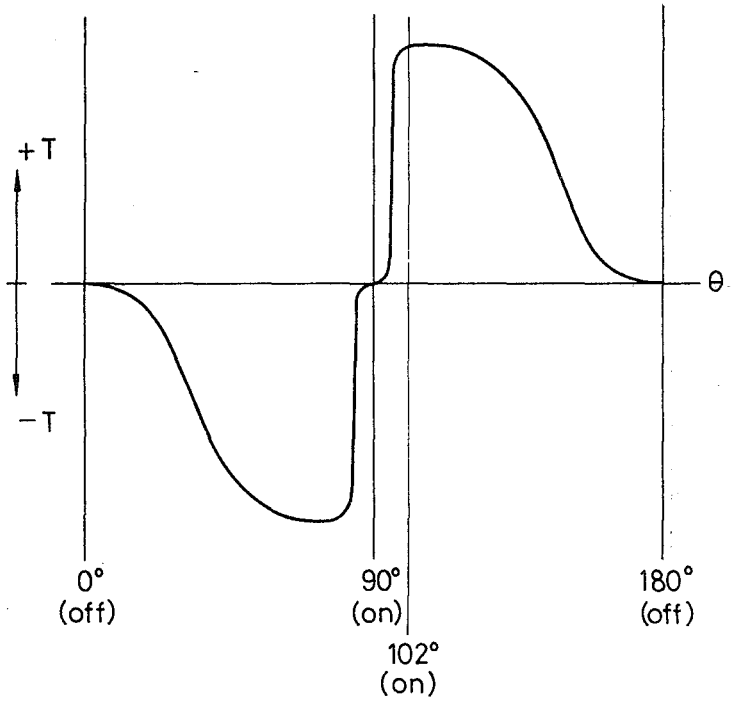
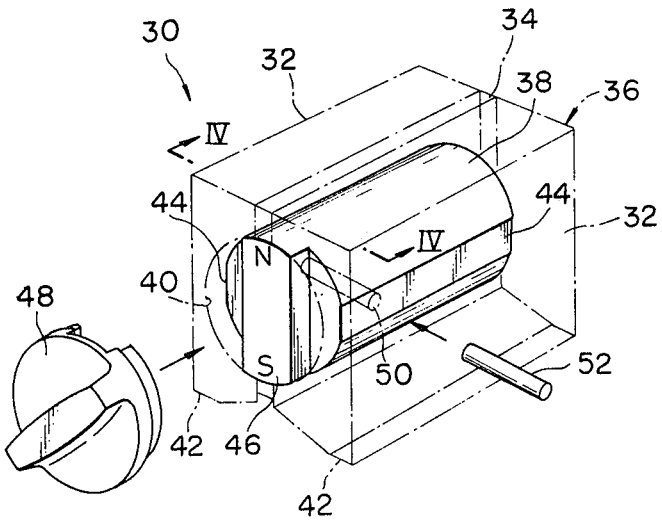


FIG. 3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IV
IV
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32
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48
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46
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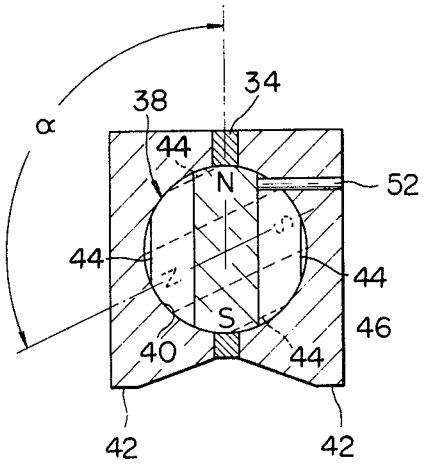
FIG. 4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SWITCHABLE PERMANENT MAGNET HOLDING DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a switchable permanent magnet holding device for holding or being held by a magnetic substance.

2. Description of the Prior Art

One of the conventional permanent magnet holding devices of the type, as generally shown at **10** in FIG. **1**, includes a magnetic circuit block **16** consisting of a pair of magnetic pole members **12** and a non-magnetic plate **14** disposed between the pair of magnetic pole members, and a columnar permanent magnet **18** rotatably disposed within a bore running through the magnetic block.

The permanent magnet **18** is magnetized in the diametrical direction thereof. When the permanent magnet **18** assumes a rotating position in which the direction of magnetization of the magnet runs in parallel to the non-magnetic plate **14**, as shown in FIG. **1**, then respective magnetic flux ϕ forms a close loop within the magnetic circuit block **16**, without running across a magnetism acting surface **20** of respective magnetic pole member **12**. Accordingly, the magnetism acting surfaces **20** remain non-exciting, when the permanent magnet **18** assumes that position, and hence the permanent magnet holding device **10** remains non-exciting.

When the permanent magnet **18** is turned, for example, counterclockwise substantially through 90° from the non-exciting rotating position, the magnetism acting surfaces **20** become excited.

So far as the permanent magnet **18** assumes the non-exciting rotating position or the excited rotating position making a right angle with respect to the non-exciting rotating position, since the magnetic circuit block **16** is held in magnetical equilibrium, the permanent magnet **18** by no means receives a gyromagnetic force.

When the permanent magnet **18** assumes an intermediate position between the exciting rotating position and the non-exciting rotating position, as shown in FIG. **2**, the magnetic equilibrium of the magnetic circuit block **16** is broken, and the permanent magnet **18** receives a gyromagnetic force. In the graph of FIG. **2**, the axis of abscissa represents an angle of rotation (θ) of the permanent magnet **18** from the non-exciting rotating position shown in FIG. **1**, and the axis of the ordinate represents a gyromagnetic force T which the permanent magnet **18** receives. The graph represents a variation in a gyromagnetic force which occurs when a magnetic substance is abutted on the magnetism acting surfaces of the block **16**. From this graph, it is seen that when the permanent magnet **18** is located at an exciting rotating position which makes a right angle with respect to the first non-exciting position, the permanent magnet **18** by no means receives a gyromagnetic force toward the first non-exciting rotating position located at a zero degree or the second non-exciting rotating position located at 180° which is opposite thereto. By displacement to some degree of the permanent magnet **18** from the exciting rotating position located at 90° in rotational angle, the permanent magnet **18** receives a strong gyromagnetic force toward the non-exciting rotating position located at a zero degree or that located at 180° to which the permanent magnet **18** has been displaced.

Because of such a structure, a problem has been encountered with the conventional permanent magnet holding device, in which when the permanent magnet holding device **10** receives shock, the permanent magnet **18** located at the excited rotating position is displaced therefrom to some degree and turned toward one of the non-exciting rotating positions due to the gyromagnetic force, as a result of which the permanent magnet holding device becomes unexpectedly non-exciting thus leading to an accident.

Such trend has been marked, particularly with a permanent magnet holding device of the type, in which, with a view to reducing a working force for rotating the permanent magnet **18**, the sliding surfaces of the permanent magnet **18** relative to the magnetic circuit block **16** make smooth so as to decrease the mechanical frictional force therebetween. In such a device, the permanent magnet **18** is easily displaced from the exciting rotating position even by a feeble external force such as oscillation, as a result of which the holding device becomes suddenly non-exciting.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a switchable permanent magnet holding device, wherein the permanent magnet holding device remains excited, irrespective of an external force, such as vibration or shock exerted thereon.

The present invention is characterized in that, in view of the fact that when a permanent magnet rotatably disposed within a magnetic circuit block is rotated in one direction to a position over 90° from a first non-exciting rotating position, then the permanent magnet receives a gyromagnetic force directed to a second non-exciting rotating position making 180° with respect to the first non-exciting rotating position; there is provided a stopper in the magnetic circuit block, so as to self-retain the permanent magnet in the exciting rotating position due to the gyromagnetic force.

According to the present invention, there is provided a switchable permanent magnet holding device which comprises; a magnetic circuit block consisting of a pair of magnetic pole members respectively having a magnetism acting surface and a non-magnetic plate disposed between the pair of magnetic pole members, and provided with a bore running in parallel to the non-magnetic plate and having a circular cross section; a permanent magnet disposed within the bore rotatably about the central axis of the bore and adapted to be turned so as to make respective magnetism acting surface non-exciting or exciting; and a stopper for impeding rotation of the permanent magnet, the stopper being adapted to engage the permanent magnet rotated to a position over a predetermined rotational angle at which the magnetism acting surfaces of the block become exciting and the magnetic circuit block is maintained in a state of magnetical equilibrium, when the permanent magnet is turned in one direction, in order to switch the non-exciting state of the magnetism acting surfaces of the block to the exciting state.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an explanatory side view of a conventional permanent magnet holding device;

FIG. **2** is a graph representing a rotational characteristic of a permanent magnet holding device according to the present invention;

FIG. 3 is an exploded perspective view of a permanent magnet holding device according to the present invention; and,

FIG. 4 is a cross sectional view taken along the line IV—IV of FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A permanent magnet holding device **30** according to the present invention comprises; a magnetic circuit block **36** including a pair of magnetic pole members **32** and a non-magnetic plate **34** disposed between the pair of magnetic pole members **32** and coupled integrally therewith; and a permanent magnet **38**.

The magnetic circuit block **36** is provided with a bore **40** for receiving therein the permanent magnet **38**, likewise in the prior art device. The bore **40** has a circular cross section and opens from one end of the magnetic circuit block **36**, to run in parallel to the non-magnetic plate **34**, as if spliting same longitudinally. Respective magnetic pole member **32** has a flat magnetism acting surface **42** similar to those of the conventional device, for magnetically attracting thereto a magnetic substance (not shown).

The permanent magnet **38** is a cylindrical permanent magnet on the whole and magnetized in a diametrical direction thereof. The diametrically opposite circumferential portions of the permanent magnet **18** which are positioned in a direction of making a right angle with respect to the direction of magnetization are bevelled to thereby form flat surfaces **44**, respectively. A diametrically extending ridge **46** is provided on one end face of the permanent magnet **38** in alignment with the direction of magnetization.

The permanent magnet **38** is fitted into the bore, with the ridge **46** facing the open end of block **36**, so that the permanent magnet **38** is rotatable about the central axis of the bore **40**. An operation knob **48** for manipulating the permanent magnet **38** is fitted on the end of the ridge portion **46**.

The position shown in FIG. **3**, of the permanent magnet **38** is a first non-exciting rotation position, in which the direction of magnetization of the permanent magnet **38** is in parallel to the non-magnetic plate **34** and the magnetism acting surfaces **42** are maintained non-exciting, as described with reference to the conventional device in FIG. **1**. When the operation knob **48** is turned counterclockwise as viewed from the side of the knob **48**, then the permanent magnet **38** rotated integrally with the operation knob **48** receives a gyromagnetic force as large as that shown in FIG. **2** according to an angle of rotation from the first non-exciting rotating position.

With a view to regulating an angle of rotation of the permanent magnet **38**, a through-hole **50** runs in one magnetic pole member **32** to open to the bore **40**. A pin **52** is inserted into the through-hole **50**. The pin **52** is secured to the aforesaid one magnetic pole member **32**, with the tip projecting into the bore **40** engageably with one side surface of the ridge **46**.

The tip of the pin **52** which projects from the through-hole engages one side wall of the ridge **46** of the permanent magnet **38** when positioned in the non-exciting rotation position, as best seen in FIG. **4**, thereby impeding clockwise movement of the permanent magnet **38**. When the operation knob **48** is turned counterclockwise, the flank of the tip portion of the pin **52** which projects from the through-hole engages the aforesaid one side wall of the ridge **46**, thereby impeding rotation over an angle α, of the permanent magnet **38**.

The angle α to be regulated by the stopper **52** is determined to be in the range of larger than but approximate to 90° and of causing a large gyromagnetic force, as shown in FIG. **2**, for example, being determined at 102°.

In the permanent magnet holding device **30** relating to the present invention, when the permanent magnet **38** is turned counterclockwise by the operation knob **48**, a gyromagnetic force against rotation of the permanent magnet, namely, the negative gyromagnetic force, acts on the permanent magnet **38**, as shown in FIG. **2**, likewise in the conventional device, until the permanent magnet **38** is rotated through 90°. When the permanent magnet **38** is rotated over 90° against the gyromagnetic force, the positive gyromagnetic force for complementing rotation of the permanent magnet **38**, as shown in FIG. **2**, acts on the permanent magnet. Owing to the positive gyromagnetic force, the permanent magnet **38** tends to further move counterclockwise. However, this trend is impeded because rotation of the permanent magnet **38** is limited to the angle α by the stopper, and hence, the permanent magnet **38** is locked at the angle α as shown by a broken line in FIG. **4**.

The angle α at which the permanent magnet **38** is locked is a position deviated to some degree from the proper exciting rotating position (90°). The magnetic flux of the permanent magnet **38** generates across respective magnetism acting surface **42**, to thereby excite respective magnetism acting surface **42**, whereby the permanent magnet holding device **30** retains a magnetic force as strong as that in the conventional device. Furthermore, since the aforesaid positive gyromagnetic force acts on the permanent magnet **38** as a biasing force toward the stopper when positioned at the angle α, the permanent magnet **38** positioned at the angle α has no likelihood of being unexpectedly rotated to the non-exciting position due to an external force such as vibration, and hence unexpected demagnetization of the permanent magnet holding device **30** is avoided.

If the operation knob **48** is turned clockwise against the aforesaid positive gyromagnetic force, the permanent magnet holding device **30** becomes non-exciting, so as to return the permanent magnet **38** to the first non-exciting position.

In the above embodiment, a solid columnar permanent magnet is used. As an alternative, a magnet assembly having a pair of pole pieces may be used. The stopper for regulating rotation of the permanent magnet may be a member integrally formed of the magnetic pole member and projecting into the bore, instead of the pin used in the above embodiment.

According to the present invention, the permanent magnet receives the gyromagnetic force toward the stopper for permanent magnet, when the former is positioned at the exciting rotating position in which the magnetism acting surfaces of the magnetic circuit block is rendered exciting whereas the permanent magnet can be retained in the excited rotating position, without a risk of being unexpectedly demagnetized.

What is claimed is:

1. A switchable permanent magnet holding device comprising; a magnetic circuit block consisting of a pair of magnetic pole members respectively having a magnetism acting surface, and a non-magnetic plate disposed between said pair of magnetic pole members, said magnetic circuit block being provided with a bore having a

circular cross section and running in parallel to the non-magnetic plate;

a permanent magnet disposed in said bore rotatably about the central axis of said bore and adapted to be switched between a position in which said magnetism acting surfaces of said block become non-exciting and a position in which said magnetism acting surfaces thereof become exciting; and,

a stopper for impeding rotation of the permanent magnet, said stopper being adapted to engage said permanent magnet rotated to a position over a predetermined angle of rotation at which said magnetism acting surfaces of said block become exciting and said magnetic circuit block is maintained in a state of magnetic equilibrium, when said permanent magnet is turned in one direction, in order to switch the non-excited state of the magnetism acting surface of said block to the exciting state.

2. A permanent magnet holding device as defined in claim **1**, wherein said permanent magnet is a columnar shaped permanent magnet magnetized in the diametrical direction thereof.

3. A permanent magnet holding device as defined in claim **2**, wherein rotation of said permanent magnet is stopped by a stopper at a position in which the direction of magnetization of the permanent magnet is deviated at an angle over 90° from a position parallel to the non-magnetic plates.

4. A permanent magnet holding device as defined in claim **3**, wherein said permanent magnet has at one end face thereof a diametrically extending ridge on which an operation knob is to be fitted, and said stopper is a projection extending from the peripheral surface of said bore and engageable with said ridge of the permanent magnet.

5. A permanent magnet holding device as defined in claim **4**, wherein said projection is a tip of a pin inserted into a through-hole provided in one of said magnetic pole members to open to said bore.

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