



(51) International Patent Classification:

G01R 33/3815 (2006.01) H01F 6/04 (2006.01)
G01R 33/38 (2006.01) F17C 13/08 (2006.01)

(21) International Application Number:

PCT/EP2020/050890

(22) International Filing Date:

15 January 2020 (15.01.2020)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

201910079940.7 28 January 2019 (28.01.2019) CN
201920143460.8 28 January 2019 (28.01.2019) CN

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

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ,
UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,
TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,
EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,
MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,

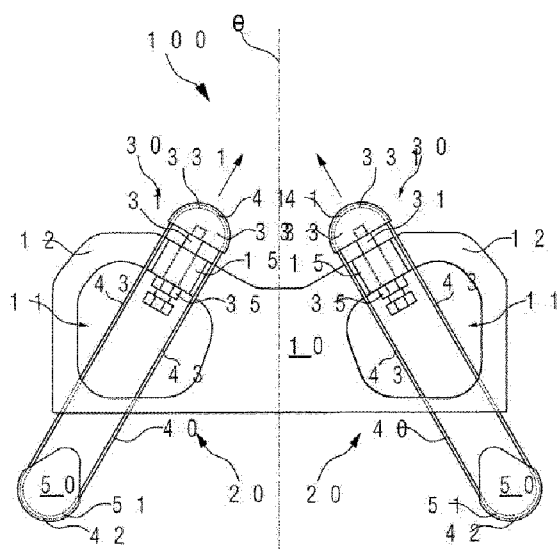
(54) Title: SUSPENSION APPARATUS FOR SUPERCONDUCTING MAGNET, SUPERCONDUCTING MAGNET AND MAG-
NETIC RESONANCE IMAGING DEVICE

Fig. 1

(57) Abstract: A suspension apparatus for a superconducting magnet, comprising a support tray (10) and at least two suspension assemblies (20). The support tray (10) has at least one through-hole (11) and comprises at least two mounting parts (15). The at least two suspension assemblies (20) pass through the support tray (10) via the through-hole (11). Each of the suspension assemblies (20) is connected to one of the mounting parts (15). The suspension apparatus is easy to install. Furthermore, a superconducting magnet comprising the suspension apparatus, and a magnetic resonance imaging device, are also provided.

TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
KM, ML, MR, NE, SN, TD, TG).

Published:

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

Description

SUSPENSION APPARATUS FOR SUPERCONDUCTING MAGNET, SUPERCONDUCTING MAGNET AND MAGNETIC RESONANCE IMAGING DEVICE

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Technical field

The present invention relates to a suspension apparatus for a superconducting magnet, in particular a suspension apparatus that is convenient to install, and a superconducting magnet comprising same, as well as a magnetic resonance imaging device.

Background art

A superconducting magnet mainly comprises a vacuum container and a cryogenic apparatus, with a superconducting coil being disposed in the cryogenic apparatus. The cryogenic apparatus is installed in the vacuum container, and must be disposed in a suspended manner, to avoid conduction heat leakage due to contact with a vacuum container housing at room temperature. The cryogenic apparatus may be suspended in the vacuum container by means of a suspension apparatus. An existing suspension apparatus comprises two fixed members, one fixed member being fixed to the cryogenic apparatus and the other fixed member being fixed to the vacuum container, and the two fixed members being connected to each other via a connecting member in order to accomplish suspension. One suspension apparatus as described above can only provide one suspending force for the cryogenic apparatus. In order to suspend the cryogenic apparatus stably in the vacuum container, it is necessary to provide suspending forces in multiple directions for the cryogenic apparatus by means of multiple suspension apparatuses as described above. Each suspension apparatus must be installed separately, with the result that the process of assembling the superconducting magnet is intricate and installation precision is affected.

Content of the invention

An object of the present invention is to provide a suspension apparatus for a superconducting magnet, which is convenient to install.

5 Another object of the present invention is to provide a superconducting magnet, having a suspension apparatus which is convenient to install.

Another object of the present invention is to provide a magnetic resonance imaging device, having a superconducting
10 magnet which is easy to assemble.

The present invention provides a suspension apparatus for a superconducting magnet, comprising a support tray and at least two suspension assemblies. The support tray has at least one through-hole and comprises at least two mounting
15 parts. The at least two suspension assemblies pass through the support tray via the through-hole. Each of the suspension assemblies is connected to one of the mounting parts.

The suspension apparatus can provide at least two suspending forces for the cryogenic apparatus. Thus, the function of at least two existing suspension apparatuses is realized by one suspension apparatus, and installation can thereby be facilitated.
20

In another schematic embodiment of the suspension apparatus, the support tray takes the form of a joined-ring body composed of at least two ring shapes. The support tray comprises at least two annular parts corresponding to the at least two ring shapes. One through-hole is provided at the center of the ring shape of each of the annular parts. One of the mounting parts is disposed on each of the annular parts.
25 Each of the suspension assemblies passes through one of the annular parts via one of the through-holes. This structure is simple and easy to machine.
30

In another schematic embodiment of the suspension apparatus, the support tray is provided with two of the annular parts and two of the mounting parts. A threaded hole runs through each of the mounting parts. The suspension apparatus is provided with two of the suspension assemblies. Each of the suspension assemblies is connected to the mounting part
35

via one of the threaded holes. The two annular parts are arranged in a mirror-image fashion relative to a plane of symmetry. An axis of the threaded hole is arranged at a slant relative to the plane of symmetry. This structure is convenient to install and adjust.

In another schematic embodiment of the suspension apparatus, the threaded hole is disposed in a hole wall of the through-hole, and the axis of the threaded hole can pass through the through-hole. Space can thereby be saved.

In another schematic embodiment of the suspension apparatus, each of the suspension assemblies comprises a tensioning member, a pulling member and a suspension member. The tensioning member is fixed to the mounting part via one of the threaded holes, a fixing position thereof relative to the mounting part being adjustable in a direction parallel to the axis of the threaded hole. The pulling member has a first pulling part and a second pulling part. The pulling member passes through the annular part via one of the through-holes, the first pulling part and the second pulling part being located at two sides of the through-hole respectively. The first pulling part is connected to the tensioning member, and configured to apply to the tensioning member a pulling force in a direction parallel to the axis of the threaded hole. The second pulling part is connected to the suspension member and configured to apply a pulling force to the suspension member. The pulling forces applied to the tensioning member and the suspension member by the pulling member are in opposite directions. This structure is convenient to install and adjust.

In another schematic embodiment of the suspension apparatus, each of the tensioning members comprises a tensioning bolt and an abutment member. The tensioning bolt is connected by screw-thread to one of the mounting parts via the threaded hole. One end of the tensioning bolt is rotatably connected to the abutment member, and a rotation axis overlaps with an axis of the tensioning bolt. The first pulling part is connected to the abutment member. This structure is simple, and is convenient to machine and operate.

In another schematic embodiment of the suspension apparatus, each tensioning member further comprises a lock nut. The lock nut is connected by screw-thread to the tensioning bolt, and can abut the mounting part, in order to prevent loosening during use.

In another schematic embodiment of the suspension apparatus, the pulling member is a rigid pull ring. The first pulling part and the second pulling part are both arc-shaped, and the pulling member further comprises two linear parts, which connect the first pulling part and the second pulling part to enclose a ring. The abutment member has a first arc-shaped end face corresponding to the shape of the first pulling part. The first pulling part abuts the first arc-shaped end face, in order to apply a pulling force to the abutment member. The suspension member has a second arc-shaped end face corresponding to the shape of the second pulling part. The second pulling part abuts the second arc-shaped end face, in order to apply a pulling force to the suspension member. Being acted upon by forces through contact with the arc-shaped end faces, the arc-shaped first pulling part and second pulling part can adapt to slight adjustments to a pulling force direction and reduce tension.

In another schematic embodiment of the suspension apparatus, the abutment member has a blind hole. One end of the tensioning bolt is rotatably inserted in the blind hole. This structure is simple, and is convenient to machine.

In another schematic embodiment of the suspension apparatus, the pulling member is a pull rod. The first pulling part and the second pulling part are located at two ends of the pull rod respectively. The tensioning bolt has a central hole arranged to run through along the axis of the tensioning bolt. The abutment member is disposed at one end of the central hole and forms a spherical-surface sliding fit with the tensioning bolt. The pulling member passes through the tensioning bolt via the central hole, and the first pulling part is connected to the abutment member. This structure can adapt to slight adjustments to a pulling force direction.

In another schematic embodiment of the suspension apparatus, the suspension member has an engagement slot. The pulling member passes through the suspension member along the engagement slot. The suspension assembly further comprises an end washer, which is connected to the second pulling part and forms a spherical-surface sliding fit with the suspension member. The pulling member can move out of the engagement slot in a direction perpendicular to the axis of the threaded hole. This structure can adapt to slight adjustments to a pulling force direction, and facilitates installation.

In another schematic embodiment of the suspension apparatus, the support tray is integrally formed, in order to make the structure more stable.

The present invention further provides a superconducting magnet, comprising a vacuum container, a cryogenic apparatus and a suspension apparatus as described above. The vacuum container has an accommodating cavity. The cryogenic apparatus is disposed in the accommodating cavity. The support tray of the suspension apparatus is connected in a fixed manner to an outer surface of the vacuum container. Each of the suspension assemblies passes through the vacuum container and is connected to the cryogenic apparatus. One suspension apparatus of the superconducting magnet can provide at least two suspending forces for the cryogenic apparatus. Thus, the function of at least two existing suspension apparatuses is realized by one suspension apparatus, and installation can thereby be facilitated.

In another schematic embodiment of the superconducting magnet, the superconducting magnet further comprises a bracket. The bracket is connected in a fixed manner to the outer surface of the vacuum container and to the support tray, and is arranged around the support tray. The connection of the support tray can thereby be made more stable.

In another schematic embodiment of the superconducting magnet, the cryogenic apparatus has a connection surface in the form of an outer cylindrical surface. The suspension apparatus is provided with two of the suspension assemblies, which are arranged in a mirror-image fashion with respect to

a first plane perpendicular to an axis of the connection surface, in order to facilitate the balancing of suspending forces.

In another schematic embodiment of the superconducting magnet, the superconducting magnet is provided with four of the suspension apparatuses. Two of the suspension apparatuses form a first suspension apparatus set, and the other two of the suspension apparatuses form a second suspension apparatus set. The first suspension apparatus set and the second suspension apparatus set are arranged in a mirror-image fashion relative to a second plane in which the axis of the connection surface lies. The two suspension apparatuses of the first suspension apparatus set are arranged in a mirror-image fashion relative to a third plane in which the axis of the connection surface lies. The second plane is perpendicular to the third plane. Thus, the four suspension apparatuses can achieve the balancing of suspending forces more easily.

The present invention further provides a magnetic resonance imaging device, comprising the superconducting magnet described above. One suspension apparatus of the superconducting magnet can provide at least two suspending forces for the cryogenic apparatus. Thus, the function of at least two existing suspension apparatuses is realized by one suspension apparatus, and installation can thereby be facilitated.

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Description of the accompanying drawings

The accompanying drawings below merely illustrate and explain the present invention schematically, without limiting the scope thereof.

30 Fig. 1 is a structural schematic diagram of a schematic embodiment of a suspension apparatus for a superconducting magnet.

Fig. 2 is a structural schematic diagram of the support tray of the suspension apparatus shown in fig. 1.

35 Fig. 3 is a schematic exploded view of the tensioning member of the suspension apparatus shown in fig. 1.

Fig. 4 is a structural schematic diagram of another schematic embodiment of a suspension apparatus for a superconducting magnet.

Fig. 5 is intended to illustrate a tensioning member of the suspension apparatus shown in fig. 4.

Fig. 6 is intended to illustrate a suspension member of the suspension apparatus shown in fig. 4.

Fig. 7 is a structural schematic diagram intended to illustrate a schematic embodiment of a superconducting magnet.

Fig. 8 is a structural schematic diagram, shown along an axis γ of a connection surface, intended to illustrate the superconducting magnet shown in fig. 7.

Key to labels

15	100	suspension apparatus
	10	support tray
	11	through-hole
	12	annular part
	15	mounting part
20	151	threaded hole
	20	suspension assembly
	30	tensioning member
	31	tensioning bolt
	311	central hole
25	33	abutment member
	331	first arc-shaped end face
	332	blind hole
	35	lock nut
	40	pulling member
30	41	first pulling part
	42	second pulling part
	43	linear part
	50	suspension member
	51	second arc-shaped end face
35	52	engagement slot
	60	end washer
	200	vacuum container
	201	accommodating cavity

300 cryogenic apparatus
301 connection surface
400 bracket
 α first plane
5 β second plane
 δ third plane
 θ plane of symmetry
 γ axis of connection surface

10 Particular embodiments

To enable clearer understanding of the technical features, objectives and effects of the invention, particular embodiments of the present invention are now explained with reference to the accompanying drawings, in which identical
15 labels indicate structurally identical components or components with similar structures but identical functions.

As used herein, "schematic" means "serving as an instance, example or illustration". No drawing or embodiment described herein as "schematic" should be interpreted as a
20 more preferred or more advantageous technical solution.

In this text, "first" and "second", etc. do not indicate order or degree of importance, etc., merely being used to indicate a distinction between parts, to facilitate document descriptions.

25 To make the drawings appear uncluttered, only those parts relevant to the present invention are shown schematically in the drawings; they do not represent the actual structure thereof as a product.

Fig. 1 is a structural schematic diagram of a schematic
30 embodiment of a suspension apparatus for a superconducting magnet. As shown in fig. 1, the suspension apparatus 100 for a superconducting magnet comprises a support tray 10 and two suspension assemblies 20. Fig. 2 is a structural schematic diagram of the support tray of the suspension apparatus shown
35 in fig. 1. As shown in figs. 1 and 2, the support tray 10 takes the form of a joined-ring body composed of two ring shapes. The support tray 10 comprises two annular parts 12 corresponding to the two ring shapes, with a mounting part 15

being disposed on each annular part 12. In this schematic embodiment, the two annular parts 12 are arranged in a mirror-image fashion relative to a plane of symmetry θ , the mirror-image arrangement being more favourable for the balancing of forces borne, but there is no restriction to this. A through-hole 11 is provided at the center of the ring shape of each annular part 12. Each suspension assembly 20 passes through one annular part 12 via one through-hole 11; one end thereof, passing out of the through-hole 11, is connected to one mounting part 15, another end being used for connecting a cryogenic apparatus of a superconducting magnet.

In this schematic embodiment, the support tray 10 is provided with two annular parts 12 and two mounting parts 15, and the suspension apparatus is provided with two suspension assemblies 20. However, there is no restriction to this; in other schematic embodiments, only one annular part 12 may be provided, i.e. the support tray 10 only has one through-hole 11, and two or more suspension assemblies 20 may pass through this one through-hole 11 at the same time. In other schematic embodiments, the quantities of mounting part(s) 15 and suspension assembly(ies) 20 may be adjusted as required, and for example may be greater than two.

In this schematic embodiment, the support tray 10 takes the form of a joined-ring body, but is not restricted to this; in other schematic embodiments, the shape thereof may be adjusted as required.

In this schematic embodiment, a threaded hole 151 runs through each mounting part 15. Each suspension assembly 20 is connected to the mounting part 15 via one threaded hole 151. An axis of the threaded hole 151 is arranged at a slant relative to the plane of symmetry θ ; the angle of slant thereof may be adjusted as required. This structure is convenient to install and adjust. However, there is no restriction to this; in other schematic embodiments, the suspension assembly 20 may be connected to the mounting part 15 in a different way.

In this schematic embodiment, each suspension assembly 20 comprises a tensioning member 30, a pulling member 40 and a suspension member 50. The tensioning member 30 is fixed to

the mounting part 15 via one threaded hole 151, and a fixing position thereof relative to the mounting part 15 can be adjusted in a direction parallel to the axis of the threaded hole 151. The pulling member 40 has a first pulling part 41 and a second pulling part 42. The pulling member 40 passes through the annular part 12 via one through-hole 11, with the first pulling part 41 and the second pulling part 42 being located at two sides of the through-hole 11 respectively. The first pulling part 41 is connected to the tensioning member 30, and configured to apply to the tensioning member 30 a pulling force in a direction parallel to the axis of the threaded hole 151. The second pulling part 42 is connected to the suspension member 50, and configured to apply a pulling force to the suspension member 50. The pulling forces applied by the pulling member 40 to the tensioning member 30 and the suspension member 50 are in opposite directions, to facilitate the balancing of forces. This structure is convenient to install and adjust. However, there is no restriction to this.

Referring to fig. 7, when the suspension apparatus 100 is in use, the support tray 10 is connected in a fixed manner to a vacuum container 200, and the suspension members 50 of the two suspension assemblies 20 are connected in a fixed manner to a cryogenic apparatus 300. By adjusting the fixing position of the tensioning member 30 on the support tray 10, the degree of tensioning of the pulling member 40 can be adjusted, in order to suspend the cryogenic apparatus 300. Each suspension apparatus 100 may provide two suspending forces for the cryogenic apparatus 300 via one pair of suspension assemblies 20. Thus, the function of two existing suspension apparatuses is realized by one suspension apparatus 100, and installation can thereby be facilitated.

In a schematic embodiment, the threaded hole 151 is disposed in a hole wall of the through-hole 11, and the axis of the threaded hole 151 can pass through the through-hole 11. Space can thereby be saved.

Fig. 3 is a schematic exploded view of the tensioning member of the suspension apparatus shown in fig. 1. As shown in fig. 3, in this schematic embodiment, each tensioning mem-

ber 30 comprises a tensioning bolt 31 and an abutment member 33. The tensioning bolt 31 is connected by screw-thread to one mounting part 15 via the threaded hole 151. One end of the tensioning bolt 31 is rotatably connected to the abutment member 33, and a rotation axis overlaps with an axis of the tensioning bolt 31. The first pulling part 41 is connected to the abutment member 33. Thus, the fixing position of the tensioning member 30 relative to the mounting part 15 can be adjusted by turning the tensioning bolt 31, without affecting the angle of the abutment member 33. This structure is simple, and is convenient to machine and operate.

In a schematic embodiment, each tensioning member 30 further comprises a lock nut 35. The lock nut 35 is connected by screw-thread to the tensioning bolt 31, and can abut the mounting part 15. Thus, once the position of the tensioning bolt 31 has been chosen, the position of the tensioning bolt 31 relative to the mounting part 15 can be locked by means of the lock nut 35, preventing loosening during use.

In this schematic embodiment, the pulling member 40 is a rigid pull ring. The first pulling part 41 and the second pulling part 42 are both arc-shaped. The pulling member 40 further comprises two linear parts 43, which connect the first pulling part 41 and the second pulling part 42 to enclose a ring in the shape of an athletic track. The abutment member 33 has a first arc-shaped end face 331 corresponding to the shape of the first pulling part 41. The first pulling part 41 abuts the first arc-shaped end face 331, in order to apply a pulling force to the abutment member 33. The suspension member 50 has a second arc-shaped end face 51 corresponding to the shape of the second pulling part 42. The second pulling part 42 abuts the second arc-shaped end face 51, in order to apply a pulling force to the suspension member 50. Being acted upon by forces through contact with the arc-shaped end faces, the arc-shaped first pulling part 41 and second pulling part 42 can adapt to slight adjustments to a pulling force direction and reduce tension.

As shown in fig. 3, in a schematic embodiment, the abutment member 33 has a blind hole 332. One end of the tension-

ing bolt 31 is rotatably inserted in the blind hole 332. This structure is simple, and is convenient to machine.

Fig. 4 is a structural schematic diagram of another schematic embodiment of a suspension apparatus for a superconducting magnet. The identical features shared by the suspension apparatus of this schematic embodiment and the suspension apparatus shown in fig. 1 are not repeated here; the structures of the suspension apparatus of this schematic embodiment which differ from the suspension apparatus shown in fig. 1 are described below.

In this schematic embodiment, the pulling member 40 is a pull rod. The first pulling part 41 and second pulling part 42 are located at two ends of the pull rod respectively. As shown in fig. 5, the tensioning bolt 31 has a central hole 311 arranged to run through along the axis of the tensioning bolt. The abutment member 33 is disposed at one end of the central hole 311 and forms a spherical-surface sliding fit with the tensioning bolt 31, in order to adapt to slight adjustments to a pulling force direction. The pulling member 40 passes through the tensioning bolt 31 via the central hole 311, and the first pulling part 41 is connected to the abutment member 33.

As shown in fig. 6, in this schematic embodiment, the suspension member 50 has an engagement slot 52. The pulling member 40 passes through the suspension member 50 along the engagement slot 52. The suspension assembly 20 further comprises an end washer 60, which is connected to the second pulling part 42 and forms a spherical-surface sliding fit with the suspension member 50, in order to adapt to slight adjustments to a pulling force direction. The pulling member 40 can move out of the engagement slot 52 in a direction perpendicular to the axis of the threaded hole 151; installation can thereby be facilitated.

In a schematic embodiment, the support tray 10 is integrally formed, so the structure thereof is more stable.

Fig. 7 is a structural schematic diagram intended to illustrate a schematic embodiment of a superconducting magnet. Fig. 8 is a structural schematic diagram, shown along an axis

y of a connection surface, intended to illustrate the superconducting magnet shown in fig. 7. As shown in figs. 7 and 8, the superconducting magnet comprises a vacuum container 200, a cryogenic apparatus 300 and a suspension apparatus 100 as shown in fig. 1. The vacuum container 200 has an accommodating cavity 201. The cryogenic apparatus 300 is disposed in the accommodating cavity 201. The support tray 10 of the suspension apparatus 100 is connected in a fixed manner to an outer surface of the vacuum container 200. Each suspension assembly 20 passes through the vacuum container 200 and the suspension member 50 thereof is connected in a fixed manner to the cryogenic apparatus 300. By adjusting the fixing position of the tensioning member 30 on the support tray 10, the degree of tensioning of the pulling member 40 can be adjusted, in order to suspend the cryogenic apparatus 300. One suspension apparatus 100 of the superconducting magnet may provide two suspending forces for the cryogenic apparatus 300 via one pair of suspension assemblies 20. Thus, the function of two existing suspension apparatuses is realized by one suspension apparatus 100, and installation can thereby be facilitated.

In other schematic embodiments, the suspension apparatus 100 could also be the suspension apparatus 100 shown in fig. 4.

In a schematic embodiment, the superconducting magnet further comprises a bracket 400. The bracket 400 is connected in a fixed manner to the outer surface of the vacuum container 200 and to the support tray 10, and is arranged around the support tray 10. The connection of the support tray 10 can thereby be made more stable.

In a schematic embodiment, the cryogenic apparatus 300 has a connection surface 301 in the form of an outer cylindrical surface. The two suspension assemblies 20 are arranged in a mirror-image fashion with respect to a first plane α perpendicular to the axis γ of the connection surface; the plane of symmetry θ overlaps with the first plane α . Thus, the resultant force of the two suspending forces applied to the cryogenic apparatus 300 by each suspension apparatus 100

is perpendicular to the axial direction of the connection surface 301, in order to facilitate the balancing of suspending forces.

As shown in fig. 8, in a schematic embodiment, the superconducting magnet is provided with four suspension apparatuses 100. Two of the suspension apparatuses 100 form a first suspension apparatus set, and the other two suspension apparatuses 100 form a second suspension apparatus set. The first suspension apparatus set and second suspension apparatus set are arranged in a mirror-image fashion relative to a second plane β in which the axis γ of the connection surface lies. The two suspension apparatuses 100 of the first suspension apparatus set are arranged in a mirror-image fashion relative to a third plane δ in which the axis γ of the connection surface lies. The second plane β is perpendicular to the third plane δ . Thus, the four suspension apparatuses 100 can achieve the balancing of suspending forces more easily.

The present invention further provides a magnetic resonance imaging device, comprising the superconducting magnet described above. One suspension apparatus 100 of the superconducting magnet may provide two suspending forces for the cryogenic apparatus 300 via one pair of suspension assemblies 20. Thus, the function of two existing suspension apparatuses is realized by one suspension apparatus 100, and installation can thereby be facilitated.

It should be understood that although the description herein is based on various embodiments, it is by no means the case that each embodiment contains just one independent technical solution. Such a method of presentation is adopted herein purely for the sake of clarity. Those skilled in the art should consider the description in its entirety. The technical solutions in the various embodiments could also be suitably combined to form other embodiments capable of being understood by those skilled in the art.

The series of detailed explanations set out above are merely particular explanations of feasible embodiments of the present invention, which are not intended to limit the scope of protection thereof. All equivalent embodiments or changes

made without departing from the artistic spirit of the present invention, such as combinations, divisions or repetitions of features, shall be included in the scope of protection of the present invention.

Patent claims

1. A suspension apparatus for a superconducting magnet, characterized by comprising:

5 a support tray (10), having at least one through-hole (11) and comprising at least two mounting parts (15); and at least two suspension assemblies (20), passing through the support tray (10) via the through-hole (11), each of the suspension assemblies (20) being connected to one of the mounting parts (15).

2. The suspension apparatus as claimed in claim 1, characterized in that the support tray (10) takes the form of a joined-ring body composed of at least two ring shapes, the support tray (10) comprising at least two annular parts (12) corresponding to the at least two ring shapes, and one said through-hole (11) is provided at the center of the ring shape of each of the annular parts (12); one of the mounting parts (15) is disposed on each of the annular parts (12); each of the suspension assemblies (20) passes through one of the annular parts (12) via one of the through-holes (11).

3. The suspension apparatus as claimed in claim 2, characterized in that the support tray (10) is provided with two of the annular parts (12) and two of the mounting parts (15); a threaded hole (151) runs through each of the mounting parts (15); the suspension apparatus is provided with two of the suspension assemblies (20), each of the suspension assemblies (20) being connected to the mounting part (15) via one of the threaded holes (151); the two annular parts (12) are arranged in a mirror-image fashion relative to a plane of symmetry (θ), an axis of the threaded hole (151) being arranged at a slant relative to the plane of symmetry (θ).

4. The suspension apparatus as claimed in claim 3, characterized in that the threaded hole (151) is disposed in a hole wall of the through-hole (11), and the axis of the threaded hole (151) can pass through the through-hole (11).

5. The suspension apparatus as claimed in claim 3, characterized in that each of the suspension assemblies (20) comprises:

5 a tensioning member (30), fixed to the mounting part (15) via one of the threaded holes (151), a fixing position thereof relative to the mounting part (15) being adjustable in a direction parallel to the axis of the threaded hole (151),
a pulling member (40), having a first pulling part (41) and a
10 second pulling part (42), the pulling member (40) passing through the annular part (12) via one of the through-holes (11), the first pulling part (41) and the second pulling part (42) being located at two sides of the through-hole (11) respectively, and the first pulling part (41) being connected
15 to the tensioning member (30), and configured to apply to the tensioning member (30) a pulling force in a direction parallel to the axis of the threaded hole (151), and
a suspension member (50), the second pulling part (42) being connected to the suspension member (50) and configured to apply
20 a pulling force to the suspension member (50), wherein the pulling forces applied to the tensioning member (30) and the suspension member (50) by the pulling member (40) are in opposite directions.

25 6. The suspension apparatus as claimed in claim 5, characterized in that each of the tensioning members (30) comprises:

a tensioning bolt (31), connected by screw-thread to one of the mounting parts (15) via the threaded hole (151), and
30 an abutment member (33), one end of the tensioning bolt (31) being rotatably connected to the abutment member (33), and a rotation axis overlapping with an axis of the tensioning bolt (31), and the first pulling part (41) being connected to the abutment member (33).

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7. The suspension apparatus as claimed in claim 6, characterized in that the pulling member (40) is a rigid pull ring, the first pulling part (41) and the second pulling part (42)

are both arc-shaped, and the pulling member (40) further comprises two linear parts (43), which connect the first pulling part (41) and the second pulling part (42) to enclose a ring; the abutment member (33) has a first arc-shaped end face (331) corresponding to the shape of the first pulling part (41), and the first pulling part (41) abuts the first arc-shaped end face (331), in order to apply a pulling force to the abutment member (33); the suspension member (50) has a second arc-shaped end face (51) corresponding to the shape of the second pulling part (42), and the second pulling part (42) abuts the second arc-shaped end face (51), in order to apply a pulling force to the suspension member (50).

8. The suspension apparatus as claimed in claim 6, characterized in that the pulling member (40) is a pull rod, the first pulling part (41) and the second pulling part (42) being located at two ends of the pull rod respectively; the tensioning bolt (31) has a central hole (311) arranged to run through along the axis of the tensioning bolt, and the abutment member (33) is disposed at one end of the central hole (311) and forms a spherical-surface sliding fit with the tensioning bolt (31); the pulling member (40) passes through the tensioning bolt (31) via the central hole (311), and the first pulling part (41) is connected to the abutment member (33).

9. The suspension apparatus as claimed in claim 8, characterized in that the suspension member (50) has an engagement slot (52), the pulling member (40) passing through the suspension member (50) along the engagement slot (52); the suspension assembly (20) further comprises an end washer (60), which is connected to the second pulling part (42) and forms a spherical-surface sliding fit with the suspension member (50); the pulling member (40) can move out of the engagement slot (52) in a direction perpendicular to the axis of the threaded hole (151).

10. The suspension apparatus as claimed in claim 1, characterized in that the support tray (10) is integrally formed.

11. A superconducting magnet, characterized by comprising:
5 a vacuum container (200), having an accommodating cavity (201);

a cryogenic apparatus (300), disposed in the accommodating cavity (201); and

10 a suspension apparatus (100) as claimed in any one of claims 1 - 10, wherein the support tray (10) is connected in a fixed manner to an outer surface of the vacuum container (200), and each of the suspension assemblies (20) passes through the vacuum container (200) and is connected to the cryogenic apparatus (300).

15

12. The superconducting magnet as claimed in claim 11, characterized in that the superconducting magnet further comprises a bracket (400), which is connected in a fixed manner to the outer surface of the vacuum container (200) and to the
20 support tray (10), and is arranged around the support tray (10).

13. The superconducting magnet as claimed in claim 11, characterized in that the cryogenic apparatus (300) has a connection surface (301) in the form of an outer cylindrical surface;
25 the suspension apparatus (100) is provided with two of the suspension assemblies (20), which are arranged in a mirror-image fashion with respect to a first plane (α) perpendicular to an axis (γ) of the connection surface.

30

14. The superconducting magnet as claimed in claim 13, characterized in that the superconducting magnet is provided with four of the suspension apparatuses (100), wherein two of the suspension apparatuses (100) form a first suspension apparatus set,
35 and the other two of the suspension apparatuses (100) form a second suspension apparatus set; the first suspension apparatus set and the second suspension apparatus set are arranged in a mirror-image fashion relative to a second

plane (β) in which the axis (γ) of the connection surface lies, and the two suspension apparatuses (100) of the first suspension apparatus set are arranged in a mirror-image fashion relative to a third plane (δ) in which the axis (γ) of the connection surface lies, the second plane (β) being perpendicular to the third plane (δ).

15. A magnetic resonance imaging device, characterized by comprising the superconducting magnet as claimed in any one of claims 11 to 14.

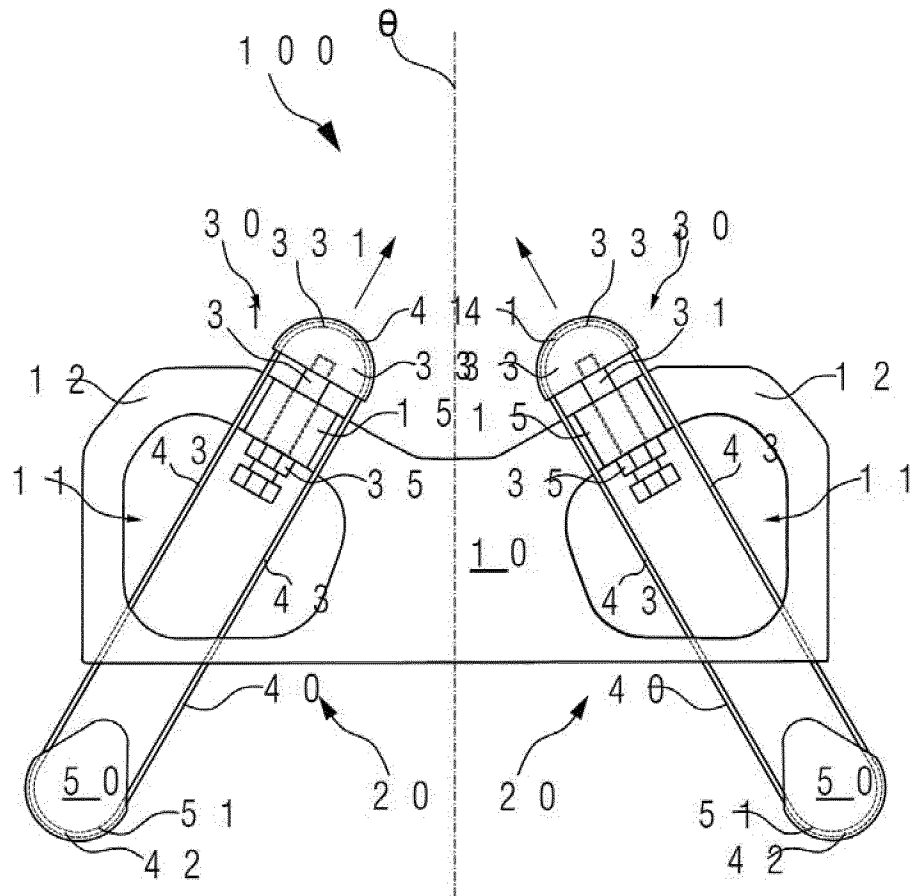


Fig. 1

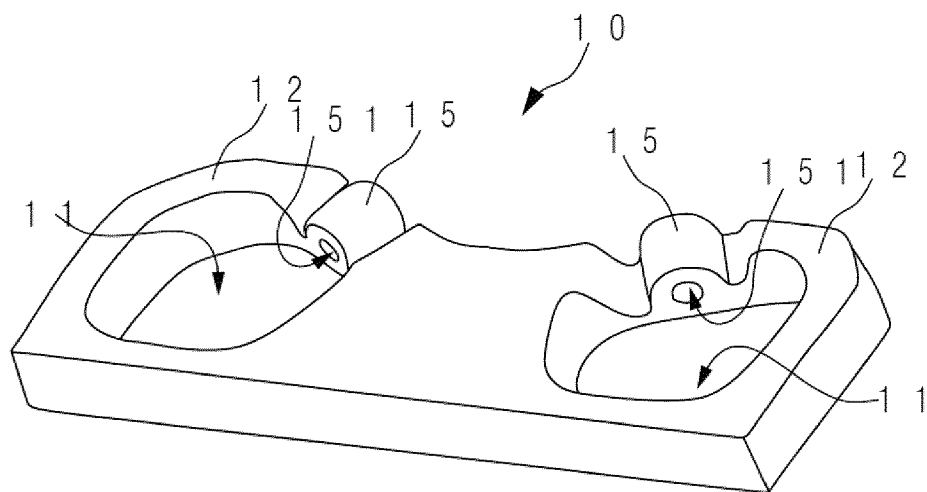


Fig. 2

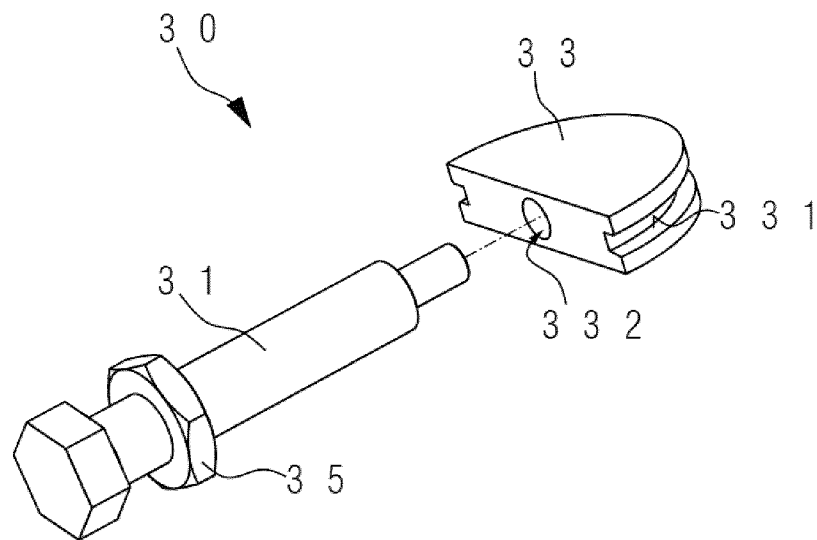


Fig. 3

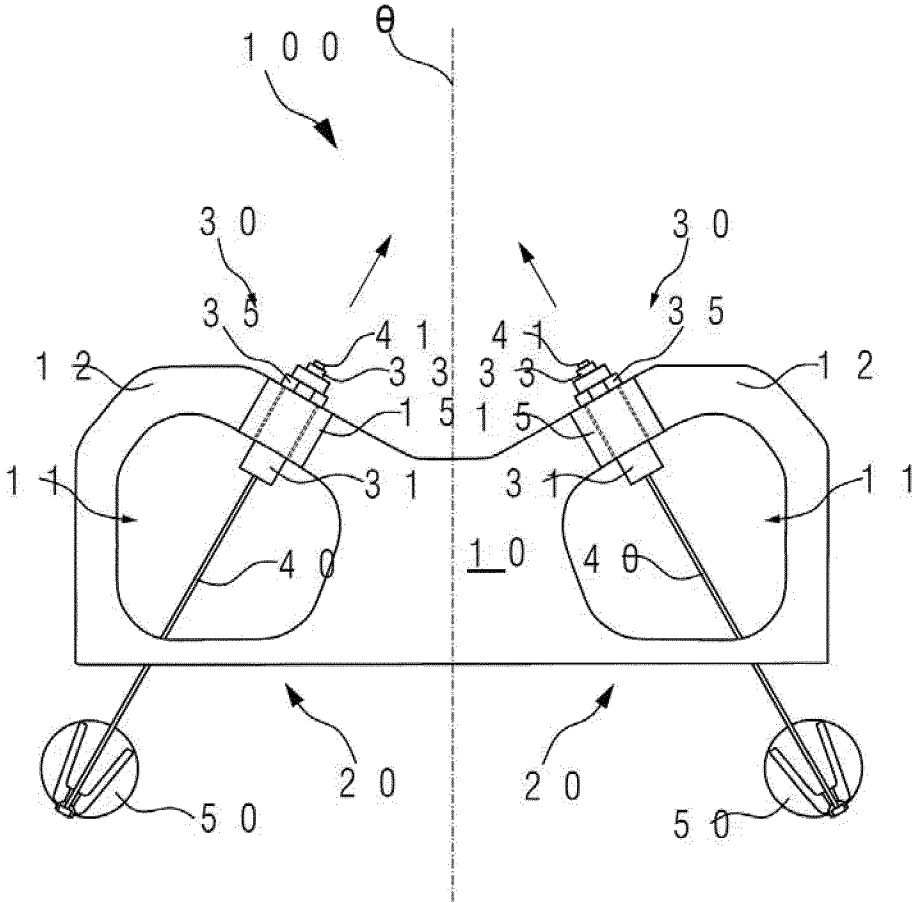


Fig. 4

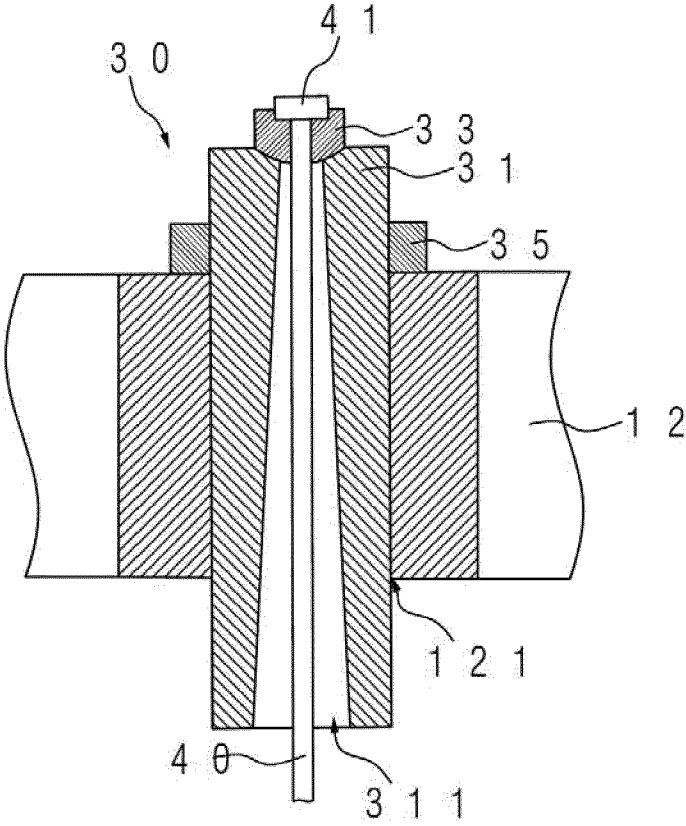


Fig. 5

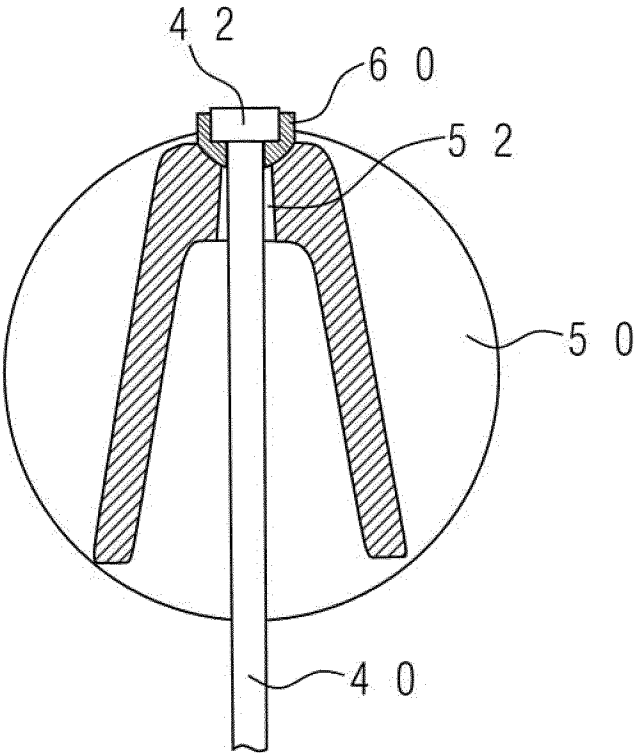


Fig. 6

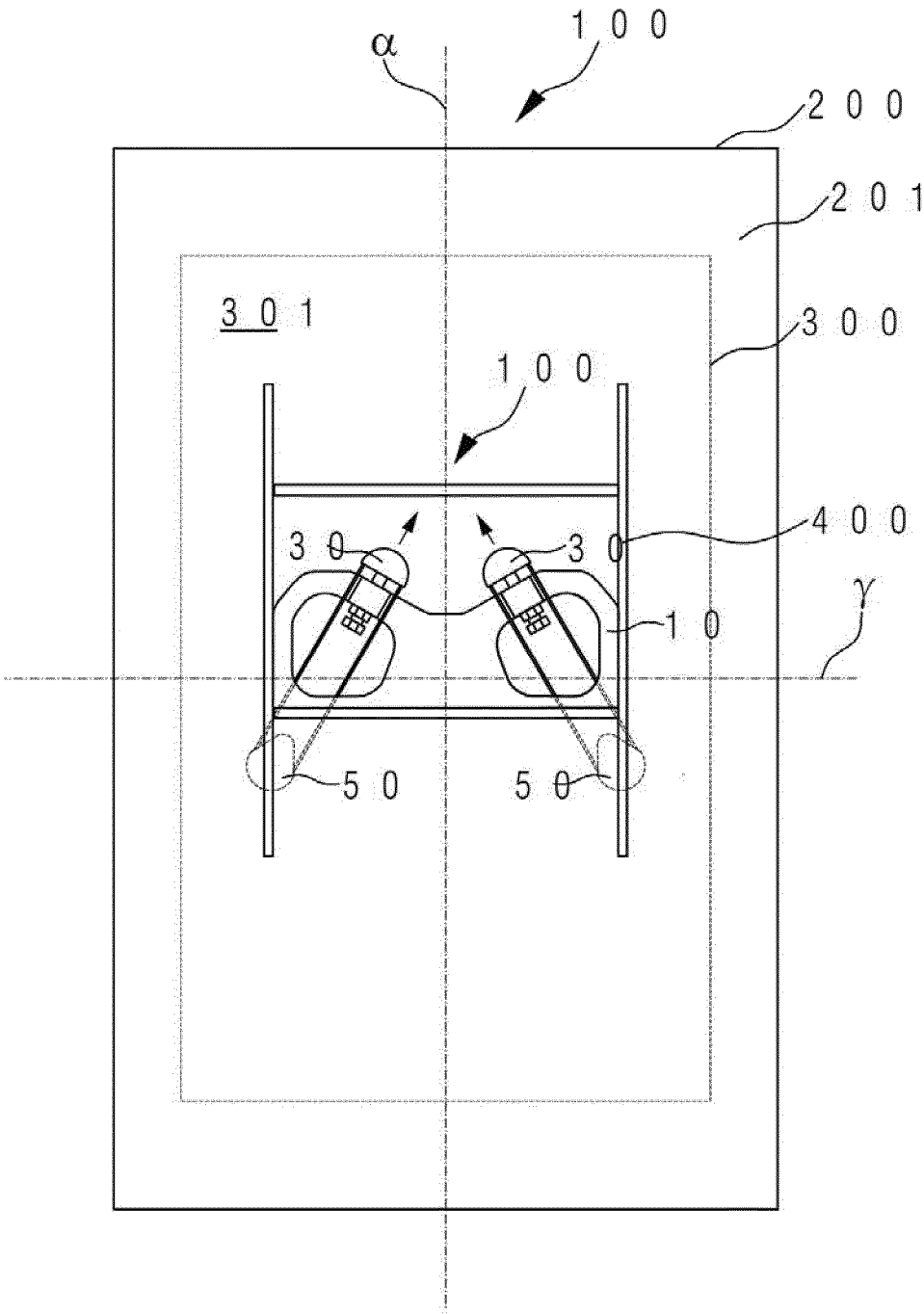


Fig. 7

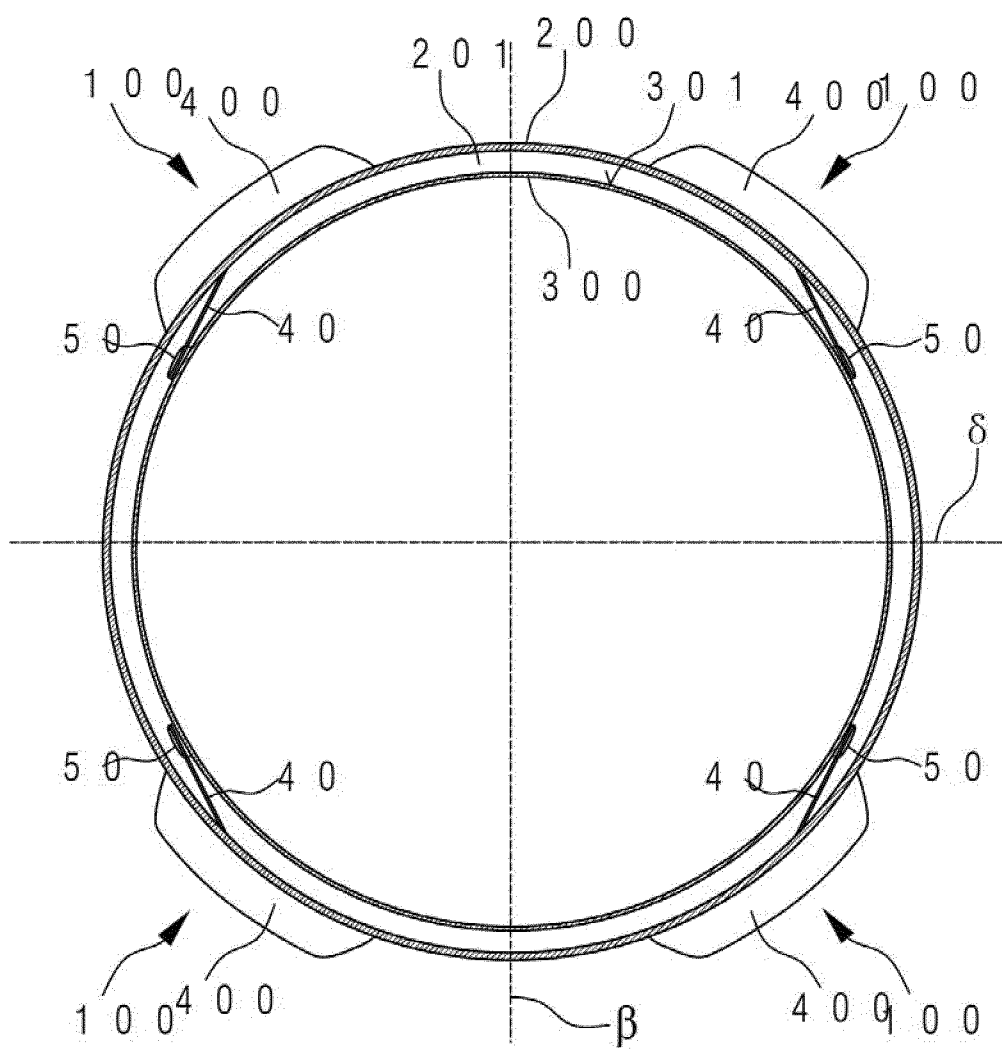


Fig. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/050890

A. CLASSIFICATION OF SUBJECT MATTER INV. G01R33/3815 G01R33/38 H01F6/04 F17C13/08 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) G01R H01F F17C		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 108 777 206 A (WEIFANG XINLI SUPERCONDUCTING MAGNETIC TECH CO LTD) 9 November 2018 (2018-11-09) figures 1,2,3 paragraph [0029] - paragraph [0038] -----	1-15
A	US 2008/022698 A1 (HOBBS MATTHEW [GB] ET AL) 31 January 2008 (2008-01-31) figures 2,3 paragraph [0014] - paragraph [0023] -----	1-15
A	US 2008/295528 A1 (MANN NICHOLAS [GB] ET AL) 4 December 2008 (2008-12-04) figures 2,3,4B,5 paragraph [0027] - paragraph [0032] ----- -/-	1-15
☒ 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 22 April 2020		Date of mailing of the international search report 04/05/2020
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Durst, Markus

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2020/050890

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	EP 0 284 875 A2 (GEN ELECTRIC [US]) 5 October 1988 (1988-10-05) figures 2,6,7,9,10 column 6 - column 9 -----	1-15
A,P	CN 208 607 985 U (SIEMENS SHENZHEN MAGNETIC RESONANCE LTD) 15 March 2019 (2019-03-15) the whole document -----	1-15

INTERNATIONAL SEARCH REPORT

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International application No

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