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Laitteita ja menetelmiä lämpöä johtavan kytkennän tekemiseksi kryostaatissa
Anordningar och förfaranden för att göra en värmeledande koppling i en kryostat
APPARATUSES AND METHODS FOR MAKING A THERMALLY CONDUCTIVE COUPLING IN A CRYOSTAT

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(57) Tiivistelmä - Sammandrag - Abstract

Lämpöä ja/tai sähköä johtavan kytkennän tekemiseksi kryostaatissa laite käsittää kohde-esineen (601), ensimmäisen mekanismin (602), joka on konfiguroitu aiheuttamaan kohde-esineen (601) ainakin ensimmäinen liike (603), joka ensimmäinen liike (603) on lineaarinen ensimmäisessä suunnassa, ja kytkinelimen (604), joka on tuettu kryostaattiin. Kytkinelin käsittää lämpökytkennän jäähdytettyyn rakenne-osaan (1301) kryostaatissa ja/tai sähkökytkennän ainakin osittain kryostaatissa sijaitsevaan piiriin. Laite käsittää toisen mekanismin, jota voidaan käyttää kohde-esineen (601) mainitulla ensimmäisellä liikkeellä (603) ja joka on konfiguroitu tällä tavalla käytettäessä aiheuttamaan ainakin osan kytkinelimestä (604) toinen liike (605). Mainitulla toisella liikkeellä (605) on komponentti kohti kohde-esineen (601) pintaa, joka osoittaa kytkinelimen (604) mainittua osaa kohti. Mainittu toinen liike (605) saa loppuun asti suoritettuna kytkinelimen (604) mainitun osan painautumaan mainittua kohde esinettä (601) vasten toisessa suunnassa, joka on kulmassa suhteessa mainittuun ensimmäiseen suuntaan.

For making a thermally and/or electrically conductive coupling in a cryostat, an apparatus comprises a target object (601), a first mechanism (602) configured to cause at least a first movement (603) of the target object (601), which first movement (603) is linear in a first direction, and a coupler (604) supported in the cryostat. The coupler comprises a thermal coupling to a cooled structural part (1301) in the cryostat and/or an electrical coupling to circuit located at least partly in the cryostat. The apparatus comprises a second mechanism operable by said first movement (603) of the target object (601) and configured to, when so operated, cause a second movement (605) of at least a part of the coupler (604). Said second movement (605) has a component towards a surface of the target object (601) facing said part of the coupler (604). Said second movement (605) makes, when completed, said part of the coupler (604) press against said target object (601) in a second direction at an angle against said first direction.

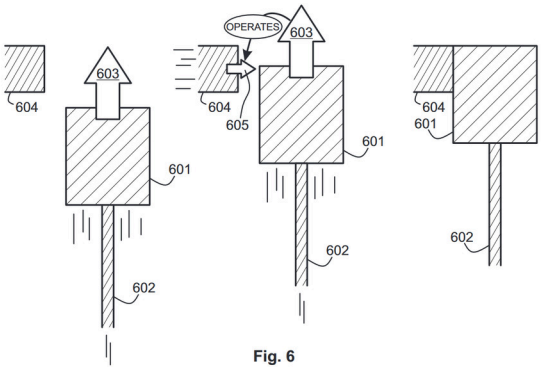

Fig. 6

APPARATUSES AND METHODS FOR MAKING A THERMALLY CONDUCTIVE COUPLING IN A CRYOSTAT

FIELD OF THE INVENTION

The invention is related to the technical field of cryogenic cooling systems. In particular the invention is related to ways in which an object moved inside a cryostat can be selectively brought into a thermally and/or electrically conductive coupling with a fixed structure of the cryostat.

BACKGROUND OF THE INVENTION

Cryogenic cooling systems are intricate pieces of machinery designed to cool a target region or payload volume down to very low temperatures and maintain such conditions for desired periods of time. The payload to be cooled may contain e.g. a scientific experiment, a quantum computer, a measurement setup, and/or something else, the correct operation of which may require temperatures in the order of only some kelvins or even well below one kelvin. A cryogenic cooling system may also be called a cryostat. In some sources, the designation cryogenic cooling system is used for just that subsystem of a cryostat that produces the low temperatures, while the cryostat is additionally said to comprise other subsystems like mechanical support, vacuum pumping, radiation shielding, cabling, and the like. In this text the terms cryostat and cryogenic cooling system are used as synonyms of each other, possibly including an interpretation that a cryostat may be somewhat simpler, like a vacuum can with a single cold source (mechanical cooler or bath of liquid cryogen), while a cryogenic cooling system may be more elaborate with one or more outer cold sources for pre-cooling and one or more inner cold sources (such as dilution refrigerators for example) to reach the coldest temperatures.

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The two principal approaches to placing a payload in a cryostat for cooling involve exposing the target region to surrounding atmospheric conditions or using a so-called fast sample exchanger (FSE). Fig. 1 is a simplified schematic illustration of a cryogenic cooling system equipped with a dilution refrigerator, a mechanical pre-cooler, and an FSE. The outermost structure is a vacuum can 101, which is shown with dashed lines in fig. 1. The topmost flange 102 is the lid of the vacuum can. The room temperature stage 103 of the mechanical pre-cooler is attached thereto. The first stage 104 of the mechanical pre-cooler is attached to a first flange 105 and the second stage 106 of the mechanical pre-cooler is attached to a second flange 107. The first and second flanges may be called the 50 K flange and the 4 K flange for example, reflecting their approximate temperatures during operation.

Further below there are more flanges, like the still flange 108 to which the still 109 of the dilution refrigerator is attached. In fig. 1 the mixing chamber 110 of the dilution refrigerator is attached to the base temperature flange 111. Reference designator 112 illustrates the targe region at which the payload is to be refrigerated. A payload is frequently referred to as the sample. There may be extending structures called cold fingers thermally coupled to the mixing chamber 110, with which the target region for the payload may be brought also elsewhere than on the flange (if any) on which the mixing chamber 110 is installed.

Cylindrical, flat-bottomed radiation shields, which are not shown in fig. 1 for graphical clarity, are typically attached to the flanges in a nested configuration, in order to keep radiated heat from surrounding, higher-temperature parts from reaching the colder parts inside. The structure may comprise other, intermediate flanges like a so-called 100 mK flange between the still flange 108 and the base temperature flange 111. Aligned

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apertures 113, 114, and 115 may exist in the flanges to provide a so-called line-of-sight port to the target region 112.

As parts of an FSE, a load lock 116 can be attached to a gate valve 117. The system depicted in fig. 1 is of the top-loading type, so the gate valve 117 is in the lid 102 of the vacuum can 101. The sample holder 118 is at the lower end of an elongate probe 119, which can be moved in its longitudinal direction (vertical direction in fig. 1) to eventually attach the sample holder 118 in place at the target region 112. Systems of bottom-loading type have the gate valve in the bottom of the vacuum can, so that the sample is loaded in from below. Systems of side-loading type are also known, in which the sample loader connects to a gate valve in a side surface of the vacuum can.

The sample holder 118 must have a thermally conductive coupling at least to the target region 112 once there. In many cases it is advantageous to also establish temporary thermally conductive couplings between the sample holder 118 and at least one of the intermediate flanges 105, 107, or 108 on the way in, to pre-cool the sample holder 118 and the sample to some intermediate temperature. All such thermally conductive couplings must be made (and released) remotely, as there are limited ways of accessing the inside of the cryostat during operation.

Basic approaches to making releasable thermally conductive couplings are known from prior art documents EP 2 409 096 B1 and WO 2021/229149 A1. Figs. 2 and 3 illustrate a precooling principle known from the former. Here the holes 201 in the flanges and the sample holder 118 are not round but are shaped in such a way that in one rotational position, the outermost parts of the sample holder 118 abut the flange adjacent to the hole 201. These parts are provided with screw holes 301. In addition to or instead of the centralized probe 119,

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the sample changer comprises screwable rods 202, whereby the sample holder 118 may be temporarily fastened to the flange by means of threads located at an outermost end of the screwable rods (or by means of separate bolts to be rotated with the screwable rods) as in Fig. 2. When sufficient precooling has been provided, the threads or bolts are unscrewed and the sample changer is rotated to a suitable position in which it can move through the hole 201 in the flange as in Fig. 3. The same threads or bolts may also be used for fixing the sample holder 118 in the target region.

Use of thermally conductive springs is also known in the prior art, which is illustrated in Figs. 4 and 5. A sample 401 is fastened to a sample holder 118 that is in this case substantially disc-shaped and manufactured from a material having good thermal conductivity. A plurality of springs 402, the material of which is both elastic and thermally conductive, are fastened around a hole in the flange 105. When the sample holder 118 is pushed between the springs in accordance with Fig. 5, they yield outwards and are pressed under their spring force against edges of the sample holder 118.

At low temperatures, it is essential to press two contacting surfaces firmly together if a good thermal conductivity across the interface is to be achieved. At the same time, all friction should be avoided in making the connection. The extremely small specific heat of solid materials close to absolute zero means that merely tightening a screw, for example, may cause a temperature increase of several kelvins. Further, utilizing surfaces that repeatedly slide against each other during operation for making a thermally and/or electrically conductive coupling causes scratching and wear of the surfaces, which may dramatically weaken the thermal and/or electrical conductivity through the interface over time.

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In addition to thermal coupling, it is often desirable to make electrical connections to the sample. Most advantageously, making electrical connections should involve mating connector pairs that can be pushed together with a linear movement. This is relatively simple if the connectors can be aligned with the inherent linear movement of the FSE. However, there may be limited space available for such connectors and/or there may be other challenges, like the need to make electrical connections without the sample holder being at its final destination yet.

It would be desirable to find novel ways of making efficient thermally and/or electrically conductive couplings remotely inside the cryostat without generating excessive amounts of waste heat in making (and releasing) the coupling and with more degrees of freedom for placing electrical connectors.

SUMMARY

An objective is to present methods and arrangements for making efficient thermally and/or electrically conductive couplings remotely inside a cryostat with little waste heat generated and with reasonable complicatedness of structural solutions.

These and further advantageous objectives are achieved by making a movement of a target object that is inserted to the cryostat activate a further mechanism that moves a coupler into contact with the target object in a transverse direction.

According to a first aspect, there is provided an apparatus for making a coupling in a cryostat, which coupling comprises at least one of: a thermally conductive coupling, an electrically conductive coupling. The apparatus comprises a target object and a first mechanism configured to cause at least a first movement of the target object, which first movement is linear in a first direction. The apparatus comprises a coupler

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supported in the cryostat, said coupler comprising at least one of: a thermal coupling to a cooled structural part in the cryostat, an electrical coupling to circuit located at least partly in the cryostat. The apparatus comprises a second mechanism operable by said first movement of the target object and configured to, when so operated, cause a second movement of at least a part of the coupler. The second movement has a component towards a surface of the target object facing said part of the coupler. The second movement makes, when completed, said part of the coupler press against said target object in a second direction at an angle against said first direction.

According to an embodiment, said part of the coupler comprises a thermal conduction surface to be pressed against said target object in said second direction at completion of said second movement. This involves at least the advantage that the coupler can be used to make a very effective thermally conductive coupling to the target object.

According to an embodiment, the coupler comprises one or more electrical connectors to engage with respective one or more counterpart connectors in the target object at completion of said second movement. This involves at least the advantage that large freedom is achieved for ways in which electrical connections can be built in the system.

According to an embodiment, the apparatus comprises a cradle that defines a hollow configured to receive the target object at a point of said first movement. Said supporting of the coupler may then allow said cradle to move, after having received the target object in said hollow, along with said target object in continuation of said first movement. The apparatus may define a space into which at least a part of said cradle pushes when moving along with said target object. A limiter of said space may be configured to, in response

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to the cradle or at least said part of the cradle pushing into said space, force said part of the coupler against said target object in said second direction. This involves at least the advantage that the mechanism can be made mechanically robust and easily repeatable in series production without much variation in performance between different manufactured units.

According to an embodiment, considered in the direction opposite to said first direction, said cradle has a widening perpendicular outer dimension, so that said part of the coupler is forced against said target object in said second direction as a result of an increasingly wider portion of the cradle pushing into said space. This involves at least the advantage that only relatively simple machining of parts is needed to achieve the desired effect.

According to an embodiment, said cradle is a uniform piece of material. Said part of the coupler that becomes forced against said target object may then be a portion of the cradle configured to undergo an elastic deformation as a result of an increasingly wider portion of the cradle pushing into said space. This involves at least the advantage that only relatively simple machining of parts is needed to achieve the desired effect.

According to an embodiment, said cradle comprises a cradle body to which said part of the coupler that becomes forced against said target object is slidably mounted. Said part of the coupler may then be configured to slide, in relation to said cradle body, in said second direction as a result of an increasingly wider portion of the cradle pushing into said space. This involves at least the advantage that only relatively simple machining of parts is needed to achieve the desired effect.

According to an embodiment, said cradle comprises a cradle body to which said part of the coupler that becomes forced against said target object is

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rotatably mounted. Said part of the coupler may then be configured to rotate, in relation to said cradle body, as a result of an increasingly wider portion of the cradle pushing into said space, so that at least a portion of said part of the coupler presses against said target object in said second direction. This involves at least the advantage that sliding movements can be reduced or avoided.

According to an embodiment, the apparatus comprises one or more clamp pieces configured to become engaged by said target object at a point of said first movement. Said supporting of the coupler may then allow said one or more clamp pieces to move, after becoming engaged by the target object and in response to said target object continuing said first movement, in a way that presses at least one portion of said one or more clamp pieces against said target object in said second direction. This involves at least the advantage that very few limitations need to be placed to the overall form and design of the target object.

According to an embodiment, the apparatus comprises fixed support for each of said one or more clamp pieces for limiting movement of the respective one of said one or more clamp pieces as a whole in a direction opposite to said second direction. Said one or more clamp pieces may then be configured to rotate, supported by said fixed support and in response to said target object continuing said first movement, in a way that increases the dimension of a portion of the respective clamp piece in the second direction. This involves at least the advantage that the rotating movement may help avoiding friction-induced sliding between parts.

According to an embodiment, the fixed support for each of said one or more clamp pieces comprises a fixed rotating axis on which the respective clamp piece is rotatably mounted. This involves at least the

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advantage that robust mechanical support can be offered for the rotating movement.

According to an embodiment, the fixed support for each of said one or more clamp pieces offers a rolling surface for the respective one of said one or more clamp pieces, which rolling surface is a smooth surface or a geared surface. Each of said one or more clamp pieces may then comprise a corresponding rolling surface for allowing the respective clamp piece to roll, supported by the mutually engaging rolling surfaces, with respect to the fixed support. This involves at least the advantage that friction can be largely avoided in the rotating movement and the number of parts needed is small.

According to an embodiment, the fixed support for each of said one or more clamp pieces comprises an elastically deformable portion configured to support the respective one of said one or more clamp pieces. Each of said one or more clamp pieces may then be configured to rotate supported by the respective elastically deformable portion in response to said target object continuing said first movement. This involves at least the advantage that holding support and rotation can be achieved with the same structural part.

According to an embodiment, the apparatus comprises fixed support for each of said one or more clamp pieces, said fixed support defining a tapering space for receiving respective ones of said one or more clamp pieces in said first direction, for making each of said one or more clamp pieces press against said target object in said second direction as a result of pushing into said tapering space. This involves at least the advantage that the amount of force that presses the respective parts together can be easily controlled by designing appropriately the surfaces and structures that define the tapering space.

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According to an embodiment, a movement-enabling joint between the fixed support and the respective clamp piece is one of: a roller bearing joint, a sliding joint. This involves at least the advantage that structural solutions of known kind and reproducible characteristics can be used.

According to an embodiment, the apparatus comprises a clamp that defines an opening for the target object. Said second mechanism may then involve a tightening mechanism configured to, under influence of an activating force in said first direction, tighten the clamp. This involves at least the advantage that a very comprehensive contact can be made around a significant part of a circumference of the target object.

According to an embodiment, the first mechanism comprises an actuator configured to move along with the target object and to engage an activating trigger of said tightening mechanism at a point of said first movement, for providing said activating force as a result of continuation of said first movement. This involves at least the advantage that a relatively simple actuation mechanism can be provided.

According to an embodiment, the second mechanism comprises a straight-line mechanism, such as a Watt’s linkage or Roberts linkage. The coupler may then be part of said straight-line mechanism, and said straight-line mechanism may be configured to perform its characteristic linear movement when taken along by said first movement of the target object, thus causing said second movement (605). This involves at least the advantage that a movement of the desired kind of a coupler can be achieved also in feed-through type solutions.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and constitute a part of this specification, illustrate

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embodiments of the invention and together with the description help to explain the principles of the invention. In the drawings:

Figure 1 is a schematic illustration of a cryostat,

figure 2 illustrates a known way of making a thermally conductive coupling,

figure 3 illustrates further handling of the system shown in fig. 2,

figure 4 illustrates a known way of making a thermally conductive coupling,

figure 5 illustrates a known way of making a thermally conductive coupling,

figure 6 illustrates a principle of using linear motion to activate transverse motion,

figure 7 illustrates another principle of using linear motion to activate transverse motion,

figure 8 illustrates an embodiment of using linear motion to activate transverse motion,

figure 9 illustrates an embodiment of using linear motion to activate transverse motion,

figure 10 illustrates an embodiment of using linear motion to activate transverse motion,

figure 11 illustrates an embodiment of using linear motion to activate transverse motion,

figure 12 illustrates an embodiment of using linear motion to activate transverse motion,

figure 13 illustrates an arrangement according to an embodiment,

figure 14 illustrates a detail of the arrangement of fig. 13,

figure 15 illustrates the use of an arrangement according to fig. 13,

figure 16 illustrates an arrangement according to an embodiment,

figure 17 illustrates a detail of the arrangement of fig. 16,

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figure 18 illustrates a detail of the arrangement of fig. 16,

figure 19 illustrates an arrangement according to an embodiment and its use,

figure 20 illustrates an arrangement according to an embodiment and its use,

figure 21 illustrates an arrangement according to an embodiment and its use,

figure 22 illustrates an arrangement according to an embodiment and its use,

figure 23 illustrates an arrangement according to an embodiment,

figure 24 illustrates an arrangement according to an embodiment and its use,

figure 25 illustrates an arrangement according to an embodiment and its use,

figure 26 illustrates an arrangement according to an embodiment and its use,

figure 27 illustrates an arrangement according to an embodiment and its use,

figure 28 illustrates an arrangement according to an embodiment and its use,

figure 29 illustrates an arrangement according to an embodiment and its use,

figure 30 illustrates an arrangement according to an embodiment and its use, and

figure 31 illustrates an arrangement according to an embodiment and its use.

DETAILED DESCRIPTION

In the following description, reference is made to the accompanying drawings, which form part of the disclosure, and in which are shown, by way of illustration, specific aspects in which the present disclosure may be placed. It is understood that other aspects may be utilised, and structural or logical changes may be made without departing from the scope of the present

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disclosure. The following detailed description, therefore, is not to be taken in a limiting sense, as the scope of the present disclosure is defined by the appended claims.

For instance, it is understood that a disclosure in connection with a described method may also hold true for a corresponding device or system configured to perform the method and vice versa. For example, if a specific method step is described, a corresponding device may include a unit to perform the described method step, even if such unit is not explicitly described or illustrated in the figures. On the other hand, for example, if a specific apparatus is described based on functional units, a corresponding method may include a step performing the described functionality, even if such step is not explicitly described or illustrated in the figures. Further, it is understood that the features of the various example aspects described herein may be combined with each other, unless specifically noted otherwise.

Fig. 6 illustrates a principal approach to making a coupling in a cryostat. The coupling involved may comprise a thermally conductive coupling, an electrically conductive coupling, or both.

A thermally conductive coupling is typically made to allow a cooler mechanism, such as a mechanical refrigerator, a dilution refrigerator, a coolant circulating system, or the like to cool an object of interest. In this text, the object of interest is called the target object and it is typically (but not mandatorily) a sample holder or some other part of an FSE. Making a thermally conductive coupling should involve providing a sufficient cross-sectional area and a sufficiently strong force pressing the surfaces involved together, so that the thermal conductivity of the coupling can reach levels that are useful for reasonable operation of the cryostat. A thermally conductive coupling may be

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made at some intermediate temperature level through which the FSE or other target object passes, and/or at the base temperature level at which the FSE or other target object should be cooled to and maintained at the base temperature of the cryostat.

An electrically conductive coupling is typically made to allow electrical signals to pass between the target object (or some further object coupled thereto) and fixed parts of the cryostat. As an example, it is often desirable to convey electrical signals to and from a sample, which may be inserted into the cryostat with an FSE. While a thermally conductive coupling between two metallic surfaces is also an electrically conductive coupling, for example for purposes of establishing a common ground potential across the whole structure, in this text the concept of electrically conductive coupling is considered merely to cover connections for electric signals, which may be electrical potentials (defined in relation to the common ground potential) and/or electrical currents. The electric signals meant here may be DC and/or AC signals.

Typically but not mandatorily, electrically conductive couplings are made with dedicated electrical connectors. Push-fit connectors that require a linear movement to make contact are often used. Non-limiting examples of push-fit connector types frequently used in cryostats are the so-called SMP connectors. Using connectors of push-fit type to make an electrically conductive coupling to a target object requires there to be a male connector on the target object and a corresponding female connector in the mating part of the cryostat, or vice versa. Considering an FSE that is moved linearly towards a target region in the cryostat, the front face (the surface that comes first in the direction of the insertion movement) may be used to place male and/or female connectors, the mating halves of which are then provided at the target region so that

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the connector halves mate when the FSE reaches its final position. However, such connectors are typically only available for connections at the target region and not at any intermediate level, as the intermediate levels can hardly contain obstacles where the FSE could not pass through. Also, the space available in the front face of the sample holder (or other part of the FSE) may be limited, for which reason it could be desirable to also be able to make electrically conductive couplings to one or more side faces of the sample holder (or other part of the FSE).

The apparatus, operation of which is considered on principal level in fig. 6, comprises a target object 601 and a first mechanism 602 configured to cause at least a first movement 603 of the target object 601. The first movement 603 meant here is linear in a so-called first direction, which in fig. 6 is the vertical direction: by using the first mechanism 602, the target object 601 can be moved linearly upwards.

As suggested above, the target object 601 is typically but not mandatorily a sample holder or some other part of an FSE, the purpose of which is to allow inserting samples in and removing samples from a cryostat without subjecting the target region of the cryostat to ambient atmospheric conditions. The first mechanism 602 may comprise one or more elongate probes that extend through a load lock. Such elongate probes, if provided, may be available for manual moving through manipulation by the end(s) of the probe(s) that are accessible outside the load lock. Additionally, or alternatively, such elongate probes may be coupled to one or more electric stepper motors or other kinds of controllable mechanisms with which it is then possible to actuate the first movement 603 of the target object 601. Other forms of the first mechanism are possible. For the purposes of this description, the exact implementation of the first mechanism is not important, as long as it

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can be used to actuate the (linear) first movement 603 of the target object 601.

The apparatus comprises a coupler 604 supported in the cryostat. The coupler 604 may comprise a thermal coupling to a cooled structural part of the cryostat (not shown in fig. 6). The thermal coupling may go through rigid parts and/or through flexible or pliable parts of the cryostat. A cooled structural part meant here may be a part of a cooler mechanism, or it may be a part from which there is a further thermally conductive coupling to a cooler mechanism. For the sake of an illustrative example, the cooled structural part of the cryostat meant here may be considered to be a flange, i.e. either the base temperature flange or some intermediate flange through which the target object 601 should pass on its way towards the target region. The cooled structural part could also be a thermal shield or some other physical part inside the cryostat.

Additionally, or alternatively, the coupler 604 may comprise an electrical coupling to circuit located at least partly in the cryostat. Advantageous ways of utilizing such an electrical coupling are described in more detail later in this text.

The apparatus comprises a second mechanism that is operable by the first movement 603 of the target object 601 and configured to, when so operated, cause a second movement 605 of at least a part of the coupler 604. In particular, the second movement 605 meant here has a component towards a surface of the target object 601 facing such a part of the coupler 604. When completed, the second movement 605 makes said part of the coupler 604 press against the target object 601 in a second direction, which is at an angle against the first direction.

Preferably but not mandatorily, the second direction is perpendicular to the first direction. In other words, if the “first” movement of the target

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object 601 is considered to be a movement forward, the "second" movement may make, when completed, at least a part of the coupler 604 press sideways against the surface of the target object 601. With the directions selected as in fig. 6, the second movement 605 is an essentially horizontal movement towards an outer side of the target object 601.

It is advantageous to configure the directions of all movements in a way that minimizes friction between parts that move in contact with each other or come into contact each other as a result of movement. For example, while the first movement 603 and second movement 605 are schematically shown in fig. 6 as orthogonal to each other, this may be interpreted as meaning that an overall movement of the target object 601 may comprise a component 603 that is perpendicular against a respective component 605 of the overall movement of the coupler 604. If the target object 601 continues to move in the direction shown with the reference designator 603 in fig. 6 after the coupler 604 comes into contact with it, it is advantageous to make the coupler 604 (also) move along with the target object 601 in the direction of the first movement 603 after that, in order to avoid - or at least minimize - friction-inducing sliding between the two.

Fig. 7 generalizes some of the concepts introduced above, in particular so that the second movement 605 of the coupler 604 is not necessarily towards a central axis of the target object 601. As shown in fig. 7, the target object 601 may have one or more surfaces oriented at an angle against the first direction that are not at the outermost perimeter of the target object 601 and not oriented outwards from the central axis but towards it. In such a case, the second movement 605 of at least part of the coupler 604 may be directed away from the central axis of the target object 601.

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Having the second direction perpendicular or essentially perpendicular to the first direction involves the advantage that the force with which the at least part of the coupler is pressed against the target surface does not interfere too much with forces used to move the target object in the first direction (inserting the target object) or its opposite direction (removing the target object). Preferably, the second direction is within plus or minus 10 degrees from a direction perpendicular to the first direction.

A feature common to the principles shown in figs. 6 and 7 is that the linear ("first") movement 603 of the target object 601 acts as the activating factor for the "second" movement of the coupler 604. The movement of the coupler 604, triggered and maintained by the movement of the target object 601, is such that for making the thermally and/or electrically conductive coupling, the coupler 604 moves towards the corresponding surface of the target object 601. This is an important difference to e.g. prior art couplings made with springs in accordance with figs. 4 and 5. While a spring may in the final, completed connection press against a side surface of a sample holder like in fig. 5, and while during the making of the connection the spring moved in a perpendicular direction because of the linear movement of the sample holder, this movement was not towards the surface of the sample holder and it did not result in making the connection. To the contrary, in the prior art case of figs. 4 and 5, the spring makes contact with the sample holder first and is then pushed and moved in a direction that is out of the surface of the sample holder, not towards it.

For making a thermally conductive coupling, the (part of the) coupler 604 that is to be pressed against the target object in said second direction at completion of the second movement 605 may comprise a thermal conduction surface. Typically but not mandatorily a thermal

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conduction surface is smooth and designed to match a corresponding portion of the surface of the target object 601. The thermal conduction surface may be made of a material of high thermal conductivity, and/or it may comprise a coating made of a material of high thermal conductivity. Materials that are known for their high thermal conductivity at cryogenic temperatures include but are not limited to copper and gold.

For making an electrically conductive coupling, the (part of the) coupler 604 that is to be pressed against the target object in said second direction at completion of the second movement 605 may comprise one or more electrical connectors. If present, such electrical connectors may be configured to engage with respective one or more counterpart connectors in the target object at the completion of the second movement 605. Typically but not mandatorily the electrical connectors, if provided, are push-fit connectors.

The principal approach explained above with reference to figs. 6 and 7 can be reduced to practice in a number of alternative ways. These are explained next on a more practical level with reference to figs. 8-12.

With reference to fig. 8, according to an embodiment the apparatus comprises a part called here the cradle. Typical to a cradle is that it defines a hollow configured to receive the target object at a point of the first movement. Such a step is schematically illustrated with reference designator 801 in fig. 8, where the acronym FSE is used for the target object for short. In other words, initially the cradle does not move together with the target object but waits for the target object inside the cryostat, temporarily supported at a location along the path that the target object will take under its so-called first movement. With reference to the concepts introduced above with reference to figs. 6

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and 7, the cradle may be considered to be a part of the coupler 604.

The way in which the coupler is supported in the cryostat allows the cradle to move, after having received the target object in said hollow, along with the target object in continuation of the first movement. With reference to the vocabulary used in fig. 8, the continuing (first) movement of the target object takes the cradle along.

According to the embodiment of fig. 8, the apparatus defines a space into which at least a part of the cradle pushes when moving along with the target object. Said space is called the limiting space in step 803 of fig. 8. A limiter of said space is configured to, in response to the cradle (or at least a part of it) pushing into said space, force that part of the coupler against the target object in the second direction that was above described as pressing against the target object 601 in said second direction at completion of said second movement 605.

The way in which (a part of) the coupler presses against the target object may involve an elastic deformation as illustrated by option 805 in fig. 8. Additionally, or alternatively, the way in which (a part of) the coupler presses against the target object may involve a movement of parts of the cradle relative to each other as illustrated by option 806 in fig. 8. In the last-mentioned case, the relative movement of parts of the cradle may involve at least one of a sliding movement 807 and a rotating movement 808.

Fig. 9 illustrates a variation in which the apparatus is not required to define a particular space into which the cradle or a part thereof would push when moving along with the target object. As such, the first two steps 801 and 802 in fig. 9 are the same as the correspondingly numbered steps above in fig. 8. At step 901, one or more parts of the cradle engage an obstacle

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that does not allow them to continue their movement in exactly the same way as before engaging the obstacle. Rather, then the (first) movement of the target object (and the corresponding movement of the cradle taken along) continues, the obstacle forces the respective part of the cradle to move towards the surface of the target object in the second direction as in step 902. Options according to which such a part of the cradle may move towards the surface of the target object are similar to the options of step 804 above in fig. 4, so they are not shown in fig. 9 to avoid graphical redundancy.

Fig. 10 illustrates a slightly different embodiment that does not involve a cradle of the same kind as the embodiment of figs. 8 and 9. Rather, in the embodiment of fig. 10, the coupler comprises one or more clamp pieces configured to become engaged by the target object at a point of its (first, linear) movement. The target object engaging such one or more clamp pieces is shown as step 1001 in fig. 10. In this embodiment, such one or more clamp pieces may be considered to belong under the concept of a coupler as used earlier in figs. 6 and 7.

The way in which the coupler is supported in the cryostat allows the one or more clamp pieces to move, after becoming engaged by the target object and in response to the target object continuing its (first, linear) movement. In the vocabulary of fig. 10, the continuing movement of the target object moves the clamp pieces. The movement of the clamp pieces takes place in a way that presses at least one portion of the one or more clamp pieces against the target object in the second direction as in step 1004 of fig. 10.

In fig. 10, step 1003 represents the attitude and/or location of the clamp piece(s) changing in relation to the target object. Several options exist for the way in which the attitude and/or location of the clamp piece(s) may change. A fixed support for each of the one

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or more clamp pieces may comprise a fixed rotating axis on which the respective clamp piece is rotatably mounted, as in option 1005. Additionally, or alternatively, a fixed support for each of the one or more clamp pieces may comprise an elastically deformable portion configured to support the respective clamp piece. According to the last-mentioned option, each clamp piece may be configured to rotate supported by the respective elastically deformable portion in response to said target object continuing its (first, linear) movement. This is option 1006 in fig. 10.

As a yet further option, shown with reference designator 1007 in fig. 10, a fixed support for each clamp piece may offer a rolling surface for the respective clamp piece. Such a rolling surface may be a smooth surface (option 1008) and/or it may comprise a geared surface or surface portion (option 1009). In such a case, each clamp piece then comprises a corresponding rolling surface for allowing it to roll, supported by the mutually engaging rolling surfaces, with respect to the fixed support.

As a yet further option, shown with reference designator 1010 in fig. 10, the apparatus may comprise a fixed support for each clamp piece so that the fixed support(s) define a tapering space for receiving respective clamp piece(s) in the first direction. In such a case, the clamp piece or each clamp piece then presses against the target object in said second direction as a result of pushing into said tapering space. A movement-enabling joint between the fixed support and the respective clamp piece may be for example a roller bearing joint or a sliding joint.

Fig. 11 illustrates a yet further embodiment in which the apparatus comprises a clamp that defines an opening for the target object. Initially, the opening is large enough for the target object to go through. However, the so-called second mechanism (using the

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vocabulary of figs. 6 and 7 above) involves a tightening mechanism that is configured to tighten the clamp under influence of an activating force in the first direction. In fig. 11, step 1101 represents an actuator comprised in the moving target object engaging an activating trigger of such a tightening mechanism. The actuator is configured to move along with the target object, as shown in step 1102 of fig. 11. The actuator then provides the activating force as a result of continuation of the (first, linear) movement of the target object. In fig. 11, this is represented by step 1103, which the actuator movement causes the aperture (i.e. opening) of the clamp to tighten around the target object.

Fig. 12 illustrates a yet further embodiment in which the so-called second mechanism comprises a straight-line mechanism. In classical mechanics, straight-line mechanisms are a known category of linkages that have the specific property of allowing some part of the mechanism to move linearly or essentially linearly through at least a portion of the full throw of the mechanism. Known examples of straight-line mechanisms include but are not limited to the Watt's linkage and the Roberts linkage.

In the last-mentioned case, the coupler may be part of the straight-line mechanism. The straight-line mechanism may then be configured to perform its characteristic linear (or essentially linear) movement when taken along by the first movement of the target object. The movement of the target object and the consequent engaging of the straight-line mechanism are shown as step 1201 in fig. 12, while step 1202 shows how the continuing (first, linear) movement of the target object actuates the straight-line mechanism. As shown in step 1203, a part of the straight-line mechanism presses against the target object in the second direction. In other words, the straight-line mechanism performing its characteristic linear movement causes the so-called

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second movement that presses a part of the coupler against the target object in the second direction that is at an angle against the first direction. This is a result of not every part of the straight-line mechanism moving just linearly, and/or the characteristic movement of the straight-line mechanism deviating from linearity outside the particular portion of the throw where it takes place linearly.

EXAMPLES

Figs. 13 and 14 illustrate an example implementation of an embodiment according to fig. 8. Fig. 15 illustrates the operation of this example implementation in three steps.

Fig. 13 is a partial cross section of the apparatus, as shown with the hatched areas in the drawing. At the top in fig. 13 is a cooled structural part 1301 of the cryostat. In this example embodiment, the cooled structural part 1301 is the base temperature flange of a cryostat that is equipped with an FSE of the bottom-loading type. Attached to the cooled structural part and supported thereby are spring-loaded rollers 1302, which may be called limiters. Two such spring-loaded rollers are shown in fig. 13, but there may be more, placed radially in a circular arrangement so that they define a generally cylindrical space therebetween, one end face of the generally cylindrical space being defined by the surface of the cooled structural part 1301. With reference to the vocabulary of fig. 8, the generally cylindrical space between the limiters may be called the limited space in fig. 13.

The apparatus of fig. 13 comprises a cradle 1303, a larger cross section of which is shown in fig. 14. The cradle 1303 has the general form of an empty, approximately cylindrical shell, defining a hollow that is configured to receive the target object 1304 at a

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point of its (first, linear) movement, which means a movement upwards in the orientation shown in fig. 13.

In fig. 13 the cradle 1303 is shown supported between the spring-loaded rollers 1302. The larger cross section in fig. 14 shows how the upper part of the outer surface of the cradle may comprise a circumferential groove 1401 in which the spring-loaded rollers 1302 lock in fig. 13, keeping the cradle 1303 in place.

This way of supporting allows the cradle 1303 to move, after having received the target object 1304 in the hollow mentioned above, along with the target object 1304 in continuation of its (first, linear) movement. For this purpose, the hollow in the cradle 1303 is narrow enough (or comprises at least one narrow enough portion) so that the target object 1304 cannot just pass clearly through the cradle 1303 in the direction of the first movement.

The apparatus of fig. 13 defines a space into which at least a part of the cradle 1303 pushes when moving along with the target object 1304. This space is the so-called limited space defined by the spring-loaded rollers 1302, which are the limiters of said space. Due to their location and the spring force generated by their springy (i.e. elastically deformable) holders, the spring-loaded rollers will squeeze the sides of the cradle 1303 towards the sides of the target object 1304 the stronger, the deeper the combination of target object 1304 and cradle 1303 proceeds into said limited space.

To analyse the squeezing effect in more detail it is useful to consider the exemplary diameters of the cradle shown in fig. 14 with symbols d1, d2, d3, and d4. Taken that the so-called first direction is upwards in the drawings, considered in the opposite direction (downwards) the cradle 1303 has a widening perpendicular outer dimension: d2 > d1. This means that an increasingly wider portion of the cradle 1303 pushes into the limited space as the (first, linear) movement of the

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target object 1304 continues and moves the cradle 1303 along. On the other hand, while the target object 1304 has the general form of a uniformly thick cylinder, the hollow defined by the cradle 1303 is slightly conical: its lower diameter d4 is large than its upper diameter d3 (d4 > d3).

Previously, with reference to fig. 8, it was stated that at least a part of the coupler will exhibit the so-called second movement that, eventually, presses such a part of the coupler against the target object in the second direction, which is at an angle against the first direction. In the embodiment of figs. 13 and 14, such a part of the coupler is a portion 1402 of the cradle 1303 that is configured to undergo an elastic deformation as a result of an increasingly wide portion of the cradle 1303 pushing into the limited space. Initially, when the cradle 1303 just received the target object 1304 into the hollow it defines, a gap remains between the hem of the cradle and the surface of the target object; see reference designator 1501 in fig. 15. When the (first, linear) movement of the target object 1304 then continues, the increasing transversally oriented force with which the spring-loaded rollers 1302 press the sides of the cradle 1303 bend the tabs 1402 in the hem of the cradle 1303 elastically inwards, forcing them against the target object 1304. In the sequence shown in fig. 15, the rightmost illustration shows the target object in its final position, in which the previously existing gap between the hem of the cradle and the surface of the target object has closed.

It is possible, but not mandatory, to form a circumferential groove in the outer surface of the cradle 1303, at or close to the lower edge of its hem; see reference designator 1403 in fig. 14. Such a circumferential groove may help to lock the combination of target object and cradle into the final position, for example if the elongate probe(s) that were used to bring the

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target object into place are to be subsequently released and retracted or otherwise directly or indirectly decoupled from the target object for the duration of the experiment or other activity performed with the cryostat.

If the coupling to be made should perform as a thermally conductive coupling, it should be ensured that when the target object (or, here: the combination of target object and cradle) has reached its final position, the thermal conductivity between the target object and the cooled structural part is as good as possible. If the spring-loaded rollers 1302 of fig. 13 and their springy holders are made of materials of high enough thermal conductance, it is possible to rely solely upon the thermal conduction path through them. However, as there may be conflicting requirements to the properties of their materials, such as good and repeatable elasticity under cryogenically cooled temperatures, it may prove difficult to make them also thermally as conductive as would be needed.

To ensure said good enough thermal conductivity, the embodiment shown in fig. 13 comprises thermal conductors 1305 made of pliable material, such as copper braid for example, connecting the cradle 1303 directly to the cooled structural part 1301. The thermal conductors are not shown in fig. 15 for reasons of graphical clarity, but it is easy to understand how they will smoothly follow along and bend to the required shape as the combination of target object and cradle moves forward through the limited space between the spring-loaded rollers. The possible use of pliable thermal conductors between parts that are movable in relation to each other but nevertheless should maintain high thermal conductivity between each other is common to all embodiments described in this text, irrespective of whether such pliable thermal conductors are shown in the respective drawings or not.

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If the coupling to be made is to perform as an electrically conductive coupling, it is possible to place pairs of mutually engaging push-fit electrical connectors on the inside of the hem of the cradle 1303 and on the outer side surfaces of the target object 1304. When the spring-loaded rollers 1302 force the tabs 1402 in the hem of the cradle 1303 against the target object, the respective pairs of electrical connectors mate. When it comes the time to remove the target object from the cryostat, the process begins by moving the combination of target object and cradle downwards. As the transversally oriented force by the spring-loaded rollers eases, the elasticity of the cradle material makes the tabs 1402 in the hem of the cradle 1303 return to their original position, disconnecting the pairs of electrical connectors.

The embodiment of figs. 13 to 15 is an example of an embodiment in which the cradle is a uniform piece of material. As explained above, the part of the coupler that becomes forced against the target object may then be a portion of the cradle, configured to undergo an elastic deformation as a result of an increasingly wider portion of the cradle pushing into the limited space. Various cuts, thinned portions, and/or other design details in the uniformly made cradle can be utilized to ensure that the elastic deformations take place in the right way. In figs. 13 to 15, examples of such design details are the vertical cuts that make the hem of the cradle 1303 appear as a set of tabs directed downwards. It is possible, although not mandatory, to have a dedicated spring-loaded roller in the coupler for each such tab to ensure that each tab can be elastically forced against the respective portion of the surface of the target object.

Figs. 16 to 18 show another example of a coupler that works according to the principle of fig. 8. In fig. 16, the cradle 1602 comprises a cradle body

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1604. Slidably mounted to the cradle body 1604 are a plurality of tab parts 1601. The slidable mounting of the tab parts 1601 is configured to allow them to move, in relation to the cradle body 1604, in the so-called second direction which is sideways in figs. 16 to 18, or radially considering the three-dimensional cylindrical symmetry of the arrangement. Each tab part 1601 is then, using the vocabulary introduced above, a part of the coupler that becomes forced against the target object. As can be seen by comparing figs. 17 and 18, each tab part 1601 is configured to slide, in relation to the cradle body 1604, in the second direction as a result of an increasingly wider portion of the cradle 1602 pushing into the limited space defined by the circular arrangement of spring-loaded rollers 1302. In place of or in addition to sliding, the movability of the tab parts 1601 in relation to the cradle body 1604 could involve other kinds of movable joints, like rotating joints for example.

One advantage of having movable parts in the cradle like in the embodiment of figs. 16 to 18 concerns the selection of springs if the limiters are spring-loaded as in the embodiment in question. The less a spring needs to bend between its intended initial and final positions, the stiffer a spring one may use, with corresponding advantageous consequences in the quantity of spring force that is eventually available for pressing the part of the coupler against the surface of the target object.

Fig. 19 shows another example of a coupler that works according to the principle of fig. 8. In the embodiment of fig. 19, the cradle 1902 comprises a cradle body 1903 to which there are rotatably mounted a plurality of L-shaped levers 1901. A connector piece 1905 is carried on the inside (with reference to the three-dimensional circular symmetry of the arrangement) of each L-shaped lever 1901. Each connector piece 1905 or,

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alternatively, each entity consisting of an L-shaped lever 1901 and the respective connector piece 1905, may in this embodiment be called the part of the coupler that becomes forced against the target object.

An additional feature in the embodiment of fig. 19 is a set of guide rails 1906 on which the cradle 1902 is mounted to ensure that it can only move (back and forth) in the so-called first direction, which is the vertical direction in the drawings. As such, similar or corresponding guide rails or other movement-guiding means could also be used in other cradle-based embodiments, like those in figs. 13-15 and figs. 16-18 for example.

In the embodiment of fig. 19, the cradle body 1903 has a middle opening, but it is merely to save in material costs and to make the "dead mass" to be cooled smaller, as the opening is too small for any part of the target object 1904 to fit in. As a whole, the cradle that comprises the cradle body 1903, the rotatably mounted L-shaped levers 1901, and the connector pieces 1905 defines, though, a hollow configured to receive the target object 1904: transversally, the hollow is limited by the L-shaped levers 1901 and connector pieces 1905, while the bottom surface of the cradle body 1903 defines the top limiting surface of the hollow. As such, it would be very much possible to form the hollow also in such a way that the target object 1904 could go partly inside the cradle body 1903.

The rotational axis of each L-shaped lever 1901 is defined by the way in which the mechanical link between it and the cradle body is realized. In the embodiment of fig. 19, the mechanical link consists of a small number of intermeshing teeth 1906, preferably designed in the cross-sectional shape of respective involute curves.

When the cradle 1902 is in its initial position, as shown on the left in fig. 19, the rotational

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axis of each L-shaped lever 1901 is below the level at which the limiters (the spring-loaded rollers 1302) initially press against the outer surfaces of the cradle 1902 (i.e. against the upper parts of the respective L-shaped levers 1901). Consequently, each L-shaped lever 1901 is in its "open" position, in which the upper end of the L-shaped lever 1901 is inclined towards the central axis of symmetry of the cradle 1902. When the target object 1904 comes from below and engages the cradle body 1903, the whole cradle 1902 (i.e. the combination of cradle body 1903, L-shaped levers 1901, and connector pieces 1905) begins to move upwards along with the target object 1904.

As seen in the left part of fig. 19, the cradle 1902 has a downwards widening cross section. Consequently, each entity consisting of an L-shaped lever 1901 and the respective connector piece 1905 is configured to rotate, as a result of an increasingly wider portion of said entity pushing into the limited space between the spring-loaded rollers 1302, around its respective rotational axis. As the portion with the meshing teeth 1906 goes above the point at which the respective spring-loaded roller exerts force, the entity consisting of an L-shaped lever 1901 and the respective connector piece 1905 quickly rotates so that the lower branch of the L moves towards the target object 1904 in the middle. The rotating movement stops when the respective connector piece 1905 presses against the side surface of the target object 1904. This final position is shown on the right in fig. 19.

Thermal connectors 1305 made of pliable, material of high thermal conductance are shown in the left part of fig. 19. If used, such thermal connectors are naturally there also when the target object and cradle reach their final position (right part of fig. 19), but they are not shown in the drawing for reasons of graphical clarity. As the material for the L-shaped levers

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1901 may be selected on basis of structural rigidity or the like and not primarily on thermal conductance, the thermal connectors 1305 (if used) advantageously connect the cooled structural part 1301 directly to the connector pieces 1905.

If the embodiment of fig. 19 is used to make an electrically conductive connection, at least some of the connector pieces 1905 may be or comprise electrical connectors, for which there are then corresponding connectors on the side(s) of the target object 1904. In such a case, the respective part that in fig. 19 appears as a thermal connector made of pliable material may be an electrical signal line. Even if, strictly speaking, the "second movement" is a movement along a curved trajectory in the embodiment of fig. 19, closest to the final position it becomes essentially perpendicular against the side of the target object 1904 so that linearly connectable push-fit connectors can be used. The exact design of the L-shaped levers and the exact orientations of structural elements can be selected so that optimal connecting directions are achieved for electrical connectors.

In the embodiments described above in figs. 13 to 19, the limiters that define the so-called limited space are springy. To be more exact, the limiters consist of rollers, each supported on an elastically deformable strut that yields in the radial direction of the target object, making the roller press against whatever causes the yielding with a spring force that becomes the larger the further back the strut yields. This is not a requirement, as fixed obstacles can be used as limiters. For example, in the embodiment of figs. 13 to 15 the wedge-shaped uniform cradle could be pushed in a cylindrically formed fixed obstacle, in which case the downwards widening cross-sectional shape of the cradle would make the obstacle walls force the elastically deformable tabs 1402 towards the sides of the target

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object. Similarly in the embodiments of figs. 16 to 18 and 19, the second movement (the sliding movement of the tab parts 1601; the rotation of the L-shaped levers 1901) could be the result of pushing against a fixed obstacle.

Also, the cylindrical form and symmetry of the target object, which was assumed above for easier illustration and understanding, is not a requirement. The target object may be of any shape that allows it to be moved in the first direction and also allows a coupler or a part thereof to be pressed against a surface of the target object in a second direction at an angle against the first direction. Limiters, if used, do not need to be placed symmetrically around the limited space; for example, if the first mechanism that moves the target object is sturdy enough to keep the target object on its general trajectory, a limiter of a kind described above may appear only on one side or only on a subset of sides of the space where the target object enters.

Figs. 20 to 22 illustrate embodiments in which the apparatus comprises one or more clamp pieces configured to become engaged by the target object 2002 at a point of its (first, linear) movement. In other words, clamp pieces are parts of the coupler supported in the cryostat and thermally coupled to a cooled structural part in the cryostat, located in such a way that when the target object moves in the first direction, the target object or at least some part of it will at some point come into contact with the clamp piece(s). The way in which the coupler is supported in the cryostat allows the one or more clamp pieces to move, after becoming engaged by the target object, in a way that presses at least one portion of at least one of the clamp pieces against the target object in the second direction. The one or more clamp pieces perform said movement in response to the target object continuing its (first, linear) movement. In other words, the linear movement of

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the target object acts to drive the movement of the one or more clamp pieces.

The embodiments of figs. 20, 21, and 22 share some common principal features. In each of them, the apparatus comprises a fixed support (see supports 2003, 2102, and 2202) for each of the one or more clamp pieces 2001, 2101, 2201 for limiting the movement of the respective clamp piece as a whole in a direction opposite to the so-called second direction. In other words, if the second direction is generally towards the surface of the target object at which the (thermally and/or electrically conductive) coupling is to be made, the fixed support 2003, 2102, or 2202 limits the way in which the respective clamp piece could move away from said surface of the target object.

Also, in all of figs. 20, 21, and 22, each clamp piece 2001, 2101, or 2201 is configured to rotate, supported by the respective fixed support 2003, 2102, or 2202 and in response to the target object 2002 continuing its (first, linear) movement, in a way that increases the dimension of a portion of the respective clamp piece 2001, 2101, or 2201 in the second direction. In other words, as a clamp piece rotates, a larger proportion of it comes to fill the gap left between the respective fixed support and the nearest surface of the target object. This, in turn, makes the respective portion of the clamp piece eventually press against the surface of the target object in the second direction. The movement of such a portion of each clamp piece resembles the movement of the connector pieces 1905 in the embodiment of fig. 19, so all the same observations can be made about using such a portion to make a thermally conductive coupling and/or equipping such a portion with an electric connector for the purpose of making an electrically conductive coupling.

Further, in each of figs. 20 to 22, each clamp piece comprises an extending top claw that reaches far

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enough towards the central axis of the target object so that the a portion of the moving target object will hit it and use it to exert to the clamp part the force that then rotates the clamp part in the way described above.

In the embodiment of fig. 21, the fixed support 2102 for each clamp piece 2101 comprises a fixed rotating axis 2103 on which the respective clamp piece 2101 is rotatably mounted. In the embodiments of figs. 20 and 22, each fixed support 2003 or 2202, respectively, offers a rolling surface for the respective clamp piece 2001 or 2201. The clamp pieces 2001 and 2201 of figs. 20 and 22 comprise a corresponding rolling surface for allowing the clamp piece 2001 or 2201 to roll, supported by the mutually engaging rolling surfaces, with respect to the respective fixed support 2003 or 2202. In the embodiment of fig. 20 the rolling surfaces are smooth surfaces, while in the embodiment of 22 they are geared surfaces. In the latter case it is advantageous to formulate the teeth of the geared surfaces according to the involute curve to obtain the smoothest possible rolling with the least possible slip and, consequently, least possible friction-generated heat.

Similar features are also found in the embodiments shown in figs. 30 and 31. Also here, the apparatus comprises a fixed support 3002 or 3102 for each of the one or more clamp pieces 3001 or 3101, for limiting the movement of the respective clamp piece 3001 or 3101 as a whole in a direction opposite to the so-called second direction. Also, in figs. 30 and 31, each clamp piece 3001 or 3101 is configured to rotate, supported by the respective fixed support 3002 or 3102 and in response to the target object 2002 or 3102 continuing its (first, linear) movement, in a way that increases the dimension of a portion of the respective clamp piece 3001 or 3101 in the second direction. The embodiment of fig. 31 has rolling surfaces of the geared type (if only consisting of a single tooth and a corresponding single recess)

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between each clamp piece 3101 and the respective fixed support 3102. It has similar rolling surfaces of the geared type also between the clamp piece 3101 and the target object 3102. In fig. 30 the fixed support 3002 for each clamp piece 3001 comprises an elastically deformable portion 3003 configured to support the respective clamp piece 3001. Here, the clamp piece 3001 is configured to rotate supported by the respective elastically deformable portion 3003 in response to the target object 2002 continuing its (first, linear) movement. In figs. 30 and 31, as in essentially all other embodiments also, thermal and/or electrical couplings to and/or from further structural parts of the cryostat may go through the shown parts 3001, 3002, 3003, 3101, and 3102 and/or through separately provided, preferably pliable conductors between movable and fixed parts of the arrangement.

Figs. 24, 27, 28, and 29 illustrate embodiments in which the apparatus comprises fixed support 2402, 2702, 2802, or 2903 for each respective clamp piece 2401, 2701, 2801, or 2901. The fixed support 2402, 2702, 2802, or 2903 defines a tapering space for receiving respective ones of the one or more clamp pieces 2401, 2701, 2801, or 2901 when they move along with the target object 2002 or 2902 after having been engaged thereby. The pushing movement of the clamp piece(s) 2401, 2701, 2801, or 2901 into said tapering space makes the respective clamp piece(s) press against the target object 2002 or 2902 in the second direction. In figs. 24, 27, and 28, the movement-enabling joint between the fixed support 2402, 2702, or 2802 and the respective clamp piece 2401, 2701, or 2801 is a roller bearing joint, while in the embodiment of fig. 29 the joint is a sliding joint.

Surfaces and structures that define the tapering space in embodiments like those in figs. 24, 27, 28, and 29 may define a linearly tapering space or a non-

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linearly tapering space. For example, in the embodiment of fig. 28 the fixed support 2802 could have an inwards curved form towards the top, so that when the clamp pieces 2801 move along with the target object 2002 they experience a progressively increasing force that press them against the target object 2002 in the second direction.

In the embodiment of fig. 24, the fixed support 2402 offers support surfaces at an oblique angle for the linearly arranged roller bearings 2403 between the clamp piece 2401 and the fixed support 2402. When the top of the target object 2002 makes contact with the inwards pointing claws at the upper end of each clamp piece 2401, the clamp pieces begin to move upwards along with the target object 2002 that continues its (first, linear) movement. The oblique angle of the support surfaces makes the movement of each clamp piece 2401 comprise also a component sideways, i.e. in the so-called second direction. As the target object and the clamp piece move upwards together, the relative movement of the clamp piece in relation to the target object consists solely of the movement in the second direction.

The embodiment of fig. 27 has circular roller bearings 2702 installed on respective fixed axes of rotation in the cryostat. Each clamp piece 2701 defines a channel with inclined walls so that when the target object 2002 takes the clamp piece along in its movement upwards, the respective roller bearing 2702 presses against one of the inclined walls and makes the clamp piece move also sideways towards the respective side surface of the target object 2002.

The embodiment of fig. 28 resembles that of fig. 24 above but with each fixed support 2802 extending through the corresponding clamp piece 2801, with linear roller bearings on both inner and outer surfaces of the fixed support 2802.

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In the embodiment of fig. 29, the sliding joint comprises mutually engaging slide surfaces in each fixed support 2903 and the respective clamp piece 2901. Inclined sections in the slide surfaces make the clamp piece 2901 move sideways towards the respective surface of the target object 2902 when the clamp piece 2901 follows the upwards movement of the target object 2902. Vertically oriented sections in the slide surfaces can be used to establish balanced positions in which the clamp piece can rest against the respective fixed support, possibly with an optimally large connecting cross section if the combination of a clamp piece 2901 and the respective fixed support 2903 is meant to act as the conduction path for heat between the target object 2902 and the cooled structural part to which the fixed support 2903 is connected.

In all those embodiments in which there are clamp pieces involved, it is possible to use thermal connectors made of pliable material to ensure good thermal conductivity between one or more of the clamp pieces and the respective cooled structural part of the cryostat. Such thermal conductors are not shown in the drawings above to ensure graphical clarity. Also, the apparatus may involve support means for keeping the clamp pieces in correct position and attitude when they are not yet engaged by the target object. Resilient means such as springs can be used to ensure that the clamp pieces return to their original position and attitude when the target object is removed. Support means and resilient means of this kind can be provided by applying routine measures known from the technology of movable mechanisms in cryostats.

It is possible to present further embodiments by combining features from cradle-based embodiments, such as those illustrated in figs. 13 to 19, and clamp piece based embodiments, such as those illustrated in figs. 20-22, 24, and 37-31. For example, one could take

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a cradle-based embodiment such as any of those in figs. 13-15, 16-18, or 19, and cut the cradle into pieces along vertical planes directed radially out from the central axis of the target object. Each such piece would then essentially become a clamp piece according to the principle shown in figs. 20-22, 24, and 37-31.

Fig. 23 illustrates an embodiment in which the apparatus for making a thermally conductive and/ or electrically conductive coupling in a cryostat comprises a clamp 2301 that defines an opening for the target object. The clamp 2301 corresponds to the concept of a coupler described earlier with reference to figs. 8 to 12. The opening in the clamp 2301 is large enough so that the target object (not shown in fig. 23) could be moved into, and possibly even right through, the opening as a part of its (first, linear) movement. The upper part of fig. 23 is a cross-sectional top view of about one half of the clamp 2301, which in this embodiment is an essentially annular piece of material of high thermal conductivity at cryogenic temperatures. The lower part of fig. 23 is a cross-sectional side view in a plane that is seen as a dashed line in the upper part.

The embodiment of fig. 23 comprises a special form of the so-called second mechanism, the purpose of which is to be operable by the first movement of the target object and to cause, when so operated, a second movement of at least a part of the coupler (i.e. the clamp 2301) so that said second movement has a component towards a surface of the target object facing said part of the coupler and said second movement makes, when completed, said part of the coupler press against said target object in a second direction at an angle against said first direction. In the embodiment of fig. 23 the second mechanism involves a tightening mechanism 2302, 2303, 2304, 2306 configured to, under influence of an activating force 2305 in the first direction, tighten the clamp 2301.

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In particular, in fig. 23 it is assumed that the so-called first mechanism, which is used to move the target object, comprises an actuator configured to move along with the target object. Such an actuator may be as simple as an extending arm coupled to the elongate probe(s) that are used to move the target object. The extending arm may point into the first direction, i.e. to the direction of movement of the target object, at some transverse distance from the target object itself – at least if the activating trigger for the second mechanism is located outside the area of the opening in the clamp as in the embodiment of fig. 23. In any case, the actuator should be configured to engage the activating trigger 2304 of the tightening mechanism at a point of the (first, linear) movement of the target object, for providing the activating force 2305 as a result of continuation of said (first, linear) movement of the target object.

In the embodiment of fig. 23, the second mechanism comprises a first cylinder 2302 placed in a hollow on one side of a gap that cuts through the annular shape of the clamp 2301. A second cylinder 2303 is similarly placed in a hollow on the other side of the gap. Both cylinders 2302 and 2303 can rotate in their respective hollows around respective rotational axes that are parallel to each other and to the radial direction of the gap. A first shaft 2303 connects the first cylinder 2302 to an axial pin parallel with said rotational axes but offset from the rotational axis of the second cylinder 2304. The activating trigger 2306 is a second shaft connected to the second cylinder 2304 so that pushing the activating trigger 2306 in the first direction (upwards in the lower part of fig. 23) rotates the second cylinder 2304, pulling the first cylinder 2302 by the first shaft 2303. This tightens the clamp 2301 sufficiently to make its inner edges press against the target object all around its cylindrical side surface.

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Figs. 25 and 26 illustrate embodiments in which the so-called second mechanism is a straight-line mechanism, such as a Watt's linkage (as in fig. 25) or Roberts linkage (as in fig. 26). Typical to straight-line mechanism based embodiments is that the coupler, at least part of which is to press against the target object in the second direction that is at an angle against the first direction, is part of the straight-line mechanism. The straight-line mechanism is configured to perform its characteristic linear movement when taken along by the first movement of the target object, thus causing the (second) movement of the at least part of the coupler.

In the embodiment of fig. 25, the straight-line mechanism 2502 comprises two Watt's linkages with a common fixed hinge point 2503 located on the imaginary extension of the central axis of the target object 2002. Considering the left Watt's linkage, its other fixed hinge point 2504 is displaced radially outwards from the central axis of the target object 2002, at a distance about three times the radius of the target object 2002. In the vertical direction, said other fixed hinge point 2504 is lower than the common fixed hinge point 2503. The two mobile hinge points 2505 and 2506 of the left Watt's linkage are initially positioned so that the upper end of the straight link section between them is tilted towards the central axis of the target object 2002.

A horizontal tab 2507 is attached to the centre point of said straight link section. Said centre point is the point that moves linearly (here: vertically) in a Watt's linkage. As shown in the right in fig. 25, when the target object 2002 engages the tabs 2507, it puts both Watt's linkages into motion. While the tabs move directly upwards with the target object 2002 (although rotating along with the straight link section between the two mobile hinge points 2505 and 2506), the coupler

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2501 attached to the lower mobile hinge point 2505 presses against the respective side of the target object 2002. The coupler 2501 may be made of thermally conductive material and there may be a thermal conductor of pliable material connecting it to a cooled structural part of the cryostat, if the the thermal conductivity through the parts of the Watt's linkage is not sufficient. Additionally, or alternatively, the coupler 2501 may comprise one or more electric connectors for mating with corresponding connector(s) on the side of the target object 2002.

In the embodiment of fig. 26, the straight-line mechanism comprises two Roberts linkages, each on one side of the linear trajectory of the target object 2602. Typical to a Roberts linkage, the sharp point of the middle triangle moves linearly through the (here: vertical) section between the two fixed hinge points 2604 and 2605. Below and above the section of linear movement, the sharp point of the middle triangle veers outwards on a curved trajectory. By placing a coupler 2601 at the sharp point of the middle triangle, it is possible to build an apparatus where the moving target object 2602 takes the coupler along and makes it move from its initial location on the lower curved trajectory to the section of linear movement, as in the middle of fig. 26. Simultaneously, the coupler 2601 presses sideways against the side surface of the target object 2602. As the vertical movement of the target object 2602 continues upwards, the linearly moving coupler 2601 eventually reaches the top end of the section of linear movement, backs away in the sideways direction, and lets the target object 2602 continue its movement upwards if needed (see right part of fig. 2602).

In all embodiments of figs. 20 to 22 and 24 to 31, it must again be noted that while the illustrations appear symmetrical in at least some sense, so that there would be clamp pieces or straight-line mechanisms on two

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sides of the target object, this is not a requirement as clamp pieces and/or straight-line mechanisms may be placed at one radial location only or at several locations around the trajectory of the target object but not in any cylindrically symmetric way.

It is obvious to a person skilled in the art that with the advancement of technology, the basic idea of the invention may be implemented in various ways. The invention and its embodiments are thus not limited to the examples described above, instead they may vary within the scope of the claims.

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CLAIMS

1. An apparatus for making a coupling in a cryostat, which coupling comprises at least one of: a thermally conductive coupling, an electrically conductive coupling; the apparatus comprising:
- a target object (601),
- a first mechanism (602) configured to cause at least a first movement (603) of the target object (601), which first movement (603) is linear in a first direction, and
- a coupler (604) supported in the cryostat, said coupler comprising at least one of: a thermal coupling to a cooled structural part (1301) in the cryostat, an electrical coupling to circuit located at least partly in the cryostat;
characterized in that
- the apparatus comprises a second mechanism operable by said first movement (603) of the target object (601) and configured to, when so operated, cause a second movement (605) of at least a part of the coupler (604) so that
-- said second movement (605) has a component towards a surface of the target object (601) facing said part of the coupler (604), and
-- said second movement (605) makes, when completed, said part of the coupler (604) press against said target object (601) in a second direction at an angle against said first direction.

2. An apparatus according to claim 1, wherein said part of the coupler (604) comprises a thermal conduction surface to be pressed against said target object (601) in said second direction at completion of said second movement (605).

3. An apparatus according to any of claims 1 or 2, wherein the coupler comprises one or more

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electrical connectors to engage with respective one or more counterpart connectors in the target object at completion of said second movement (605).

4. An apparatus according to any of claims 1 to 3, wherein:
- the apparatus comprises a cradle (1303, 1602, 1902) that defines a hollow configured to receive (801) the target object (1304, 1603, 1904) at a point of said first movement (603),
- said supporting of the coupler allows said cradle (1303, 1602, 1902) to move (802), after having received (801) the target object (1304, 1602, 1904) in said hollow, along with said target object (1304, 1602, 1904) in continuation of said first movement (603),
- the apparatus defines a space into which at least a part of said cradle (1303, 1602, 1902) pushes (803) when moving along with said target object (1304, 1603, 1904), and
- a limiter (1302) of said space is configured to, in response to the cradle (1303, 1602, 1902) or at least said part of the cradle (1303, 1602, 1902) pushing into said space, force (804) said part (1402, 1601, 1901, 1905) of the coupler against said target object (1304, 1602, 1904) in said second direction.

5. An apparatus according to claim 4, wherein:
- considered in the direction opposite to said first direction, said cradle (1303, 1602, 1902) has a widening perpendicular outer dimension, so that said part (1402, 1601, 1901, 1905) of the coupler is forced against said target object (1304, 1602, 1904) in said second direction as a result of an increasingly wider portion of the cradle (1303, 1602, 1902) pushing into said space.

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6. An apparatus according to claim 5, wherein:
- said cradle (1303) is a uniform piece of material, and
- said part (1402) of the coupler that becomes forced against said target object (1304) is a portion of the cradle (1303) configured to undergo an elastic deformation (805) as a result of an increasingly wider portion of the cradle (1303) pushing into said space.

7. An apparatus according to claim 5, wherein:
- said cradle (1602) comprises a cradle body (1604) to which said part (1601) of the coupler that becomes forced against said target object (1603) is slidably mounted, and
- said part (1601) of the coupler is configured to slide (807), in relation to said cradle body (1604), in said second direction as a result of an increasingly wider portion of the cradle (1602) pushing into said space.

8. An apparatus according to claim 5, wherein:
- said cradle (1902) comprises a cradle body (1903) to which said part (1901, 1905) of the coupler that becomes forced against said target object (1904) is rotatably mounted, and
- said part (1901, 1905) of the coupler is configured to rotate (808), in relation to said cradle body (1903), as a result of an increasingly wider portion of the cradle (1902) pushing into said space, so that at least a portion (1905) of said part (1901, 1905) of the coupler presses against said target object (1904) in said second direction.

9. An apparatus according to any of claims 1 to 3, wherein:

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- the apparatus comprises one or more clamp pieces (2001, 2101, 2201, 2401, 2701, 2801, 2901, 3001, 3101) configured to become engaged by said target object (2002, 2602, 2902, 3102) at a point of said first movement (603),
- said supporting of the coupler allows said one or more clamp pieces (2001, 2101, 2201, 2401, 2701, 2801, 2901, 3001, 3101) to move (1002), after becoming engaged (1001) by the target object (2002, 2602, 2902, 3102) and in response to said target object (1304, 1602) continuing said first movement (603), in a way that presses at least one portion of said one or more clamp pieces (2001, 2101, 2201, 2401, 2701, 2801, 2901, 3001, 3101) against said target object (2002, 2602, 2902, 3102) in said second direction.

10. An apparatus according to claim 9, wherein:
- the apparatus comprises fixed support (2003, 2102, 2202, 3002, 3102) for each of said one or more clamp pieces (2001, 2101, 2201, 3001, 3101) for limiting movement of the respective one of said one or more clamp pieces (2001, 2101, 2201, 3001, 3101) as a whole in a direction opposite to said second direction,
- said one or more clamp pieces (2001, 2101, 2201, 3001, 3101) are configured to rotate, supported by said fixed support (2003, 2102, 2202, 3002, 3102) and in response to said target object (2002, 3102) continuing said first movement (603), in a way that increases the dimension of a portion of the respective clamp piece (2001, 2101, 2201, 3001, 3101) in the second direction.

11. An apparatus according to claim 10, wherein:
- the fixed support (2102) for each of said one or more clamp pieces (2101) comprises a fixed rotating

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axis (2103) on which the respective clamp piece (2101) is rotatably mounted.

12. An apparatus according to claim 10, wherein:
- the fixed support (2003, 2202, 3102) for each of said one or more clamp pieces (2001, 2201, 3101) offers a rolling surface for the respective one of said one or more clamp pieces (2001, 2201, 3101), which rolling surface is a smooth surface or a geared surface,
- each of said one or more clamp pieces (2001, 2201, 3101) comprises a corresponding rolling surface for allowing the respective clamp piece (2001, 2201, 3101) to roll, supported by the mutually engaging rolling surfaces, with respect to the fixed support (2003, 2202, 3102).

13. An apparatus according to claim 10, wherein:
- the fixed support (3002) for each of said one or more clamp pieces (3001) comprises an elastically deformable portion (3003) configured to support the respective one of said one or more clamp pieces (3001),
- each of said one or more clamp pieces (3001) is configured to rotate supported by the respective elastically deformable portion (3003) in response to said target object (2002) continuing said first movement (603).

14. An apparatus according to claim 9, wherein:
- the apparatus comprises fixed support (2402, 2702, 2802, 2903) for each of said one or more clamp pieces (2401, 2701, 2801, 2901), said fixed support (2402, 2702, 2802, 2903) defining a tapering space for receiving respective ones of said one or more clamp pieces (2401, 2701, 2801, 2901) in said first

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direction, for making each of said one or more clamp pieces (2401, 2701, 2801, 2901) press against said target object (2002, 2902) in said second direction as a result of pushing into said tapering space.

15. An apparatus according to claim 14, wherein a movement-enabling joint between the fixed support (2402, 2702, 2802, 2903) and the respective clamp piece (2401, 2701, 2801, 2901) is one of: a roller bearing joint, a sliding joint.

16. An apparatus according to any of claims 1 to 3, wherein:
- the apparatus comprises a clamp (2301) that defines an opening for the target object (601),
- said second mechanism involves a tightening mechanism (2302, 2303, 2304, 2306) configured to, under influence of an activating force (2305) in said first direction, tighten the clamp (2301).

17. An apparatus according to claim 16, wherein:
- the first mechanism comprises an actuator configured to move along with the target object (601) and to engage an activating trigger (2306) of said tightening mechanism at a point of said first movement (603), for providing said activating force (2305) as a result of continuation of said first movement (603).

18. An apparatus according to any of claims 1 to 3, wherein:
- the second mechanism comprises a straight-line mechanism, such as a Watt’s linkage (2502) or Roberts linkage (2603),
- the coupler (2501, 2601) is part of said straight-line mechanism, and
- said straight-line mechanism is configured to perform its characteristic linear movement when taken

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along by said first movement (603) of the target object, thus causing said second movement (605).

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PATENTTIVAATIMUKSET

1. Laite kytkennän tekemiseksi kryostaatissa, jolloin kytkentä käsittää ainakin yhden seuraavista: lämpöä johtava kytkentä, sähköä johtava kytkentä;
jossa laitteessa on
- kohde-esine (601),
- ensimmäinen mekanismi (602), joka on konfiguroitu aiheuttamaan kohde-esineen (601) ainakin ensimmäinen liike (603), jolloin ensimmäinen liike (603) on lineaarinen ensimmäisessä suunnassa, ja
- kytkinelin (604), joka on tuettu kryostaattiin, jolloin mainittu kytkinelin käsittää ainakin yhden seuraavista: lämpökytkentä jäähdytettyyn rakenneosaan (1301) kryostaatissa, sähkökytkentä ainakin osittain kryostaatissa sijaitsevaan piiriin;
tunnettu siitä, että
- laitteessa on toinen mekanismi, joka on käytettävissä kohde-esineen (601) mainitulla ensimmäisellä liikkeellä (603) ja joka on konfiguroitu tällä tavalla käytettäessä aiheuttamaan ainakin osan kytkinelimestä (604) toinen liike (605), niin, että
-- mainitulla toisella liikkeellä (605) on komponentti kohti kohde-esineen (601) pintaa, joka osoittaa kohti kytkinelimen (604) mainittua osaa, ja
-- mainittu toinen liike (605) saa loppuun asti suoritettuna kytkinelimen (604) mainitun osan painautumaan mainittua kohde-esinettä (601) vasten toisessa suunnassa, joka on kulmassa suhteessa mainittuun ensimmäiseen suuntaan.

2. Patenttivaatimuksen 1 mukainen laite, jossa kytkinelimen (604) mainittu osa käsittää lämmönjohtopinnan painettavaksi mainittua kohde-esinettä (601) vasten mainitussa toisessa suunnassa, kun mainittu toinen liike (605) suoritetaan loppuun.

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3. Patenttivaatimuksen 1 tai 2 mukainen laite, jossa kytkinelin käsittää yhden tai useamman sähköliittimen kytkeytymiseksi kohde-esineessä olevaan yhteen tai useampaan vastaavaan vastaliittimeen, kun mainittu toinen liike (605) suoritetaan loppuun.

4. Jonkin patenttivaatimuksista 1 - 3 mukainen laite, jolloin
- laitteessa on kehto (1303, 1602, 1902), joka määrittää onkalon, joka on konfiguroitu vastaanottamaan kohde-esine (1304, 1603, 1904) mainitun ensimmäisen liikkeen (603) eräässä kohdassa,
- kytkinelimen mainittu tuenta antaa mainitun kehdon (1303, 1602, 1902) liikkua (802), sen vastaanotettua (801) kohde-esineen (1304, 1602, 1904) mainittuun onkaloon, yhdessä mainitun kohde-esineen (1304, 1602, 1904) kanssa mainitun ensimmäisen liikkeen (603) jatkuessa,
- laitteessa on tila, johon ainakin osa mainitusta kehdosta (1303, 1602, 1902) työntyy (803) sen liikkuessa mainitun kohde-esineen (1304, 1603, 1904) kanssa, ja
- mainitun tilan rajoitin (1302) on konfiguroitu, vasteena kehdon (1303, 1602, 1902) tai ainakin osan kehdosta (1303, 1602, 1902) työntymiseen mainittuun tilaan, pakottamaan (804) kytkinelimen mainittu osa (1402, 1601, 1901, 1905) mainittua kohde-esinettä (1304, 1602, 1904) vasten mainitussa toisessa suunnassa.

5. Patenttivaatimuksen 4 mukainen laite, jossa
- mainitulla kehdolla (1303, 1602, 1902) on mainittuun ensimmäiseen suuntaan nähden vastakkaisessa suunnassa katsottuna levenevä kohtisuora ulkomitta niin, että kytkinelimen mainittu osa (1402, 1601, 1901, 1905) pakotetaan mainittua kohde-esinettä (1304, 1602, 1904) vasten mainitussa toisessa suunnassa sen seurauksena,

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että kehdon (1303, 1602, 1902) levenevä osa työntyy mainittuun tilaan.

6. Patenttivaatimuksen 5 mukainen laite, jossa
- mainittu kehto (1303) on yhtenäinen materiaalikappale, ja
- kytkinelimen mainittu osa (1402), joka pakotetaan mainittua kohde-esinettä (1304) vasten, on kehdon (1303) osa, joka on konfiguroitu käymään läpi elastinen muodonmuutos (805) sen seurauksena, että kehdon (1303) levenevä osa työntyy mainittuun tilaan.

7. Patenttivaatimuksen 5 mukainen laite, jossa
- mainitussa kehdossa (1602) on kehdon runko (1604), johon kytkinelimen mainittua kohde-esinettä (1603) vasten pakotettava osa on asennettu liukuvasti, ja
- kytkinelimen mainittu osa (1601) on konfiguroitu liukumaan (807) suhteessa mainittuun kehdon runkoon (1604) mainitussa toisessa suunnassa sen seurauksena, että kehdon (1602) levenevä osa työntyy mainittuun tilaan.

8. Patenttivaatimuksen 5 mukainen laite, jossa
- mainitussa kehdossa (1902) on kehdon runko (1903), johon kytkinelimen mainittua kohde-esinettä (1904) vasten pakotettava mainittu osa (1901, 1905) on asennettu pyörivästi, ja
- kytkinelimen mainittu osa (1901, 1905) on konfiguroitu pyörimään (808) suhteessa mainittuun kehdon runkoon (1903) sen seurauksena, että kehdon (1902) levenevä osa työntyy mainittuun tilaan, niin, että ainakin osio (1905) kytkinelimen mainitusta osasta (1901, 1905) painautuu mainittua kohde-esinettä (1904) vasten mainitussa toisessa suunnassa.

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9. Jonkin patenttivaatimuksista 1 - 3 mukainen laite, jolloin
- laitteessa on yksi tai useampia puristinkappaleita (2001, 2101, 2201, 2401, 2701, 2801, 2901, 3001, 3101), joihin mainittu kohde-esine (2002, 2602, 2902, 3102) on konfiguroitu kytkeytymään mainitun ensimmäisen liikkeen (603) kohdassa,
- kytkinelimen mainittu tuenta antaa mainitun yhden tai useamman puristinkappaleen (2001, 2101, 2201, 2401, 2701, 2801, 2901, 3001, 3101) liikkua (1002) kohde-esineen (2002, 2602, 2902, 3102) kytkeydyttyä (1001) niihin ja vasteena siihen, että mainittu kohde-esine (1304, 1602) jatkaa mainittua ensimmäistä liikettä (603), niin, että ainakin osio mainitusta yhdestä tai useammasta puristinkappaleesta (2001, 2101, 2201, 2401, 2701, 2801, 2901, 3001, 3101) painautuu mainittua kohde-esinettä (2002, 2602, 2902, 3102) vasten mainitussa toisessa suunnassa.

10. Patenttivaatimuksen 9 mukainen laite, jolloin
- laitteessa on kiinteä tuki (2003, 2102, 2202, 3002, 3102) kullekin mainitusta yhdestä tai useammasta puristinkappaleesta (2001, 2101, 2201, 3001, 3101) vastaavan mainitusta yhdestä tai useammasta puristinkappaleesta (2001, 2101, 2201, 3001, 3101) liikkeen rajoittamiseksi kokonaisuutena mainittuun toiseen suuntaan nähden vastakkaisessa suunnassa,
- mainittu yksi tai useampi puristinkappale (2001, 2101, 2201, 3001, 3101) on konfiguroitu pyörimään mainitun kiinteän tuen (2003, 2102, 2202, 3002, 3102) tukemana ja vasteena siihen, että mainittu kohde-esine (2002, 3102) jatkaa mainittua ensimmäistä liikettä (603), niin, että vastaavan puristinkappaleen (2001, 2101, 2201, 3001, 3101) osion mitta kasvaa toisessa suunnassa.

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11. Patenttivaatimuksen 10 mukainen laite, jossa

- kunkin mainitusta yhdestä tai useammasta puristinkappaleesta (2101) kiinteässä tuessa (2102) on kiinteä pyörintäakseli (2103), jolle vastaava puristinkappale (2101) on asennettu pyörivästi.

12. Patenttivaatimuksen 10 mukainen laite, jossa

- kunkin mainitusta yhdestä tai useammasta puristinkappaleesta (2001, 2201, 3101) kiinteä tuki (2003, 2202, 3102) tarjoaa vierintäpinnan vastaavalle mainitusta yhdestä tai useammasta puristinkappaleesta (2001, 2201, 3101), joka vierintäpinta on tasainen pinta tai hammastettu pinta,
- kussakin mainitusta yhdestä tai useammasta puristinkappaleesta 2001, 2201, 3101) on vastaava vierintäpinta vastaavan puristinkappaleen (2001, 2201, 3101) vierinnän mahdollistamiseksi kiinteään tukeen (2003, 2202, 3102) nähden keskenään kytkeytyvien vierintäpintojen tukemana.

13. Patenttivaatimuksen 10 mukainen laite, jossa

- kunkin mainitusta yhdestä tai useammasta puristinkappaleesta (3001) kiinteässä tuessa (3002) on elastisesti muotoa muuttava osio (3003), joka on konfiguroitu tukemaan vastaavaa mainituista yhdestä tai useammasta puristinkappaleesta (3001),
- kukin mainitusta yhdestä tai useammasta puristinkappaleesta (3001) on konfiguroitu pyörimään vastaavan elastisesti muotoa muuttavan osion (3003) tukemana vasteena siihen, että mainittu kohde-esine (2002) jatkaa mainittua ensimmäistä liikettä (603).

14. Patenttivaatimuksen 9 mukainen laite, jolloin

- laitteessa on kiinteä tuki (2402, 2702, 2802, 2903)

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kullekin mainituista yhdestä tai useammasta puristinkappaleesta (2401, 2701, 2801, 2901), jolloin mainittu kiinteä tuki (2402, 2702, 2802, 2903) rajaa kapenevan tilan vastaavien mainituista yhdestä tai useammasta puristinkappaleesta (2401, 2701, 2801, 2901) vastaanottamiseksi mainitussa ensimmäisessä suunnassa kunkin mainituista yhdestä tai useammasta puristinkappaleesta (2401, 2701, 2801, 2901) saamiseksi painautumaan mainittua kohde-esinettä (2002, 2902) vasten mainitussa toisessa suunnassa työntymisen mainittuun kapenevaan tilaan seurauksena.

15. Patenttivaatimuksen 14 mukainen laite, jossa kiinteän tuen (2402, 2702, 2802, 2903) ja vastaavan puristinkappaleen (2401, 2701, 2801, 2901) välinen liikkeen mahdollistava liitos on yksi seuraavista: vierintälaakeri, liukuliitos.

16. Jonkin patenttivaatimuksista 1 - 3 mukainen laite, jolloin
- laitteessa on puristin (2301), jossa on aukko kohde-esinettä (601) varten,
- mainittu toinen mekanismi sisältää kiristysmekanismin (2302, 2303, 2304, 2306), joka on konfiguroitu aktivoivan voiman (2305) vaikutuksesta ensimmäisessä suunnassa kiristämään puristinta (2301).

17. Patenttivaatimuksen 16 mukainen laite, jossa
- ensimmäisessä mekanismissa on toimilaite, joka on konfiguroitu liikkumaan yhdessä kohde-esineen (601) kanssa ja kytkeytymään mainitun kiristysmekanismin aktivointiliipaisimeen (2306) mainitun ensimmäisen liikkeen (603) kohdassa mainitun aktivoivan voiman (2305) aikaansaamiseksi mainitun ensimmäisen liikkeen (603) jatkumisen seurauksena.

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18. Jonkin patenttivaatimuksista 1 - 3 mukainen laite, jossa

- toinen mekanismi käsittää suoraliikemekanismin, kuten Wattin vivuston (2502) tai Roberts-vivuston (2603),
- kytkinelin (2501, 2601) on osa mainittua suoraliikemekanismia, ja
- mainittu suoraliikemekanismi on konfiguroitu toteuttamaan tunnusomainen lineaarinen liikkeensä kohde-esineen mainitun ensimmäisen liikkeen (603) mukana ja aiheuttamaan siten mainittu toinen liike (605).

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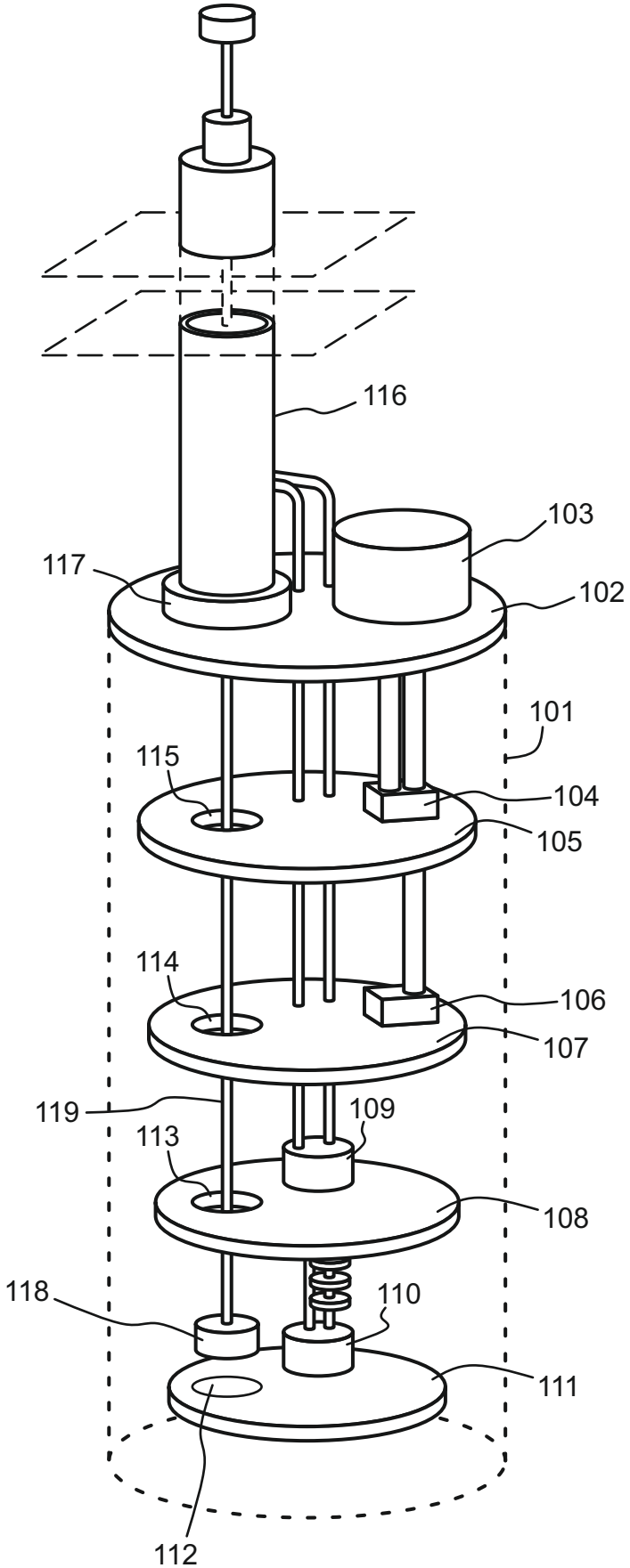

Fig. 1
PRIOR ART

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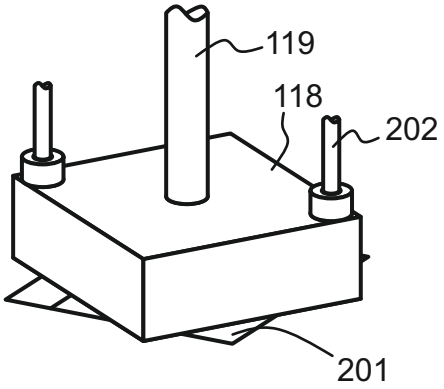

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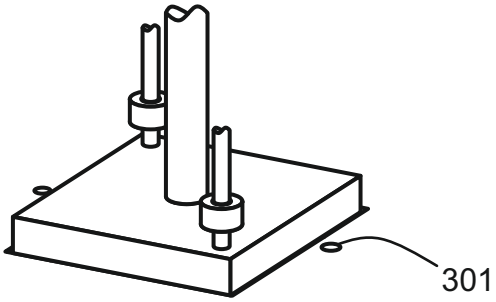

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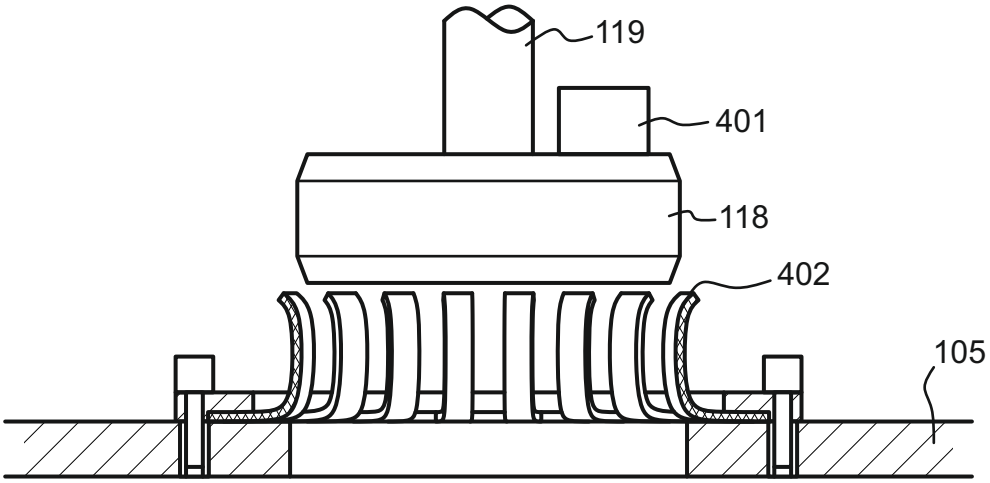

Fig. 4
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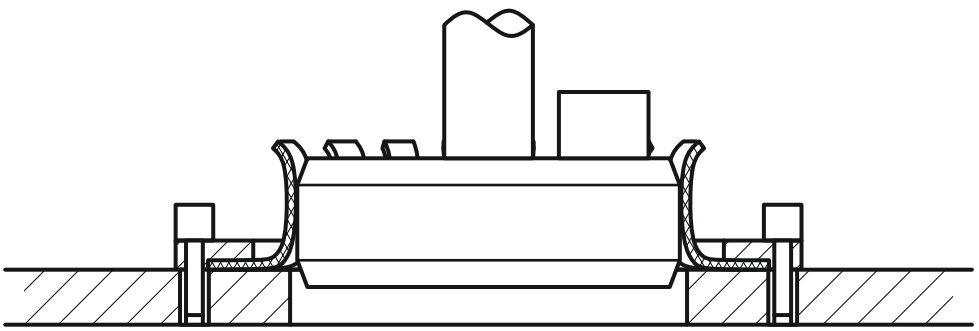

Fig. 5
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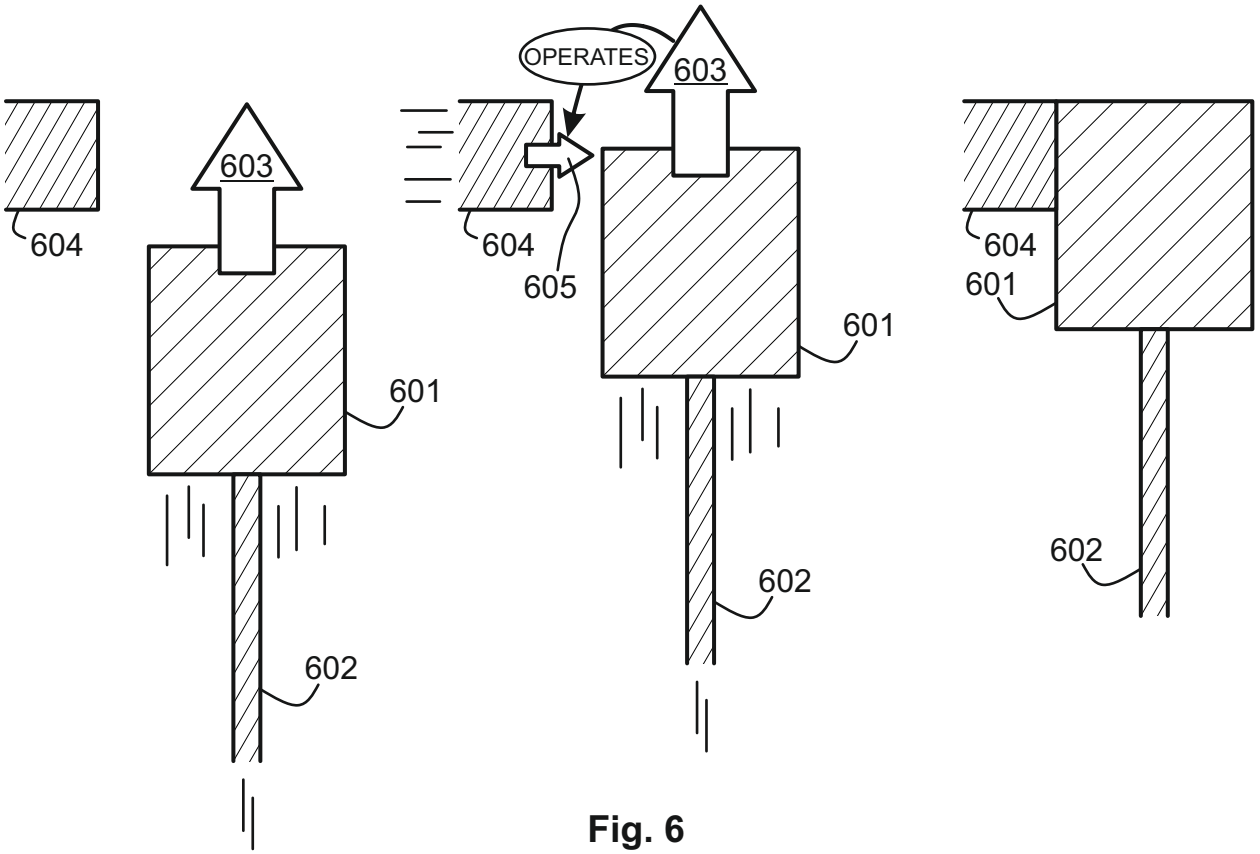

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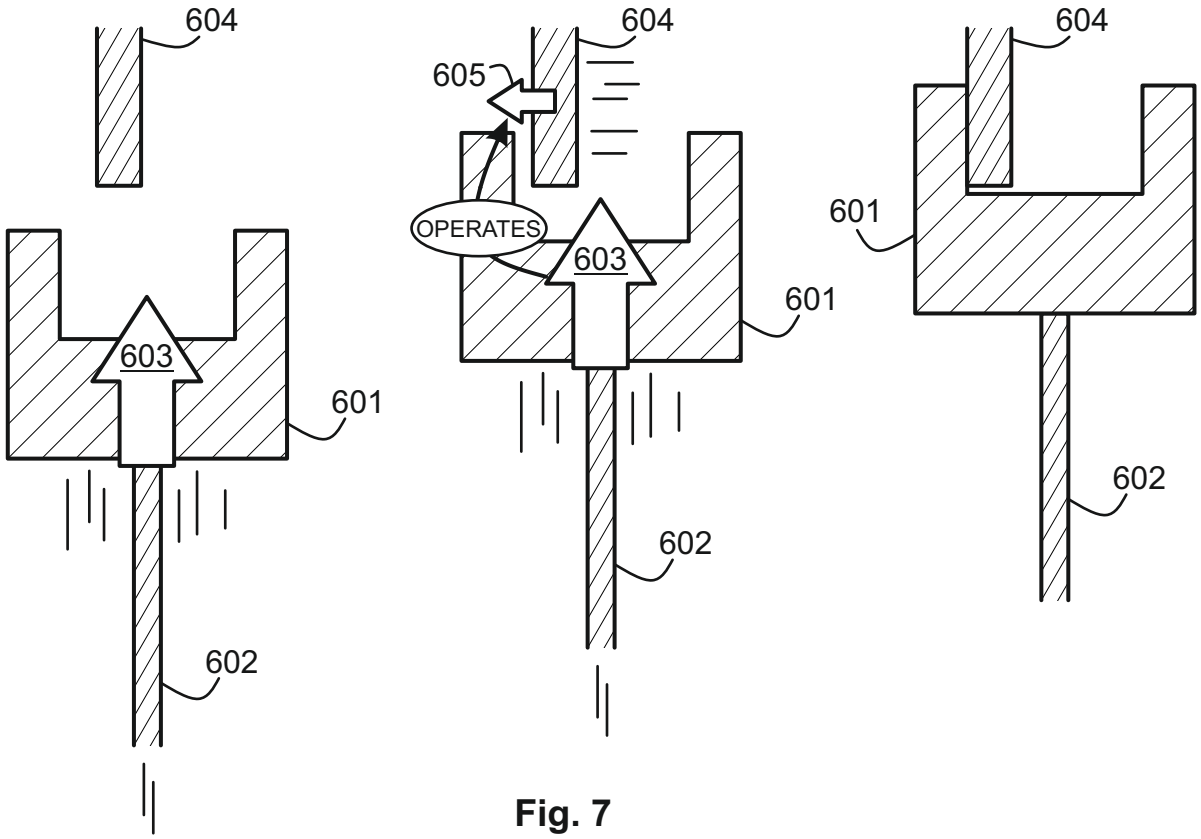

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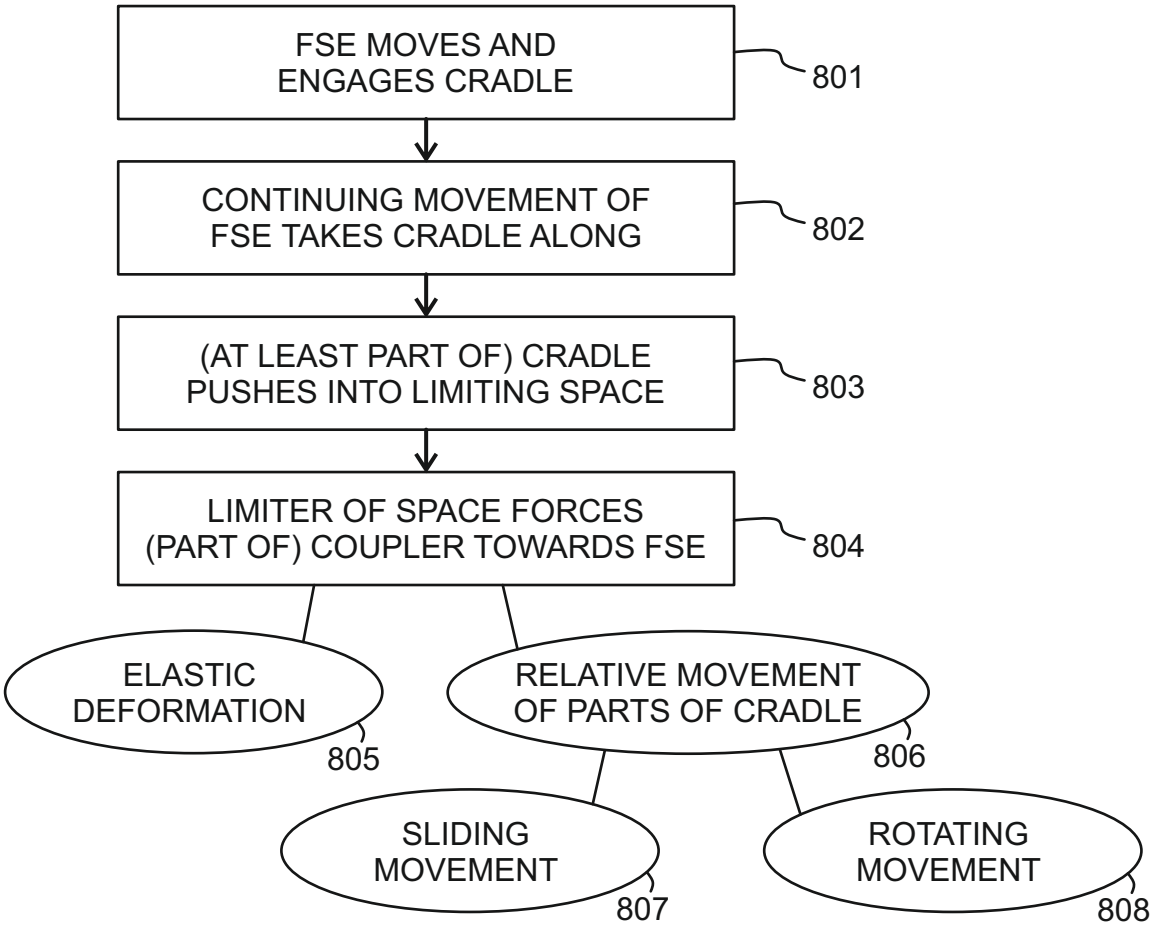

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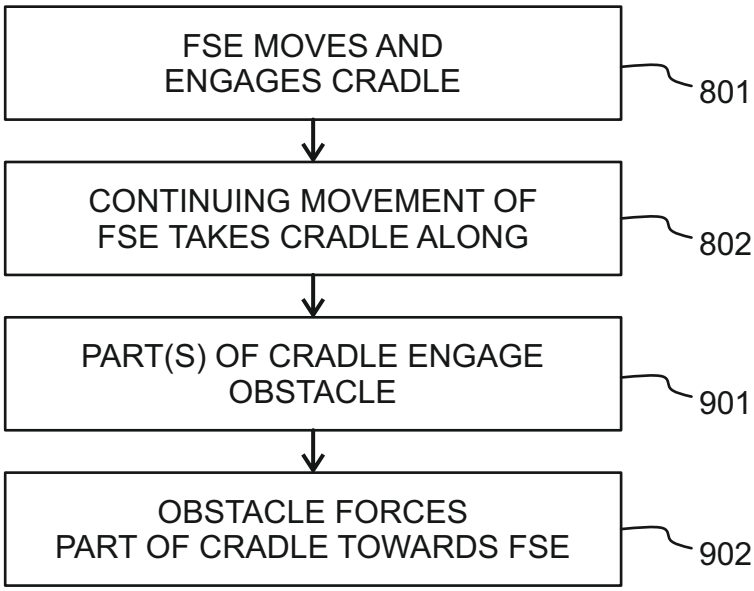

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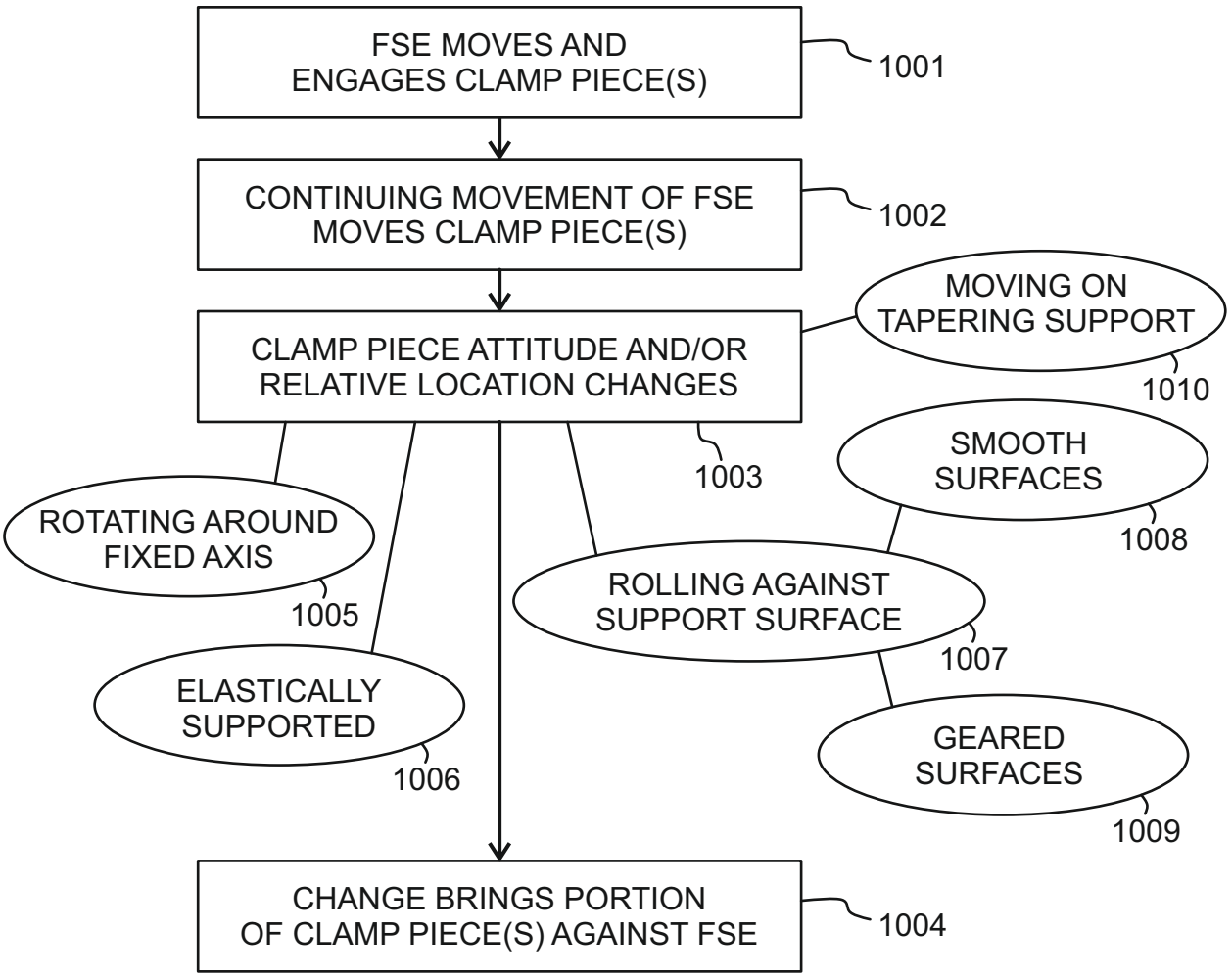

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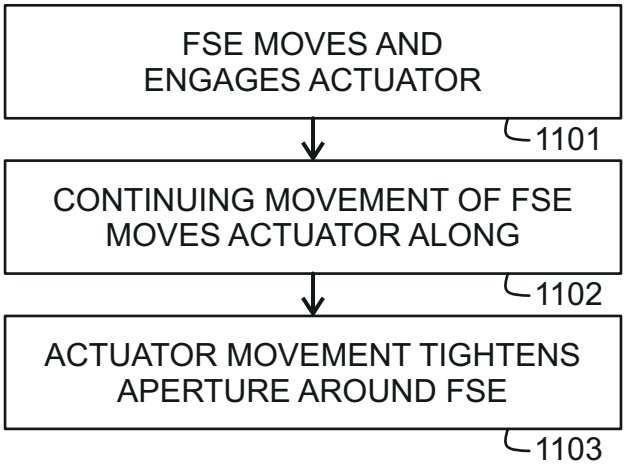

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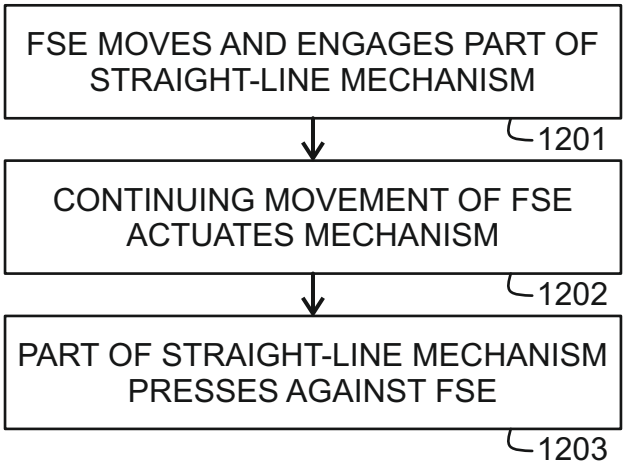

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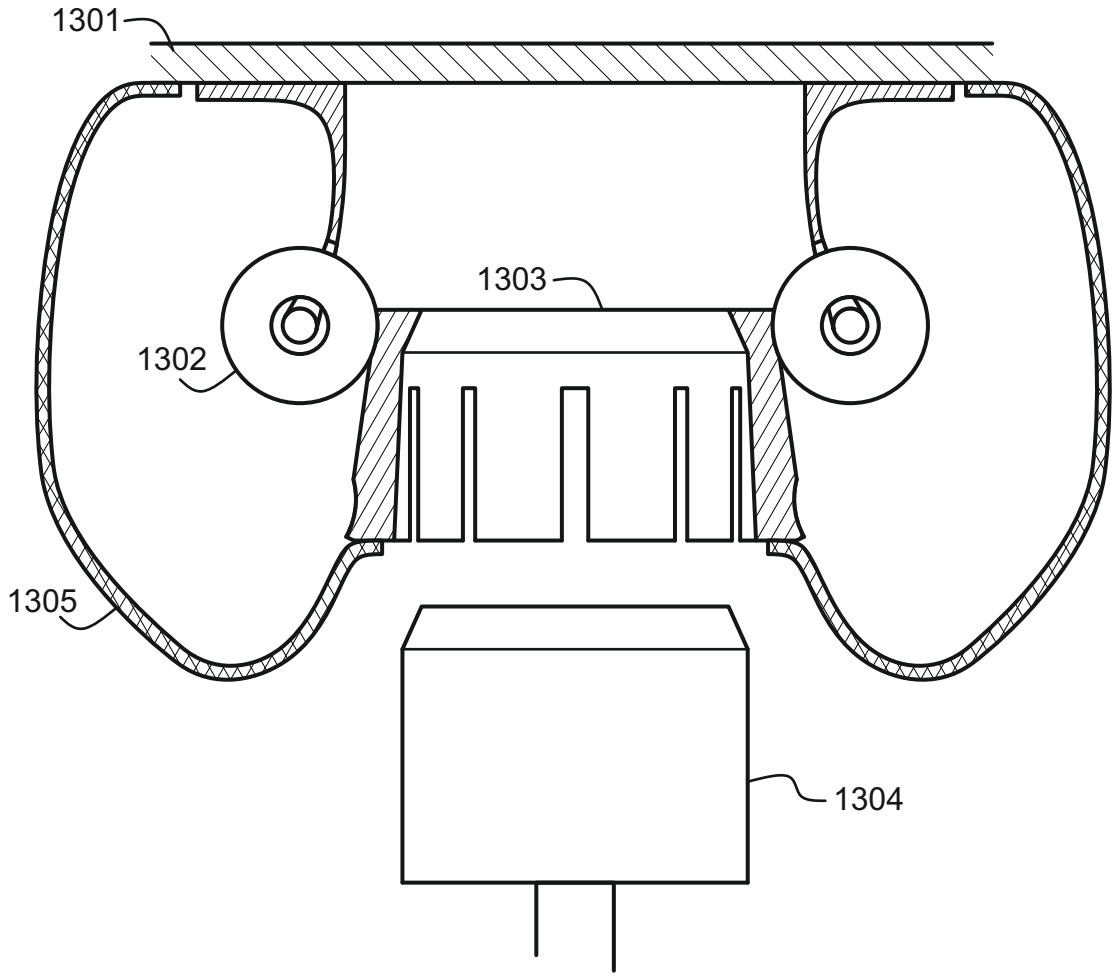

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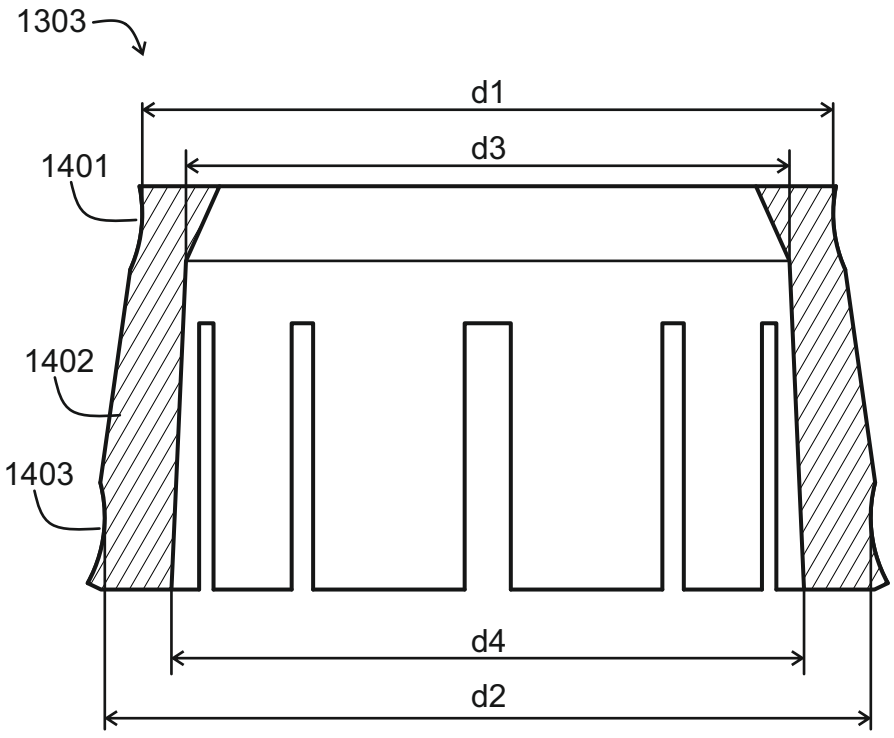

Fig. 14

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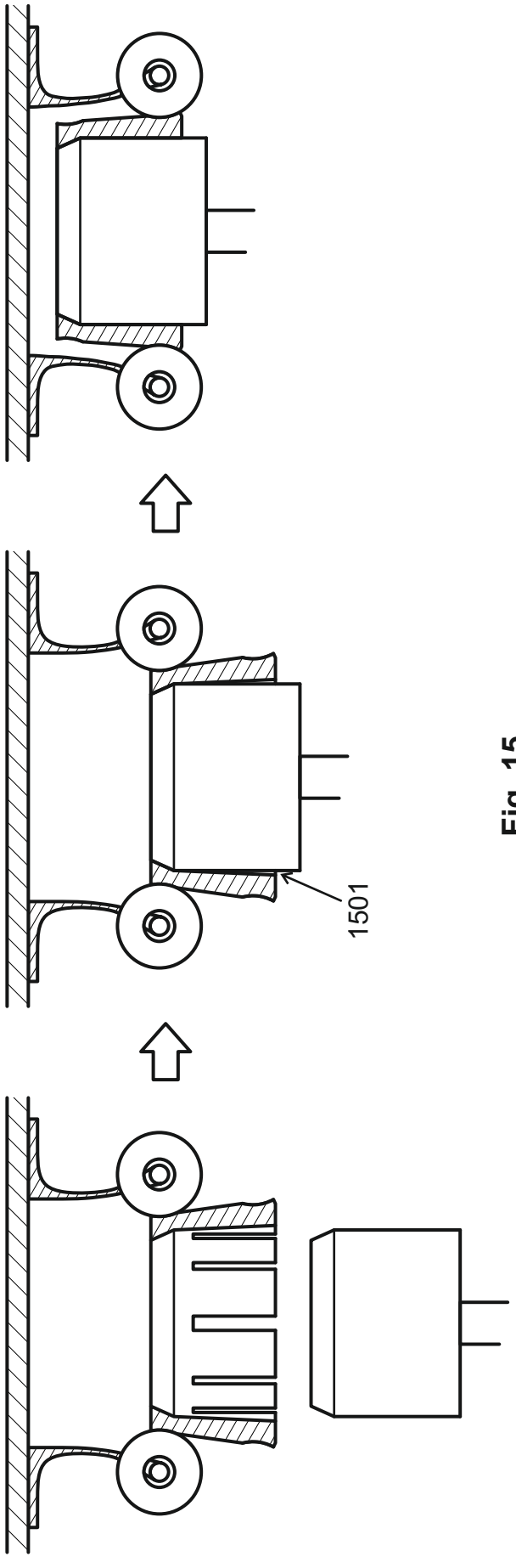

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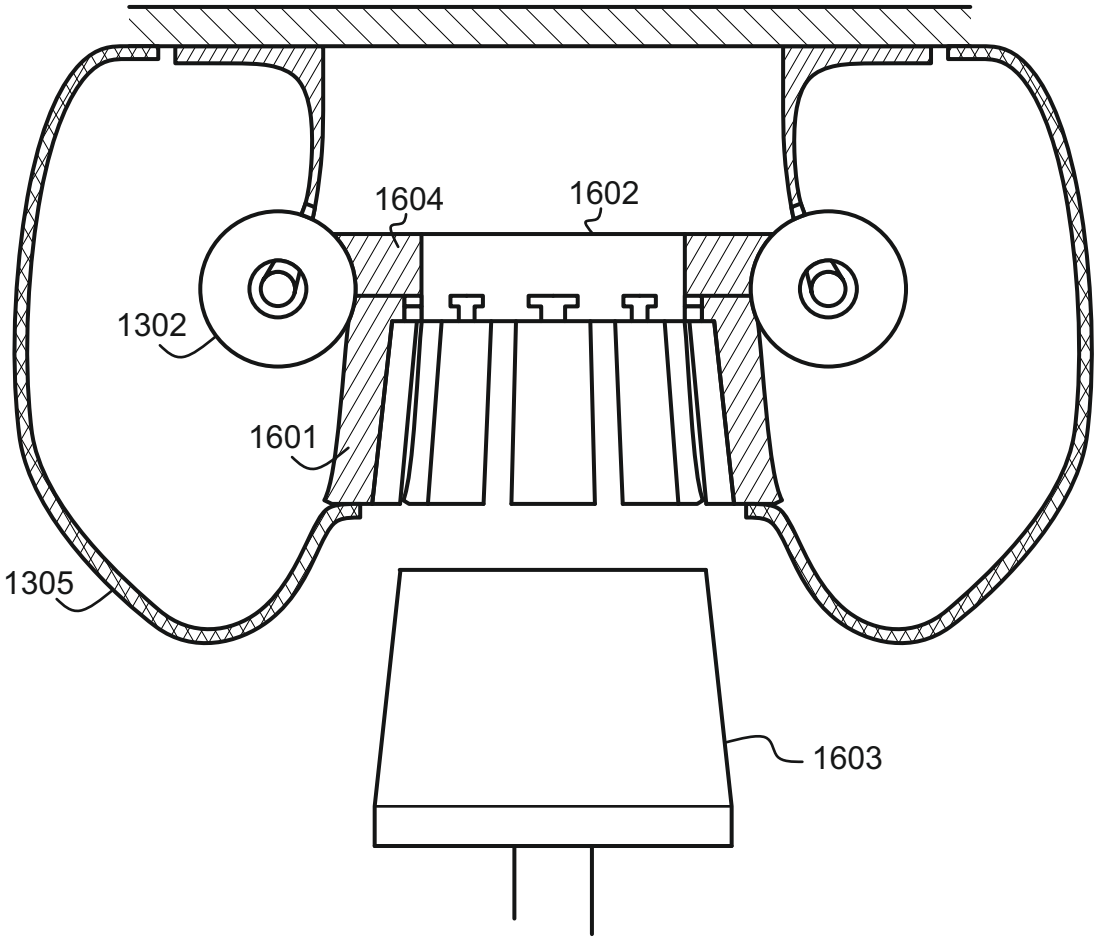

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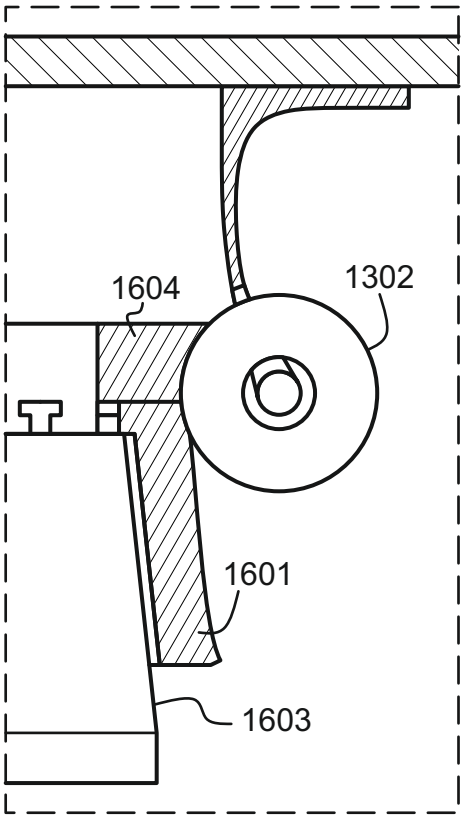

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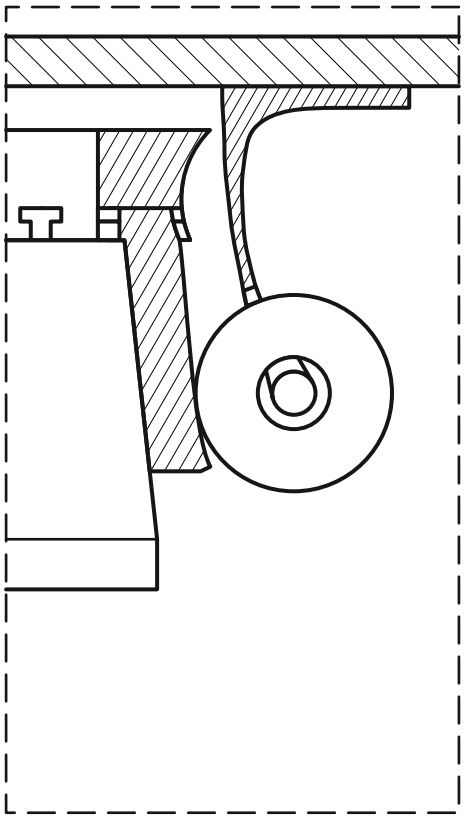

Fig.18

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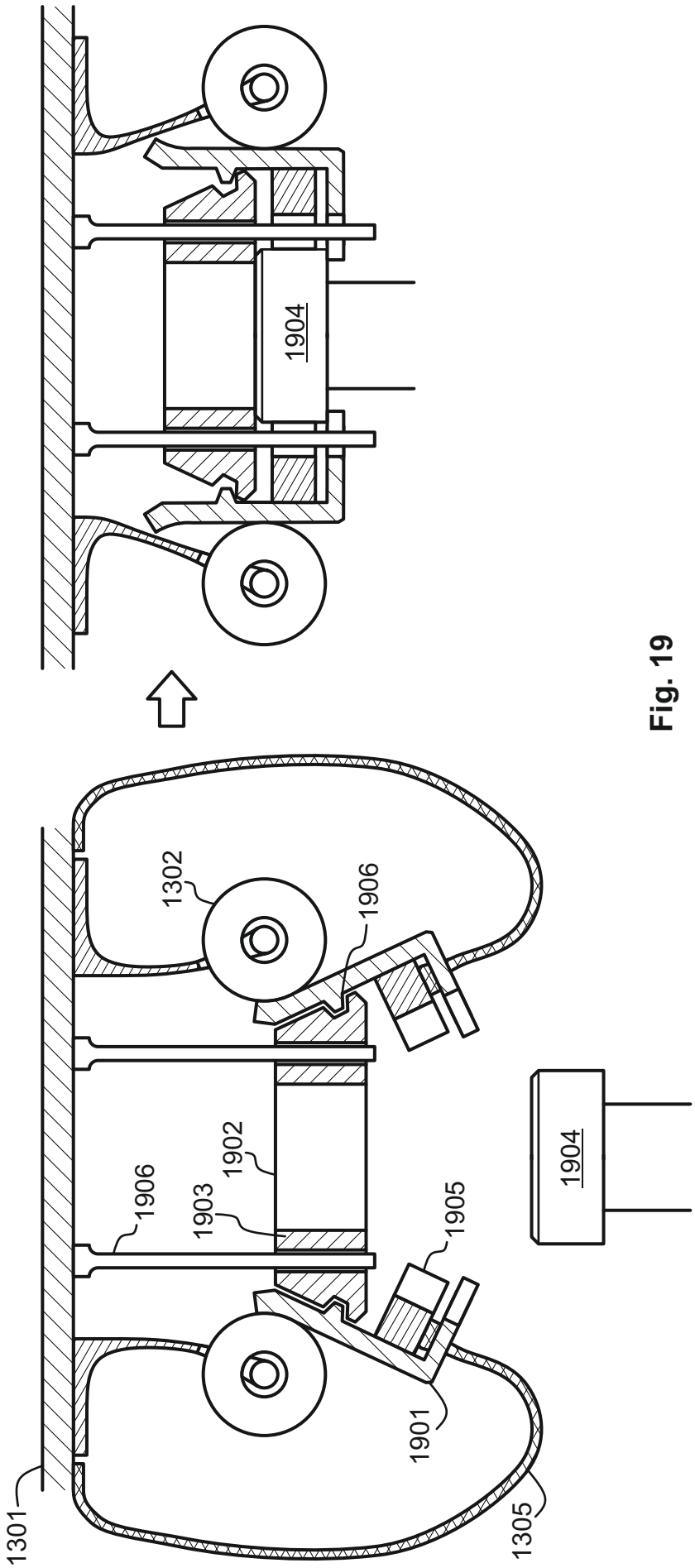

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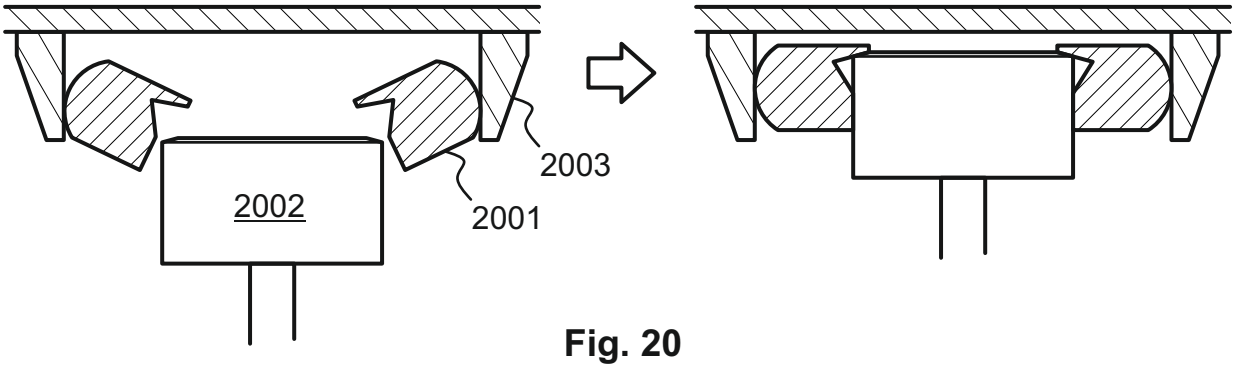

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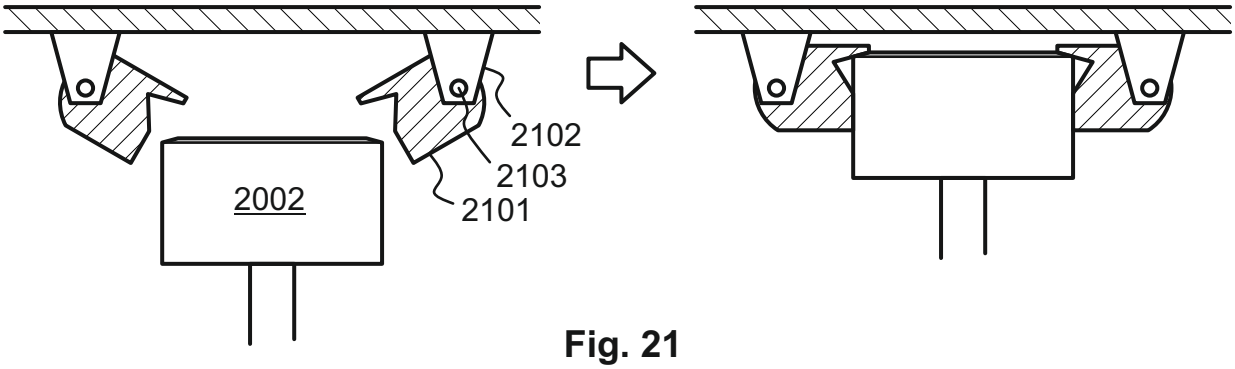

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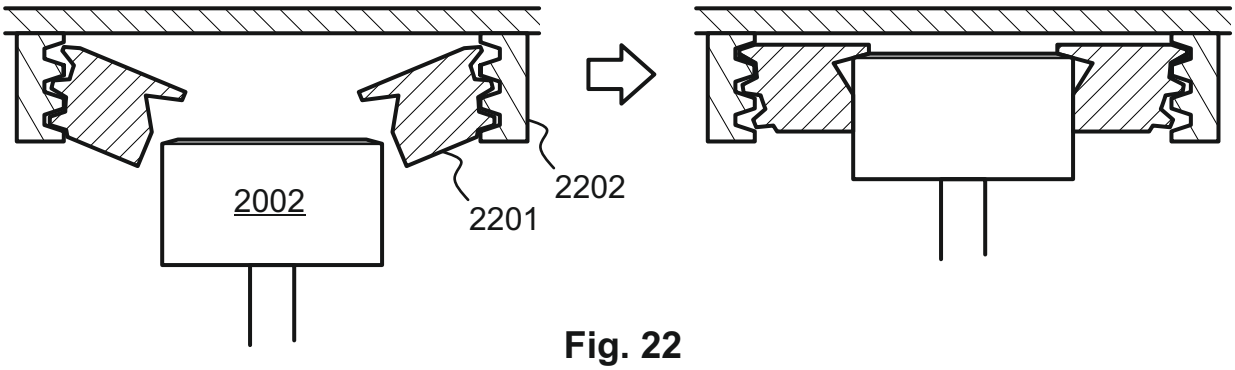

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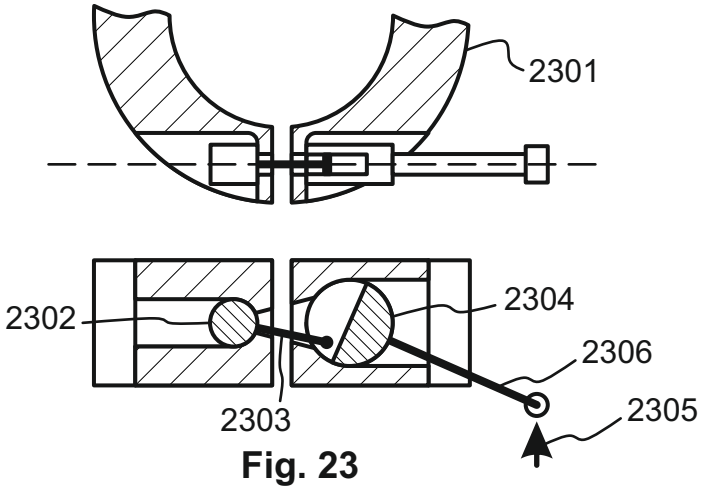

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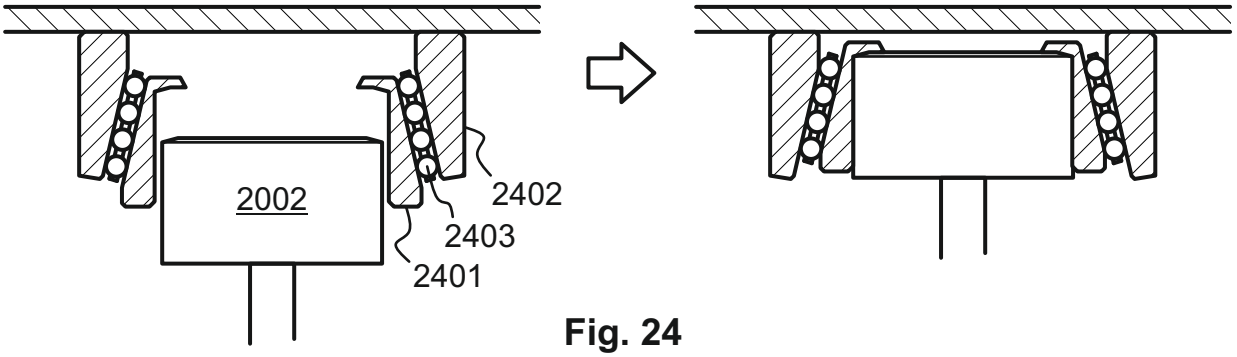

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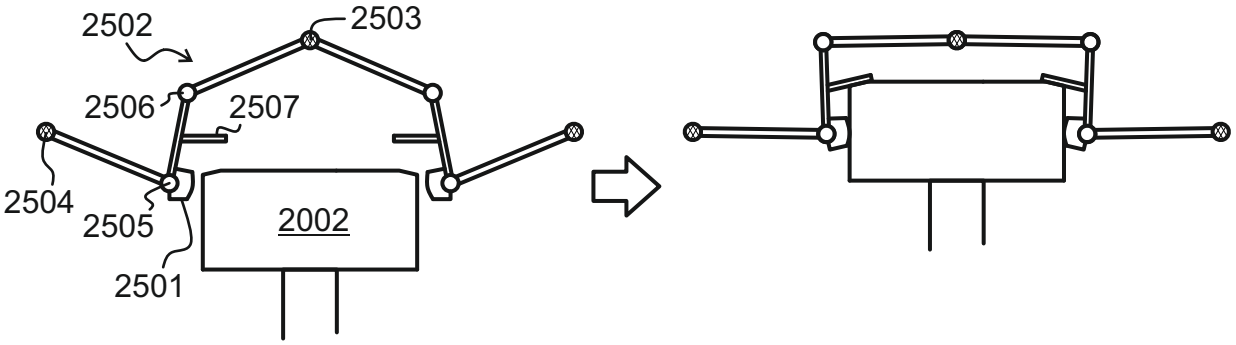

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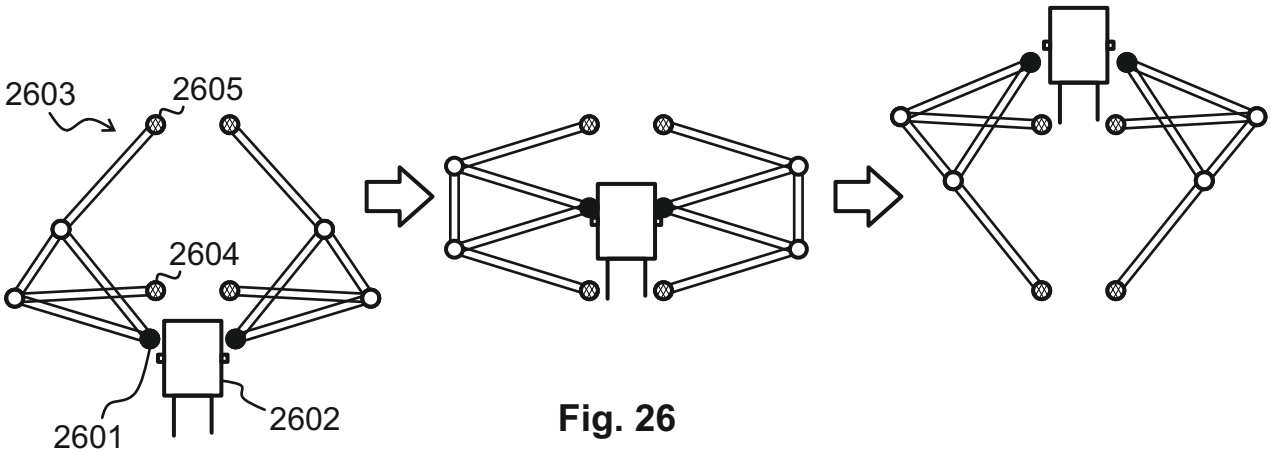

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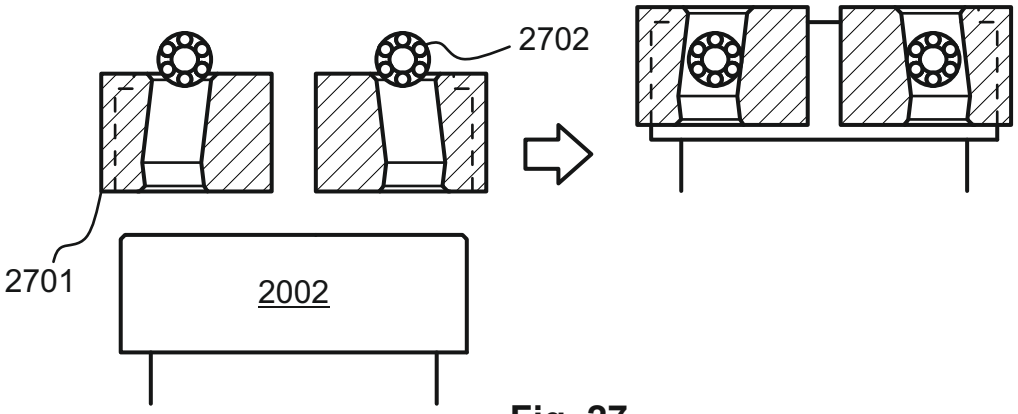

Fig. 27

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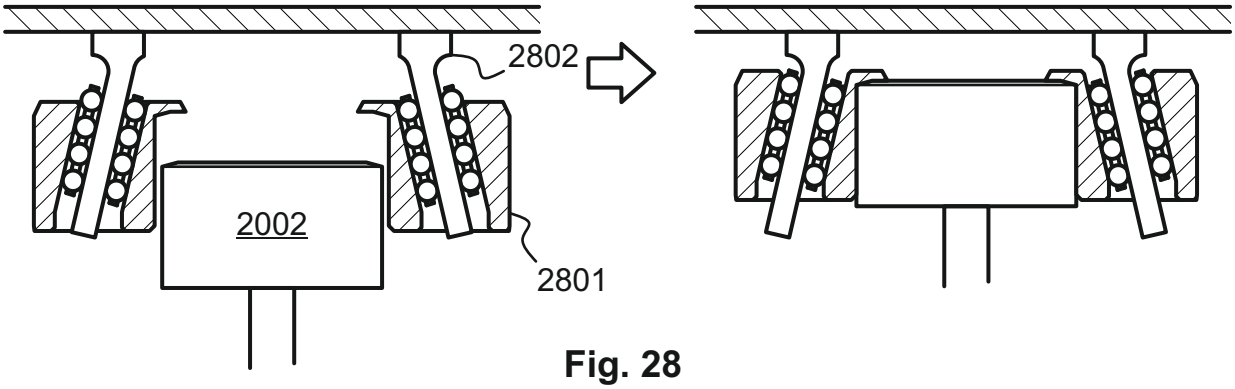

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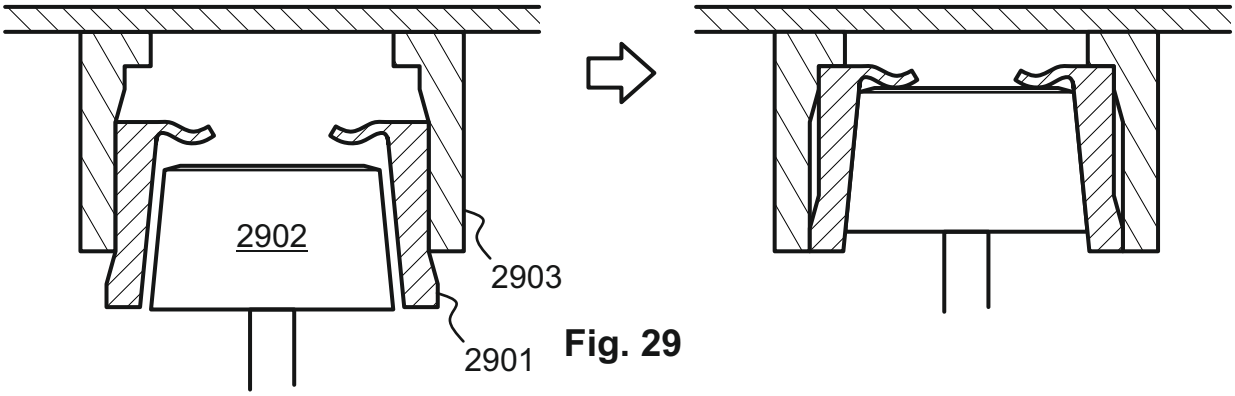

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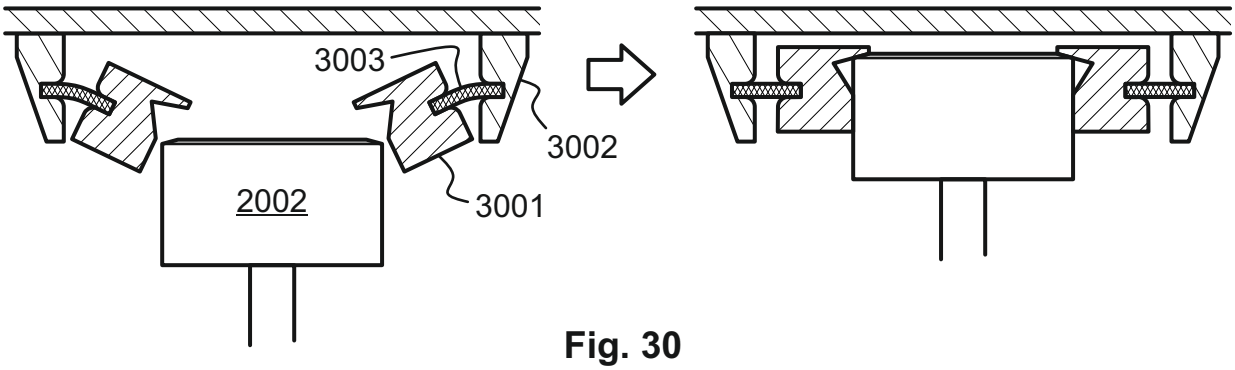

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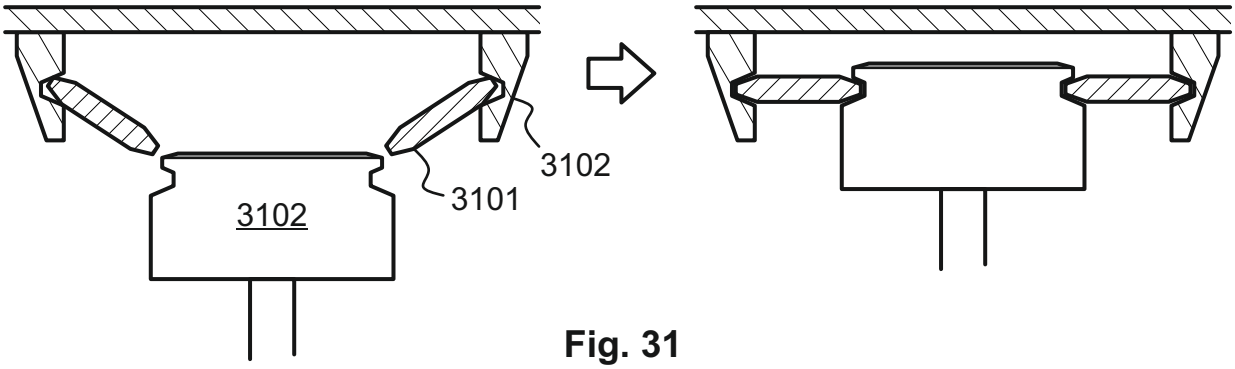

Fig. 31

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