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(54) **CONTACTLESS ROTARY JOINT**

KONTAKTLOSER DREHÜBERTRAGER

JOINT ROTATIF SANS CONTACT

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Description

Field of the invention

[0001] The invention relates to contactless rotary joints. Such contactless rotary joints may be used in CT scanners. In general these contactless rotary joints have at least one inductive power coupler for transferring high power levels and a high-speed data link for broadband transmission of data.

Description of the related art

[0002] A contactless rotary joint with an inductive power coupler and a bidirectional high-speed data link is disclosed in the US patent US 7,717,619 B2. Such a rotary joint is able to transfer power of more than hundred kilowatts and data in the 10 Gbit/s range. Due to the high power level coupled by the inductive power coupler which is based on a rotating transformer there may be interference to the data link. Such interference may lead to data loss or even to a complete failure of the data link. To reduce interference preferably the magnetic cores of the rotating transformer are E-shaped and have differential windings. With further increasing power requirements and increasing data rates the risk of interference increases. While the power level in the rotating transformer and therefore the stray fields increase, the bandwidth and therefore the sensitivity of the data link also increases.

[0003] Document US2008049904 A1 discloses a contactless rotary joint for a CT scanner having a stationary and a rotating part, at least the rotating part comprising: a rotary joint body, said body having a free inner bore holding; a capacitive data link for transmission of data; and holding a rotating transformer having a rotating transformer magnetic core for transmission of electrical power, having at least one winding; the contactless rotary joint being having at least one shield being provided for shielding electrical and/or magnetic fields generated by the rotating transformer.

Summary of the invention

[0004] The problem to be solved by the invention is to improve contactless rotary joints by further minimizing the risk of interference even when the power level in the rotating transformer and the bandwidth of the data link increases. A further object of the invention is to reduce coupling between a rotating transformer and a contactless data link. Another object of the invention is to provide measures which may be implemented on a non-metal rotary joint body.

[0005] The solution of the problem is described in the independent claim. The dependent claims relate to further improvements of the invention.

[0006] Rotating transformers produce electric and magnetic stray fields. One of the objects for designing a rotating transformer is to keep the magnetic field flux within pre-determined areas. For this purpose often soft magnetic cores like specific ferrite or iron cores are used. Generally a rotating transformer has a gap between the rotating parts thus allowing rotation. Specifically in the CT scanners the gap is comparatively broad as the rotating part of the gantry is comparatively heavy. In some cases the gantry may even be tilted and therefore requires additional space for mechanical movement between the rotating and stationary part, leading to a gap in the range of about 1 mm. This gap and limited magnetic conductivity of the magnetic cores leads to a magnetic stray field.

[0007] In addition to the magnetic fields a rotating transformer also generates strong electric fields. The windings of the rotating transformer carry significant voltages and currents. The voltages may be in an order of magnitude of 500 Volts. Furthermore there are high frequency peaks from the switching semiconductors supplying the AC voltage to the transformer windings. Due to the high power and the resulting high magnetic flux the magnetic core have a comparatively large cross section resulting in a comparatively high capacitance to any other component in their proximity. Therefore the electric fields can interfere with other components. One means of reducing interference is keeping distance between the interfering parts.

[0008] In general electric and magnetic fields can affect data transmission of a capacitive data link. It may generate significant common mode voltage in the data link's transmission line. Also other electronic and mechanical parts may be affected by electric and magnetic fields. For example the bearing between the rotating and the stationary part of the gantry may corrode due to currents flowing through the bearing between rotating and stationary parts.

[0009] Basis of the invention is the diversion of electric and magnetic fields and the voltages and currents generated thereby.

[0010] In general contactless rotary joints have a rotary joint body which carries the components which are necessary for transferring electrical signals or power. With the rotary joint body may be made of metal which gives a high mechanical stability and provides for some shielding between the individual components. The drawback is the close electrical coupling between the components attached thereto which again increases interference. Furthermore metal structures are generally radiating high-frequency signals as they are transmitted by the capacitive data link transmission lines.

[0011] The embodiments provide solutions for reducing interference in non-metal or plastic materials rotary joint bodies. In general rotary joint systems comprise of the first rotary joint body and second rotary joint body mounted rotatable in close proximity to each other. In general they are very similar and almost symmetrically to each other. In most cases there is a capacitive data link comprising of a transmission line and a transmitter and an inductive transformer comprising of a transformer magnetic core with windings attached to a rotary joint body.

[0012] In a preferred embodiment at least one shielding is provided. The shielding preferably uses interference from the rotating transformer. Such a shielding is preferably a conducting backplane mounted to a side of the rotary joint body opposing the rotating transformer magnetic core.

[0013] In a further embodiment there is an inner shield within the rotary joint body located between the rotating transformer magnetic core and the capacitive data link transmission line. This shield may be molded into the rotary joint body.

[0014] A further preferred embodiment relates to a core shield which at least partially encloses the rotating transformer magnetic core.

[0015] In another embodiment at least one shield has a higher thermal conductivity than the rotary joint body. Therefore it helps dissipating heat from the rotating transformer. Preferably at least one shield is thermally connected to the rotating transformer core. For further improving heat dissipation to be environment at least one fin is provided, which is thermally connected to shield.

[0016] In another embodiment there is a magnetic core shield surrounding the backside of the rotating transformer magnetic core.

[0017] In a further embodiment the backplane comprises of a material with soft magnetic properties for an improved shielding of magnetic fields.

[0018] In a further embodiment the transmission line may have multiple segments for transmission of data.

[0019] In a further embodiment at least one winding may have multiple segments.

[0020] In a further embodiment a shielded temperature sensor may be provided. This temperature sensor has a sensor shield which is electrically connected to the shield and preferably to the backplane. Furthermore the sensor is thermally coupled to at least one of magnetic core or winding.

[0021] In a further embodiment a metal tape is mounted to the rotary joint body. The metal tape has openings, preferably slits or holes. These openings may be optically or magnetically detected for identifying the position of the tape and therefore the position of the rotary joint body.

[0022] In general the concepts shown herein may also be used for other types of contactless transformers like linear movable couplers.

Description of Drawings

[0023] In the following the invention will be described by way of example, without limitation of the general inventive concept, on examples of embodiment with reference to the drawings.

- Figure 1 shows a basic contactless rotary joint.
- Figure 2 shows an embodiment with a slip ring track.
- Figure 3 shows an embodiment with a conducting backplane.
- Figure 4 shows an embodiment with improved heat dissipation.
- Figure 5 shows an embodiment with an inner shield.
- Figure 6 shows an embodiment with the magnetic core shield.
- Figure 7 shows an electrical shield connection.

[0024] In figure 1 a basic contactless rotary joint is shown. It comprises of a primary part and a secondary part which are rotatable against each other around the rotation axis 101. Basically the primary part and the secondary part are very similar. In the embodiments shown herein the primary part has a rotary joint body 100 which carries the other rotary joint components. Preferably the rotary joint body is a disk shaped. It may also be drum shaped. In most cases there is a free inner bore. This is specifically required in computer tomography (CT) scanners for accommodating the patient. One of the components attached to or incorporated into the body is a contactless data link which is shown as a capacitive data link transmission line 110 in this embodiment. It is connected to a data transmitter 111 by connecting line 112. Data link transmission line 110 is almost encircling the rotary joint body 100, thus allowing data transmission independent of rotation angle. Data link receiver 213 is located at a predetermined position and not encircling the body. It is mounted rotatable in close proximity of the transmission line to pick up signals emitted from of the transmission line. It is attached to the secondary side by means of a second bracket 214. Therefore data link receiver 213 moves against data link transmission line 110 during rotation. This contactless data link may communicate data from the primary part to the secondary part. For transmission of power a rotating transformer is provided. It comprises of a magnetic core 120. In this embodiment it is an E-shaped core having a forward winding 121 and a backward winding 122. Preferably the windings are made of litz wire. The magnetic core may comprise a plurality of individual core segments.

[0025] Opposed to the primary part is a secondary part which has a secondary rotary joint body 200. It further comprises a second capacitive data link with a transmission line 210 fed via second connecting line 212 by second data transmitter 211. The second capacitive data link is able to transfer data from the secondary part to the primary part. It also has a data receiver 113 which is mounted by bracket 114 to rotary joint body 100. In this embodiment a capacitive data link is shown for each direction. It is obvious that there may be only one data link for only one direction. In general in CT scanners at least one data link from rotating to stationary part is required. Furthermore a second rotating transformer is provided having a second rotating transformer magnetic core 220 and a second forward winding 221 as well as a second backward winding 222.

[0026] The rotating transformer cores of the primary side 120 and the secondary side 220 are mounted in close proximity to allow coupling of their magnetic fields.

[0027] It can be seen that the primary side having rotary joint body 100 and secondary side heading rotary joint body 200 are symmetric and almost identical. Therefore in a further embodiment reference is made only to rotary joint body 100 and the parts attached thereto. It is obvious for someone skilled in the art to make the second part symmetrical to the first one.

[0028] Rotary joint body 110 is preferably made of a plastic material providing isolation to the components mounted thereon or therein. This rotary joint body may also be made of metal providing electric shielding and good heat dissipation. The main disadvantage of a metal rotary joint body is the comparatively high costs. Furthermore a metal rotary joint body tends to radiate RF signals from the transmission line 110 as it is connected to the ground of this transmission line. Isolation between the transmission line and a metal rotary joint body 110 would be very complex as it requires a comparatively low capacity.

[0029] In figure 2 another embodiment, not being an embodiment of the invention, is shown. Here an additional first slip ring track 131 and a second slipring track 132 are provided for transferring auxiliary signals or standby power. They may further be used for grounding. In this case the slipring tracks may be connected to at least one of the metal planes, structures or shield shown herein. Here the corresponding secondary side rotary joint body would not have further slipring tracks but slipring brushes to interface with these tracks. There may be one or any other number of slipring tracks. Furthermore there may be slipring tracks on the secondary side and corresponding brushes on the primary side.

[0030] In figure 3 a further embodiment having a conducting backplane 140 is shown which is preferably a metal plate or foil but may be any other electrically conducting material, acting as a shield. The metal structure acts as a reference plane for the field of the windings contained within magnetic core 120. It acts as a shield for the electric stray fields and parts of the magnetic stray fields of the magnetic core. When the conducting backplane 140 is electrically connected to a magnetic core 120 there is a current between them.

[0031] In figure 4 another embodiment with improved heat dissipation is shown. The conducting backplane may also improve heat dissipation of the rotating transformer. For this purpose it has higher heat conductivity than the rotary joint body. It may further comprise at least one fin 151 to improve heat transfer and heat dissipation to the environment. It is also preferred, if the backplane has at least one heat conductor 152 to the rotating transformer for improving heat transfer. There may also be a heat conducting material between the inductive transformer and the backplane. Furthermore it is preferred if this heat conducting material is an isolator. It is further preferred, if the distance between the rotating transformer magnetic core 120 and the backplane 140 is minimized, preferably below 5 mm to improve heat transfer. Furthermore there may be guiding structures within the rotary joint body or the backplane to generate an additional airflow to the rotating transformer magnetic core 120.

[0032] In figure 5 an embodiment having an inner shield 141 is shown. This inner shield 141 prevents interfering of fields generated from the rotating transformer with the capacitive data link. Preferably the inner shield 141 has a closed ring shaped structure. It furthermore is connected to the system ground. It preferably comprises a soft magnetic material to improve shielding. It may comprise a metal sheet, a mesh or a foil. It may preferably be casted or molded into the rotary joint body 100.

[0033] Figure 6 shows an embodiment with the magnetic core shield 142. Here the core shield preferably surrounds magnetic core 120. It completely encloses the free sides of the magnetic core it offers the best possible shielding.

[0034] In figure 7 an electric shield connection is shown. The wire of a winding 123, which may be any one of forward winding 121 or backward winding 122 is within rotating transformer magnetic core 120. It is connected to a shielded cable 150 by cable connection 145. The shield of shielded cable 150 is connected to shield 143 which may be any of the shields disclosed herein by a low impedance and/or low resistance connection 144. The connections may be crimping, soldering or welding connections.

List of reference numerals

[0035]

100	rotary joint body
101	rotational axis
110	capacitive data link
111	data transmitter
112	connecting line
113	data receiver
114	receiver bracket
120	rotating transformer magnetic core
121	forward winding
122	backward winding
123	winding
131	first slipring track
132	second slipring track
140	backplane
141	inner shield
142	core shield
143	shield
144	shield connection
145	cable connection
150	shielded cable
151	fins
152	heat conductor
200	second rotary joint body
210	second capacitive data link
211	second data transmitter

212 second connecting line
113 second data receiver
114 second receiver bracket
220 second rotating transformer magnetic core
221 second forward winding
222 second backward winding

Claims

1. Contactless rotary joint for a CT scanner having a stationary and a rotating part, at least the rotating part comprising: a rotary joint body (200) of a plastic material, said body having a free inner bore holding a capacitive data link having a data transmission line (110) for transmission of data, and holding a rotating transformer having a rotating transformer magnetic core (220), for transmission of electrical power, having at least one winding (221, 222); the contactless rotary joint being **characterized by** at least one shield (141, 142) being provided for shielding electrical and/or magnetic fields generated by the rotating transformer, to reduce interference with the capacitive data link, and by at least one shield having a higher thermal conductivity than the rotary joint body (200) and adapted to help dissipating heat from the rotating transformer, said shield being thermally connected to the rotating transformer core.

2. Contactless rotary joint for a CT scanner according to claim 1, **characterized by** said at least one shield having a higher thermal conductivity having at least one fin (151) for increasing heat dissipation to the environment.

3. Contactless rotary joint for a CT scanner according to any one of the preceding claims,
characterized by the rotary joint body having a disk shape, and the rotating transformer magnetic core being held at one side of the disc, while a conducting backplane is mounted to the opposing side of the disc.

4. Contactless rotary joint for a CT scanner according to any one of the preceding claims,
characterized by the shield for shielding electrical and/or magnetic fields being an inner shield (141) being molded into the rotary joint body.

5. Contactless rotary joint for a CT scanner according to any one of the preceding claims,
characterized by a core shield (142) at least partially enclosing the rotating transformer magnetic core .

6. Contactless rotary joint for a CT scanner according to any one of the preceding claims,
characterized by the rotating transformer's at least one winding being connected to an inverter by a shielded cable (150), wherein the shield of the cable is connected to at least one shield and the inner conductor is connected to the at least one winding.

7. Contactless rotary joint for a CT scanner according to any one of claims 3 to 6, **characterized by** the backplane (140) comprising a material with soft magnetic properties.

8. Contactless rotary joint for a CT scanner according to any one of the preceding claims,
characterized by the transmission line having multiple segments for transmission of data.

9. Contactless rotary joint for a CT scanner according to any one of the preceding claims,
characterized by the at least one winding having multiple segments.

10. Contactless rotary joint for a CT scanner according to any one of the preceding claims,
characterized by a shielded temperature sensor having a shield electrically connected to the backplane and the sensor being thermally coupled to at least one of magnetic core or winding.

11. Contactless rotary joint for a CT scanner according to any one of the preceding claims,
characterized by a metal tape being mounted to the rotary joint body and having openings for optically or magnetically reading the position of the tape and therefore the position of the rotary joint body.

Patentansprüche

1. Kontaktloser Drehübertrager für einen Computertomographen mit einem stationären und einem rotierenden Teil, wobei zumindest der rotierende Teil umfasst: einen Drehübertragerkörper (200) aus Kunststoffmaterial, wobei der Körper einen freie Innenöffnung hat, welche eine kapazitive Datenstrecke mit einer Datenübertragungsleitung (110) zur Übertragung von Daten beinhaltet, und beinhaltend einen Drehtransformator mit einem Drehtransformator-Magnetkern (220), zur Übertragung von elektrischer Energie, mit zumindest einer Wicklung (221, 222); wobei der kontaktlose Drehübertrager **gekennzeichnet ist durch** zumindest einen Schirm (141, 142), welcher bereitgestellt ist zum Abschirmen von elektrischen und/oder magnetischen Feldern, welche **durch** den Drehtransformator erzeugt werden, um Störung bei der kapazitiven Datenstrecke zu reduzieren, und **durch** zumindest einen Schirm mit einer höheren Wärmeleitfähigkeit als der Drehübertragerkörper (200), und der angepasst ist, um beim Ableiten von Wärme vom Drehtransformator mitzuwir-

ken, wobei der Schirm mit dem Drehtransformatorkern wärmeleitend verbunden ist.

2. Kontaktloser Drehübertrager für einen Computertomographen nach Anspruch 1,
dadurch gekennzeichnet, dass
der zumindest eine Schirm mit einer höheren Wärmeleitfähigkeit zumindest eine Lamelle (151) zur Erhöhung der Wärmeableitung an die Umgebung hat.

3. Kontaktloser Drehübertrager für einen Computertomographen nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, dass
der Drehübertragerkörper eine Scheibenform hat, und der Drehtransformator-Magnetkern an einer Seite der Scheibe gehalten wird, während eine leitende Rückplatte auf der gegenüberliegenden Seite der Scheibe befestigt ist.

4. Kontaktloser Drehübertrager für einen Computertomographen nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, dass
der Schirm zum Abschirmen von elektrischen und/oder magnetischen Feldern ein innerer Schirm (141) ist, welcher in den Drehübertragerkörper gegossen ist.

5. Kontaktloser Drehübertrager für einen Computertomographen nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, dass
ein Kernschirm (142) zumindest teilweise den Drehtransformatorkern umschließt.

6. Kontaktloser Drehübertrager für einen Computertomographen nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, dass
die zumindest eine Wicklung des Drehtransformators über ein abgeschirmtes Kabel (150) mit einem Wandler verbunden ist, wobei der Schirm des Kabels mit dem zumindest einen Schirm verbunden ist und der innere Leiter mit der zumindest einen Wicklung verbunden ist.

7. Kontaktloser Drehübertrager für einen Computertomographen nach einem der Ansprüche 3 bis 6,
dadurch gekennzeichnet, dass
die Rückwand (140) ein Material mit weichmagnetischen Eigenschaften umfasst.

8. Kontaktloser Drehübertrager für einen Computertomographen nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, dass
der Übertragungsleitung mehrere Segmente zum Übertragen von Daten hat.

9. Kontaktloser Drehübertrager für einen Computertomographen nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, dass
die zumindest eine Wicklung mehrere Segmente hat.

10. Kontaktloser Drehübertrager für einen Computertomographen nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, dass
ein abgeschirmter Temperatursensor einen Schirm hat, welcher elektrisch mit der Rückwand verbunden ist, und der Sensor wärmeleitend mit zumindest einem von dem Magnetkern oder der Wicklung verbunden ist.

11. Kontaktloser Drehübertrager für einen Computertomographen nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, dass
ein metallisches Band an den Drehübertragerkörper befestigt ist und Öffnungen zum optischen oder magnetischen Lesen der Position des Bandes und damit der Position des Drehübertragerkörpers hat.

Revendications

1. Raccord tournant sans contact pour un scanner TDM possédant une partie fixe et une partie rotative, la partie rotative, au minimum, comprenant : un corps de raccord rotatif (200) fait d'une matière plastique, lequel corps possède un alésage intérieur libre contenant une liaison de données capacitive avec une ligne de transmission de données (110) pour la transmission de données, et contenant un transformateur rotatif qui possède un noyau magnétique de transformateur rotatif (220) pour la transmission de puissance électrique et qui possède au moins une spire (221, 222), le raccord tournant sans contact étant **caractérisé en ce qu'**au moins un blindage (141, 142) est prévu pour arrêter les champs électriques et/ou magnétiques produits par le transformateur rotatif, afin de réduire les interférences avec la liaison de données capacitive, et **en ce qu'**au moins un blindage a une plus grande conductibilité thermique que le corps de raccord rotatif (200) et est adapté pour aider à dissiper la chaleur du transformateur rotatif, ledit écran étant en liaison thermique avec le noyau de transformateur rotatif.

2. Raccord tournant sans contact pour un scanner TDM selon la revendication 1, **caractérisé en ce qu'**au moins un blindage ayant une plus grande conductibilité thermique possède au moins une ailette (151)

pour accroître la dissipation de chaleur vers l'environnement.

3. Raccord tournant sans contact pour un scanner TDM selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le corps de raccord rotatif est en forme de disque et le noyau magnétique de transformateur rotatif est retenu sur un côté du disque, tandis qu'un fond de panier conducteur est monté sur le côté opposé du disque.

4. Raccord tournant sans contact pour un scanner TDM selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le blindage destiné à arrêter les champs électriques et/ou magnétiques est un blindage intérieur (141) moulé dans le corps de raccord rotatif.

5. Raccord tournant sans contact pour un scanner TDM selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'**un blindage de noyau (142) renferme au moins partiellement le noyau magnétique de transformateur rotatif.

6. Raccord tournant sans contact pour un scanner TDM selon l'une quelconque des revendications précédentes, **caractérisé en ce que** l'au moins une spire du transformateur rotatif est connectée à un inverseur par un câble blindé (150), le blindage du câble étant connecté à l'au moins un blindage et le conducteur intérieur étant connecté à l'au moins une spire.

7. Raccord tournant sans contact pour un scanner TDM selon l'une quelconque des revendications 3 à 6, **caractérisé en ce que** le fond de panier (140) comprend un matériau ayant des propriétés magnétiques faibles.

8. Raccord tournant sans contact pour un scanner TDM selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la ligne de transmission possède plusieurs segments pour la transmission de données.

9. Raccord tournant sans contact pour un scanner TDM selon l'une quelconque des revendications précédentes, **caractérisé en ce que** l'au moins une spire possède plusieurs segments.

10. Raccord tournant sans contact pour un scanner TDM selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'**il comporte un capteur de température blindé, possédant un blindage connecté électriquement au fond de panier, et le capteur est en couplage thermique avec au moins soit le noyau magnétique, soit la spire.

11. Raccord tournant sans contact pour un scanner TDM selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'**un ruban métallique est monté sur le corps de raccord rotatif et possède des ouvertures pour la lecture optique ou magnétique de la position du ruban et ainsi de la position du corps de raccord rotatif.

Fig. 1

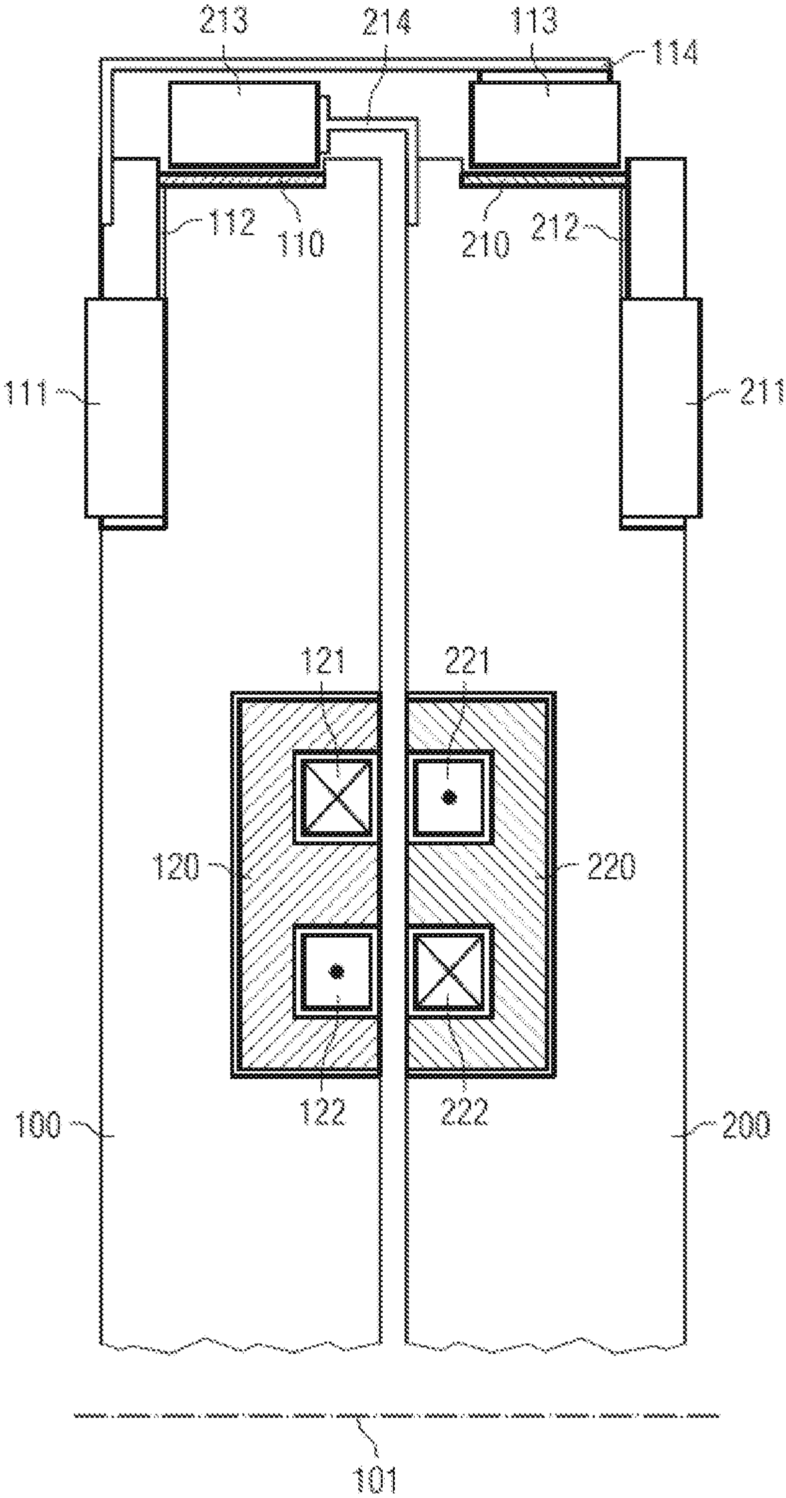

213
214
113
114
112
110
210
212
111
211
121
221
120
220
122
222
100
200
101

Fig. 2

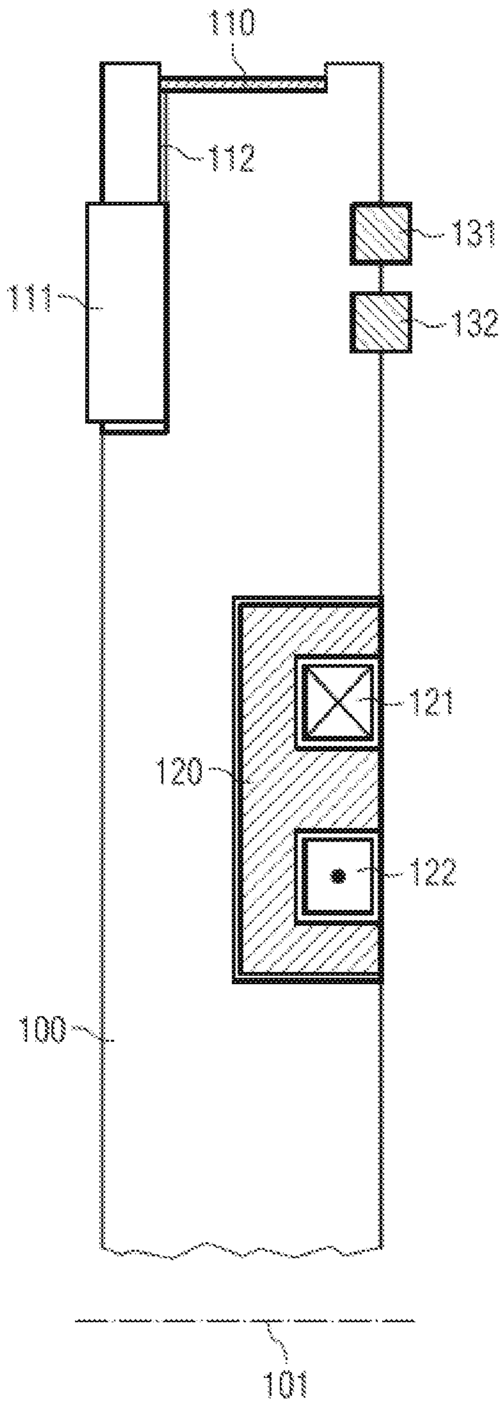


Fig. 3

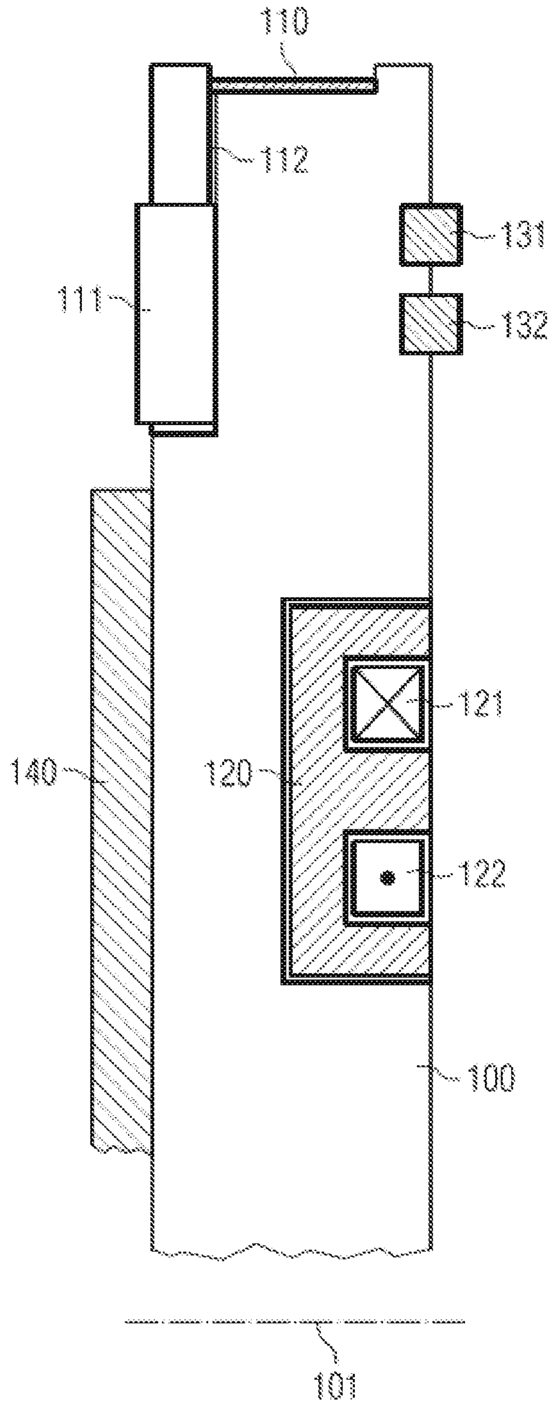


Fig. 4

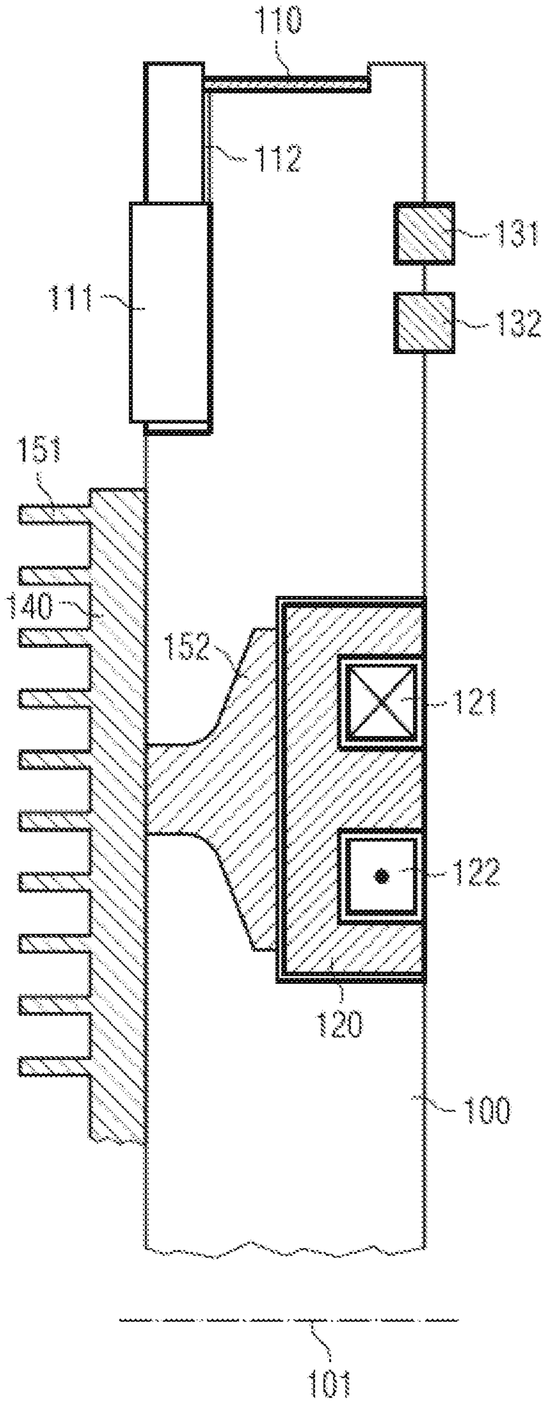


Fig. 5

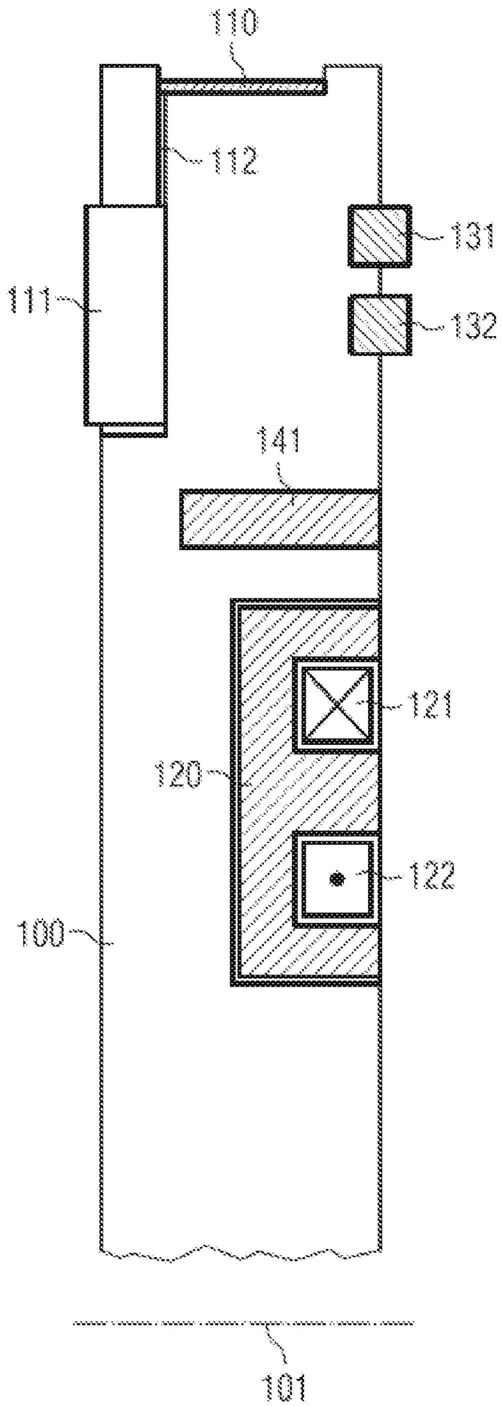


Fig. 6

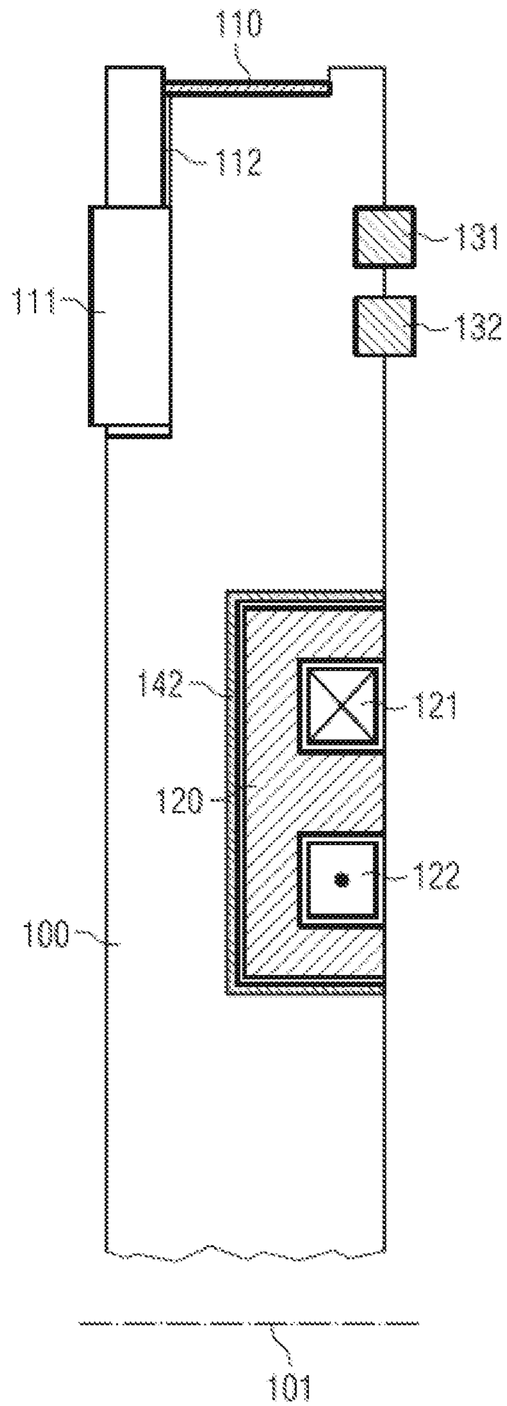
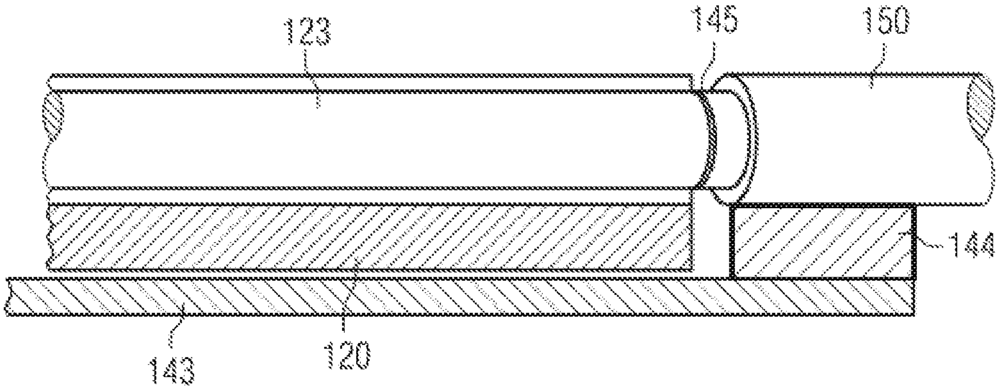


Fig. 7



REFERENCES CITED IN THE DESCRIPTION

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- US 2008049904 A1 **[0003]**