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(71) Applicant: VARIAN, INC. [US/US]; 3120 Hansen Way, D-102, Palo Alto, CA 94304 (US).

(72) Inventors: DEAN, Stephen; 300 Oxpens Road, Cary, NC 27513 (US). SWON, James; 39506 Glenn Glade, Chapel Hill, NC 27514 (US). FERNANDO, C., J., Anthony; 1002 Grandover Drive, Durham, NC 27713 (US).

(74) Agent: FISHMAN, Bella; Varian, Inc., Legal Department, 3120 Hansen Way, D-102, Palo Alto, CA 94304 (US).

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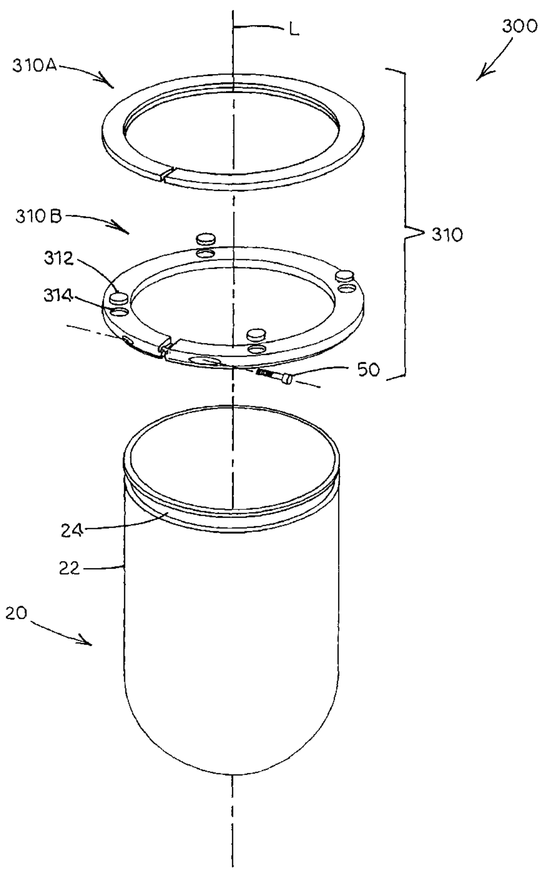

(57) Abstract: A vessel centering system comprises a vessel, an annular spacer member, a fastening element, and a first magnetic element. The vessel includes an outer surface and a vessel groove formed on a circumference of the vessel outer surface. The spacer member is fitted in the vessel groove and extends outwardly with respect to the vessel. The first and second lateral end surfaces define a spacing therebetween. The spacer member includes a tangential bore extending along a line generally tangential to a curvature of the spacer member. The fastening element, which could be screw, is disposed in the tangential bore in engagement with the ring member and extends across the ring spacing. The first magnetic element is supported by or enclosed within the spacer member. A vessel plate with a vessel mounting aperture is structured to accommodate the mounting or installation of the vessel. A second magnetic element is supported by the vessel plate. When the vessel is inserted in the aperture of a vessel plate, magnetic attraction causes the first and second magnetic elements to become aligned with each other, ad concentricity between the inner surfaces of the vessel and a shaft extending into the vessel is thereby established.

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MAGNETICAL VESSEL CENTERING SYSTEM AND METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

This is a continuation-in-part of U.S. Patent Application Serial No. 09/697,963, filed October 27, 2000, the entire contents of which are herein incorporated by reference.

BACKGROUND OF THE INVENTION

The present invention generally relates to the preparation or testing of sample substances contained in vessels in which stirring devices or other instruments operate. More particularly, the present invention relates to the centering and alignment of such vessels with respect to the stirring device.

In the pharmaceutical industry, the stirring or agitation of sample drugs or other substances in vessels is an important step in sample preparation procedures. Examples of such procedures include those performed for the purpose of testing and analyzing the rate at which doses release from pharmaceutical products, such as tablets or capsules, under controlled conditions. The procedural steps, test duration, dissolution medium, and apparatus employed in dissolution tests typically must comply with established, well-recognized guidelines, such as those promulgated by United States Pharmacopeia (USP), in order for the test to be accepted as valid for the specific substance tested.

The apparatus utilized for carrying out dissolution testing typically includes a vessel plate having an array of apertures into which test vessels are mounted. When the procedure calls for heating the media contained in the vessels, a water bath is often provided underneath the vessel plate such that each vessel is at least partially immersed in the water bath to enable heat transfer from the heated bath to the vessel media. In one exemplary type of test configuration (e.g., USP-NF Apparatus 1), a cylindrical basket is attached to a metallic drive shaft and a pharmaceutical sample is loaded into the basket. One shaft and basket combination is manually or automatically lowered into each test vessel mounted on the vessel plate, and the shaft and basket are caused to rotate. In another type of test configuration (e.g., USP-NF Apparatus 2), a blade-type paddle is attached to each shaft, and the pharmaceutical sample is dropped into each vessel such that it falls to the bottom of the vessel. When proceeding in accordance with the general requirements of Section <711> (Dissolution) of USP24 - NF19, each shaft must be positioned in its respective vessel so that its axis is not more than 2 mm at any point from the vertical axis of the vessel.

It is therefore an important criterion in certain uses of vessels in which shafts operate that the vessel, and especially its inner surfaces, be aligned concentrically with respect to the shaft, and various approaches have heretofore been taken to assist in meeting this criterion.

One approach is disclosed in U.S. Patent No. 5,403,090 to Hofer et al., in which at least two embodiments of a vessel aligning structure are provided to lock a standard USP dissolution test vessel into a stable, centered position in a vessel plate relative to a stirring shaft. The vessel is extended through one of the apertures of the vessel plate such that the flanged section of the vessel rests on the top of the vessel plate.

In one embodiment disclosed in U.S. Patent No. 5,403,090, the vessel aligning structure includes an annular ring having a tapered cylindrical section depending downwardly against the inner surface of the vessel, and an annular gasket surrounding the annular ring. When the vessel aligning structure is pressed onto the vessel, the annular gasket is compressed between the vessel aligning structure and the flanged section of the vessel. A mounting receptacle is secured to the vessel plate adjacent to each aperture of the vessel plate. The vessel aligning structure further includes a horizontal bracket arm which slides into the mounting receptacle and is secured by a wing nut and associated threaded stud. The bracket arm also supports the mounting assembly for the motor and stirring shaft associated with that particular vessel location of the vessel plate.

In another embodiment disclosed in U.S. Patent No. 5,403,090, the vessel aligning structure includes a plurality of mounting blocks secured to the vessel plate. One mounting block is positioned over each aperture of the vessel plate. Each mounting block includes a tapered cylindrical section depending downwardly against the inner surface of the vessel. The mounting block has two alignment bores which fit onto corresponding alignment pegs protruding upwardly from the vessel plate.

Another approach to vessel alignment is disclosed in U.S. Patent No. 5,589,649 to Brinker et al, in which each aperture of a vessel plate is provided with three alignment fixtures circumferentially spaced in 120 degree intervals around the aperture. Each alignment fixture includes two semi-rigid alignment arms or prongs extending into the area above the aperture. The flanged section of the vessel rests on top of the alignment arms, such that each pair of alignment arms contact the outer surface of the vessel and the vessel is thereby supported by the alignment fixtures. The alignment arms are described as exerting compressive or "symmetrical spring" forces that tend to center the vessel within the aperture of the vessel plate in which the vessel is installed in order to align the vessel with respect to a stirring element.

Many current vessel centering systems require an unacceptably large footprint around the vessels of a dissolution testing apparatus. As acknowledged by those skilled in the art, a vessel centering system that takes up less area would permit the design of a smaller overall apparatus. The use of a smaller apparatus would be highly desirable in view of the costs associated with building and maintaining pharmaceutical laboratory space.

In addition, current vessel centering systems require the manipulation of two or more components to account for the often poor and/or inconsistent manufacturing tolerances observed in the wall thickness of the extruded glass tubing from which vessels are formed and in the vessel manufacturing process itself. As noted in the publication "Dissolution Discussion Group®," Vol. 1, Section 29.2 (VanKel Technology Group, 1999), glass vessels can be made by hand from large-bore glass tubing. The glass tubing is placed in a rotating device similar to a lathe, heat is applied, and the tubing is separated and sealed to form a hemispheric or other shaped bottom section. Heat is continually applied while the vessel is blown into the desired shape. This labor-intensive process can result in dimensional irregularities in the finished glass product. While plastic vessels are manufactured with better tolerances since they are fashioned from molds, plastic vessels are generally less desirable in many applications due to drug affinity with the surface and slower heat-up rate. Accordingly, there presently exists a need for developing a vessel centering system that adequately addresses the poor tolerance issue.

It is believed that a continuing need exists for practical and effective solutions to providing a vessel centering system. The present invention is provided to address these and other problems associated with the centering and alignment of vessels.

SUMMARY OF THE INVENTION

The present invention generally provides a vessel centering or alignment system which establishes and maintains a high degree of concentricity between the inner surfaces of a vessel and its associated shaft. The invention finds advantageous utility in any application in which concentricity is desired as between a vessel and a shaft or other elongate instrument extended into and operating within the vessel. The invention is particularly useful in connection with a sample handling or dissolution apparatus in which one or more vessels are to be installed onto or into some type of a vessel plate or rack. The invention is broadly characterized as providing a vessel which has a structurally distinct, locking flanged section.

According to one embodiment of the present invention, a vessel is adapted for improved centering with respect to a spindle when such vessel is installed in a vessel plate. The vessel comprises a vessel wall, an annular, spacer member, and a fastening or locking element. The vessel wall includes an outer surface and a vessel groove formed on a circumference of the vessel outer surface. The spacer member is fitted in the vessel groove and extends outwardly with respect to the vessel wall, terminating at a first lateral end surface and a second lateral end surface. The fastening element engages the spacer member near the first and second lateral end surfaces.

According to another embodiment of the present invention, the spacer member includes an outer surface, a first lateral end surface, a second lateral end surface, a first tangential bore, and a second tangential bore. The first tangential bore extends from a first outer aperture of the spacer member outer surface to a first inner aperture of the first lateral end surface. The second tangential bore extends from a second outer aperture of the spacer member outer surface to a second inner aperture of the second lateral end surface. The first and second lateral end surfaces define a gap therebetween. The first and second tangential bores extend along a line generally tangential to a curvature of the spacer member. The fastening element is disposed in the first and second tangential bores. The fastening element extends through the first inner aperture, across the gap, and through the second inner aperture, such that the fastening element is movable along the generally tangential line of the first and second tangential bores to engage the spacer member and tighten or lock the spacer member in the vessel groove.

According to yet another embodiment of the present invention, a vessel centering system comprises a vessel, an annular, spacer member, a fastening element, and an elastometric component. The vessel includes an outer surface and a vessel groove formed on a circumference of the vessel outer surface. The spacer member is fitted in the vessel groove and extends outwardly with respect to the vessel, terminating at first and second lateral end surfaces. The first and second lateral end surfaces define a gap therebetween. The spacer member includes a tangential bore and an annular groove. The tangential bore extends along a line generally tangential to a curvature of the spacer member. The fastening element is disposed in the tangential bore in engagement with the spacer member and extends across the gap. The elastometric component is disposed in the annular groove.

According to a further embodiment of the present invention, a vessel centering system comprises a vessel including an outer surface and a vessel groove formed on a circumference of the vessel outer surface, an annular, C-shaped ring member fitted in the vessel groove and extending outwardly with respect to the vessel, and means for tightening the ring member against the vessel groove.

According to an additional embodiment of the present invention, a vessel centering system includes a radial extension element disposed in contact with a ring member fitted to a precision groove cut along an outer circumference of a vessel.

According to yet another embodiment of the present invention, a plurality of biased bearings are substituted for the elastometric component.

According to a still further embodiment of the present invention, the vessel centering system comprises means for presenting a vessel alignment surface for the vessel centering system.

According to an additional embodiment of the present invention, a vessel centering system comprises a vessel plate, a vessel, an annular, spacer member, and a mechanical contact element. The vessel plate includes a vessel plate aperture. The vessel plate aperture includes a first edge and a second edge which cooperatively define an annular shoulder. The vessel extends through the vessel plate aperture, and includes an outer surface and a vessel groove formed on a circumference of the vessel outer surface. The spacer member is fitted in the vessel groove and disposed on the first edge of the vessel plate aperture. The spacer member terminates at a first lateral end surface and a second lateral end surface. The mechanical contact element is disposed in engagement with the spacer member at the first and second lateral end surfaces.

The present invention also provides a method for aligning a vessel concentrically with respect to a shaft extending into the vessel, wherein an annular member is fitted in a groove formed around an outer surface of a flangeless vessel body, thereby forming a multi-piece flanged vessel. The ring member is locked or tightened in the vessel groove by utilizing a fastening element engaging the ring member.

The present invention further provides a method for assembling a vessel centering system. A circumferential groove is formed on an outer surface of a flangeless vessel body. An annular, spacer member can be formed such that the spacer member terminates at a first lateral end surface and a second lateral end surface, with the first and second lateral end surfaces defining a gap therebetween. A tangential bore is formed in the spacer member such that the tangential bore extends along a line generally tangential to a curvature of the spacer member and includes two bore sections opposing each other across the gap of the spacer member. A fastening element is provided and is adapted to engage the spacer member at the tangential bore. The spacer member is fitted in the vessel groove to form a multi-piece flanged vessel. The spacer member is secured in the vessel groove by adjusting a position of the fastening element with respect to the tangential bore.

According to another embodiment of the present invention, a vessel is adapted for improved centering with respect to a spindle or other instrument when installed in a vessel plate. The vessel comprises a vessel wall, a ring member, and a magnetic element. The vessel wall includes an outer surface and a vessel groove formed on a circumference of the vessel outer surface. The ring member is fitted in the vessel groove and extends outwardly with respect to the vessel wall. The magnetic element is supported by the ring member.

According to yet another embodiment of the present invention, the ring member supporting the magnetic element terminates at a gap defined by a first lateral end surface of the ring member and a second lateral end surface of the ring member. A fastening element engages the ring member at the first and second lateral end surfaces.

According to still another embodiment of the present invention, a vessel is adapted for improved centering with respect to a spindle or other instrument when installed in a vessel plate. The vessel comprises a vessel wall, an upper ring member, a lower ring member, a magnetic element, and a fastening element. The vessel wall includes an outer surface and a vessel groove formed on a circumference of the vessel outer surface. The upper ring member is fitted in the vessel groove and extends outwardly with respect to the vessel wall. The upper ring member terminates at a first upper ring member end surface and a second upper ring member end surface. An upper gap is defined between the first and second upper ring member end surfaces. The lower ring member is fitted in the vessel groove in adjacent contact with the upper ring member, and extends outwardly with respect to the vessel wall. The lower ring member terminates at a first lower ring member end surface and a second lower ring member end surface. A lower gap is defined between the first and second lower ring member end surfaces and is substantially aligned with the upper gap. The magnetic element is mounted to the lower ring member and is covered by the upper ring member. The fastening element extends between the first and second end surfaces of the upper and lower ring members.

According to a further embodiment of the present invention, a vessel is adapted to be centered with respect to a spindle or other instrument when installed in a vessel plate. The vessel comprises a vessel wall, a ring member, a magnetic element, and a fastening element. The vessel wall includes an outer surface and a vessel groove formed on a circumference of the vessel outer surface. The ring member is fitted in the vessel groove and extends outwardly with respect to the vessel. The ring member includes an outer surface, a first lateral end surface, a second lateral end surface, and first and second tangential bores. The first tangential bore extends from a first outer aperture of the ring member outer surface to a first inner aperture of the first lateral end surface, and the second tangential bore extends from a second outer aperture of the ring member outer surface to a second inner aperture of the second lateral end surface. The first and second lateral end surfaces define a gap therebetween. The first and second tangential bores extend along a line generally tangential to a curvature of the ring member. The magnetic element is supported by the ring member. The fastening element is disposed in the first and second tangential bores. The fastening element extends through the first inner aperture, across the gap, and through the second inner aperture, such that the fastening element is movable along the generally tangential line of the first and second tangential bores in engagement with the ring member.

According to a still further embodiment of the present invention, a vessel centering system comprises a vessel including an outer surface and a vessel groove formed on a circumference of the vessel outer surface, an annular spacer member fitted in the vessel groove and extending outwardly with respect to the vessel, a magnetic element supported by the spacer member, and means for tightening the spacer member against the vessel groove. The tightening means can include a fastening element engaging a bore of the spacer member.

According to a yet further embodiment of the present invention, a vessel centering system comprises a vessel plate, a vessel, an annular spacer member, and first and second magnetic elements. The vessel plate includes the first magnetic element, and also includes a vessel plate aperture. The vessel extends through the vessel plate aperture. The vessel includes an outer surface and a vessel groove formed on a circumference of the vessel outer surface. The annular spacer member is fitted in the vessel groove and is disposed on the vessel plate. The second magnetic element is supported by the spacer member, and is aligned with the first magnetic element by magnetic attraction.

According to an additional aspect of the present invention, a method is provided for aligning a vessel concentrically with respect to a shaft extending into the vessel. A flangeless vessel body is provided, which has a groove formed circumferentially around an outer surface of the vessel. An annular spacer member is fitted in the vessel groove. The spacer member includes a first magnetic element. The vessel body and the spacer member cooperatively form a multi-piece flanged vessel. The spacer member is secured in the vessel groove by utilizing a fastening element engaging the spacer member.

It is therefore an object of the present invention to provide a vessel centering system adapted to easily and quickly achieve concentricity as between the inner surfaces of a vessel and a stirring element or other spindle or shaft-type instrument inserted into the vessel.

It is another object of the present invention to provide a multi-piece flanged vessel wherein the flanged section is a separate, removable structural component.

It is a further object of the present invention to provide a flanged vessel wherein the flanged portion can be locked onto the vessel wall or removed therefrom.

It is yet another object of the present invention to provide a vessel adapted for improved installation with a vessel plate, such as a vessel plate typically provided with a liquid handling apparatus or dissolution testing apparatus.

Some of the objects of the invention having been stated hereinabove, other objects will become evident as the description proceeds when taken in connection with the accompanying drawings as best described hereinbelow.

Brief Description of the Drawings

Figure 1 is a perspective view of a vessel centering system provided according to the present invention;

Figure 2 is a vertical cross-sectional view of the vessel centering system illustrated in Figure 1, and additionally of a shaft-based instrument operable in conjunction with the vessel centering system;

Figure 3 is a detailed vertical cross-sectional and partial cutaway view of the vessel centering system installed on a vessel plate according to the present invention;

Figure 4 is a detailed perspective and partial cutaway view of the vessel centering system illustrating an inner cross-sectional portion of a ring member provided according to the present invention;

Figure 5 is a top plan view of a spacer member or removable flange piece according to an embodiment of the present invention;

Figure 6 is a detailed vertical cross-sectional and partial cut-away view of an alternative embodiment of the vessel centering system installed in a vessel plate;

Figure 7A is a top plan view of the vessel centering system according to one embodiment of the present invention wherein biased radial members are utilized;

Figure 7B is a top plan view of the vessel centering system according to another embodiment of the present invention wherein biased radial members are oriented differently from those radial members illustrated in Figure 7A;

Figure 8 is an exploded, perspective view of a vessel centering system according to another embodiment of the present invention in which magnets are utilized;

Figure 9 is a bottom plan view of a region of a vessel plate containing magnets to accommodate the mounting of the vessel centering system illustrated in Figure 8;

Figure 10 is a top plan view of the vessel centering system illustrated in Figure 8 mounted in the vessel plate illustrated in Figure 9;

Figure 11 is a detailed vertical cross-sectional and partial cut-away view of the embodiment of the vessel centering system illustrated in Figures 8 – 10, and showing the interaction of a pair of magnets in accordance with the present invention;

Figure 12 is a front elevation view of a section of a two-part vessel alignment ring provided in accordance with the present invention; and

Figure 13 is a top plan view of a vessel centering system mounted in a vessel plate in accordance with a further embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to Figures 1 and 2, a vessel centering/alignment system generally designated **10** is provided in accordance with the present invention, and is particularly suited for use in conjunction with a dissolution testing apparatus. Broadly stated, vessel centering system **10** includes a vessel generally designated **20** and a vessel alignment ring generally designated **30**. Vessel **20** includes a vessel wall **22** having an inner surface **22A** and an outer surface **22B**. In the preferred embodiment, vessel **20** is a modification of a standard USP vessel having, for example, a lateral cylindrical section **20A** and a bottom hemispherical section **20B** (although bottom section **20B** could be flat, dimpled, or have some other suitable configuration). Vessel alignment ring **30** serves as the flanged section of vessel **20**, yet preferably is provided as a separate component such that vessel **20** could be characterized as having a multi-piece design. Vessel **20** is preferably constructed of a glass (or other transparent) material, and alignment ring **30** is preferably constructed of a polymeric material such as PVC or TEFLON material. Alignment ring **30** is C-shaped, and thus terminates at two lateral end surfaces **32A** and **32B** separated by a gap **34**, as best shown in Figure 4. As particularly shown in Figure 2, an annular groove **24** is precision cut or ground into outer surface **22B** of vessel wall **22** and is concentric with inner surface **22A**. One way to properly form annular groove **24** relative to inner surface **22A** is to chuck or attach a lathe to inner surface **22A**, such that the lathe moves about a central, longitudinal axis **L** of vessel **20** as annular groove **24** is cut.

Alignment ring **30** is mounted in this annular groove **24**. Annular groove **24** removes the irregularities that may be inherent in the extruded glass tubing or result from the glass manufacturing process. As will also become apparent from the present disclosure, vessel centering system **10** ensures concentricity as between inner surface **22A** of vessel **20** and an instrument operative within vessel **20** such as a shaft-based agitator device **80**, or any other device adapted for extension into vessel **20** along central axis **L** thereof. In addition, alignment ring **30** is designed for easy removal from vessel **20** either manually or by using a tool.

Referring to Figure 4, a fastening or clamping means such as a tangential screw **50** is employed to squeeze, tighten, or otherwise secure alignment ring **30** into annular groove **24** and around the periphery of vessel **20**, thus effectively locking alignment ring **30** into position with respect to vessel **20**. To accommodate tangential screw **50**, a tangential screw bore **36** is formed through the body of alignment ring **30** along a direction generally tangential to the curvature of alignment ring **30**. In the exemplary embodiment shown, tangential bore **36** spans across gap **34** between lateral end surfaces **32A** and **32B** such that tangential bore **36** includes two generally aligned bore sections **36A** and **36B**. First bore section **36A** extends between an outer surface **38** of alignment ring **30** and first lateral end surface **32A**, and opens at an outer aperture **41A** of outer surface **38** and at an inner aperture **43A** of first lateral end surface **32A**. Similarly, second bore section **36B** extends between outer surface **38** of alignment ring **30** and second lateral end surface **32B**, and opens at another outer aperture **41B** of outer surface **38** and at an inner aperture **43B** of second lateral end surface **32B**.

It will be understood that tangential screw **50** is but one type of fastening element which could be adapted to operate within the context of the present invention. Other fasteners or clamps, now or later developed, may be found suitable for serving the same purpose or function as that of tangential screw **50**. Preferably, second bore section **36B** includes an enlarged diameter section **36B'** to define a shoulder **36B"** within second bore section **36B**, and first bore section **36A** includes a threaded section **36A'** adapted to mate with the threads of tangential screw **50**. In this manner, a suitable tool (not shown) can be inserted through second outer aperture **41B** into second bore section **36B** and brought into operative engagement with a head portion **52** of tangential screw **50**. It will be understood that means other than a tool could be used to rotate tangential screw **50** or otherwise adjust its position relative to tangential bore **36**. Because tangential screw **50** is forced into movable engagement with threaded section **36A'** of first bore section **36A** and its head portion **52** is forced into engagement with shoulder **36B"** of second bore section **36B**, rotation of tangential screw **50** acts to adjust the position of tangential screw **50** with respect to tangential bore **36**, thereby adjusting the width of gap **34** and altering the outermost diameter and profile of alignment ring **30** to tighten or lock alignment ring **30** in place.

Referring to Figure 3, vessel **20** is adapted to be installed in a vessel plate **60**. In accordance with the present invention, vessel plate **60** includes one or more apertures, generally designated **62**, which are modified to receive vessel **20**. In this respect, modified vessel plate **60** could be considered as forming a part of vessel centering system **10**. Each vessel plate aperture **62** is defined by a first edge **64** and a second edge **66** of vessel plate **60**, which together define an annular shoulder **68** with which alignment ring **30** engages. Preferably, alignment ring **30** includes an annular groove **45**, and a removable resilient or elastometric component **70** such as an annular gasket or O-ring (or other elastometric centering means) is fitted into annular groove **45** concentric with alignment ring **30** and vessel **20**.

It can be seen that alignment ring **30** serves as a spacer means for bridging the annular gap presented between precision annular groove **24** and second edge **66** of vessel plate **60**, and for establishing the concentricity of vessel **20** with respect to longitudinal axis **L**. At the same time, elastometric component **70** serves as an outer frictional surface or radial extension of vessel **20**, and as a means for spanning the small (and potentially variable) annular gap presented between alignment ring **30** and the inner diameter of aperture **62** (i.e., second edge **66** of vessel plate **60**). The use of elastometric component **70** thus enhances the establishment of the concentricity of vessel **20** with respect to longitudinal axis **L** and agitator device **80**, rather than serving the conventional role of a seal.

It can also be seen that the frictional outer surface presented by elastometric component **70** prevents vertical displacement of vessel **20** out of its installed position in vessel plate **60**. This latter feature is advantageous in the situation where vessel or vessels **20** of vessel plate **60** have been immersed in a water bath, and the media content in one or more vessels **20** has been reduced to the point where vessel or vessels **20** are forcibly displaced upwardly due to buoyancy effects. Elastometric component **70** prevents its associated vessel **20** from "popping out" of vessel plate **60** in response to such buoyancy effects.

Referring to Figure 5, an alternative embodiment of an alignment ring, generally designated **130**, is illustrated according to the invention. Figure 5 illustrates that the alignment ring of the present invention, as a spacer means and a means for ensuring concentricity, can assume configurations other than a C-ring such as alignment ring **30** discussed hereinabove. By way of example in Figure 5, alignment ring **130** includes two or more segments **130A** and **130B** and accordingly defines two or more gaps **134A** and **134B**. In addition, two or more tangential bores **136A** and **136B** (with generally aligned bore sections) and corresponding tangential screws **150A** and **150B** are provided.

Referring to Figure 6, an alternate embodiment of the present invention is provided wherein an annular groove **145** is formed in a vessel plate aperture, generally designated **162**, instead of being formed in alignment ring **30** shown in Figure 3 (or alignment ring **130** shown in Figure 5). Annular groove **145** extends into second edge **66** of a modified vessel plate **160**. Elastomeric component **70** is fitted into annular groove **145**. In this manner, elastomeric component **70** serves as an inner frictional surface of vessel plate aperture **162** to perform its gap-spanning and concentric positioning functions.

Referring to Figure 7A, an alternative embodiment of the present invention is provided wherein the gap-spanning and concentric positioning means take the form of radially outwardly biased (such as by spring loading) bearings or dimples **270A**, **270B** and **270C**, instead of elastomeric component **70**. By way of example, three bearings **270A**, **270B** and **270C** are provided and are circumferentially spaced 120° from each other. Each bearing **270A**, **270B** and **270C** and its associated biasing mechanism **275A**, **275B** and **275C** are supported in or by a flanged section **230** (which can be integrally manufactured with a vessel **220** or provided as a separate, removable component as in other embodiments discussed above). Hence, bearings **270A**, **270B** and **270C** extend outwardly from flanged section **230** and are biased to make contact with a vessel plate aperture **262** of a vessel plate **260** to establish the concentricity of vessel **220**. In this embodiment, neither flanged section **230** nor aperture **262** require an annular gap **45** (see Figure 3) or **145** (see Figure 6). However, conformingly-shaped depressions or recesses **280A**, **280B** and **280C** may be provided along the inner diameter of aperture **262** at the respective locations of bearings **270A**, **270B** and **270C** to at least partially receive the outer profile of bearings **270A**, **270B** and **270C**.

Referring to Figure 7B, the respective orientations of bearings **270A**, **270B** and **270C** and their associated biasing mechanisms **275A**, **275B** and **275C** have been inverted such that they are radially inwardly biased toward a flanged section **230'** (which can be integrally manufactured with vessel **220** or provided as a separate, removable component as in other embodiments discussed above). Each bearing **270A**, **270B** and **270C** and its associated biasing mechanism

275A, **275B** and **275C** are supported in or by a vessel plate **260'**. Hence, bearings **270A**, **270B** and **270C** extend inwardly from an aperture **262'** of vessel plate **260'** and are biased to make contact with flanged section **230'** to establish the concentricity of vessel **220**. As in the embodiment illustrated in Figure 7A, neither flanged section **230'** nor aperture **262'** require an annular gap **45** (or **145**). However, conformingly-shaped depressions or recesses **280AA**, **280BB** and **280CC** may be provided along the outer diameter of flanged section **230'** at the respective locations of bearings **270A**, **270B** and **270C** to at least partially receive the outer profile of bearings **270A**, **270B** and **270C**.

Referring to Figure 8, a further alternative embodiment of the present invention is illustrated in which a vessel centering or alignment system, generally designated **300**, takes advantage of magnetic attractive forces for the purpose of properly centering or aligning vessel **20**. As in previously described embodiments, a multi-part system is provided in which an annular or ring member, generally designated **310**, is fitted in a circumferential groove **24** formed around a peripheral section of vessel wall **22**. As before, one or more tangential screws **50** and corresponding structural features (or other fastener elements such as clamps) can be employed to secure ring member **310** to groove **24**. In this particular embodiment, one or more magnetic elements **312** are provided with system **300** to interact with complementary magnetic elements supported in the vicinity of the apertures in which each such system **300** is to be mounted or installed. In the preferred embodiment illustrated in Figure 8, ring member **310** includes mounting bores **314** in which magnetic elements **312** are disposed. In the specific embodiment illustrated in Figure 8, ring member **310** comprises two parts: an upper part or ring member generally designated **310A**, and a lower part or ring member generally designated **310B**. Magnetic element or elements **312** could be mounted to or supported by either upper ring member **310A** or lower ring member **310B**. In the illustrated embodiment, magnetic elements **312** are disposed in mounting bores **314** of lower ring member **310B**, and upper ring member **310A** is placed in removable contact with lower ring member **310B** to cover the exposed top surfaces of magnetic elements **312** and thereby effect a complete enclosure of magnetic elements **312**.

Proper alignment or centering can be achieved by causing magnetic elements **312** supported by ring member **310** to interact with complementary magnetic elements supported in the vicinity of the apertures or mounting holes of a vessel plate. Referring to Figure 9, the underside of one section of a vessel plate **320** surrounding an aperture **322** of vessel plate **320** is illustrated. One or more magnetic elements **324** (illustrated in phantom) are supported by vessel plate **320** and situated around the periphery of each aperture **322** of vessel plate **320.** In the specific embodiment shown in Figure 9, magnetic elements **324** are housed in mounting blocks **326** that depend from a bottom surface **320A** of vessel plate **320.** Mounting blocks **326** could be formed with vessel plate **320**, or alternatively be provided as separate components that are attached to bottom surface **320A.** Magnetic elements **324** supported by vessel plate **320** are precisely positioned such that, upon insertion or installation of each vessel **20** into each aperture **322**, each magnetic element **324** is attracted by magnetic force to a corresponding one of magnetic elements **312** supported by ring member **310** (see Figure 8). As a result, the magnetic attraction causes vessel **20** with ring member **310** to rotate and/or translate until each magnetic element **312** of ring member **310** becomes coaxially aligned with each corresponding magnetic element **324** of vessel plate **320**, with the axis of alignment being each central longitudinal axis of each pair of magnetic elements **312** and magnetic elements **324** . After this self-centering or self-alignment occurs, vessel **20** is held in a properly centered position under the influence of the magnetic forces localized with respect to each pair of magnetic elements **312** and **324.**

Figure 10 is a top view of a section of vessel plate **320**, in which vessel **20** has been installed in one aperture **322** of vessel plate **320** and self-alignment has occurred. The partially cutaway cross-sectional view in Figure 11 also shows this alignment resulting from magnetic attraction, as well as the proximity of one pair of magnetic elements **312** and **324** to each other and their co-alignment with each other. Figure 11 further shows that, instead of disposing ring member **310** on a topmost surface **320B** of vessel plate **320**, ring member **310** can be disposed in a shoulder **331** of vessel plate **320** defined by a horizontal surface **333** and a vertical or lateral surface **335** of vessel plate **320.**

Referring to Figure 12, some details are illustrated of ring member **310** when provided in two-part form. Upper ring member **310A** terminates at two lateral end surfaces **341** and **343**, respectively, which are separated by an upper gap **345.** Similarly, lower ring member **310B** terminates at two lateral end surfaces **351** and **353**, respectively, which are separated by a lower gap **355.** When upper ring member **310A** is brought into contact with lower ring member **310B**, upper gap **345** is generally aligned with lower gap **355** to form a single gap, the width of which can be varied by adjusting tangential screw **50** within tangential bore **36** having first and second bore sections **36A** and **36B** and outer apertures **41A** and **41B**, respectively. In the specific embodiment shown in Figure 12, each lateral end surface **351** and **353** of lower ring member

310B is profiled to define a respective shoulder **361** and **363**, such that lower gap **355** has a stepped profile. This configuration is useful for receiving protrusions **366** and **368** that depend from upper ring member **310A** at or near its lateral end surfaces **341** and **343**. When upper ring member **310A** is mounted onto lower ring member **310B**, protrusions **366** and **368** respectively engage shoulders **361** and **363**. Accordingly, the effect of tangential screw **50** in urging lateral end surfaces **351** and **353** of lower ring member **310B** towards each other is to likewise urge lateral end surfaces **341** and **343** of upper ring member **310A** towards each other. Protrusions **366** and **368** are dimensioned so as not to interfere with first and second sections **36A** and **36B** of tangential bore **36**.

It will be understood that the interfacial features of upper ring member **310A** and lower ring member **310B** could alternatively be inverted. That is, tangential bore **36** and its related structural features could be formed on upper ring member **310A** instead of lower ring member **310B**, lower ring member **310B** could define the stepped gap, and protrusions **366** and **368** could extend from lower ring member **310B** to engage the surfaces defining the stepped gap of upper ring member **310A**. Moreover, magnetic elements **312** could be supported by upper ring member **310A** rather than by lower ring member **310B**.

Referring now to Figure 13, a further alternative embodiment of the present invention is illustrated in which a ring member, generally designated **410**, has been fitted to vessel **20** and the system installed in a vessel plate **420**. In this particular embodiment, ring member **410** supports one or more radially-oriented magnetic elements **412**, such as in mounting bores **414**, and vessel plate **410** supports radially-oriented magnetic elements **424** such as in mounting bores **426**. Due to the magnetic attraction between corresponding pairs of magnetic elements **412** and **424**, self-centering or self-alignment of vessel **20** occurs and magnetic elements **412** and **424** radially oppose each other. It should be noted that in this embodiment, magnetic elements **412** and **424** are disposed along axes generally perpendicular or transverse to longitudinal axis **L** (see Figure 8) of vessel **20**. By contrast, in the embodiment shown in Figures 8 – 11, magnetic elements **312** and **324** are disposed along axes generally parallel with longitudinal axis **L** of vessel **20**.

It can therefore be seen from the foregoing description that the present invention provides a useful system for centering and aligning a vessel with respect to a stirring element or other elongate instrument intended to operate within such vessel.

It will be understood that various details of the invention may be changed without departing from the scope of the invention. Furthermore, the foregoing description is for the purpose of illustration only, and not for the purpose of limitation–the invention being defined by the claims.

WHAT IS CLAIMED IS:

1. A vessel centering apparatus adapted for improved centering with respect to a spindle or other instrument when installed in a vessel plate, the vessel comprising:
   (a) a vessel wall including an outer surface and a vessel groove formed on a circumference of the vessel outer surface;
   (b) a ring member fitted in the vessel groove and extending outwardly with respect to the vessel wall; and
   (c) a first magnetic element supported by the ring member.

2. The apparatus according to claim 1, comprising a vessel plate including a second magnetic element and a vessel plate aperture, wherein the vessel wall extends through the vessel plate aperture, the ring member is supported by the vessel plate, and the first magnetic element is aligned with the second magnetic element by magnetic attraction.

3. The apparatus according to claim 2, wherein the vessel plate aperture includes a first edge and a second edge cooperatively defining an annular shoulder, and the ring member is disposed on the first edge.

4. The apparatus according to claim 3, wherein the second magnetic element is supported by the vessel plate at a location below the first edge of the vessel plate aperture.

5. The apparatus according to claim 4, comprising a mounting block extending from the vessel plate at a location proximate to the first edge of the vessel plate aperture, wherein the second magnetic element is supported by the mounting block.

6. The apparatus according to claim 2, 3, 4 or 5 wherein the vessel wall is coaxially disposed about a longitudinal axis, and the first and second magnetic elements are co-aligned with each other along a direction generally parallel with the longitudinal axis.

7. The apparatus according to claim 2 or 3, wherein the vessel wall is coaxially disposed about a longitudinal axis, and the first and second magnetic elements are co-aligned with each other along a direction generally perpendicular to the longitudinal axis.

8. The apparatus according to any of the preceding claims wherein the ring member includes upper and lower portions, the lower portion includes a recess, the first magnetic element is disposed in the recess, and the upper portion contacts the lower portion to enclose the first magnetic element.

9. The apparatus according to claim 8, wherein the upper portion of the ring member terminates at first and second upper portion end surfaces, an upper portion gap is defined between the first and second upper portion end surfaces, the lower portion of the ring member terminates at first and second lower portion end surfaces, a lower portion gap is defined between the first lower portion and the second lower portion end surfaces, the upper portion gap is generally aligned with the lower portion gap, and the vessel comprises a fastener element engaging the ring member across the upper portion gap or the lower portion gap.

10. The apparatus according to any of claims 1 through 8, wherein the ring member terminates at a first lateral end surface and at a second lateral end surface and defines a gap therebetween, and the vessel comprises a fastening element engaging the ring member at the first and the second lateral end surfaces.

11. The apparatus according to claim 9 or 10, wherein the ring member includes a tangential bore extending along a line generally tangential to a curvature of the ring member, and the fastening element is disposed in adjustable engagement with the ring member at the tangential bore.

12. The apparatus according to claim 11 wherein:

(a) the ring member includes an outer surface having first and second outer apertures;

(b) the tangential bore includes a first tangential bore section extending from the first outer aperture to a first inner aperture of the first lateral end surface, and a second tangential bore section extending from the second outer aperture to a second inner aperture of the second lateral end surface; and

(c) the fastening element is disposed in the first and second tangential bore sections, extends through the first inner aperture, and the second inner aperture, and is adjustable along the generally tangential line of the first and second tangential bore sections to adjust a tightness of the fit of the ring member in the vessel groove.

13. A method for aligning a vessel concentrically with respect to a shaft extending into the vessel, comprising the steps of:

(a) providing a flangeless vessel body having a groove formed circumferentially around an outer surface of the vessel;

(b) fitting an annular spacer member in the vessel groove, the spacer member including a first magnetic element, wherein the vessel body and the spacer member cooperatively form a multi-piece flanged vessel; and

(c) securing the spacer member in the vessel groove by utilizing a fastening element engaging the spacer member.

14. The method according to claim 13, comprising the step of installing the vessel in an aperture of a vessel plate, the vessel plate including a second magnetic element, wherein magnetic attraction between the first and second magnetic elements causes the vessel to become aligned in the aperture.

15. The method according to claim 13 or 14 comprising the step of providing the spacer member in two-part form, wherein a first part of the spacer member contacts a second part of the spacer member, and the first magnetic element is enclosed by the first and second parts.

16. The method according to claim 13, 14 or 15 wherein the step of fitting the spacer member in the vessel groove includes using a fastener element to engage the spacer member.

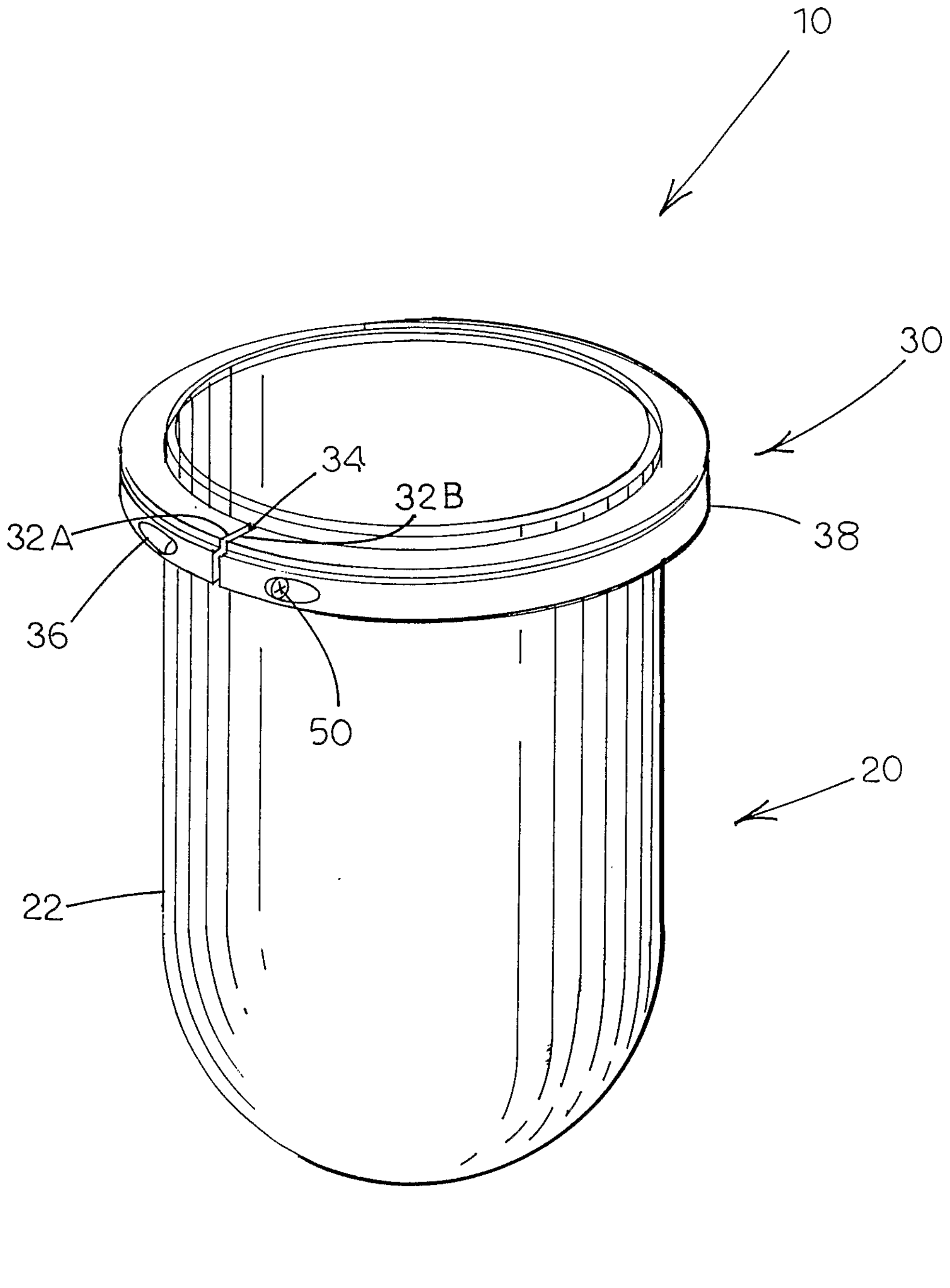

Fig.1

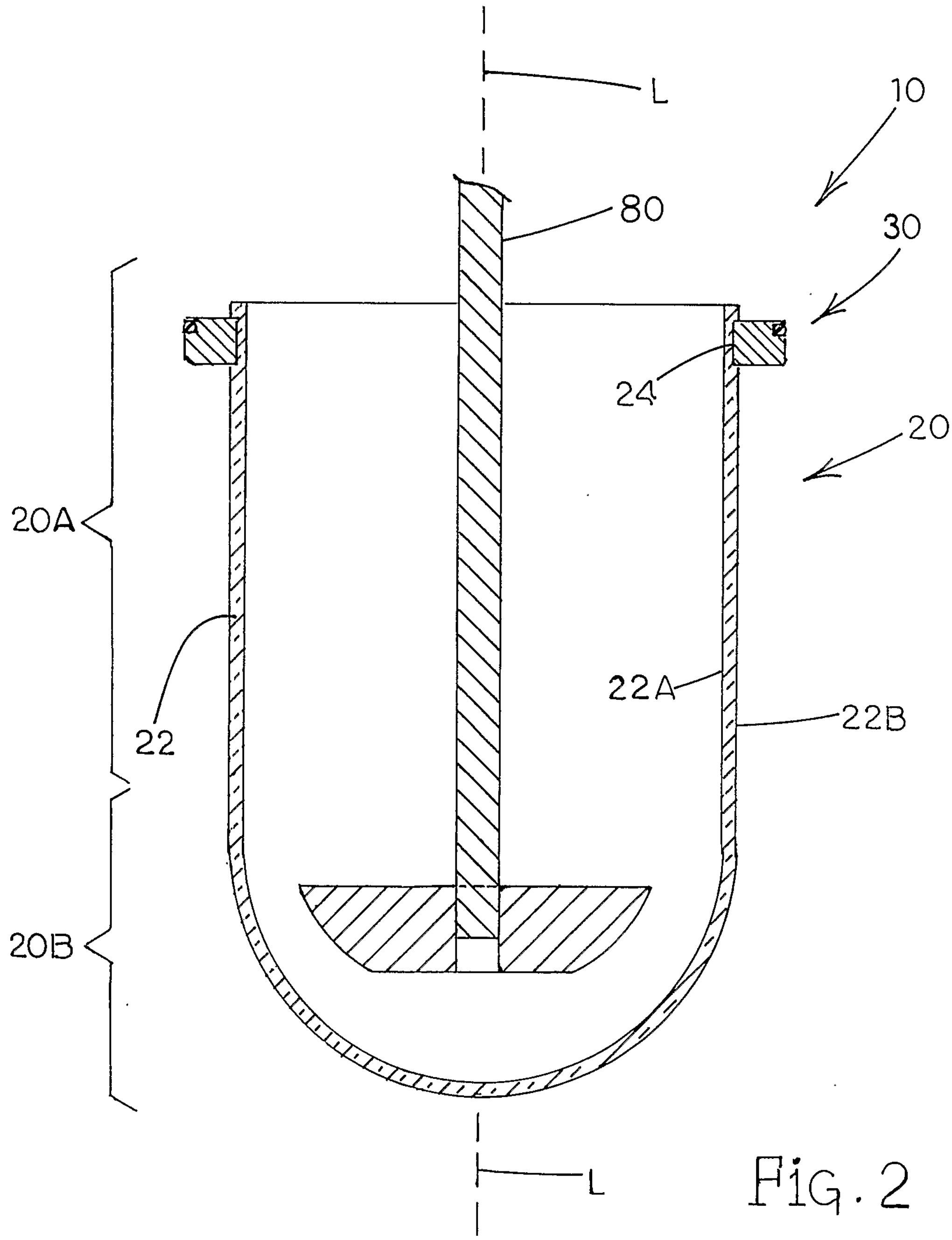

Fig. 2

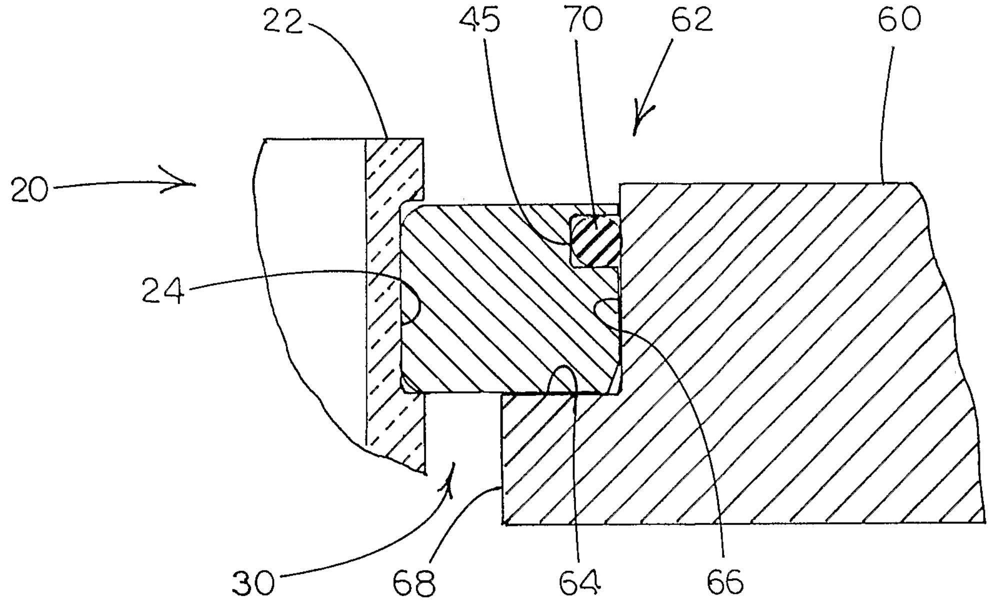
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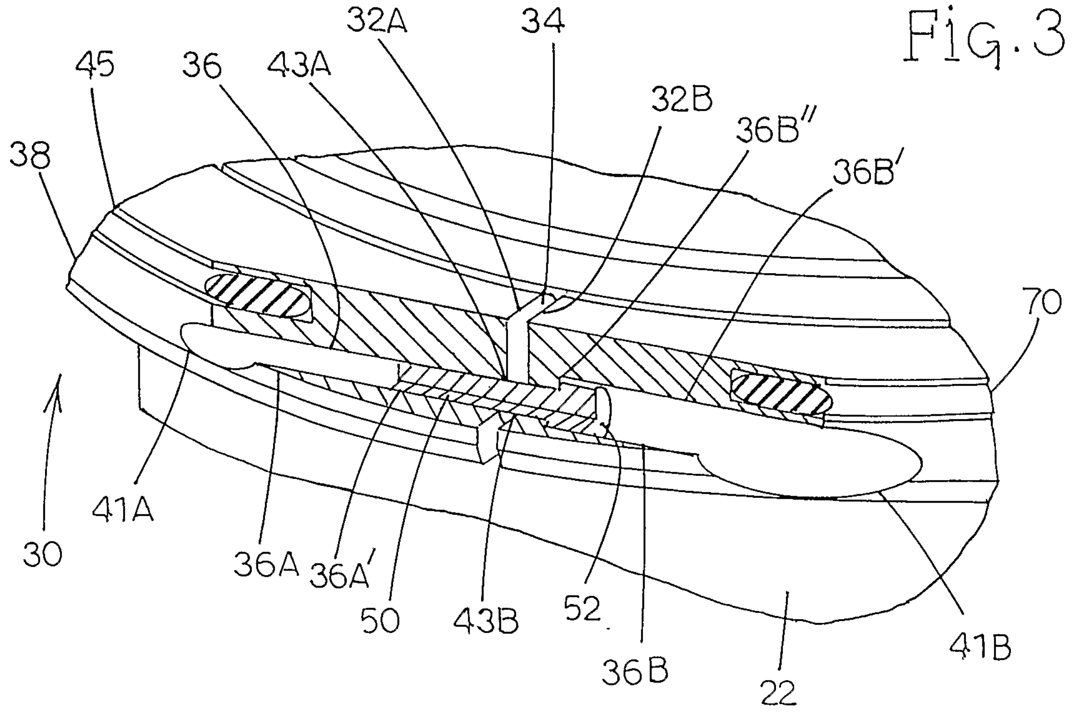
Fig.3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41B

Fig.4

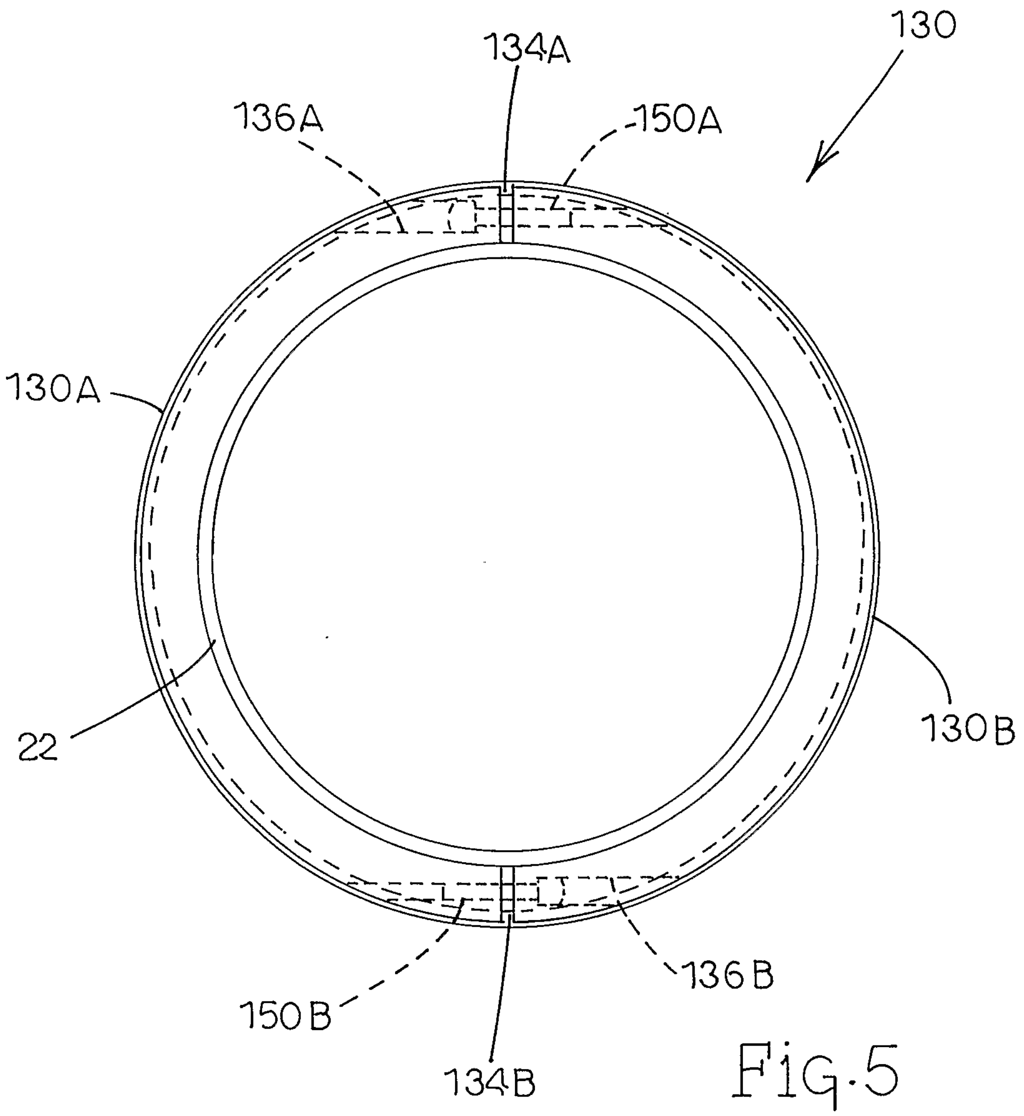


Fig.5

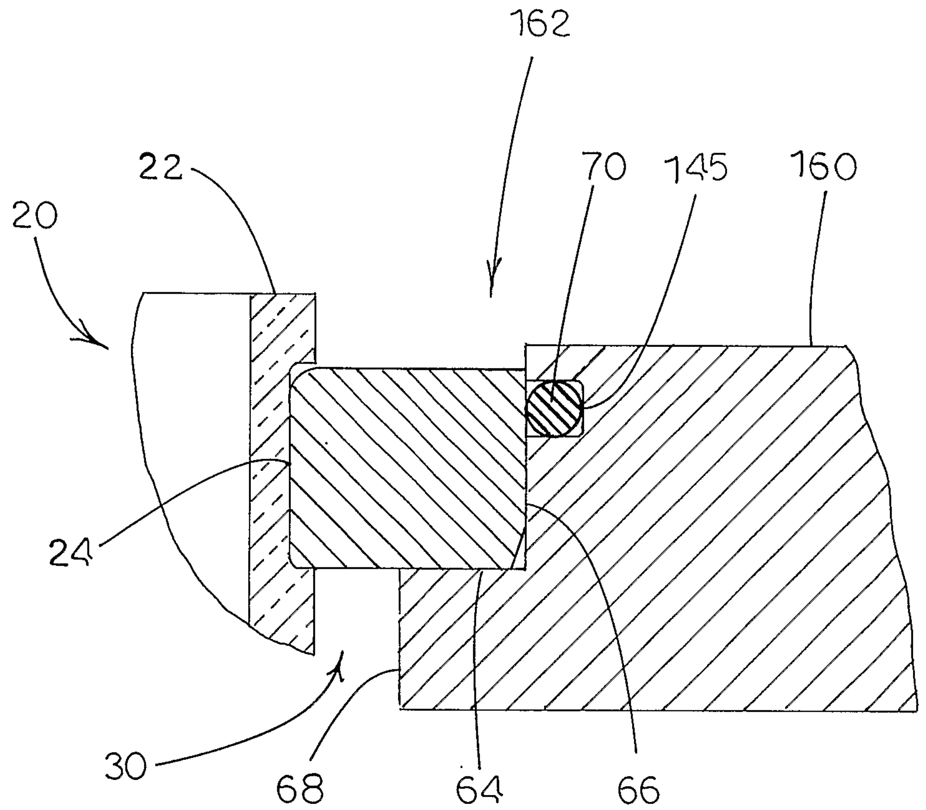
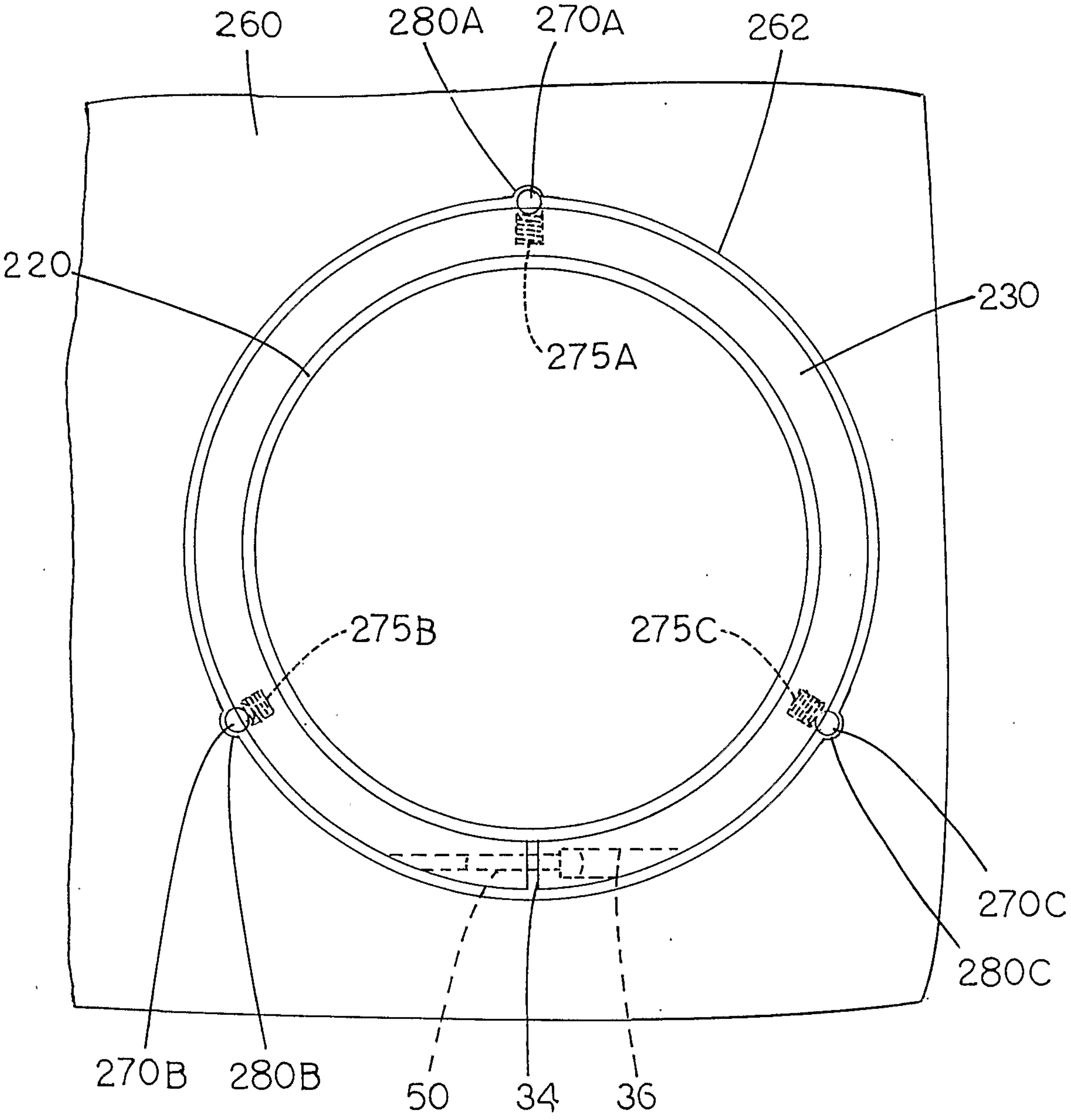


Fig. 6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280C
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280B
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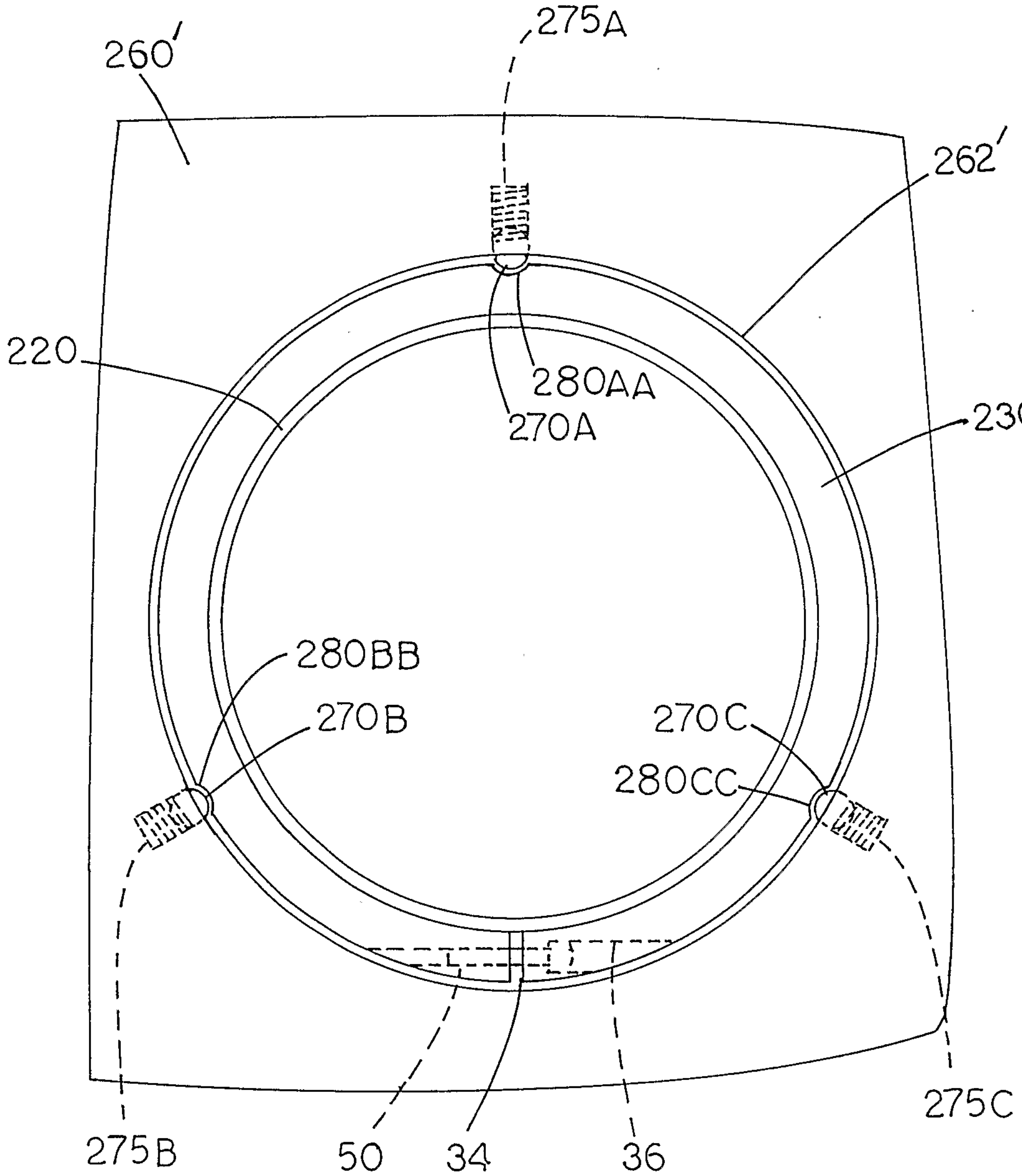
36

Fig. 7A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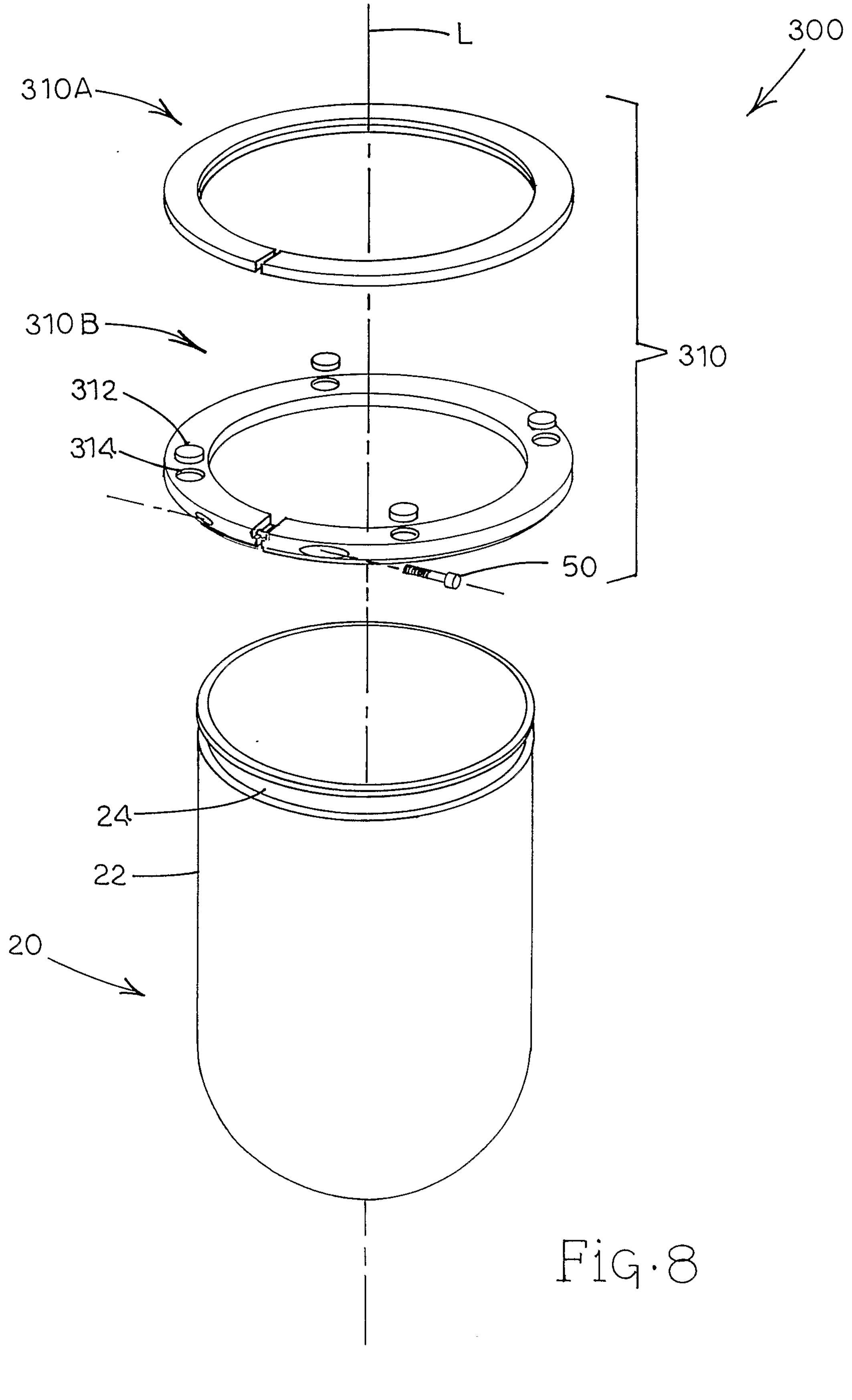
275C

Fig.7B



Fig·8

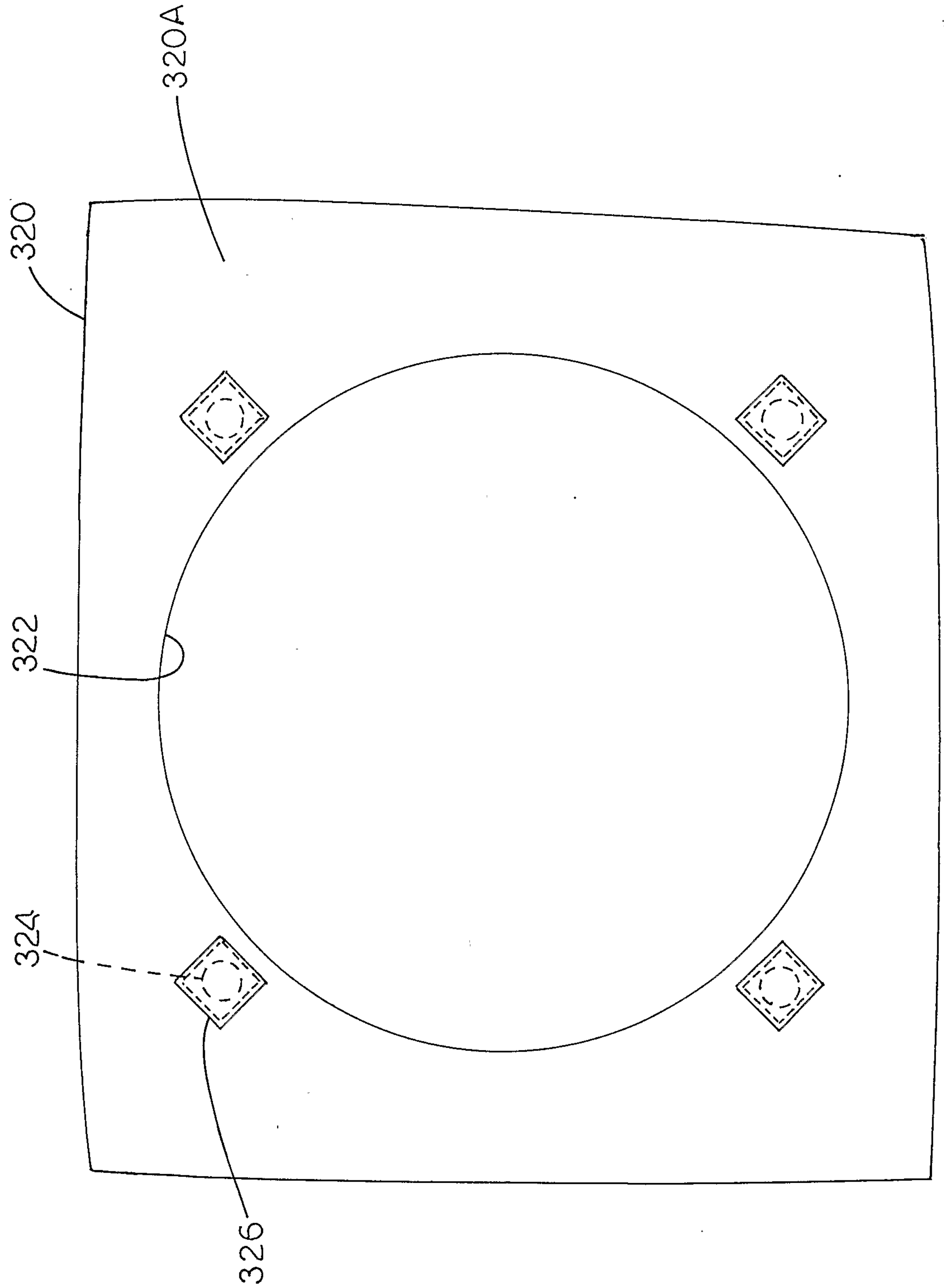


Fig.9

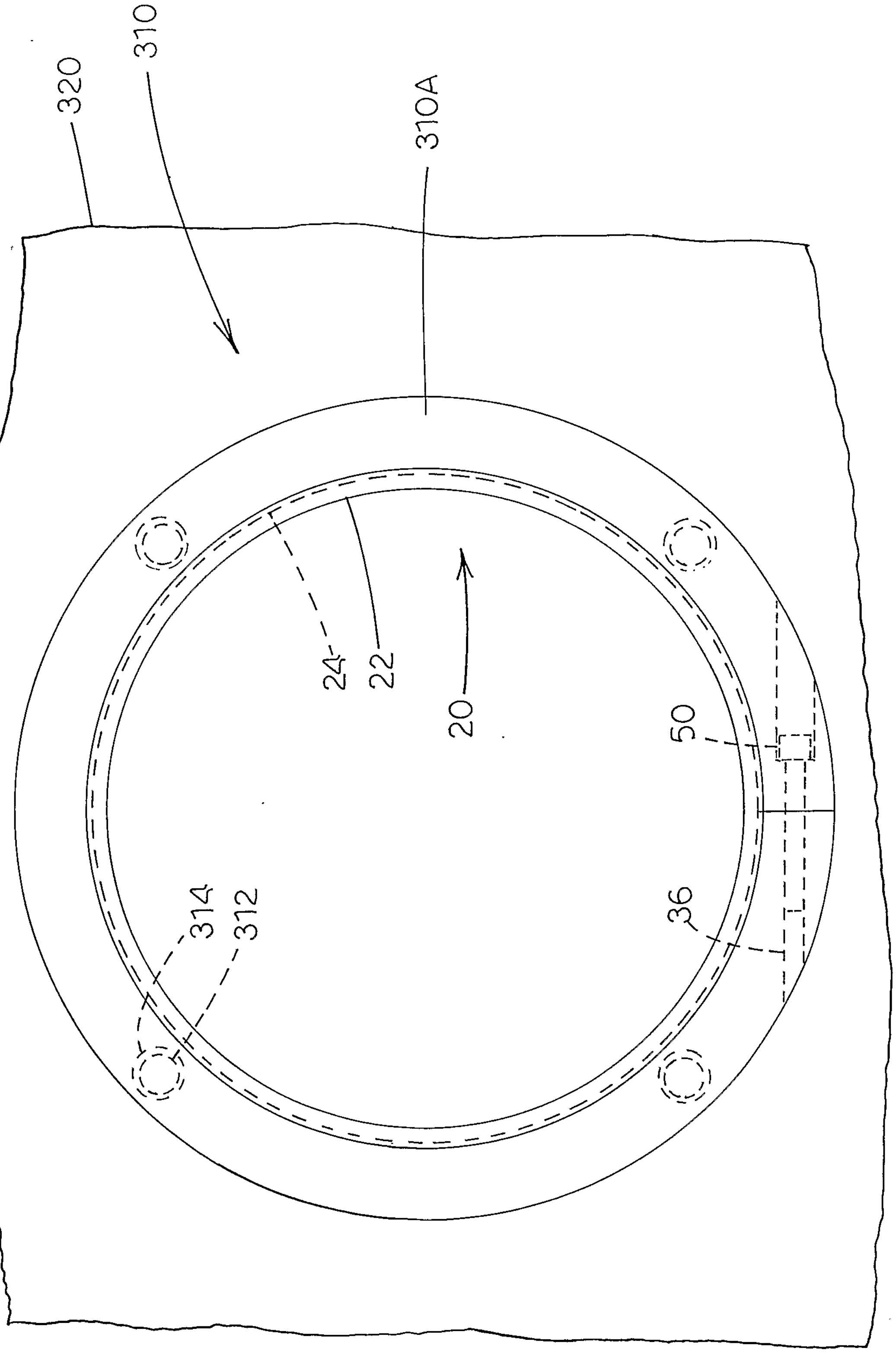


Fig.10

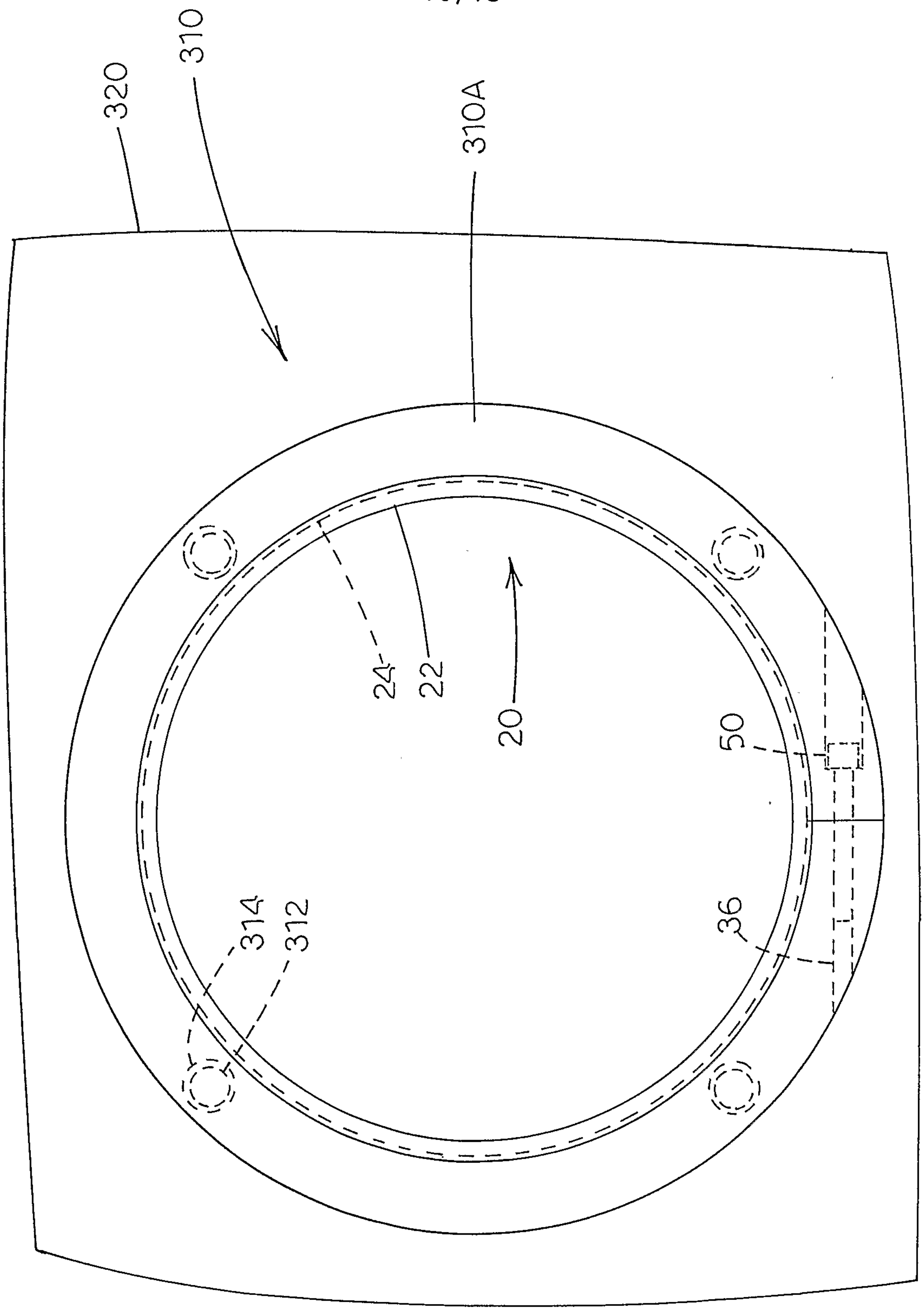


Fig.10

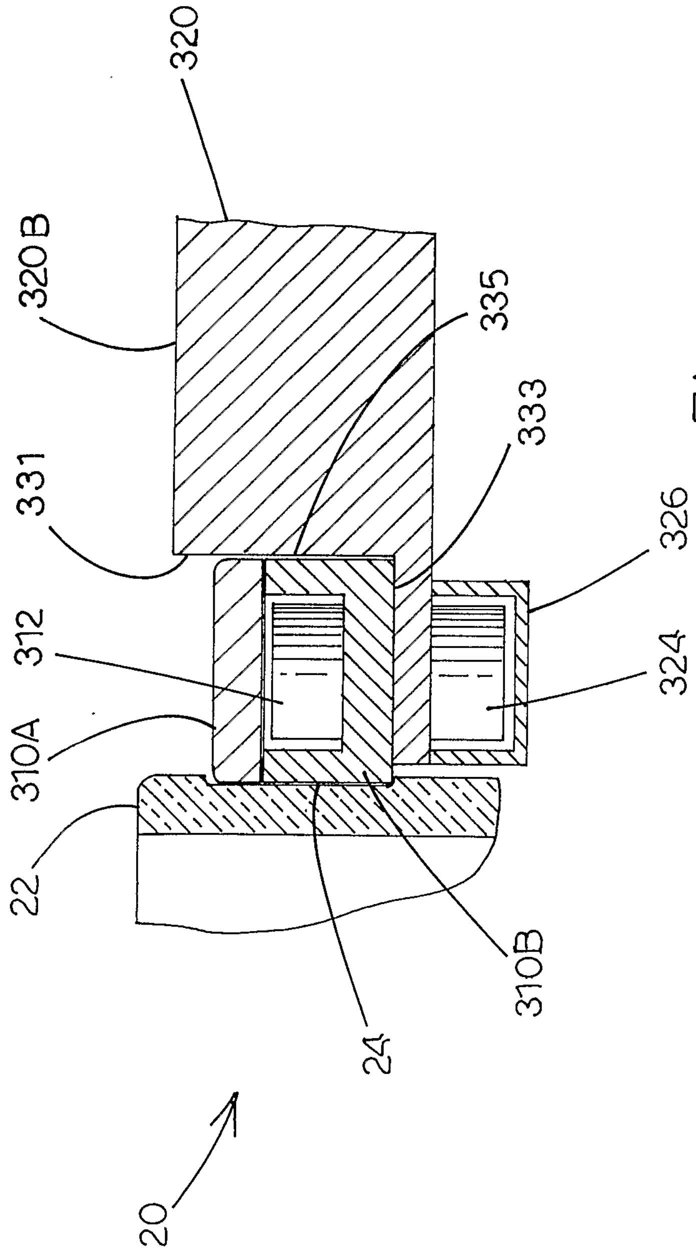
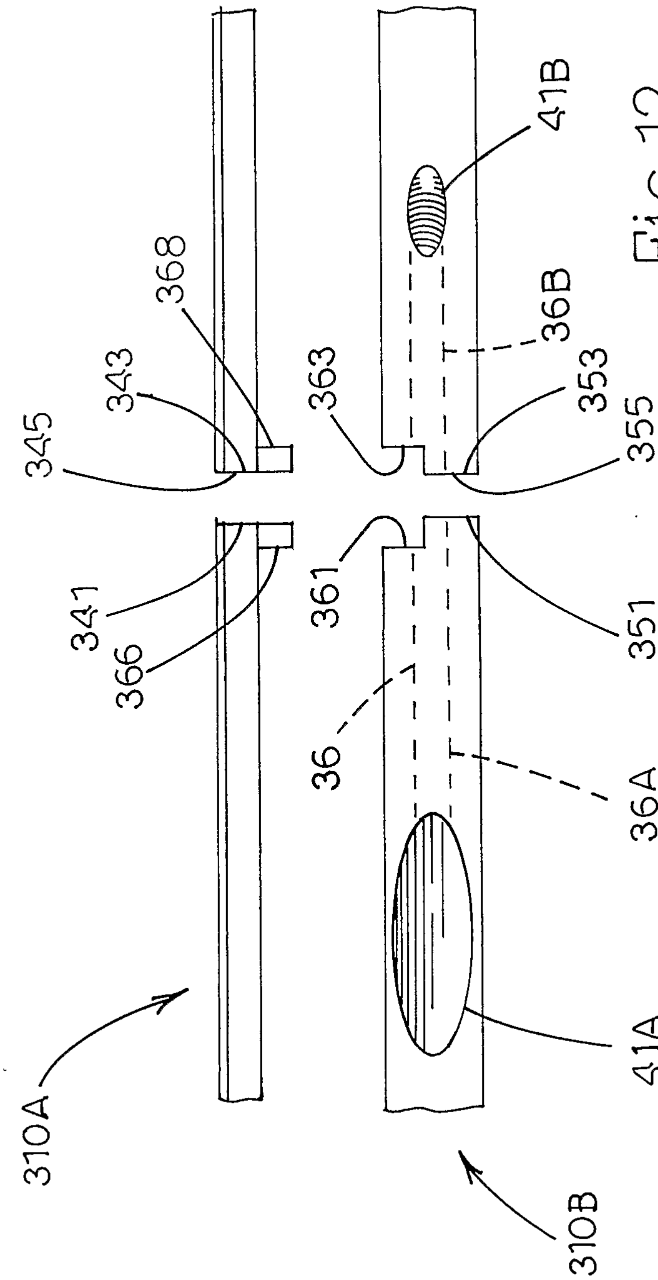


FIG. 11


310A
310B
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36B
41A
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355

Fig.12

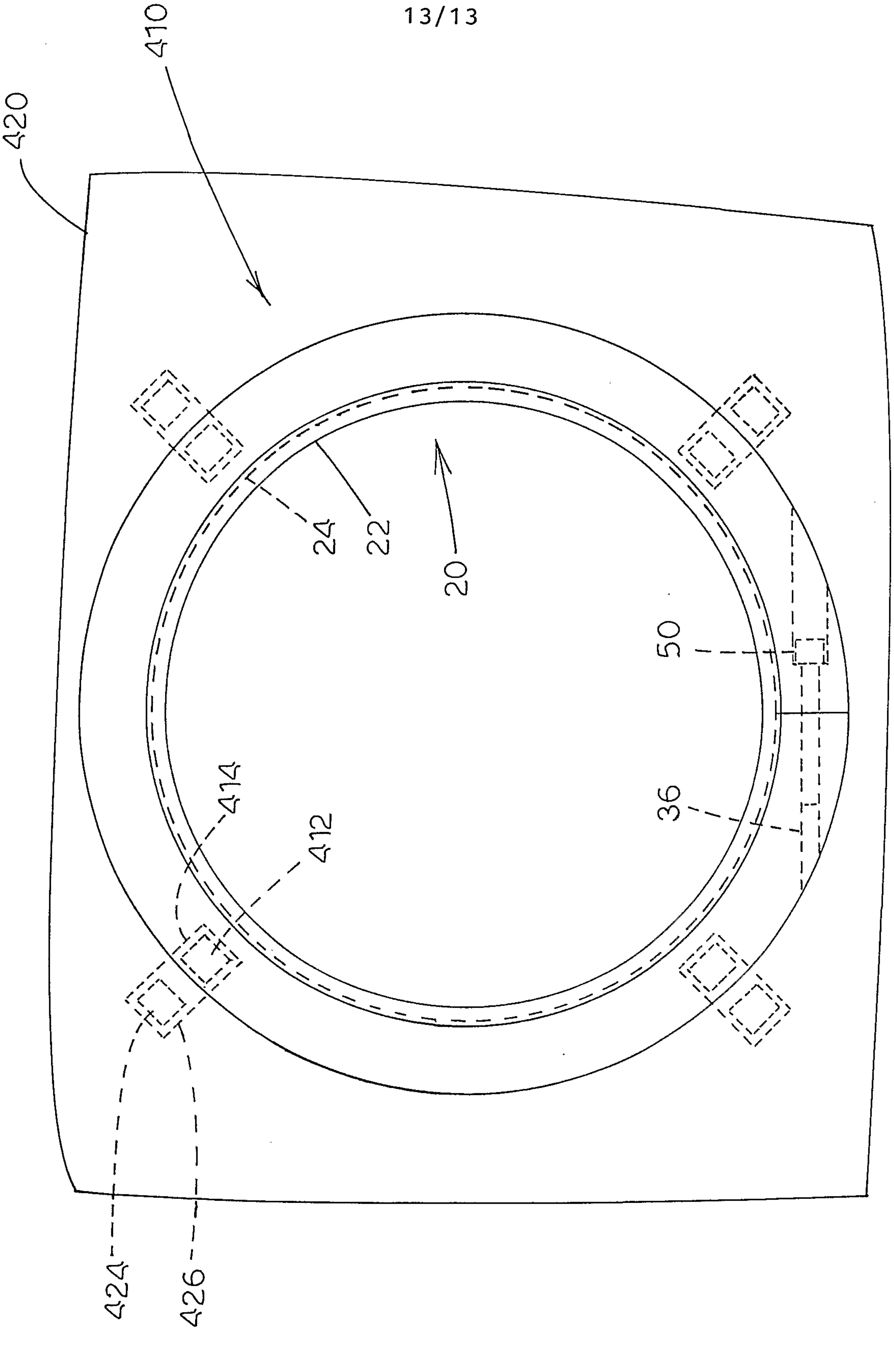

Fig.13

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 02/07825

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B01L9/06 B65D23/00 B01F11/00 B01F15/00 B01L3/14

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B01F B01L G01N B65D B01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	WO 98 38478 A (ICON DYNAMICS LLC) 3 September 1998 (1998-09-03) abstract ---	1-16
A	US 5 589 649 A (BRINKER GERALD ET AL) 31 December 1996 (1996-12-31) figure 13 column 7, line 11 -column 7, line 36 ---	2-16
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
13 June 2002	24/06/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Tiede, R

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

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PCT/US 02/07825

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