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(54) Title: MAGNETO-RHEOLOGICAL DAMPING ASSEMBLY

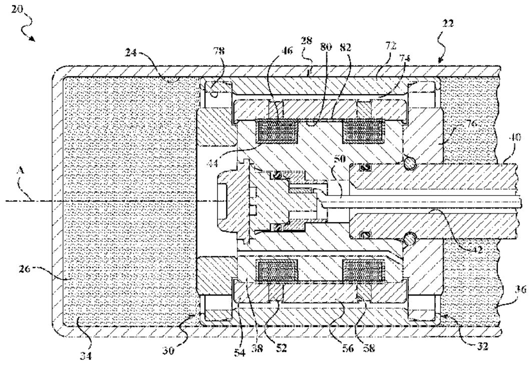

Fig. 1

(57) Abstract: A magneto-rheological damping assembly including a piston (28) defining a core (38). A pair of spaced electromagnets (46) are disposed about the core (38) and are connected to a controller (48) for selectively generating a magnetic flux. A pair of permanent magnets (52) are disposed about the electromagnets (46) and a pole segment (54;154;56;156) is disposed therebetween. A main gap (74) extends through the piston (28) through which magneto-rheological fluid (26) is conveyed. Flux generated by the magnets controls the viscosity of the fluid in the main gap (74) to control the damping force of the assembly. The controller (48) defines an off operating state for cancelling the flux from the permanent magnets (52) across the main gap (74). The core (38) and the pole segment (54;154;56;156) define a closed auxiliary gap (80) extending axially between the electromagnets (46) and radially between the core (38) and the internal pole segment (56) for preventing leakage of flux across the main gap (74) when the assembly is in the off operating state.

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A Magneto-Rheological Damping Assembly

BACKGROUND OF THE INVENTION

Field of the Invention

A magneto-rheological damping assembly.

Description of the Prior Art

Magneto-rheological (MR) damping assemblies are well known in the art. Such devices are known and used in the automotive field in vehicle suspension systems in the form of shock absorbers, struts, and other motion or vibration damping structures. MR Dampers use magneto-rheological, or MR fluid, which exhibits a thickening behavior (a rheology change) upon being exposed to magnetic fields of a sufficient strength. The higher the magnetic field strength to which the MR fluid is exposed, the higher the viscosity of the fluid, and the higher the damping force of the device.

One such assembly is shown in U.S. Patent Application 2010/0089711 (Hereinafter known as the ‘711 application). The ‘711 application discloses a piston extending along an axis defining a compression end and a rebound end. The piston defines a core. An electromagnet is disposed annularly about and engages the core for selectively generating a magnetic flux. The damping force of the assembly is a function of the current supplied to the electromagnet. To provide for desirable level of damping in the absence of a current to the electromagnet and to reduce the required operating current in the device, a permanent magnet is disposed annularly about the electromagnet for generating a magnetic flux. It is known in the art to include a plurality of electromagnets spaced axially from one another. One such assembly is disclosed in U.S. Patent 6,419,057 (Hereinafter referred to as the ‘057 patent). The ‘057 patent further discloses a pole segment, or area constructed of a material having a high magnetic permeability for concentrating the magnetic flux from the electromagnets and permanent magnets, disposed axially between permanent magnets.

The ‘711 application further discloses a main gap extending axially between the compression end and rebound end of the piston and disposed adjacent a pole segment for conveying the MR fluid through the piston. The flux from the magnets changes the viscosity of the fluid in the main gap to control the damping force of the assembly. To control the magnetic flux generated by the electromagnet, the ‘711 application discloses a controller. The controller defines an off operating state for applying a negative current through the electromagnets for cancelling the flux from the permanent magnets across the main gap to achieve a low damping force.

The ‘711 application also discloses an auxiliary gap of a material that is less magnetically permeable than the core of the piston to provide for an area of high magnetic reluctance. This is a necessary element of the design because without the auxiliary gap, when it is desirable for flux to travel across the main gap (when the device is not in the off operating state), most of the flux would get short circuited into the core rather than passing across the main gap, leading to an undesirably small damping force.

An identified problem of the prior art is that due to the location of the auxiliary gap, sufficient cancellation of the flux across the main gap is not attainable in the off-operating state due to a leakage of flux from the permanent magnets across the main gap. This is particularly problematic because it results in an undesirably high damping force when the assembly is in the off operating state and it prevents filling of the MR assembly with fluid through the main gap during assembly.

SUMMARY OF THE INVENTION

The invention provides for such a magneto-rheological damping assembly wherein the piston core and the internal pole segment define a closed auxiliary gap having an annular shape and extending axially between the electromagnets and radially between the core and the internal pole segment for preventing leakage of flux from the permanent magnets across the main gap when the assembly is in the off operating state.

The internal location of the auxiliary gap between the magnets allows for complete cancellation of the flux from the permanent magnets in the main gap when the assembly is in the off operating state. Complete cancellation of flux across the main gap advantageously allows the assembly to be filled with fluid through the main gap during assembly. Further, a lower minimum damping force is attainable when the assembly is operating in the off-operating state. An important characteristic related to MR devices is known as the “turn-up ratio” which is defined as the maximum damping force generated by the device divided by its minimum damping force (in the off operating state). It is generally desirable to have a high turn-up ratio such that the damper can fluctuate within a wide range of damping forces. Because complete cancellation of flux across the main gap is attainable, the invention provides for a higher turn-up ratio than the prior art. Furthermore, Because the auxiliary gap is located between the magnets, core and pole segment, it can easily be manufactured with different radial lengths, wherein the length corresponds to the damping range of the assembly. This is desirable because assemblies with a tuned damping range can easily be manufactured for various damping purposes.

BRIEF DESCRIPTION OF THE DRAWINGS

Other advantages of the present invention will be readily appreciated, as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Figure 1 is a side view of the magneto-rheological assembly;

Figure 2 is a perspective view of the pole segments, permanent magnets and piston rod;

Figure 3 is a schematic of the controller and electromagnet arrangement;

Figure 4 is a side perspective and fragmentary view of the second enabling embodiment;

Figure 5 is a side view of the magneto-rheological assembly when the controller is in the off operating state;

Figure 6 is a side view of the magneto-rheological assembly when the controller is in the fail firm operating state;

Figure 7 is a side view of the magneto-rheological assembly when the controller is in the off state; and

Figure 8 is a graph of the flux density versus current characteristics of the magneto-rheological assembly.

DETAILED DESCRIPTION OF THE ENABLING EMBODIMENTS

Referring to the Figures, wherein like numerals indicate corresponding parts throughout the several views, a magneto-rheological damping assembly **20** is generally shown.

The assembly **20** includes a cylindrical shaped housing **22** that extends along an axis **A** and presents an open interior **24** containing a magneto-rhological fluid **26**. A cylindrical shaped piston **28** is slidably disposed is in the open interior **24** of the housing **22**. It should be appreciated that the piston **28** and the housing **22** could have other cross-sectional shapes however they should correspond with and complement one another. The piston **28** has a compression end **30** and a rebound end **32** and the housing **22** defines a compression chamber **34** on the compression end **30** of the piston **28** and a rebound chamber **36** on the rebound end **32** of the piston **28**.

The piston **28** defines a steel cylindrical shaped core **38**. It should be appreciated that the core **38** could be constructed of other materials, however the chosen material should have a high magnetic permeability to provide for a low reluctance path for magnetic flux to travel. A piston rod **40** having a bore **42** extends axially from the piston core **38** on the rebound end **32** of the piston **28**. A pair of axially spaced grooves **44** extend annularly about the core **38**. An electromagnet **46** is disposed in each of the grooves **44** for selectively generating a magnetic flux. The electromagnets **46** are electrically connected to a controller **48** through a plurality of wires **50** that extend through the piston rod **40** bore **42** for controlling the magnetic flux generated by the electromagnets **46**. Further, a permanent magnet **52, 152** is disposed annularly about each of the electromagnets **46** for generating a magnetic flux.

A pair of steel external pole segments **54, 154** and an internal pole segment **56, 156** are disposed bout the core **38** wherein the external pole segments **54, 154** are axially spaced from one another and the internal pole segment **56, 156** is disposed axially therebetween. Like the core **38**, the pole segments **54, 154, 56, 156** are constructed of steel because of its high magnetic permeability which provides for a path of low reluctance for the magnetic flux from the magnets to travel, creating a desirable magnetic circuit in the piston **28**. It should be appreciated that the pole segments **54, 154, 56, 156** could be constructed of other materials, however it should have a high magnetic permeability.

In the first enabling embodiment, the pole segments **54, 56** and permanent magnets **52** are each separate ring shaped components. During assembly of the piston **28**, the pole segments **54, 56** and permanent magnets **52** are slid over the core **38** one after another such that the permanent magnets **52** are each sandwiched between the internal pole segment **56** and one of the external pole segments **54** in a pole void **58**.

In a second enabling embodiment as best shown in Figure 4 that is more feasible for production, the external pole segments **154** and the internal pole segments **156** are defined by a single integral pole cylinder **60**. A first and a second set of four radial slots **62, 64** that are circumferentially spaced from one another by a plurality of webs **66** are machined into the cylinder, and each set of slots **62, 64** is axially aligned with one of the electromagnets **46**. In this embodiment, each of the permanent magnets **152** is comprised of four magnet segments **68** and each of the magnet segments **68** is disposed in one of the radial slots **62, 64** of the pole cylinder **60**. Further, the pole cylinder **60** further defines a by-pass groove **70** extending axially along the cylinder in two of the webs **66** that are axially aligned with one another. The purpose of the by-pass groove **70** is to provide a magnetic flux free zone for the fluid to pass when the piston **28** slides in the housing **22** at low speeds. During assembly, the magnet segments **68** are embedded into the slots **62, 64**. To avoid handling magnetized segments **68**, the magnet segments **68** are unmagnetized prior to being embedded in the slots, and are magnetized thereafter. The pole cylinder **60** is then press fitted over the core **38**.

The piston **28** further includes a steel flux ring **72** disposed annularly about and radially spaced from the pole segments **54, 154, 56, 156** to define a main gap **74** through which the magneto-rheological fluid **26** is conveyed when the piston **28** slides in the housing **22**. Like the core **38** and pole segments **54, 154, 56**, **156** the flux ring **72** is constructed of steel to provide a path of low magnetic reluctance for the flux to travel. It should be appreciated that the flux ring **72** could be constructed of other materials having a high magnetic permeability. The flux generated from the magnets that passes across the main gap **74** raises the viscosity of the magneto-rheological fluid **26**. The imparted damping force resisting the motion of the piston **28** depends on the viscosity of the fluid, such that an increase in the viscosity of the fluid leads to an increased damping force and a decrease in the viscosity of the fluid leads to a decreased damping force. The viscosity of the fluid can be changed by controlling the magnetic flux generated by the magnets **46**, **52**, **152** acting on the fluid in the main gap **74**. It should be appreciated that the main gap could have various radial lengths to provide for different damping characteristics.

The piston **28** further includes an aluminum end plate **76** that engages the piston core **38**, the flux ring **72** and the piston rod **40**. The purpose of the end plate **76** is to hold the components in place. Because the end plate **76** is constructed of a non-magnetic aluminum material, it limits flux from exiting the piston **28**. It should be appreciated that the end plate **76** could be constructed of other materials having a low magnetic permeability. Each of the end plates **76** includes an opening **78** that is disposed radially between the external pole segments **54** and the flux ring **72** and aligned with the main gap **74** to allow fluid to be conveyed between the main gap **74** and the housing **22**.

As best shown in Figures 5, 6, and 7, the controller **48** defines an off operating state, a fail firm operating state and an on operating state, all of which control the path and the amount of magnetic flux directed through the piston **28**. When the off operating state is activated, a negative current is applied through the electromagnets **46** to cancel the flux from the permanent magnets **52, 152** across the main gap **74**, resulting in a minimum damping force. When the fail firm operating state is selected, no current is applied through the electromagnets **46**, such that only a flux from the permanent magnets **52, 152** crosses the main gap **74** resulting in a mid-level damping force. It is desirable to have a fail firm operating state because it provides for an above minimum level damping force in the event that power is lost to the electromagnets **46**. When the on operating state is activated, a positive current is applied through the electromagnets **46** such that flux produced from the electromagnets **46** and the permanent magnets **52** crosses the main gap **74** resulting in a maximum damping force. It should be appreciated that the controller **48** can be operated at levels between the aforementioned operating states to provide for various levels of damping.

The piston core **38** and the internal pole segment **56, 156** define a closed auxiliary gap **80** having an annular shape extending axially between the electromagnets **46** and radially between the core **38** and the internal pole segment **56, 156**. The auxiliary gap **80** could either be an air gap or it could be filled with another material, ideally one with a lower magnetic permeability than the core **38**. In the first enabling embodiment, a non-magnetic stainless steel auxiliary gap ring **82** is disposed in the gap. During operation, the magnetic flux produced from the magnets **46**, **52**, **152** flows in two paths, either between the magnets across the auxiliary gap **80** into the core **38** of the piston **28** or across the main gap **74** to the flux ring **72**. The auxiliary gap **80** provides for an area of increased reluctance in the flow path to the core **38** of the piston **28** such that more flux is biased toward traveling across the main gap **74** rather than through the core **38**. This is a necessary element of the design because without the auxiliary gap **80**, when the device is in the fail firm operating state, most of the flux would get short circuited into the core **38,** leading to an undesirably small damping force. A problem associated with the prior art was that due to the location of the auxiliary gap, where an end extended outside of the piston, complete cancellation of flux was not possible in the off operating state because of flux leakage across the main gap. However, the closed location of the auxiliary gap **80** in the present invention between the magnets, core **38** and pole segments **54, 154, 56, 156** advantageously prevents leakage of flux across the main gap **74** when the assembly **20** is in the off operating state. This provides for a lower damping force in the off operating state and a higher turn-up ratio than that of the prior art. Further, it allows the assembly to be filled with fluid during assembly (a problem with the prior art). During filling of the assembly **20**, the off operating state is activated by energizing the electromagnets **46** with a preset DC current.

The radial length of the auxiliary gap **80** is an important design parameter for the assembly **20**. Because the auxiliary gap is located between the magnets **46**, **52**, **152**, core **38** and pole segments **54, 154, 56, 156**, it **80** can easily be manufactured with different radial lengths, wherein the length corresponds to the damping range of the assembly **20**. This is desirable because assemblies **20** with a tuned damping range can easily be manufactured for various damping purposes. As shown in Figure 8, the radial length of the auxiliary gap **80** determines the slope of the flux density versus current characteristics of the assembly **20**. Increasing the radial length of the auxiliary gap **80** increases the magnitude of the required to be applied in the electromagnets **46** to achieve zero flux across the main gap **74** (off operating state). Further, increasing the radial length of the auxiliary gap **80** increases the flux density (corresponding to the damping force) across the main gap **74** when the assembly **20** is in the fail firm operating state. Furthermore, increasing the radial length of the main gap **74** decreases the flux density (corresponding to the damping force) across the main gap **74** when the assembly **20** is in the on operating state.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings and may be practiced otherwise than as specifically described while within the scope of the appended claims. These antecedent recitations should be interpreted to cover any combination in which the inventive novelty exercises its utility. The use of the word "said" in the apparatus claims refers to an antecedent that is a positive recitation meant to be included in the coverage of the claims whereas the word "the" precedes a word not meant to be included in the coverage of the claims. In addition, the reference numerals in the claims are merely for convenience and are not to be read in any way as limiting.

ELEMENT LIST

Element Symbol	Element Name
A	Axis
20	Assembly
22	Housing
24	open interior
26	magneto-rheological fluid
28	Piston
30	compression end
32	rebound end

34	compression chamber
36	rebound chamber
38	core
40	piston rod
42	bore
44	grooves
46	electromagnet
48	controller
50	wires
52	permanent magnet
54	external pole segments
56	internal pole segment
58	pole void
60	pole cylinder
62	first set of four radial slots
64	second set of four radial slots
66	webs
68	magnet segments
70	by-pass groove
72	flux ring
74	main gap
76	end plate
78	opening
80	auxiliary gap
82	auxiliary gap ring

What is claimed is:

1. A magneto-rheological damping assembly comprising;

a piston extending along an axis and defining a compression end and a rebound end,

said piston defining a core,

a pair of electromagnets spaced axially from one another and disposed annularly about and engaging said core for selectively generating a magnetic flux,

a permanent magnet disposed annularly about each of said electromagnets for generating a magnetic flux,

an internal pole segment constructed of a material having a high magnetic permeability for concentrating the magnetic flux from said electromagnets and said permanent magnets disposed axially between said permanent magnets,

said piston defining a main gap extending axially between said compression end and said rebound end of said piston and disposed adjacent said pole segment for conveying fluid through said piston wherein the flux from said magnets changes the viscosity of the fluid in said main gap,

a controller for controlling the magnetic flux generated by said electromagnets,

said controller defining an off operating state for applying a negative current through said electromagnets for cancelling the flux from said permanent magnets across said main gap, said piston core and said internal pole segment defining a closed auxiliary gap having an annular shape extending axially between said electromagnets and radially between said core and said internal pole segment for preventing leakage of flux from said permanent magnets across said main gap when said assembly is in said off operating state.

2. The assembly as set forth in claim 1 wherein an auxiliary gap ring constructed of a material having a low magnetic permeability is disposed in said auxiliary gap.

3. The assembly as set forth in claim 2 wherein said auxiliary gap ring is constructed of a non-magnetic stainless steel material.

4. The assembly as set forth in claim 2 wherein said core defines a pair of grooves extending annularly about said core and spaced axially from one another.

5. The assembly as set forth in claim 4 wherein each of said electromagnets is disposed in one of said grooves.

6. The assembly as set forth in claim 5 wherein said piston further includes a pair of external pole segments constructed of a material having a high magnetic permeability spaced axially from one another for concentrating the magnetic flux from said electromagnets and said permanent magnets.

7. The assembly as set forth in claim 6 wherein said internal pole segment is disposed axially between said external pole segments.

8. The assembly as set forth in claim 7 wherein said piston further defines a flux ring constructed of a material having a high magnetic permeability disposed annularly about and radially spaced from said pole segments to define said main gap.

9. The assembly as set forth in claim 8 wherein said piston further defines an end plate constructed of a non-magnetic aluminum material engaging said piston core and said flux ring and disposed at said ends of said piston.

10. The assembly as set forth in claim 9 wherein each of said end caps includes an opening disposed radially between said pole segments and said flux ring and aligned with said main gap.

11. The assembly as set forth in claim 10 wherein each of said external pole segments and said internal pole segment of said pole assembly are axially spaced to define a pole void therebetween.

12. The assembly as set forth in claim 11 wherein each of said permanent magnets has a ring shape and is sandwiched between one of said external pole segment and said internal pole segment in one of said pole voids.

13. The assembly as set forth in claim 10 wherein said external pole segments and said internal pole segments of said pole assembly are defined by an integral pole cylinder.

14. The assembly as set forth in claim 13 wherein said pole cylinder defines a first set of four radial slots circumferentially spaced from one another by a plurality of webs wherein said first set of radial slots is axially aligned with one of said electromagnets and a second set of four radial slots circumferentially spaced from one another by a plurality of webs wherein said second set of radial slots is axially aligned with the other of said electromagnets.

15. The assembly as set forth in claim 14 wherein each of said permanent magnets is comprised of four magnet segments and each of said magnet segments is disposed in one of said radial slots of said pole cylinder.

16. The assembly as set forth in claim 15 wherein said pole assembly defines a by-pass groove extending axially along said pole cylinder in two of said webs being axially aligned with one another.

17. A magneto-rheological damping assembly comprising;

a housing extending along an axis and having a cylindrical shape and presenting an open interior,

a magneto-rheological fluid disposed in said open interior of said housing, a piston defining a compression end and a rebound end and slidably disposed in said open interior of said housing defining a compression chamber on said compression end of said piston and a rebound chamber on said rebound end of said piston,

said piston defining a core having a cylindrical shape,

a piston rod extending axially from said core on said rebound of said piston,

said piston rod defining a bore,

said core defining a pair of grooves extending annularly about said core and spaced axially from one another,

an electromagnet disposed in each of said grooves for selectively generating a magnetic flux,

a controller for controlling the magnetic flux generated by said electromagnets,

a plurality of wires extending through said piston rod bore between said controller and said electromagnet for electrically connecting said electromagnets and said controller,

a permanent magnet disposed annularly about each of said electromagnets for generating a magnetic flux,

a pair of external pole segments constructed of a material having a high magnetic permeability for concentrating the magnetic flux from said electromagnets and said permanent magnets disposed about said core and spaced axially from one another,

an internal pole segment constructed of a material having a high magnetic permeability for concentrating the magnetic flux from said electromagnets and said permanent magnets disposed axially between said external pole segments,

said piston defining a flux ring constructed of a material having a high magnetic permeability disposed annularly about and radially spaced from said pole segments to define a main gap for conveying fluid through said piston wherein the flux from said magnets changes the viscosity of the fluid in said main gap,

said piston further defining an end plate constructed of a non-magnetic aluminum material engaging said piston core and said flux ring and said piston rod disposed at said ends, of said piston,

each of said end plates includes an opening disposed radially between said pole segments and said flux ring and aligned with said main gap,

said controller defining an off operating state for applying a negative current through said electromagnets for canceling the flux from said permanent magnets across said main gap and a fail firm operating state for preventing current through said electromagnets and an on state for applying a positive current through said electromagnets for inducing a flux across said main gap,

said piston core and said internal pole segment defining a closed auxiliary gap having an annular shape extending axially between said electromagnets and radially between said core and said internal pole segment for preventing leakage of flux from said permanent magnets across said main gap when said assembly is in said off operating state, and

an auxiliary gap ring of a non-magnetic stainless steel material disposed in said auxiliary gap.

18. The assembly as set forth in claim 17 wherein each of said external pole segments and said internal pole segments are axially spaced define a pole void therebetween,

each of said permanent magnets has a ring shape and is sandwiched between one of said external pole segments and said internal pole segment in said annular void.

19. The assembly as set forth in claim 17 wherein said external pole segments and said internal pole segments are defined by an integral pole cylinder,

said pole cylinder defines a first set of four radial slots circumferentially spaced from one another by a plurality of webs wherein said first set of radial slots is axially aligned with one of said electromagnets and a second set of four radial slots circumferentially spaced from one another by a plurality of webs wherein said second set of radial slots is axially aligned with the other of said electromagnets.

each of said permanent magnets is comprised of four magnet segments wherein each of said magnet segments is disposed in one of said radial slots of said pole cylinder,

said pole cylinder defines a by-pass groove extending axially along said cylinder in two of said webs being axially aligned with one another.

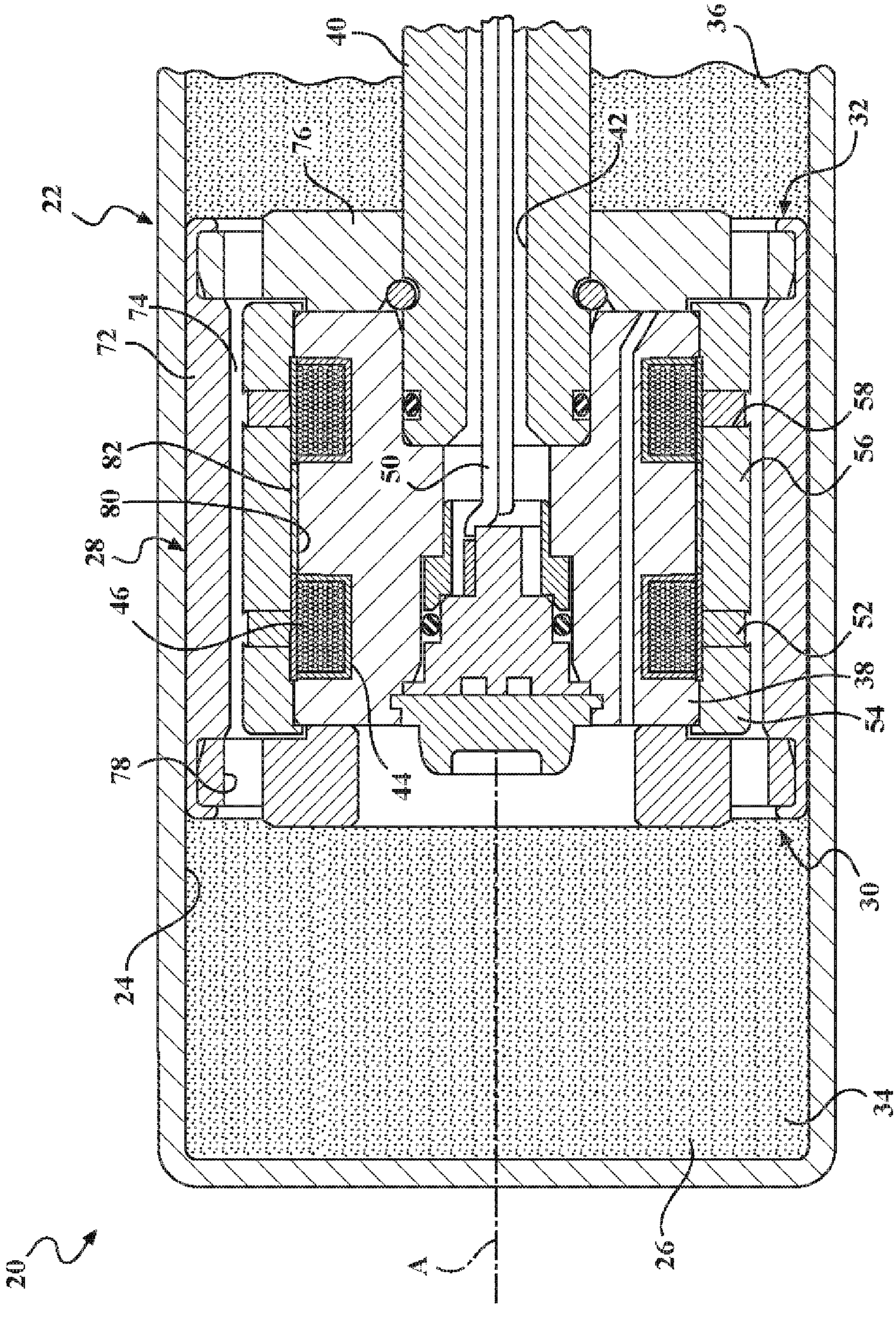
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Fig. 1

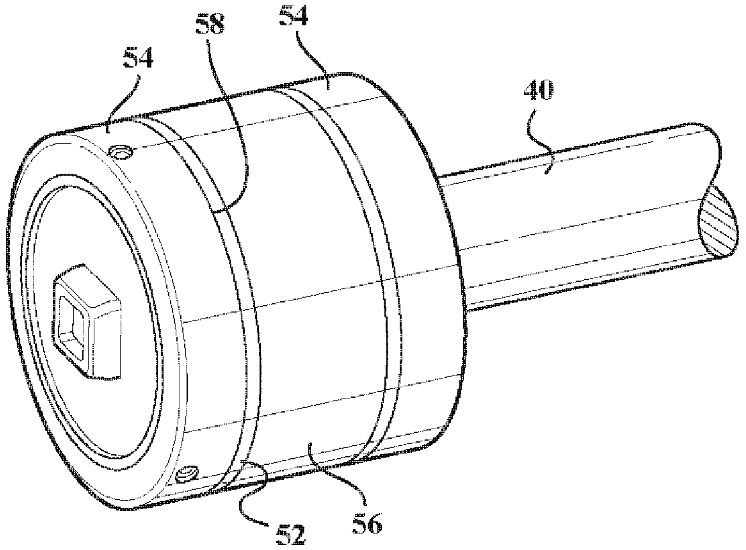


Fig. 2

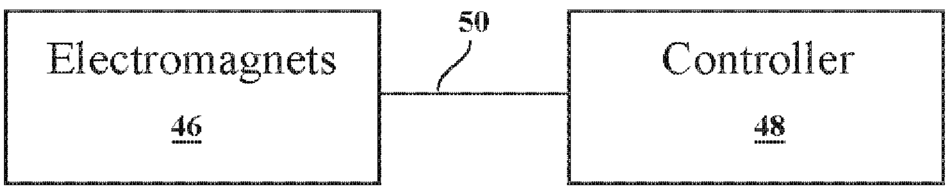


Fig. 3

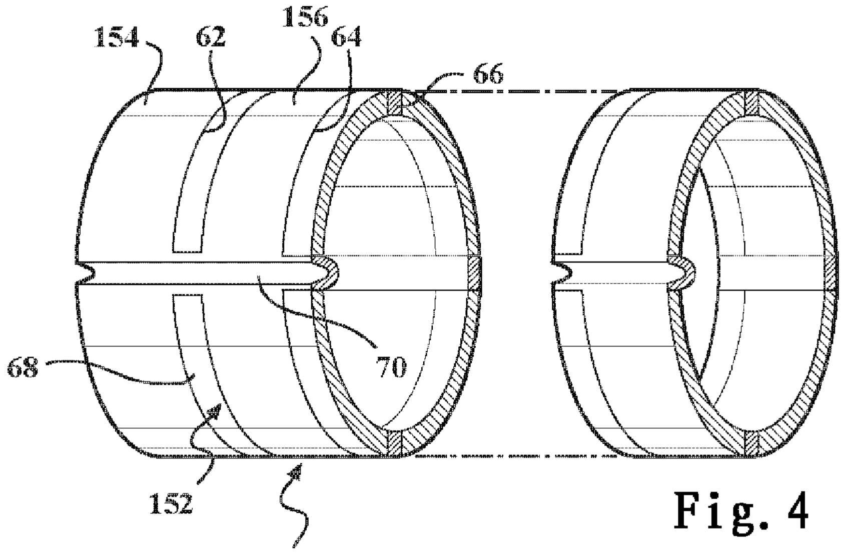
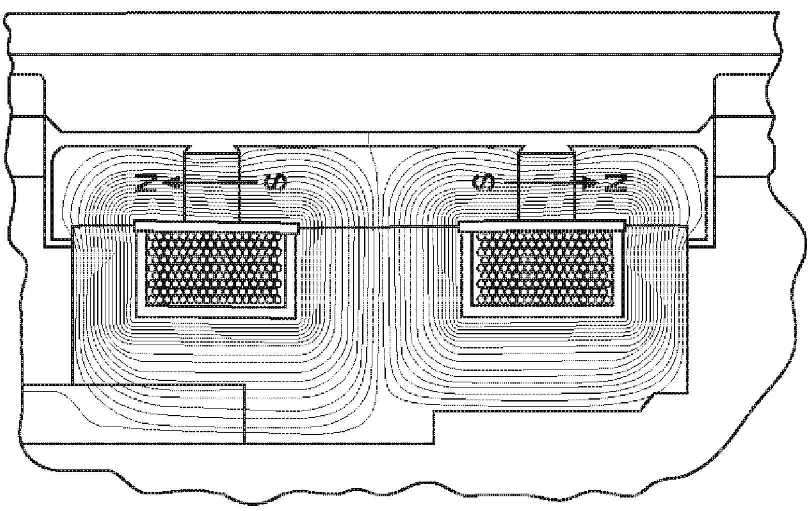
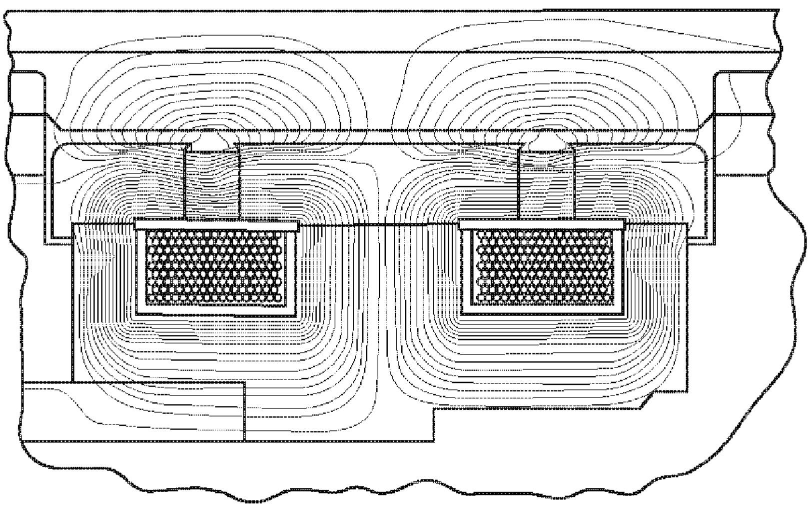


Fig. 4



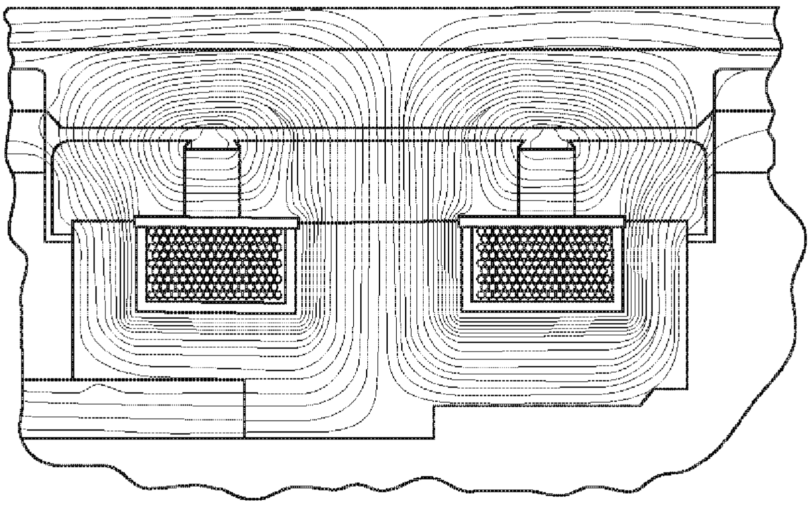
Off Operating State

Fig. 5



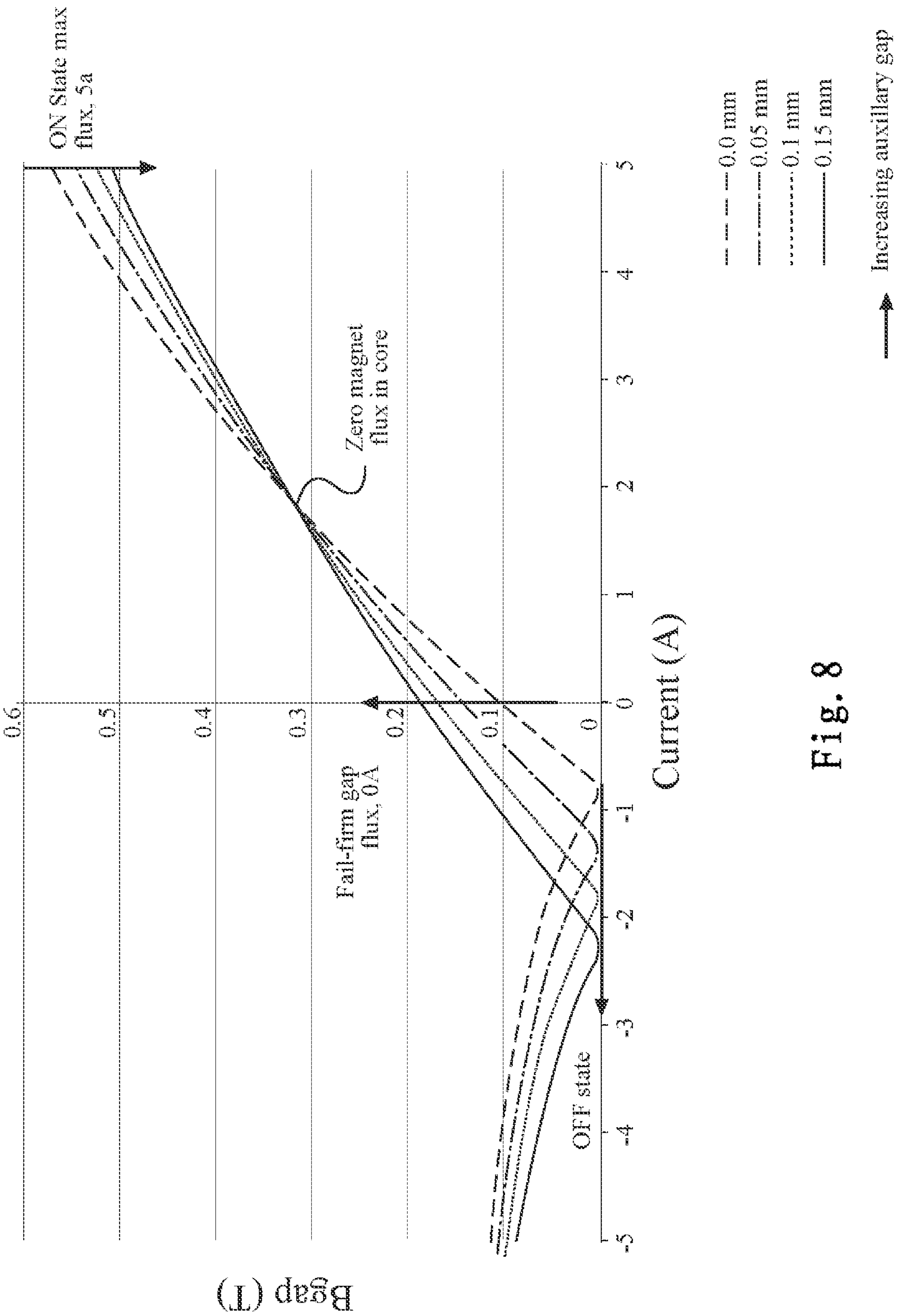
Fail Firm Operating State

Fig. 6



On Operating State

Fig. 7



ON State max flux, 5a
Zero magnet flux in core
Fail-firm gap flux, 0A
OFF state
0.0 mm
0.05 mm
0.1 mm
0.15 mm
Increasing auxilary gap
Bgap (T)
Current (A)
0.6
0.5
0.4
0.3
0.2
0.1
0
-5
-4
-3
-2
-1
0
1
2
3
4
5

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2011/078068

A. CLASSIFICATION OF SUBJECT MATTER

F16F 9/53 (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)

IPC:F16F 9/-

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)

WPI,EPODOC,CNPAT,CNKI:magneto;rheolog+;damp+;piston;electromagnet;permanent magnet;gap;磁流变;阻尼;间隙;气隙;活塞;磁芯;磁心;铁芯;铁心;电磁线圈;永磁 (in Chinese words)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 1587738 A (UNIV BEIJING POLYTECHNIC) 02 Mar. 2005(02.03.2005)the whole document	1-19
A	CN 1392354 A (UNIV CHINA SCI & TECHNOLOGY) 22 Jan. 2003(22.01.2003) the whole document	1-19
A	CN 1621707 A (UNIV CHONGQING) 01 Jun. 2005(01.06.2005) the whole document	1-19
A	US 2010096818 A1(MARJORAM et al.) 22 Apr. 2010(22.04.2010) the whole document	1-19
A	EP 2177784 A2(DELPHI TECHNOLOGIES INC) 21 Apr. 2010(21.04.2010) the whole document	1-19
A	JP 2009243674 A(HONDA MOTOR CO LTD)22 Oct. 2009(22.10.2009) the whole document	1-19

☐ 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

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 Jan. 2012 (29.01.2012)	**08 Mar. 2012 (08.03.2012)**

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2011/078068

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 1587738 A	02.03.2005	CN 100356082 C	19.12.2007
CN 1392354 A	22.01.2003	CN 1189679 C	16.02.2005
CN 1621707 A	01.06.2005	CN 100334368 C	29.08.2007
US 2010096818 A1	22.04.2010	NONE	
EP 2177784 A2	21.04.2010	US 2010089711 A1	15.04.2010
JP 2009243674 A	22.10.2009	NONE	