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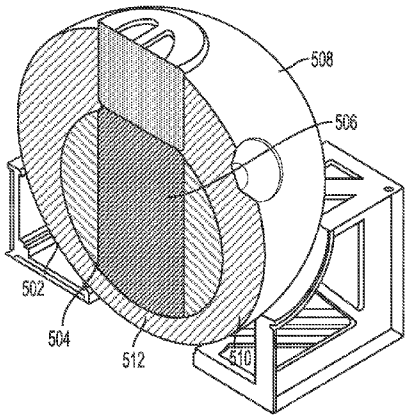


FIG. 5

(57) Abstract: Methods, apparatus, and device, for a cryogenic storage system that stores and/or transports a liquid or gas at a temperature below ambient temperature. The cryogenic storage system has an enclosure and a cavity. The cryogenic storage system has a dewar that is positioned within the cavity of the enclosure. The dewar has a payload area that is configured to hold a liquid below ambient temperature. The dewar is configured to hold a liquid below ambient temperature and passively stabilize in an upright position. The dewar is formed with an inner wall and an outer wall and has an opening that allows access to the payload area.

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CRYOSPHERE

BACKGROUND

[0001] 1. Field

[0002] This specification relates to a system, device or apparatus for cryogenically storing, transporting and/or shipping a liquid or gas below ambient temperatures.

[0003] 2. Description of the Related Art

[0004] Lab technicians, scientists, medical professionals, such as doctors or nurses, and other technicians may cryogenically store and transport liquids or gases to various facilities, such as hospitals, labs and/or research facilities. When transporting the liquids or gases at cryogenic temperatures, the technicians and/or professionals store the liquid or gas in a dewar, which is used to hold the liquid or gas at a refrigerated or cryogenic temperature. The dewar may take several different forms including open buckets, flasks and/or self-pressurizing tanks. The dewar may be a double-walled metal or glass flask that has a vacuum between the walls. This provides thermal insulation between the walls.

[0005] The technician or professional may fill the dewar with the liquid or gas and package the dewar using shipping material. Then, the technician or professional provides the package including the dewar to a shipper to transport the contents to the final destination where it is unpacked. The liquid or gas, however, slowly boils so the dewar may have an opening on top, which is designed to allow the gas to escape. In addition, while being shipped, the dewar may be tilted or overturned resulting in the liquid or gas flowing out of the dewar.

[0006] Accordingly, there is a need for a system, device or apparatus to protect the liquid or gas in the dewar from evaporation and from pouring out while being transported.

SUMMARY

[0007] In general, one aspect of the subject matter described in this specification is embodied in a cryogenic storage system. The cryogenic storage system ("storage system") stores and/or transports a liquid or a gas. The storage system has an enclosure and a cavity. The storage system has a dewar that is positioned within the cavity of the enclosure. The dewar has a payload area that is configured to hold a liquid below ambient temperature. The dewar is configured to hold a liquid below ambient temperature and passively stabilize in an upright position. The dewar is formed with an inner wall and an outer wall and has an opening that allows access to the payload area.

[0008] These and other embodiments may optionally include one or more of the following features. The dewar may be shaped as a sphere and may have a center of mass or gravity within a bottom portion of the dewar, which passively stabilizes the dewar when the dewar is tilted, angled or rotated within the enclosure. The dewar may be a double-walled flask. The dewar may be a spherical dewar. The spherical dewar may be configured to return to the upright position within the enclosure when the enclosure is rotated or angled. The spherical dewar may have a bottom portion and a top portion. The bottom portion may weigh more than the top portion such that the spherical dewar remains upright or stabilizes when tilted or rotated. The enclosure may be shaped as a cube and may have multiple sides. The enclosure may have a circular opening on each side to provide access to the dewar when the dewar is placed inside the enclosure.

[0009] The storage system may have a removable vapor plug. The removable vapor plug may be configured to be inserted into the opening of the dewar to limit access to the cavity of the dewar. The removable vapor plug may have a handle portion and a neck. The storage system may have a temperature monitoring device. The temperature monitoring device may be configured to monitor temperature within the dewar and may be positioned within the

neck. The temperature monitoring device may be configured to wirelessly connect with an electronic device and may transmit a temperature within the dewar to the electronic device.

[0010] The storage system may have a ball transfer device. The ball transfer device may be connected to and interface between the dewar and the enclosure. The ball transfer device may be configured to minimize friction between the dewar and the enclosure.

[0011] In another aspect, the subject matter is embodied in an enclosure for a dewar. The enclosure has a cavity that is configured to receive and enclose the dewar. The enclosure has multiple sides. Each side has an opening that allows access to the dewar when the dewar is inserted into the enclosure. The enclosure has a ball transfer device. The ball transfer device connects to the dewar and is configured to minimize friction between the dewar and the enclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Other systems, methods, features, and advantages of the present invention will be apparent to one skilled in the art upon examination of the following figures and detailed description. Component parts shown in the drawings are not necessarily to scale, and may be exaggerated to better illustrate the important features of the present invention.

[0013] FIG. 1 shows an example cryogenic storage system according to an aspect of the invention.

[0014] FIG. 2 shows a spherical dewar situated within the enclosure according to an aspect of the invention.

[0015] FIG. 3 shows the spherical dewar rotating within the enclosure according to an aspect of the invention.

[0016] FIG. 4 shows an opened spherical dewar to allow the liquid or gas to be inserted according to an aspect of the invention.

[0017] FIG. 5 shows a cross-sectional view of the cryogenic storage system of FIG. 1 according to an aspect of the invention.

[0018] FIGS. 6A-6C show the liquid or gas within the payload area in different orientations according to an aspect of the invention.

[0019] FIG. 7 is an example vapor plug of the cryogenic storage system of FIG. 1 according to an aspect of the invention.

[0020] FIG. 8A is an example corrugated neck tube of the cryogenic storage system of FIG. 1 according to an aspect of the invention.

[0021] FIG. 8B shows the corrugated neck tube connected to the dewar of the cryogenic storage system of FIG. 1 according to an aspect of the invention.

[0022] FIG. 9 is an example ball transfer device of the cryogenic storage system of FIG. 1 according to an aspect of the invention.

DETAILED DESCRIPTION

[0023] Disclosed herein are systems, apparatuses and devices for transporting and storing a liquid or gas, such as liquid nitrogen. The system, apparatus or device may be a cryogenic storage system that stores and transports liquid. Particular embodiments of the subject matter described in this specification may be implemented to realize one or more of the following advantages.

[0024] The cryogenic storage system may have an enclosure that is made from a polymeric material so that the enclosure is able to withstand cryogenic temperatures. That is, the polymeric material is resistant to brittleness and not as susceptible to shattering at cryogenic temperatures. The enclosure may hold or suspend a dewar that contains the liquid or gas. Moreover, the enclosure surrounds the dewar to protect the dewar from any impacts. The enclosure may freely suspend or hold the dewar, such that the dewar freely rotates and/or moves about within the enclosure without impacting the inner sides of the enclosure. Moreover, the dewar may be spherical and have passive stabilization. That is, the dewar may have a center of mass that is located directly opposite from the opening and a center of gravity that is at or near the bottom of the dewar near the center of mass so that the dewar remains in or returns to an upright or vertical position when tilted. By being able to freely rotate within the enclosure and by having passive stabilization, the dewar remains upright regardless of the orientation of the enclosure to prevent spillage. Moreover, by stabilizing the dewar upright, the cryogenic storage system reduces the amount of evaporation of the liquid within the dewar. For example, the cryogenic storage system reduces the nitrogen evaporation rate within the dewar, which extends the life of the dewar in a shipment.

[0025] Other benefits and advantages include that the enclosure has multiple faces that provide access to the dewar, which improves physical access to the opening of the dewar for

inserting and/or removing the liquid or gas. Additionally, the dewar may have an electronic device that conveys and monitors the temperature inside the dewar and has a connection device that reduces the amount of friction between the enclosure and the dewar when the dewar freely rotates.

[0026] FIG. 1 shows a perspective view of the cryogenic storage system 100, and FIG. 2 shows a cross-sectional view of the cryogenic storage system 100. The cryogenic storage system ("storage system") 100 includes an enclosure 102, a dewar 104, such as a double-walled flask, and a vapor plug 106. The enclosure 102 is three-dimensional (3D) and may be shaped as a cube. The enclosure 102 may be shaped as any type of three-dimensional object, such as a cube, tetrahedron, dodecahedron or octahedron, and may be made from a polymeric material so that the enclosure 102 does not shatter at cryogenic temperatures.

[0027] The enclosure 102 has multiple sides 108 or faces. The sides 108 form a closed enclosure that surrounds or encloses the dewar 104. The sides 108 may be a planar or latticed surface that connects to the other sides to form the enclosure 102 and surround the dewar 104. The dewar 104 inserted into or placed into a cavity of the enclosure 102 so that the dewar 104 resides within the enclosure 102. The multiple sides 108 may snap together using one or more fasteners. The multiple sides 108 may snap together at one or more corners 112, for example. In some implementations, the enclosure may be formed from multiple modular pieces. The multiple modular pieces may be connected and/or fastened together to form the enclosure 102. The multiple sides may have one or more enclosure openings 110. The one or more enclosure openings 110 may be circular and/or shaped in the same shape as the dewar opening. The one or more enclosure openings 110 provide access to the dewar 104 as the dewar 104 rotates within the enclosure 102. Thus, the opening 402 of the dewar 104 may be access regardless of the orientation of the enclosure 102.

[0028] For example, the enclosure 102 is shaped as a cube and has 6 sides 108. Each side is connected to at least another side at a corner 112. On each side, there is an enclosure opening 110. The enclosure opening allows access to the vapor plug 106 and the dewar opening, when the dewar opening is aligned with the enclosure opening 110 on the side of the enclosure 102. Thus, as the dewar rotates within the cavity of the enclosure, the one or more enclosure openings 110 provide access to the vapor plug 106 and the dewar opening, when the one or more enclosure openings 110 align with the dewar opening.

[0029] The enclosure 102 may have an inner framework 114 and an outer framework 116. The outer framework 116 protects the dewar 104 from impacts, vibration and/or shocks. For example, the outer framework 116 separates the dewar 104 from other objects, such as other boxes or the side of a truck, when the enclosure 102 is shipped or stored. The inner framework 114 forms the cavity within the enclosure 102 where the dewar 104 is situated. The dewar may be suspended, placed or otherwise situated within the cavity of the inner framework 114 so that the dewar 104 is able to rotate within the cavity.

[0030] The storage system 100 may include a ball transfer device 900 that is connected between the enclosure 102 and the dewar 104. The ball transfer device 900 facilitates the movement of the dewar relative to the enclosure 102. The ball transfer device 900 may be positioned at an inner phalange or wing 202 that is between the enclosure 102 and the dewar and provide for a frictionless or near-frictionless surface. The ball transfer device 900 minimizes or eliminates friction between the dewar and the enclosure 102, which allows the dewar to freely move or rotate within the enclosure 102. FIG. 9 further describes the structure of the ball transfer device 900.

[0031] The storage system 100 includes a dewar 104. The dewar 104 may be double-walled flask and may be shaped as a sphere or any other polyhedron. The dewar 104 may be situated centrally within a central cavity of the enclosure 102 and may freely rotate and/or

move within the central cavity. The dewar 104 may rotate in the direction 302, 304 about a central vertical axis 306 or in any other direction three-dimensionally, as shown in FIG. 3 for example.

[0032] The dewar 104 has an inner wall 504, an outer wall 502 and an opening 402. The storage system 100 may have a plug, such as the vapor plug 106, which may be inserted into the opening 402 to seal or partially seal the dewar 104 while allowing some gas to escape, as shown in FIG. 4 for example. The opening 402 leads to a cavity or payload area 506 that is within the dewar 104. FIG. 5 shows the payload area 506 in the cross-sectional view of the dewar 104. The dewar 104 may form a vacuum between the inner wall 504 and the outer wall 502 to hold or store a liquid or gas below ambient temperatures. The dewar 104 may have a pump-out port 412. The pump-out port 412 may be used to create a vacuum between the inner wall 504 and the outer wall 502 of the dewar 104, which allows the space in between the inner wall 504 and the outer wall 502 to be completely evacuated.

[0033] The dewar 104 has an inner wall 504 and an outer wall 502 with a vacuum between the inner wall 504 and the outer wall 502. The outer wall 502 has an opening 402 that allows a liquid or gas to be inserted or placed into the payload area 506. The opening 402 may be positioned opposite the center of gravity or mass 512 of the dewar 104, such that the opening 402 remains upright when the dewar 104 is passively stabilized. The opening 402 allows gases to escape from the payload area 506 of the dewar 104 to relieve the gas expansion within the dewar 104.

[0034] The inner wall 504 forms and/or encloses the payload area 506 within the dewar 104. The payload area 506 may be a cylindrical cavity within the dewar 104 that extends longitudinally from the top portion 508 through to the bottom portion 510 of the dewar 104. The payload area 506 holds or stores the liquid or gas below ambient temperatures. An absorbent material 606 may be at or surrounding a bottom portion of the payload area 506.

The absorbent material 606 may maintain the temperature within the payload area 506 below the ambient temperature.

[0035] The dewar 104 has a top portion 508 and a bottom portion 510. The top portion 508 is where the opening 402 is located and remains upright due to passive stabilization of the dewar 104. The bottom portion 510 includes the center of gravity or mass 512. Since the center of gravity or mass 512 is located within the bottom portion 510 of the dewar 104, the dewar 104 stabilizes around the center of gravity or mass 512 so that the dewar 104 remains upright. By stabilizing the dewar 104 around the center of gravity or mass 512 regardless of the orientation of the enclosure 102, the storage system 100 reduces the amount and/or rate of evaporation of the liquid or gas and/or absorbent material, e.g., the nitrogen evaporation rate is reduced. The amount and/or rate of evaporation of the liquid or gas and/or absorbent material is based on the amount of the cross-sectional surface area 604a-c of the liquid or gas 602, as shown in FIGS. 6A-6C for example. Additionally, by having passive stabilization, the dewar 104 increases an amount of shipping density within a shipping container, as the dewar 104 may be enclosed in an enclosure 102 of any shape which allows the shipper to use any shape for the enclosure 102 that best fits the available space or empty volume within the shipping container.

[0036] FIG. 6A shows the liquid or gas 602 and the absorbent material 606 within the payload area 506 of the dewar 104 when the dewar 104 is upright. The absorbent material 606 may be positioned within or surrounding the bottom portion of the payload area 506 of the dewar 104. The cross-sectional surface area 604a of the liquid or gas 602 has a diameter, D, when the dewar 104 is upright because the payload area 506 is upright or vertical. If the payload area 506 were to be angled or tilted, as shown in FIGS. 6B and 6C for example, the liquid or gas 602 would have cross-sectional surface areas 604b-c of $D+\Delta D$, respectively, that are greater than the cross-sectional surface area 602a, D, when the payload area 506 is

upright or vertical. As the payload area 506 tilts or angles, the shape of the cross-sectional surface area 604a transitions from a circular shape due to the cylindrical nature of the payload area 506 to the elliptical shape of the cross-sectional surface areas 604b-c. The size of the elliptical cross-sectional surface areas 604b-c increase as the angle increases. The increased cross-sectional surface areas 602b-c result in an increased evaporation rate and/or amount of the liquid or gas 602 and/or an increased burn rate or amount of the absorbent material 606. The increased cross-sectional surface areas 604b-c expose more of the liquid or gas 602 to a higher temperature medium causing a faster burn rate for the absorbent material 606 to cool the liquid or gas 602. Moreover, the liquid and/or gas may spill out or escape from the opening 402 of the dewar 104 as the payload area 506 is tilted. Additionally, as liquid or gas 602 spills out and/or the cross-sectional surface area 602b-c increases, a partial vacuum is created, which draws in warm air that further increases the average temperature and causes a faster burn rate for the absorbent material 606 to cool the liquid or gas 602.

[0037] Since the dewar 104 within the storage system 100 has passive stabilization that maintains the dewar 104 in the upright position regardless of the orientation of the enclosure 102, the payload area 506 within the dewar 104 maintains the upright position or returns to the upright position when the dewar 104 is tilted, rotated and/or otherwise angled. Thus, the storage system 100 reduces the amount and/or rate of evaporation of the liquid or gas 602 and reduces the burn rate of the absorbent material 606 by maintaining the dewar 104 in the upright position and/or passively adjusting the dewar 104 so that the dewar 104 returns to or maintains the upright and/or vertical position. Moreover, by reducing the burn rate of the absorbent material 606, which may be nitrogen, the dynamic holding time of the dewar 104 increases. The dynamic holding time is the time that the dewar 104 maintains the internal temperature at or below -150°C during transportation.

[0038] The storage system 100 includes a vapor plug 106. FIGS. 4, 7A and 7B show the vapor plug 106. The vapor plug 106 may have a handle portion 408 and a neck 410. The handle portion 408 may have a handle or grip that allows a user to twist the vapor plug 106 in a clockwise or counter clockwise direction to insert at least a portion of the neck 410 into the opening 402. The vapor plug 106 may be removable. That is, the vapor plug 106 may be inserted into the opening 402 of the dewar 104 to close or partially close the dewar 104 and prevent access to the payload area 506. The handle portion 408 and/or the neck 410 may be made from a non-conductive material, such as a polymer or fiberglass like material.

[0039] The vapor plug 106 may be turned or twisted clockwise and/or counter-clockwise, as shown in FIG. 4 for example. For example, the vapor plug 106 may be turned clockwise when inserted into the opening 402 to secure the vapor plug 106 within the opening 402 and turned counter-clockwise to remove the vapor plug 106 from the opening 402 to allow insertion of the liquid or gas into the payload area 506. In another example, the vapor plug 106 may be turned counter-clockwise when inserted into the opening 402 to secure the vapor plug 106 within the opening 402 and turned clockwise to remove the vapor plug 106 from the opening 402. The vapor plug 106 may be inserted into the opening 402 such that there remains a gap that allows gas to escape to prevent pressure from building up as the liquid within the payload area 506 evaporates.

[0040] The vapor plug 106 may have a locking device 704, as shown in FIG. 7. The locking device 704 may be positioned on the neck of the vapor plug 106. The locking device 704 may be one or more magnets that interlock with one or more other magnets within a top inner portion of the payload area 506 of the dewar 104. The magnets may have opposing polarities so that when vapor plug 106 is turned in certain position within dewar 104 the magnets lock vapor plug within the dewar 104. Conversely, when vapor plug 106 is rotated

about its axis to another position, the opposing polarity of the magnets may force vapor plug out of dewar 104.

[0041] The locking device 704 locks when the vapor plug 106 is inserted within the payload area 506. Since there may be a gap between the vapor plug 106 and the inner portion of the payload area 506 of the dewar 104, the locking device 704 locks the vapor plug 106 in place with the dewar 104 to prevent the vapor plug 106 from falling out when the dewar 104 is oriented or rotated in different directions. The gap between the vapor plug 106 and the dewar 104 allows gas to escape due to the expansion of the gas or evaporation of the liquid within the payload area 506 to prevent pressure from building up within the payload area 506.

[0042] The storage system 100 may include an electronic thermocouple 702, which may positioned, embedded or included within, or connected to the neck 410 of the vapor plug 106. The electronic thermocouple 702 may be an electronic device or sensor that measures and monitors the temperature within the dewar 104. The electronic thermocouple 702 may wireless transmit and/or communicate with another electronic device, such as a smart data logger, using a wireless protocol. The electronic thermocouple 702 may communicate and provide the temperature to the smart data logger and/or may receive instructions from the smart data logger to monitor the temperature. The smart data logger may display or otherwise communicate the temperature to a user or another electronic platform. This allows for real-time monitoring of the temperature within the dewar 104 by other individuals.

[0043] The storage system 100 may include a corrugated neck tube 800, as shown in FIGS. 8A-8B for example. The corrugated neck tube 800 may be thin-walled. The corrugated neck tube 800 connects the inner wall 504 with the outer wall 502 of the dewar 104. The corrugated neck tube 800 reduces the overall height of the neck tube but keeps the overall length of the path, which conducts the heat, the same as a straight neck tube. The corrugated neck tube 800 may have a serpentine path 802 that provides the heat conduction.

By reducing the height of the neck tube but keeping the overall path length the same as a straight neck tube, the corrugated neck tube 800 reduces the overall size of the dewar 104. Moreover, by keeping the overall path length for heat conduction the same as a straight neck tube, the corrugated neck tube 800 reduces the amount of heat that is conducted into the dewar 104. Thus, the corrugated neck tube 800 provides for the same heat conduction with a shorter neck tube (e.g., shorter overall height or size) than a straight neck tube of similar overall path length. For example, the height of the corrugated neck tube 800 may be 2-3 inches long, whereas, the overall path length for heat conduction may be 6 inches long because the overall path length for heat conduction may be a serpentine path along the thin-walled corrugated neck tube.

[0044] The storage system 100 includes a ball transfer device 900, as shown in FIG. 9 for example. The ball transfer device 900 may be connected to the enclosure 102 at the inner phalange or wing 202. The ball transfer device 900 may provide an interface between the enclosure 102 and the dewar 104 and allow the dewar 104 to freely rotate within the cavity of the enclosure 102.

[0045] The ball transfer device 900 may have a head 902 and a body 904. The head 902 and the body 904 may be shaped as cylinders. The diameter of the head 902 may be greater than the diameter of the body 904. The ball transfer device 900 may be inserted into a hole or opening of the inner phalange or wing 202. For example, the body 904 may be inserted into the opening and the head 902 may form a seal around the opening of the inner phalange or wing 202. The head 902 and body 904 may have an opening and a cavity where a ball bearing 906 and spring 908 reside.

[0046] The ball transfer device 900 may have a ball bearing 906, a cup 910 and a spring 908 that sits or rests in a cavity of the ball transfer device 900. The ball bearing 906 may have a top portion and a bottom portion. The top portion of the ball bearing 906 may

protrude from the head 902 of the ball transfer device 900. The top portion of the ball bearing 906 that protrudes contacts the dewar 104 when the dewar 104 sits in the cavity of the enclosure 102. The ball bearing 906 minimizes the friction between the enclosure 102 and the dewar 104 allowing the dewar 104 to freely rotate or move within the enclosure 102. The ball bearing 906 provides for a frictionless or a reduced friction surface. The bottom portion of the ball bearing 906 that is within the cavity of the body 904 may rest on the cup 910, which engages with the spring 908.

[0047] The cup 910 interfaces between a bottom portion of the ball bearing 906 and the spring 908, such that when a force is applied on the top portion of the ball bearing 906, the bottom portion of the ball bearing 906 presses against the cup 910, which provides a downward force on the spring 908 so that the spring 908 contracts. This allows the dewar 104 to freely rotate within the enclosure 102 and allows the enclosure 102 to absorb shocks and vibrations during storage and/or transport. When the dewar 104 presses against the ball bearing 906, the ball bearing 906 further enters into the cavity of the body 904 while the spring 908 further contracts. This allows the dewar 104 to jostle instead of remain rigid so that any shocks or vibrations are absorbed. When the event causing the shocks or vibrations has passed, the spring 908 returns or expands back into a normal state and keeps the dewar 104 positioned within the cavity of the enclosure 102. Moreover, the one or more ball bearings 906 allow the dewar 104 to rotate or angle so that the dewar 104 remains passively stabilized and upright regardless of the orientation of the enclosure 102.

[0048] The spring 908 may contract when a downward force is applied to the ball bearing 906, such as when the dewar 104 exerts an outward force on the ball bearing 906 due to shocks or vibrations on the enclosure 102. For example, when the enclosure 102 is moved, shifted or dropped a vibrational force is exerted on the enclosure 102. If the dewar 104 moves or shifts in response to the vibrational force, the dewar 104 may exert an outward

force on the ball transfer device 900, and instead of violently contacting the enclosure 102, the dewar 104 exerts a force on the ball bearing 906, which retracts within the cavity of the body 904 and causes the spring 908 to contract and absorb the force.

[0049] Exemplary embodiments of the methods/systems have been disclosed in an illustrative style. Accordingly, the terminology employed throughout should be read in a non-limiting manner. Although minor modifications to the teachings herein will occur to those well versed in the art, it shall be understood that what is intended to be circumscribed within the scope of the patent warranted hereon are all such embodiments that reasonably fall within the scope of the advancement to the art hereby contributed, and that that scope shall not be restricted, except in light of the appended claims and their equivalents.

CLAIMS

What is claimed is:

1. A cryogenic storage system, comprising:

an enclosure having a cavity; and

a dewar that is positioned within the cavity of the enclosure and has a payload area that is configured to hold a liquid below ambient temperature and passively stabilize in an upright position, the dewar being formed with an inner wall and an outer wall.

2. The cryogenic storage system of claim 1, wherein the dewar is shaped as a sphere and has a center of gravity or mass within a bottom portion of the dewar that passively stabilizes the dewar when the dewar is tilted, angled or rotated within the enclosure.

3. The cryogenic storage system of claim 1, wherein the enclosure is a cube, wherein the enclosure has a plurality of sides and a circular opening on each side of the plurality of sides to provide access to the dewar when the dewar is placed inside the cubicle enclosure.

4. The cryogenic storage system of claim 1, further comprising:

a corrugated neck tube that connects the inner wall and the outer wall and is configured to reduce an amount of heat conducted into the dewar, wherein the corrugated neck tube has a serpentine path to conduct the amount of heat; and

a removable vapor plug that is configured to be inserted into the opening of the dewar to close the dewar and prevent access to the cavity of the dewar.

5. The cryogenic storage system of claim 4, wherein the removable vapor plug has a handle portion and a neck.

6. The cryogenic storage system of claim 5, further comprising:

a temperature monitoring device that is configured to monitor temperature within the dewar, wherein the temperature monitoring device is positioned within the neck.

7. The cryogenic storage system of claim 6, wherein the temperature monitoring device is configured to:

wirelessly connect with an electronic device; and

transmit a temperature within the dewar to the electronic device.

8. The cryogenic storage system of claim 1, further comprising:

a ball transfer device that is connected to and interfaces between the dewar and the enclosure, the ball transfer device is configured to minimize friction between the dewar and the enclosure.

9. The cryogenic storage system of claim 1, wherein the dewar is a spherical dewar that rotates in three-dimensions.

10. The cryogenic storage system of claim 9, wherein the spherical dewar is configured to maintain the upright position and return to the upright position when the dewar is tilted, rotated or angled.

11. The cryogenic storage system of claim 10, wherein the spherical dewar has a bottom portion and a top portion, wherein the bottom portion weighs more than the top portion such that the spherical dewar remains upright or stabilizes when tilted or rotated.

12. A dewar for storing a liquid below an ambient temperature, comprising:

an inner wall that forms a cavity within and encloses a stored liquid;

an outer wall, the outer wall and the inner wall having an opening that allows access for the liquid into the cavity; and

a vacuum port that is configured to produce a vacuum insulation between the inner wall and the outer wall.

13. The dewar of claim 12, further comprising:

a vapor plug that is configured to be inserted into the cavity to plug the opening and prevent the liquid from entering or exiting the cavity of the dewar.

14. The dewar of claim 13, wherein the vapor plug has a handle and a cork, wherein the cork is configured to receive a temperature monitoring device.

15. The dewar of claim 13, wherein the vapor plug is a magnetic vapor plug.

16. The dewar of claim 13, wherein the magnetic vapor plug may be rotated to a position in the cavity to where magnets secure the vapor plug to the cavity.

17. The dewar of claim 13, wherein the magnetic vapor plug may be rotated to a position in the cavity where magnets create force to push the magnetic vapor plug out of the cavity

18. The dewar of claim 13, further comprising a vapor plug locking device that locks the vapor plug to the dewar.

19. The dewar of claim 12, wherein the dewar has a bottom portion and a top portion, wherein the bottom portion weighs more than the top portion such that the dewar remains upright or stabilizes when tilted or rotated.

20. The dewar of claim 12, further comprising:

a corrugated neck tube that connects the inner wall with the outer wall, wherein the corrugated neck tube has a serpentine path that conducts heat, wherein the dewar is shaped as a sphere.

21. An enclosure for a dewar, comprising:

a cavity that is configured to receive and enclose the dewar;

a plurality of sides, each side of the plurality of side having an opening that allows access to the dewar when the dewar is inserted into the enclosure; and

a ball transfer device that connects to the dewar and is configured to minimize friction between the dewar and the enclosure.

22. The enclosure of claim 22, wherein the cavity is configured to allow the dewar to move in three dimensions.

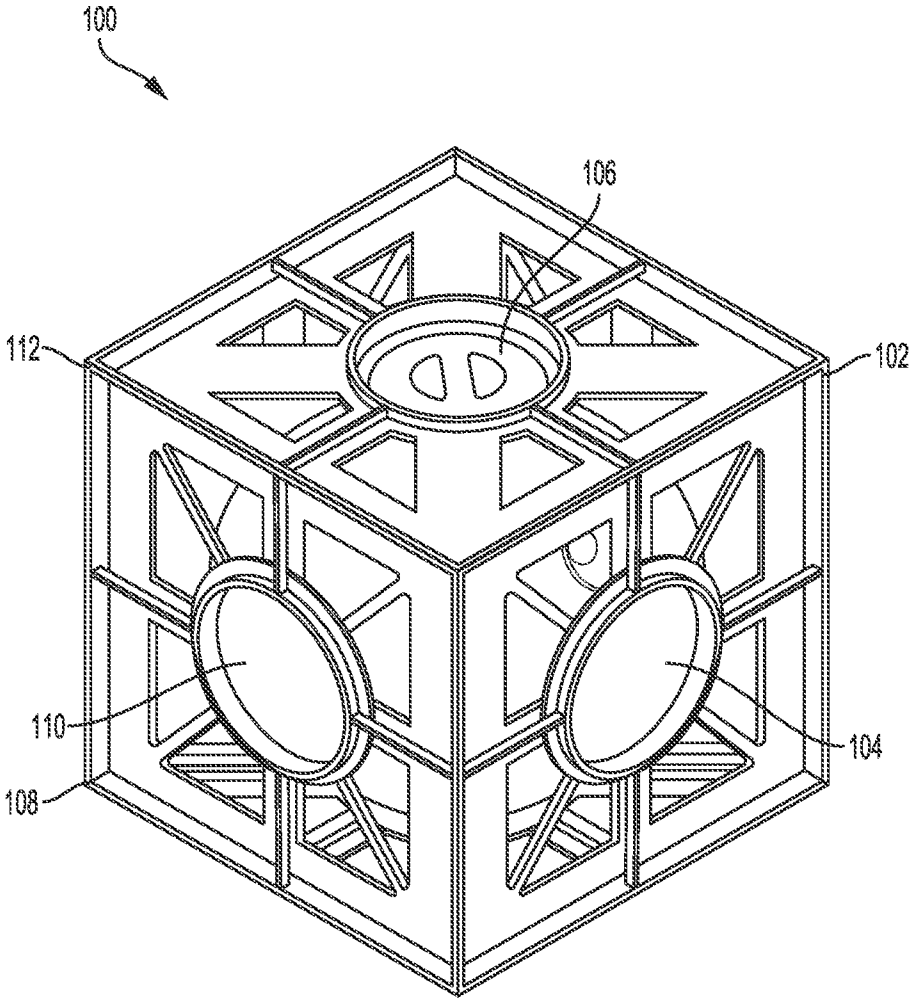


FIG. 1

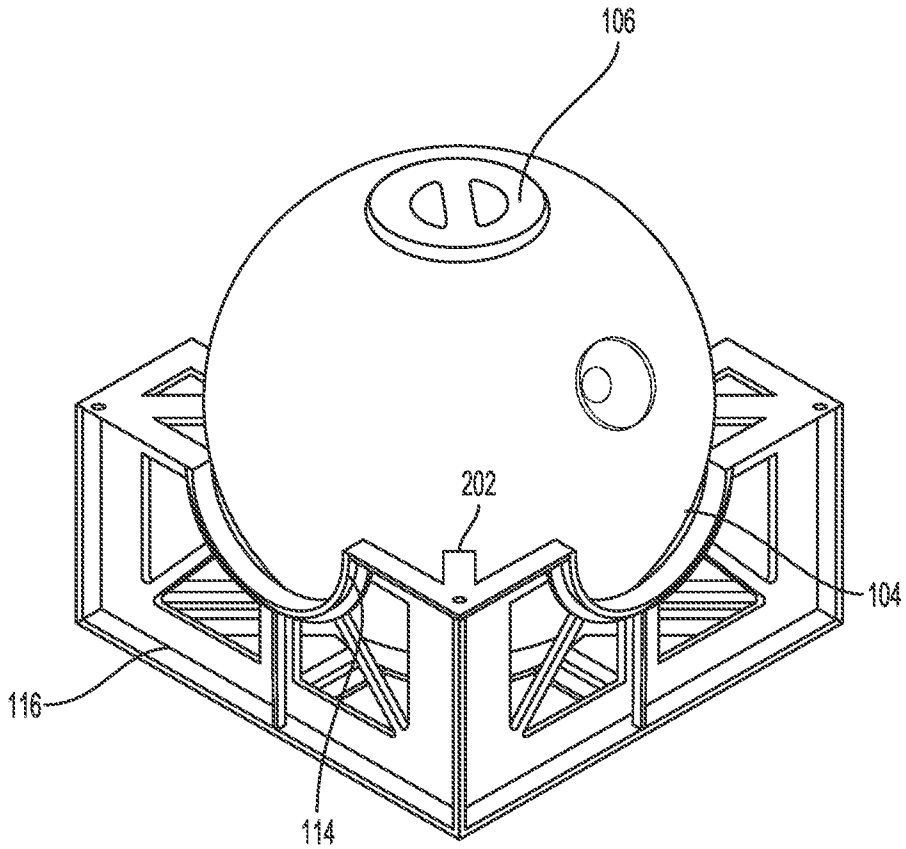


FIG. 2

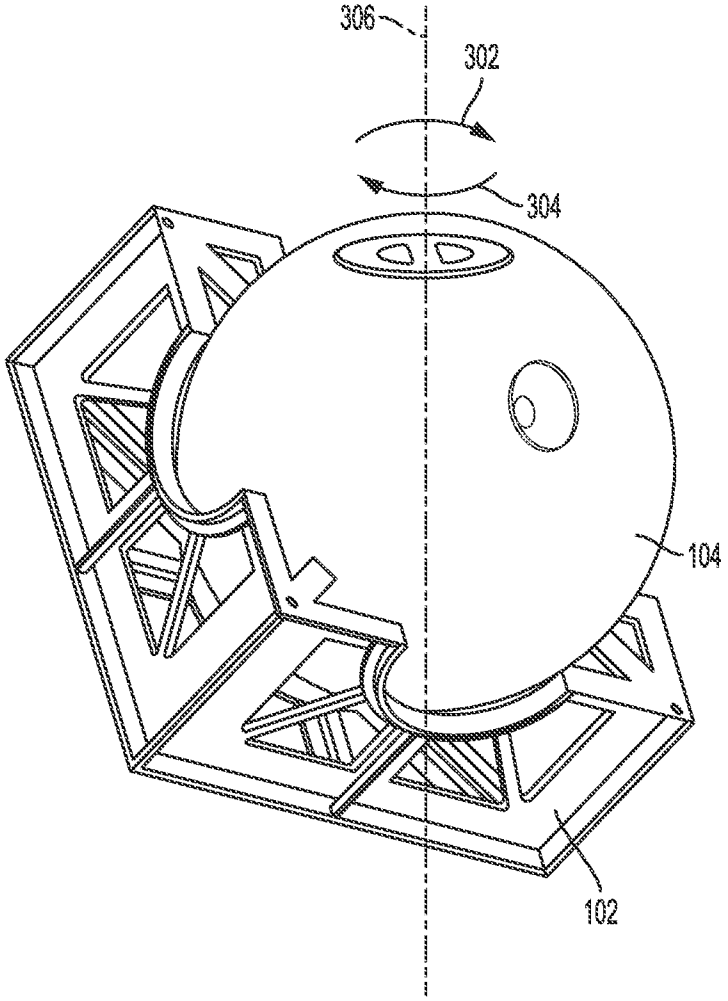


FIG. 3

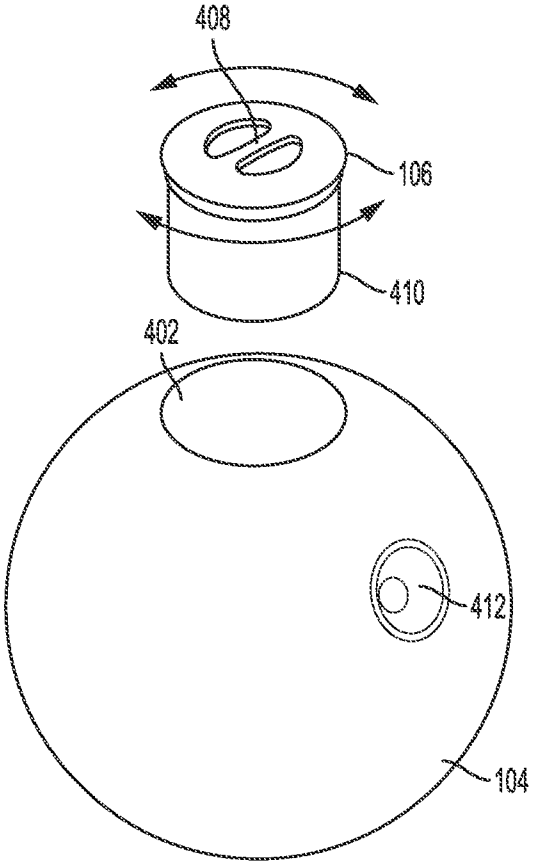


FIG. 4

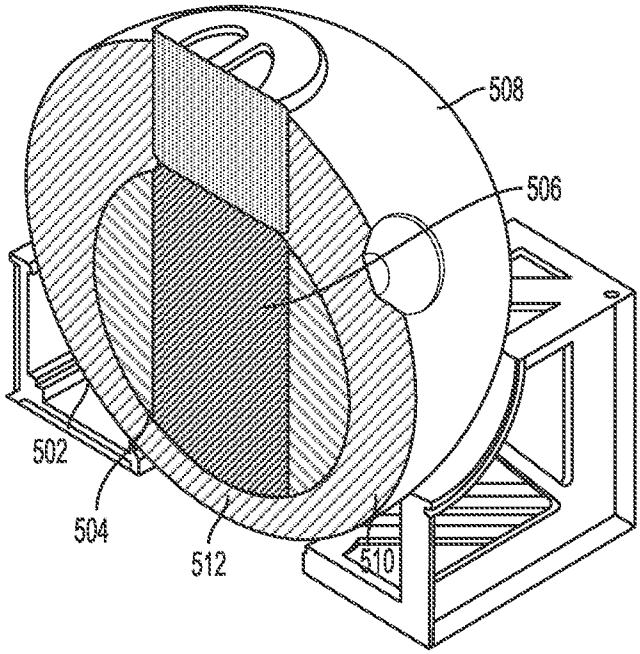


FIG. 5

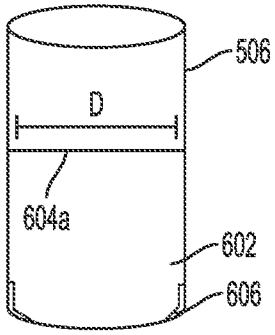


FIG. 6A

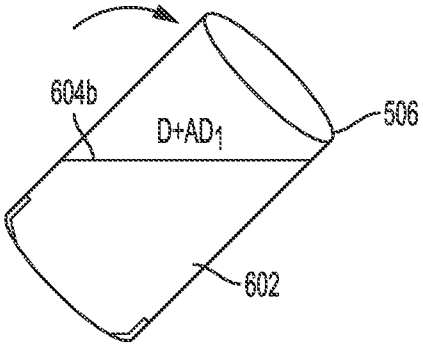


FIG. 6B

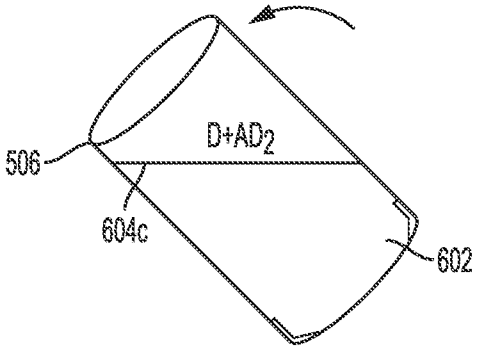


FIG. 6C

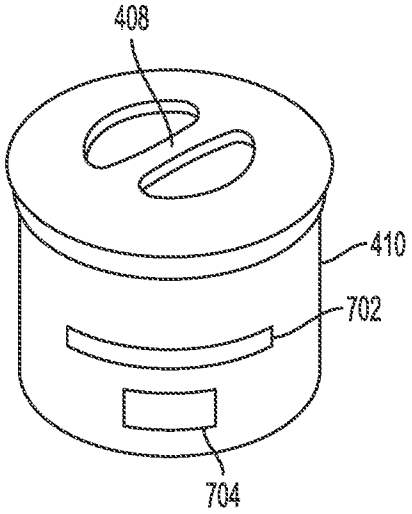


FIG. 7

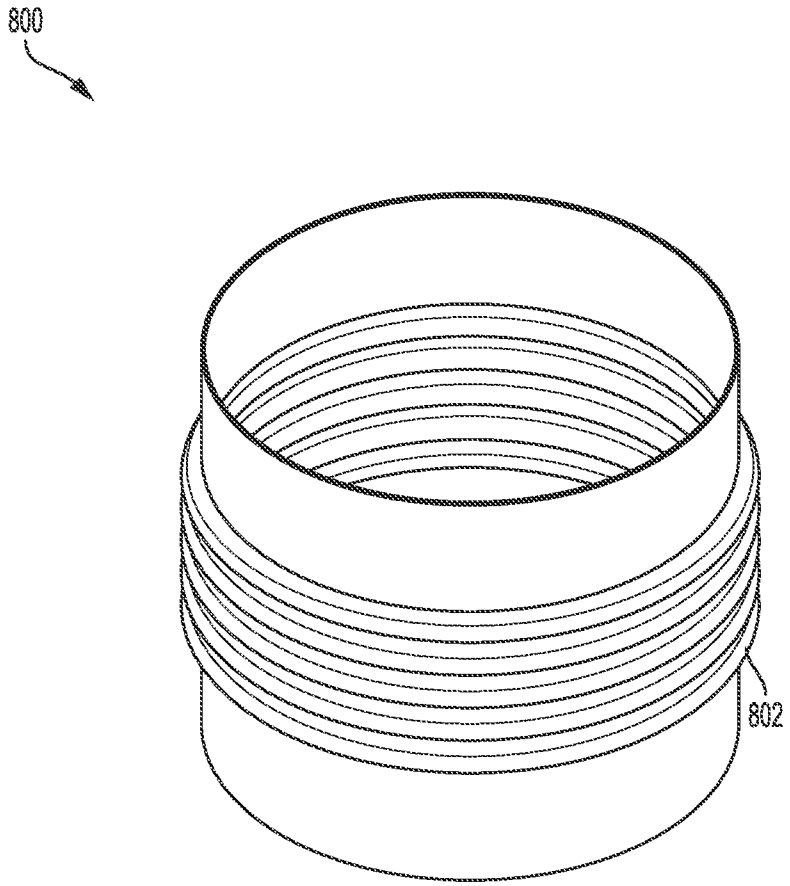


FIG. 8A

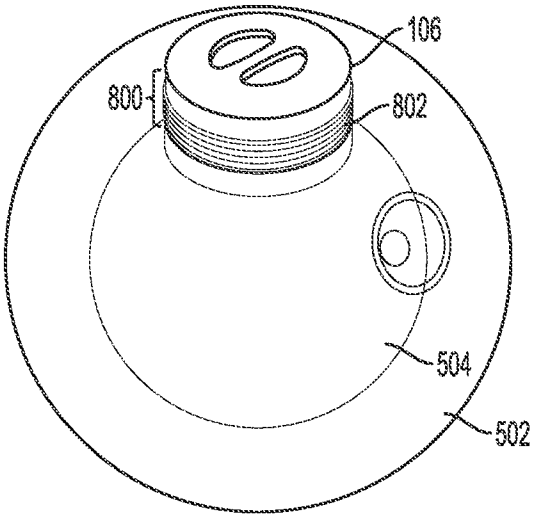


FIG. 8B

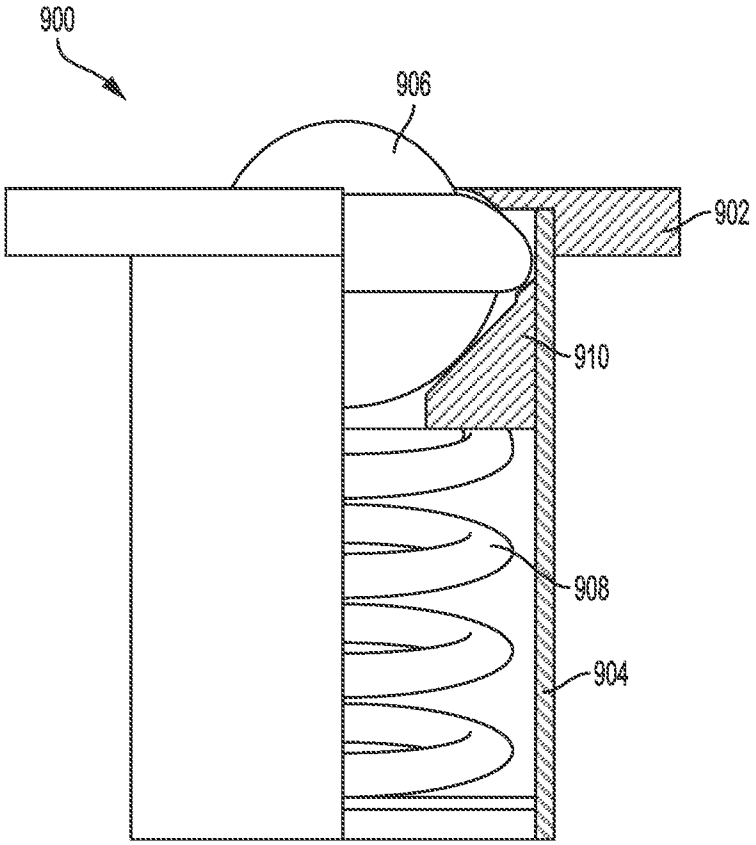


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2019/012553

A. CLASSIFICATION OF SUBJECT MATTER

F17C 3/08(2006.01)i, F17C 13/08(2006.01)i, F17C 13/02(2006.01)i, F17C 13/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F17C 3/08; B65D 81/00; F17C 1/00; F17C 13/00; F17C 13/04; F17C 7/04; F17C 9/02; F25B 9/00; F25J 1/00; F17C 13/08; F17C 13/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & keywords: cryogenic, dewar, sphere, upright, weight, ball bearing, plug

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2002-0113070 A1 (EMMEL, GREGG) 22 August 2002 See paragraphs [0025]-[0028], [0032], [0035], [0038], [0047], [0052], [0071], [0100], [0105] and figures 1-3, 5A, 5C.	12,13
Y		1-11,14-22
Y	US 4919300 A (ANDERSON et al.) 24 April 1990 See column 2, line 46 - column 3, line 58 and figures 1-4.	1-11,19-22
Y	US 2002-0166326 A1 (GIESY et al.) 14 November 2002 See paragraphs [0030], [0033], [0040] and figures 1, 3.	4-7,14,20
Y	US 2013-0014517 A1 (DIEDERICHS et al.) 17 January 2013 See paragraphs [0035], [0039] and figure 4.	6,7,14
Y	JP 09-329297 A (SHOWA KOATSU KOGYO K.K.) 22 December 1997 See paragraphs [0007]-[0012] and figures 1-5.	15-18

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 May 2019 (08.05.2019)	**08 May 2019 (08.05.2019)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2019/012553

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