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(54) **DISTILLATION APPARATUS AND METHOD OF TRANSPORTING THE SAME**

DESTILLATIONSVORRICHTUNG UND TRANSPORTVERFAHREN DAFÜR

APPAREIL DE DISTILLATION ET SON PROCEDE DE TRANSPORT

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US-A- 4 116 150 US-B1- 6 202 305  
US-B1- 6 360 545 US-B1- 6 378 331**

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**Description**

**[0001]** The present invention relates to a distillation column in combination with an insulation structure or container. The invention is primarily concerned with large distillation columns, for example columns having a diameter of about 3.5m (about 11 ft) or more, and is of particular application to cryogenic distillation columns. However, the invention could also be employed with other separation columns such as hydrocarbon gas separation columns.

**[0002]** There are many examples of apparatus comprising a distillation column and an insulation structure or container. For example, US-B-6360545 discloses apparatus comprising a cryogenic unit, e.g. an air separation unit, and an insulating containment enclosure. The apparatus is designed to contain cryogenic liquid leaking from the cryogenic unit and is particularly suitable for off shore applications.

**[0003]** At present, the maximum production of oxygen from an air separation plant is about 3500 metric tons/day (about 3860 short tons/day). Over the next few years, it is believed that there will be a need for plants that are capable of producing oxygen at a rate that is well over 3500 metric tons/day (3860 short tons/day). One way to satisfy this demand would be to provide a plurality of conventional oxygen plants in parallel. However, another way would be to use a column having a larger diameter, e.g. a diameter of about 6m (about 20 ft).

**[0004]** The maximum size of a cryogenic air distillation column is limited by a number of factors. One such factor is the ability of the final column to be transported by road.

**[0005]** Conventionally, smaller cryogenic air distillation columns, e.g. those having a diameter of 3m (10 ft) or less, are usually transported within the insulation structure or "cold box". The combination is usually transported horizontally by road on the back of a lorry having a low load platform. Such columns are usually transported on specially designed "transport saddle" structures with the insulation structure in place around the column. One advantage of such an arrangement is that the column is delivered to site with the insulation structure, together with the necessary pipe work within the cold box, already in place. The column and insulation structure combination is simply hoisted into position on site. An insulation material, usually perlite, is added to the cavity between the column and the inner wall of the insulation structure and the pipe work within the cold box is then connected to the pipe work of the remaining parts of the plant.

**[0006]** One advantage of shipping a conventional distillation column within the insulation structure is that the quality of the construction can be controlled to a greater degree. Cryogenic air separation units may be required almost anywhere. Most locations have airborne contaminants such as dirt and/or grease and, in some locations, these contaminants will include corrosive contaminants, for example, salt (if the location is near the sea) or sand (if the location is in a desert). Transportation of a fully assembled column within the insulation structure means that the internal components of the column are not exposed to any airborne contaminants on site.

**[0007]** Transport saddles have to be supported by shipping beams which form part of the insulation structure. This is a disadvantage of conventional support means as the saddles and beams take up space within the insulation structure and make it difficult to run piping to one face (e.g. the lower face during transportation) of the cold box. A further disadvantage is that the saddles impose significant local stresses in the wall of the distillation column to the extent that it is often necessary to thicken up the distillation column wall in the vicinity of the saddles.

**[0008]** Large columns, e.g. ones that have a diameter of about 3.5m (about 11 ft) or more, cannot be transported by road in combination with an insulation structure using conventional support means. A column having a diameter of about 6m (about 20 ft) is about the largest diameter column that can be transported by road fully assembled but, at present, it cannot be transported within its insulation structure. This is because the saddles and shipping beams provided within the cold box would make the column and cold box combination too tall, even when provided on its side, to travel under all but the highest bridges. Therefore, the conventional proposal is to transport large columns to site, either as an assembled column (without the cold box) or as column parts. The column would then be erected on site and the insulation structure erected around the column. However, this is far less convenient and, where the column is transported in sections, there is a risk that the internal components of the large column are contaminated and/or damaged by airborne contaminants. There is a need, therefore, for a new and convenient method of transporting large columns to site such that this risk is reduced.

**[0009]** US-B-6202305 discloses a method of constructing air distillation apparatus comprising an interior column provided within an exterior framework. The method has particular application to apparatus comprising a column that is so large, e.g. having a height as much as 60 metres, that it has usually to be transported separately from the framework and constructed on site. The method comprises constructing modules in which a section of the column is pulled into and joined to a corresponding section of the framework and in which the modules are joined together on site. In the exemplified embodiment, screw jacks are used to support and position a column section within a corresponding framework section in a module. The screw jacks are placed between a belt provided on and around the column section and a cross member of a face of the framework section.

**[0010]** US-A-4116150 discloses a container for the storage or transportation of cryogenic liquids. The container has corner supports that react against tension loads on the walls of the container when the container is loaded with cryogenic liquid.

**[0011]** DE-A-19737520 discloses a cryogenic air distillation installation comprising at least one rectifying column disposed within an insulating chamber. The rectifying column is secured in the insulating chamber by means of rope shaped members provided between the exterior of the column and the interior of the insulating chamber. In the exemplified embodiment, the insulating chamber is cylindrical and the rope shaped members extend radially from a ring provided on and around the exterior of the column to the interior wall of the insulating chamber.

**[0012]** DE-A-19804438 discloses a steel construction for shaft and cavern construction. The steel construction is particularly suitable for use in nuclear research and with magnet technology. The steel construction consists of a cylindrical body surrounded by a number of coaxial polygonal support rings. Each support ring is formed of a number of segments and is spaced apart from a neighbouring support ring by integral support lugs. Support ribs are provided between the innermost support ring adjacent the corners of the polygonal ring and the cylindrical body.

**[0013]** According to a first aspect of the present invention, there is provided apparatus comprising a distillation column and an insulation structure, characterised in that said column is supported within said structure from interior corners of said structure. The column may be a hydrocarbon distillation column but, in preferred embodiments, the column is a cryogenic air distillation column.

**[0014]** One advantage of supporting a column within an insulation structure from interior corners of the structure is that, for an insulation structure of given dimensions, larger columns may be transported by road than would be possible if conventional (non-removable) saddles and shipping beams are employed to support the column. In this way, assembly of large columns can take place in a controlled environment thereby reducing the risk of contamination of the internal components. The present invention is, therefore, suitable for use with large columns having a diameter of at least 3.5m (11 ft) and is particularly suitable for use with columns having a diameter of about 5m (about 16 ft) or about 6m (about 20 ft).

**[0015]** The column of the present invention is usually supported using sets of radial supports provided between each corner of the insulation structure and the outer wall of the column. The radial supports are typically made from material having low thermal conductivity giving low heat leak. Suitable materials include stainless steel.

**[0016]** Radial supports provided between each corner of the insulation structure and the column have an added advantage over saddles as they are suitable for use as seismic or wind supports once the column is erected on site whereas the saddles are only suitable for vertical or near vertical loading when the column is being transported. In addition, more space within the insulation structure is available making it possible to run piping along the lower face of the insulating structure.

**[0017]** The number of sets of radial supports depends on the overall length of the column. Typically, two sets of radial supports are used although more could be used to reducing the bending stresses in the column.

**[0018]** The use of radial supports imposes significant local stresses in the wall of the distillation column. The contact points between the supports and the column wall may be stiffened by increasing the thickness of the wall in the area of these points. However, in preferred embodiments, internal stiffening structures or "bracing" may be used. The bracing may be made from piping or from structural sections having, for example, channelled, angled, T- or I-cross sections. Such bracing structures would usually be left inside the column when the column is in use as it would be undesirable to open the column on site to remove the bracing structure. Therefore, the bracing structure is preferably made from a material that is suitable for exposure to the conditions inside the column during use. For a cryogenic distillation column, the bracing is typically made from the same material as the column. This material is usually selected from aluminium (or an aluminium alloy), stainless steel (various grades), 9% nickel steel or any other material suitable for cryogenic temperatures.

**[0019]** The use of internal bracing means that the thickness of the column wall is usually less than the thickness required to support the column both during transit and when erected on site, e.g. hoisted from the horizontal position to the vertical position, without an internal stiffening structure. The thickness of the column wall is a function of operating pressure, design code, diameter of material of construction. These factors change from one plant to the next as is readily appreciated by the skilled person.

**[0020]** According to a second aspect of the present invention, there is provided a method of transporting apparatus comprising a column and an insulation structure, said method comprising supporting said column within said structure from interior corners of said structure and transporting said apparatus. The apparatus may have any or all of the features described above.

**[0021]** The following is a description, by way of example only and with reference to the accompanying drawings, of presently preferred embodiments of the invention. In the drawings:

FIGURE 1 is a representation of a radial cross-section of a conventional distillation column having a diameter of no more than 3m (10 ft) in combination with an insulation structure;

FIGURE 2 is a representation of an axial partial cross-section of the column and insulation structure combination depicted in Figure 1;

FIGURE 3 is a representation of a radial cross-section of a distillation column in combination with an insulation structure according to the present invention;

FIGURE 4 is a representation of an axial partial cross-section of the column and insulation structure combination depicted in Figure 3;

FIGURE 5 is a representation of a radial cross-section of a column of the present invention comprising a first internal stiffening structure;

FIGURE 6 is a representation of a radial cross-section of a column of the present invention comprising a second internal stiffening structure; and

FIGURE 7 is a representation of a radial cross-section of a column of the present invention comprising a third internal stiffening structure.

**[0022]** Referring to Figures 1 and 2, a conventional cryogenic air distillation column 2 having a diameter of no more than 3m (10 ft) is located within an insulation structure or "cold box" 4. The column 2 is supported on a transport saddles 6 and shipping beams 8 which take up space and make it difficult to run piping (not shown) to the lower surface of the cold box 4. In Figure 2, the column 2 is supported by two saddles 6. Each saddle 6 is about 20% of the total length of the column 2 away from the nearest end of the column 2 respectively in order to reduce the bending stressing within the column 2. The saddles 6 impose significant local stresses in the distillation column wall such that it is often necessary to increase the thickness of the column wall in contact with the saddles.

**[0023]** Referring to Figures 3 and 4, a cryogenic distillation column 32 having a diameter of at least 3.5m (11 ft), for example about 5m (16 ft) or about 6m (20 ft), is located within a cold box 34. The column 32 is supported by radial supports 36 provided between corner members 38 of the frame of the cold box 34. Using radial supports in this way allows a column having a larger-than-conventional diameter to be transported in a given size of cold box. In addition, space is available between the lower surface of the cold box 34 and the column 32 in which piping (not shown) is located.

**[0024]** Radial supports will typically impose significant local stresses in the distillation column such that it will be necessary to either increase the thickness of the column wall locally and/or to use an internal stiffening structure or "bracing" to react to the loads. Figures 5 to 7 depict three arrangements of suitable internal stiffening structures. In each arrangement, the bracing is usually fabricated from tubular members or structural sections (e.g. channels, angles and T- or I-beams). The column 52 in Figure 5 is braced with internal radial supports 54. The column 62 in Figure 6 is braced with internal supports 64 provided in a square arrangement. The column 72 in Figure 7 is braced with internal supports 74 arranged about the interior surface of the column wall.

**[0025]** Whilst the present invention has been discussed with particular reference to the production of oxygen from an air separation process, it is to be understood that the invention can be applied to the production of any gas using cryogenic separation processes or indeed to the distillation of a gaseous hydrocarbon mixture.

**[0026]** Throughout the specification, the term "means" in the context of means for carrying out a function, is intended to refer to at least one device adapted and/or constructed to carry out that function.

**[0027]** It will be appreciated that the invention is not restricted to the details described above with reference to the preferred embodiments but that numerous modifications and variations can be made without departing from the scope of the invention as defined by the following claims.

## Claims

1. Apparatus comprising a distillation column (32, 52, 62, 72) and an insulation structure (34), **characterised in that** said column (32, 52, 62; 72) is supported within said structure (34) from interior corners of said structure (34).
2. Apparatus as claimed in Claim 1 wherein the column (32, 52, 62, 72) has a diameter of at least 3.5m (11 ft).
3. Apparatus as claimed in Claim 1 or Claim 2 wherein the column (32, 52, 62, 72) has a diameter of about 5m (16 ft) or about 6m (20 ft).
4. Apparatus as claimed in any of the preceding claims wherein the column (32, 52, 62, 72) is supported using radial supports (36) provided between each corner of the insulation structure (34) and the outer wall of the column (32, 52, 62, 72).
5. Apparatus as claimed in Claim 4 wherein the column (32, 52, 62, 72) is supported using at least two sets of radial supports (36) provided along the length of the column (32, 52, 62, 72).
6. Apparatus as claimed in Claim 4 or Claim 5 wherein the column (52, 62, 72) comprises an internal stiffening structure (54, 64, 74) to disperse local stresses imposed on the wall of the column (52, 62, 72) by the radial supports (36).

7. Apparatus as claimed in Claim 6 wherein the internal stiffening structure (54, 64, 74) remains in the column (52, 62, 72) during distillation.
8. Apparatus as claimed in Claim 6 or Claim 7 wherein the thickness of the wall of the column (52, 62, 72) is less than the thickness required to support the column (52, 62, 72) both during transit and when erected on site without an internal stiffening structure (54, 64, 74).
9. Apparatus as claimed in any of the preceding claims wherein the column (32, 52, 62, 72) is a cryogenic air distillation column.
10. Apparatus substantially as hereinbefore described with reference to Figures 3 to 7.
11. A method of transporting apparatus comprising a column (32, 52, 62, 72) and an insulation structure (34), said method comprising supporting said column (32, 52, 62, 72) within said structure (34) from interior corners of said structure (34) and transporting said apparatus.
12. A method as claimed in Claim 11 wherein the apparatus is as defined in any of Claims 2 to 9.

## Patentansprüche

1. Vorrichtung mit einer Destillationssäule (32, 52, 62, 72) und einer Isolierungsstruktur (34), **dadurch gekennzeichnet, dass** die Säule (32, 52, 62, 72) in der Struktur (34) von inneren Ecken der Struktur (34) gehalten ist.
2. Vorrichtung nach Anspruch 1, wobei die Säule (32, 52, 62, 72) einen Durchmesser von wenigstens 3,5 m (11 ft) hat.
3. Vorrichtung nach Anspruch 1 oder Anspruch 2, wobei die Säule (32, 52, 62, 72) einen Durchmesser von ungefähr 5 m (16 ft) oder ungefähr 6 m (20 ft) hat.
4. Vorrichtung nach einem der vorhergehenden Ansprüche, wobei die Säule (32, 52, 62, 72) unter der Verwendung von radialen Trägern (36) gehalten ist, die zwischen jeder Ecke der Isolierungsstruktur (34) und der äußeren Wand der Säule (32, 52, 62, 72) vorgesehen sind.
5. Vorrichtung nach Anspruch 4, wobei die Säule (32, 52, 62, 72) unter der Verwendung von wenigstens zwei Sätzen von radialen Trägern (36) gehalten ist, die längs der Länge der Säule (32, 52, 62, 72) vorgesehen sind.
6. Vorrichtung nach Anspruch 4 oder Anspruch 5, wobei die Säule (52, 62, 72) eine interne Versteifungsstruktur (54, 64, 74) aufweist, um lokale Belastungen bzw. Beanspruchungen zu verteilen, bzw. zu streuen, die auf die Wand der Säule (52, 62, 72) durch die radialen Träger (63) ausgeübt werden.
7. Vorrichtung nach Anspruch 6, wobei die interne Versteifungsstruktur (54, 64, 74) während der Destillation in der Säule (52, 62, 72) verbleibt.
8. Vorrichtung nach Anspruch 6 oder 7, wobei die Dicke der Wand der Säule (52, 62, 72) kleiner als die Dicke ist, die benötigt wird, um die Säule (52, 62, 72) sowohl während des Transportes als auch während des Aufstellens auf einem Einsatzort ohne eine interne Versteifungsstruktur (54, 64, 74) zu halten.
9. Vorrichtung nach einem der vorhergehenden Ansprüche, wobei die Säule (32, 52, 62, 72) eine Kryogen- bzw. Tieftemperatur-Luftdestillationssäule ist.
10. Vorrichtung, im Wesentlichen, wie sie unter Bezugnahme auf die Figuren 3 bis 7 beschrieben wurde.
11. Verfahren zum Transport einer Vorrichtung mit einer Säule (32, 52, 62, 72) und einer Isolierungsstruktur (34), wobei das Verfahren die Halterung der Säule (32, 52, 62, 72) in der Struktur (34) von inneren Ecken der Struktur (34) und den Transport der Vorrichtung aufweist.
12. Verfahren nach Anspruch 11, wobei die Vorrichtung in einem der Ansprüche 2 bis 9 definiert ist.

## Revendications

- 5 1. Dispositif comprenant une colonne de distillation (32, 52, 62, 72) et une structure d'isolation (34), **caractérisé en ce que** ladite colonne (32, 52, 62, 72) est supportée à l'intérieur de ladite structure (34) depuis les coins intérieurs de ladite structure (34).
2. Dispositif selon la revendication 1 dans lequel la colonne (32, 52, 62, 72) possède un diamètre d'au moins 3,5 m.
- 10 3. Dispositif selon la revendication 1 ou 2 dans lequel la colonne (32, 52, 62, 72) possède un diamètre d'environ 5 m ou environ 6 m.
- 15 4. Dispositif selon l'une quelconque des revendications précédentes, dans lequel la colonne (32, 52, 62, 72) est supportée en utilisant des supports radiaux (36) prévus entre chaque coin de la structure d'isolation (34) et la paroi externe de la colonne (32, 52, 62, 72).
- 20 5. Dispositif selon la revendication 4, dans lequel la colonne (32, 52, 62, 72) est supportée en utilisant au moins deux jeux de supports radiaux (36) prévus le long de la longueur de la colonne (32, 52, 62, 72).
- 25 6. Dispositif selon la revendication 4 ou 5, dans lequel la colonne (52, 62, 72) comprend une structure de renforcement interne (54, 64, 74) pour disperser des efforts locaux imposés sur la paroi de la colonne (52, 62, 72) par les supports radiaux (36).
7. Dispositif selon la revendication 6, dans lequel la structure de renforcement interne (54, 64, 74) reste dans la colonne (52, 62, 72) pendant la distillation.
- 30 8. Dispositif selon la revendication 6 ou 7, dans lequel l'épaisseur de la paroi de la colonne (52, 62, 72) est inférieure à l'épaisseur requise pour supporter la colonne (52, 62, 72) à la fois pendant le transport et lorsqu'elle est érigée sur site sans une structure de renforcement interne (54, 64, 74).
- 35 9. Dispositif selon l'une quelconque des revendications précédentes, dans lequel la colonne (32, 52, 62, 72) est une colonne de distillation cryogénique de l'air.
- 40 10. Dispositif sensiblement tel que décrit ci-dessus en référence aux figures 3 à 7.
- 45 11. Procédé de transport d'un dispositif comprenant une colonne de distillation (32, 52, 62, 72) et une structure d'isolation (34), ledit procédé comprenant le support de ladite colonne (32, 52, 62, 72) à l'intérieur de ladite structure (34) depuis les coins intérieurs de ladite structure (34) et le transport dudit dispositif.
- 50 12. Procédé selon la revendication 11 dans lequel le dispositif est tel que défini dans l'une quelconque des revendications 2 à 9.
- 55

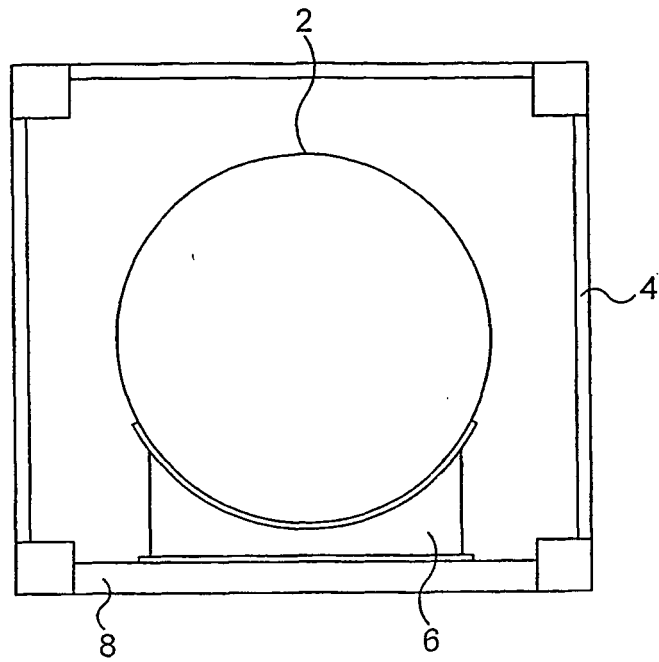


FIG. 1 (prior art)

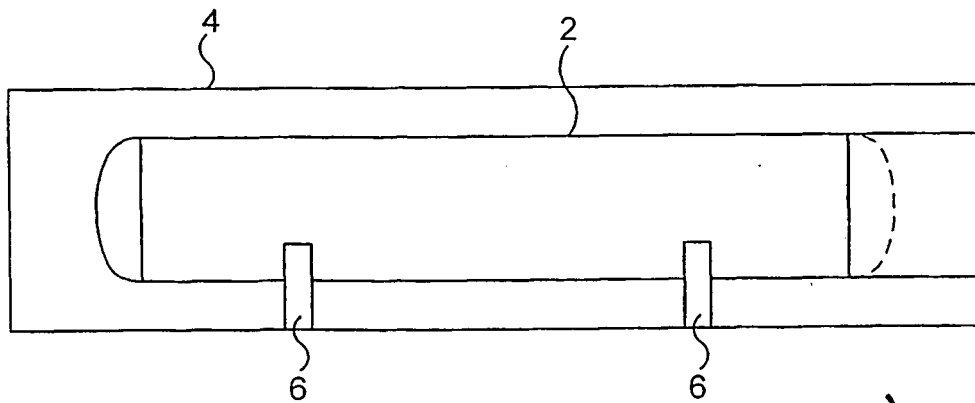


FIG. 2 (prior art)

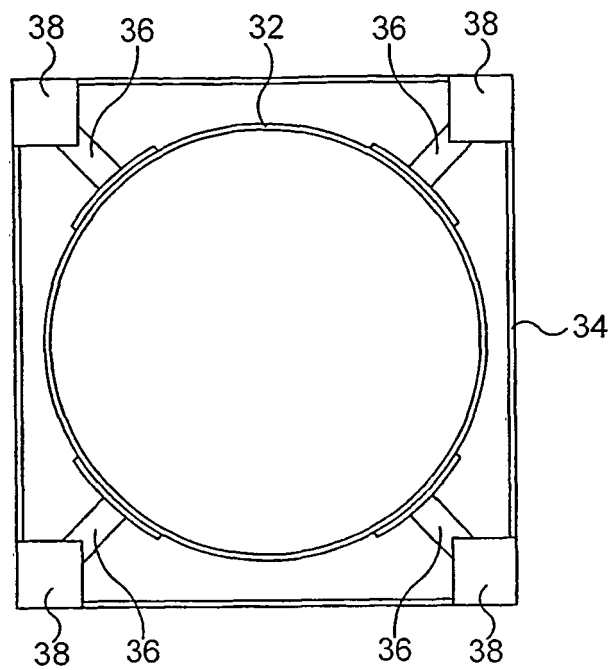


FIG. 3

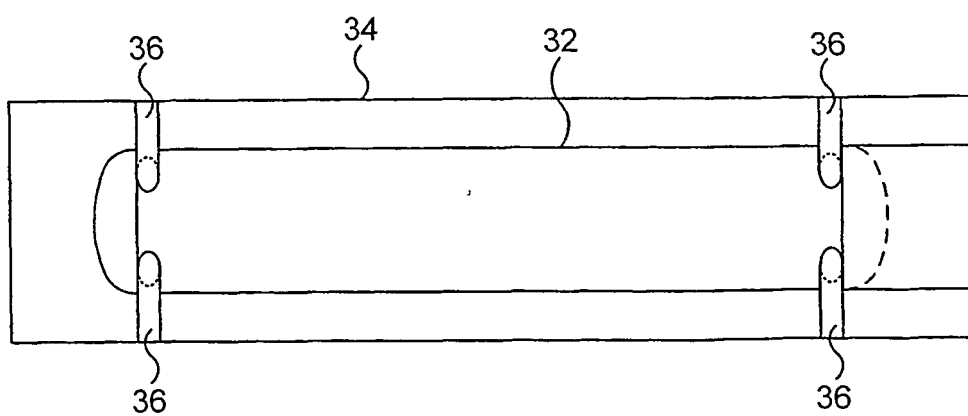


FIG. 4

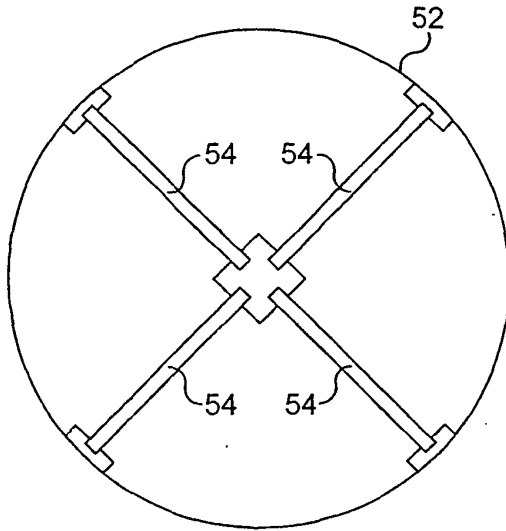


FIG. 5

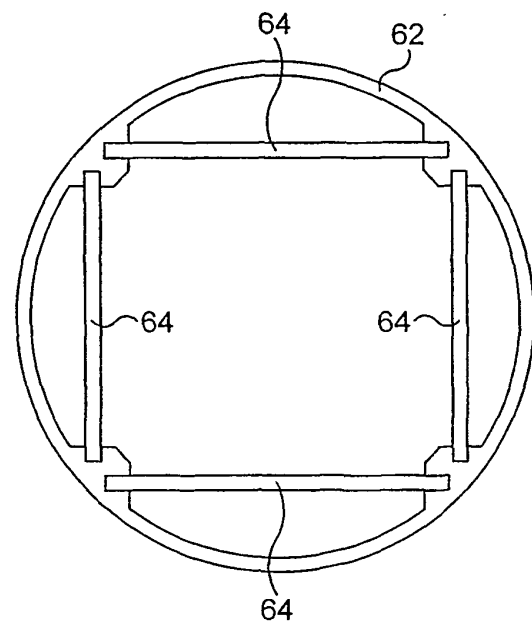


FIG. 6

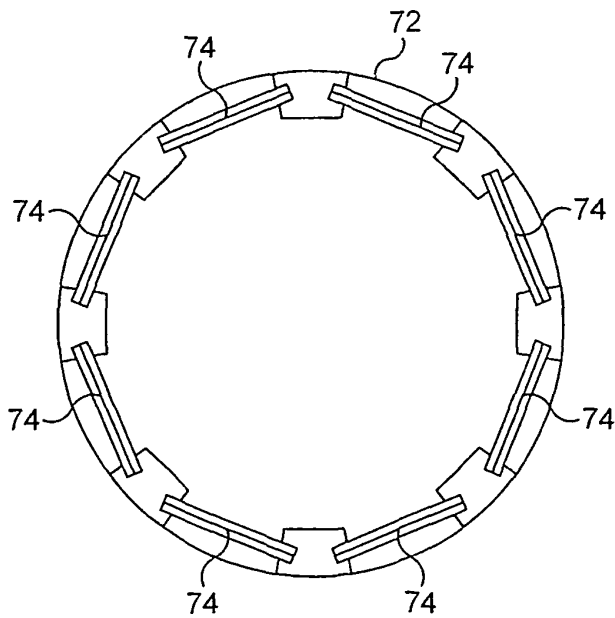


FIG. 7