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- (54) **Title:** AN ADAPTOR, A MODIFIED STRESS TESTING DEVICE AND A METHOD OF PERFORMING A MULTI-AXIAL STRESS TEST

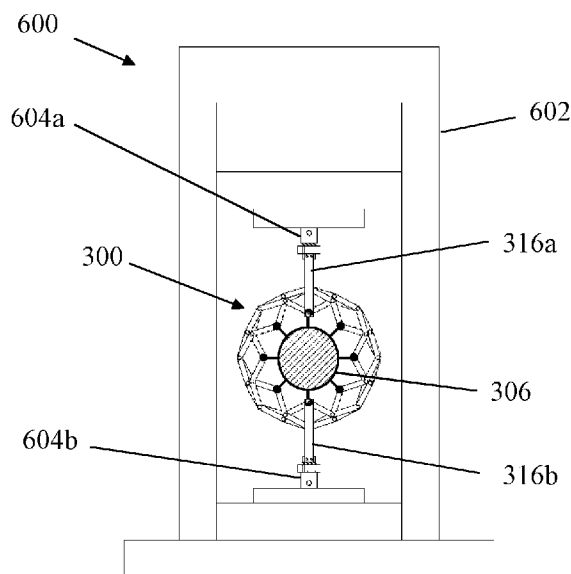


FIG 6b

(57) **Abstract:** A transformable adaptor (200) for a uniaxial stress testing device is disclosed. The adaptor (200) is arranged to move between a contracted and an expanded configuration, and is connectable to the stress testing device via two adaptor connectors (212a, 212b) such that the adaptor connectors undergo uniaxial displacement relative to each other along a driving axis (202) as the transformable adaptor moves between the contracted and expanded configurations. The adaptor is connectable to the sample via at least three sample connectors (210a; 210b; 210c; 210d). The adaptor (200) is arranged to translate the uniaxial displacement into a first test displacement of a first pair of the sample connectors (210a; 210b; 210c; 210d) relative to each other along a first test displacement axis (206a), and a second test displacement of a second pair of the sample connectors (210a; 210b; 210c; 210d) relative to each other along a second test displacement axis (206b), wherein the first test displacement axis (206a) and the second test displacement axis (206b) define an adaptor plane (208). The adaptor plane (208) is parallel to the driving axis (202). A method of performing a multi-axial stress test is also disclosed.

AN ADAPTOR, A MODIFIED STRESS TESTING DEVICE AND A METHOD OF
PERFORMING A MULTI-AXIAL STRESS TEST

This invention relates to an adaptor, a modified stress testing device and a method of
5 performing a multi-axial stress test.

Stress tests performed on samples of a material include uniaxial stress tests and multi-
axial stress tests. In a uniaxial stress test, a sample is deformed along a single axis,
leading to a uniaxial stress state in the sample. In a multi-axial stress test, a sample is
10 deformed along at least two axes, leading to a biaxial or triaxial stress state in the
sample. In particular, a biaxial stress test may be performed, in which deformations
acting in two axes are applied to the sample. In order to carry out a uniaxial tensile
test (generating a uniaxial state of stress in a sample by applying a uniaxial stretching
deformation), it is known to use a uniaxial stress testing device which has two
15 opposing clamps which are arranged to move relative to each other along a single axis.
The relative movement of the opposing clamps (which are attached to the sample)
impose a kinematic state (e.g. a deformation) on the sample. A state of stress is thus
generated by the imposed deformation, which can be measured by measuring one or
more forces experienced by the sample. If a biaxial test is required, a biaxial stress
20 testing device may be used, which provides two pairs of clamps, each pair driven
independently, such that they move relative to each other in two different axes of
motion. Such biaxial stress testing devices require complex drive systems in order to
impose controlled deformations along two axes, and are therefore complicated to
manufacture and use.

25 An adaptor (which may be referred to in the art as a fixture) may be provided to adapt
a uniaxial stress testing device such that a biaxial state of deformation can be applied
to a sample. Such an adaptor is arranged to translate a uniaxial deformation applied by
a uniaxial stress testing device into a biaxial deformation that can be applied to the
30 sample.

A known adaptor 100 for a uniaxial stress testing machine is shown in Figure 1. This
known adaptor 100 is arranged to convert a uniaxial driving deformation acting in the
direction of arrows A and B, into a biaxial deformation acting in the direction of
35 arrows C, D, E, and F. The uniaxial deformation may be supplied by attaching the

adaptor 100 to a uniaxial stress testing machine (not shown in Figure 1) via adaptor clamps 102a, 102b. The adaptor 100 is arranged to hold a cruciform shaped sample 104 in a set of four sample clamps 106a, 106b, 106c, 106d. The adaptor further comprises four pairs of pivotally connected bars which are connected between the sample clamps and the adaptor clamps as shown in Figure 1. When the uniaxial deformation is applied in the direction of arrows A and B, the deformation is translated by the pivotally connected bars into forces in the direction of arrows C, D, E and F. The adaptor 100 therefore translates a uniaxial driving deformation into a biaxial deformation which is applied to the sample 104.

This known adaptor 100 has a number of drawbacks. In particular, the arrangement of bars required to generate a biaxial deformation limits the access available to the sample. As shown in Figure 1, the pivotally connecting bars surround the sample and so make it difficult to find access for a camera used to monitor the sample during testing. Therefore it is known to mount a camera on moving parts of the adaptor, for example, a camera may be mounted to one of the adaptor clamps 102a, 102b. As the adaptor clamps 102a, 102b move with respect to the sample 104, the camera will also move with respect to the sample. This has the disadvantage of the sample in the resulting images changing size both because of the action of the deformation applied to the sample and because of the movement of the camera with respect to the sample.

According to a first aspect of the invention, there is provided a transformable adaptor for a uniaxial stress testing device, the adaptor arranged to move between a contracted and an expanded configuration, and being connectable to the stress testing device via two adaptor connectors such that the adaptor connectors undergo uniaxial displacement relative to each other along a driving axis as the transformable adaptor moves between the contracted and expanded configurations, wherein the adaptor is connectable to the sample via at least three sample connectors, and wherein the adaptor is arranged to translate the uniaxial displacement into a first test displacement of a first pair of the sample connectors relative to each other along a first test displacement axis, and a second test displacement of a second pair of the sample connectors relative to each other along a second test displacement axis, wherein the first test displacement axis and the second test displacement axis define an adaptor plane, the adaptor plane being parallel to the driving axis.

By providing an adaptor that translates the uniaxial driving displacement of the adaptor connectors into multi-axial displacements of the sample connectors that are in a plane parallel to the driving axis, the adaptor does not obscure the view of (or other
5 access to) the sample. This is advantageous over known adaptors, such as that shown in Figure 1, in which the view of the sample is obstructed by the components of the adaptor required to translate the uniaxial displacement into biaxial deformations experienced by the sample.

10 In some embodiments, there may be more than three sample connectors. There may for example be at least: four, six, eight, ten, twelve, fourteen, sixteen or twenty sample connectors, or a range of sample connectors defined between any two of these values.

Optionally, the adaptor is a planar adaptor. This means that the adaptor will generally
15 be in the adaptor plane such that it does not obscure the view of the sample. Contrary to this, the known adaptors of the type shown in Figure 1 have parts that extend significantly out of the adaptor plane which will obscure the view of the sample during testing.

20 Optionally, the adaptor may be arranged to move between the contracted position and the expanded position such that the sample connectors move in known configurations when displaced along the first test displacement axis and the second test displacement axis. This means that the deformation applied to the sample has a known relationship with the uniaxial displacement such that the deformation applied to the sample can be
25 related to the displacement along the driving axis.

Optionally, the known configurations comprise a series of ellipses or circles. A circular known configuration means that the displacement of the connectors along the first test displacement axis is equal to the displacement of the connectors along the
30 second test displacement axis. In other embodiments, the known configurations may comprise a series of ellipses of different eccentricity, in which the test displacements are greater in one direction compared to another.

Optionally, the adaptor may comprise an adaptor portion which comprises a plurality
35 of adaptor members, and a sample portion arranged to receive the sample. In some

embodiments, the sample portion may be an empty space within the adaptor which is arranged to receive the sample.

Optionally, the adaptor members may be pivotally connected to each other. This
5 allows the adaptor to move between the contracted position and the expanded position.

Optionally, each adaptor member may comprise at least two pivot points. This allows the adaptor members to move with respect to each other such that the adaptor can move between the contracted position and the expanded position.
10

Optionally, the adaptor members may be arranged to move in the adaptor plane. This means that as the adaptor moves between the contracted and expanded positions, the adaptor members do not obscure the view to the sample from a point perpendicular to the adaptor plane.
15

Optionally, each sample connector may be connected to (e.g. positioned at, or located at) one of the pivot points. The pivot points may be arranged in the known configuration and provide a suitable place from which to attach the sample.

20 Optionally, each adaptor connector may be connected to (e.g. positioned at, or located at) one of the pivot points.

Optionally, the pivot points may comprise a first set of pivot points and a second set of pivot points, wherein the first set of pivot points is nearer to the sample portion
25 than the second set of pivot points.

Optionally, the adaptor portion surrounds the sample portion.

Optionally, each sample connector may be connected to (e.g. positioned at, or located
30 at) one of the first set of pivot points. By connecting the sample connectors to the first set of pivot points a greater range of deformation applied to the sample may be achieved.

Optionally, each adaptor connector may be connected to (e.g. positioned at, or located
35 at) one of the first set of pivot points. By connecting both the adaptor connectors and

the sample connectors to the same first set of pivot points, the magnitude of the displacement of the adaptor connectors is replicated at the sample connectors.

Optionally, the adaptor members are substantially identical in shape and size. This means that adaptor members are arranged to move symmetrically with respect to each other to provide equal test displacements (e.g. for equibiaxial testing). This also means that the adaptor is more easily manufactured and assembled. In other embodiments, for example where equal displacements are not required, the adaptor members may not be identical, i.e. some or all of the adaptor members may be different sizes or shapes.

Optionally, the first set of pivot points comprises innermost pivot points closest to the sample portion and the number of pivot points in the first set of pivot points, n , depends on the number of adaptor members, b , according to the expression: $b = 2n$.

Optionally, each adaptor member may comprise two or more angulated portions, and wherein the angle between each angulated portion, θ , depends on the number of pivot points in the first set of pivot points, n , according to the expression: $\theta = \pi(1 - 2/n)$. In other embodiments, in particular where equibiaxial testing is not required, there may be a different relationship between θ and n .

Optionally, any one or more of the sample connectors may comprise a sensor arranged to measure the force experienced by the sample via that sample connector. This allows the stress state of the sample to be measured.

According to a second aspect, the invention provides a modified stress testing device comprising an adaptor according to any preceding claim. Using the modified uniaxial stress testing device of this invention, a multi-axial stress test may be performed without requiring a multi-axial stress testing device.

Optionally, the modified stress testing device may further comprise a camera arranged to monitor the sample during application of the test force, wherein the camera is directed along a camera axis perpendicular to the adaptor plane (or along a camera axis that is angled such that it is not parallel to the adaptor plane or not along the driving axis. For example, the camera axis may be angled at 10°, 20°, 30°, 40°, 50°,

60°, 70°, 80° to the adaptor plane, or any range between any two of these values). The combination of the planar nature of the adaptor and the position of the camera means that the view of the camera is not obstructed when the adaptor moves between the contracted and expanded positions.

5

Optionally, the camera may be mounted to be stationary relative to the sample. This means that the image recorded by a stationary camera will vary only according to the changing size of the sample, not because of the relative distance between the camera and the sample.

10

According to a third aspect, the invention provides a method of performing a multi-axial stress test, the method comprising: connecting an adaptor to a uniaxial stress testing device via two adaptor connectors; connecting a sample to be tested to the adaptor via at least three sample connectors; and driving the adaptor such that the
15 adaptor connectors undergo uniaxial displacement relative to each other along a driving axis and such that the uniaxial displacement is translated by the adaptor into a first test displacement of a first pair of the sample connectors relative to each other along a first test displacement axis, and a second test displacement of a second pair of the sample connectors relative to each other along a second test displacement axis, ,
20 wherein the first test displacement axis and the second displacement axis define an adaptor plane, the adaptor plane being parallel to the driving axis.

This advantageously allows a uniaxial stress testing device to perform a multi-axial
25 stress test by using the adaptor of this invention to transform the uniaxial driving displacement into a multi-axial test displacement. In some embodiments, there may be more than three sample connectors. There may for example be at least: four, six, eight, ten, twelve, fourteen, sixteen or twenty sample connectors, or a range of sample connectors defined between any two of these values. The skilled person in this field
30 will understand how to configure the multiple sample connectors. For example, when there are eight sample connectors and biaxial testing is required, then there may be four sample connectors facilitating displacement along a first test displacement axis and four sample connectors facilitating displacement along a second test displacement axis. Alternatively, there may be two sample connectors facilitating displacement
35 along a first test displacement axis and six sample connectors facilitating

displacement along a second test displacement axis. Alternatively, there may be three sample connectors facilitating displacement along a first test displacement axis and five sample connectors facilitating displacement along a second test displacement axis.

5

Optionally, the method may further comprise monitoring the sample during application of the test forces, wherein the monitoring is carried out by a camera acting along an axis perpendicular to the adaptor plane (and therefore perpendicular to the driving axis). This allows the sample to be monitor by the camera such that the adaptor does not obscure the view of the sample.

10

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

15 **Figure 1** shows a prior art adaptor for a uniaxial stress testing device;

Figures 2a and 2b show a schematic perspective view of an adaptor according to an embodiment of the invention;

20 **Figure 2c** shows a side view of the adaptor shown in Figures 2a and 2b;

Figures 3a, 3b and 3c show a detailed view of an adaptor according to an embodiment of the invention;

25 **Figure 3d** shows a close up view of an adaptor member of the adaptor shown in Figure 3a, 3b and 3c;

Figures 4a and 4b show an adaptor according to another embodiment of the invention;

30

Figures 5a and 5b show an adaptor according to another embodiment of the invention.

Figures 6a and 6b show a modified stress testing device according to an embodiment of the invention.

35

Figure 7a shows an end view of an adaptor connector suitable for use with the adaptor of the invention;

- 5 **Figure 7b** shows a top view of an adaptor connector suitable for use with the adaptor of the invention;

Figure 7c shows a first side view of an adaptor connector suitable for use with the adaptor of the invention; and

10

Figure 7d shows a second side view of an adaptor connector suitable for use with the adaptor of the invention.

An adaptor 200 according to an embodiment of the invention is shown schematically
15 in Figures 2a and 2b. The adaptor is arranged to move between a contracted and an expanded configuration, the contracted configuration being shown in Figure 2a and the expanded configuration being shown in Figure 2b. The adaptor 200 can be connected to a uniaxial stress testing device (not shown in Figures 2a and 2b) via two adaptor connectors such that it is driven by a uniaxial driving displacement. The uniaxial
20 driving displacement acts along a driving axis 202. As a result of the uniaxial displacement, the adaptor connectors undergo uniaxial displacement relative to each other along the driving axis 202 which moves the adaptor between the contracted and expanded configurations.

25 The adaptor 200 is connectable to a sample 204 via at least three sample connectors, but in the example shown schematically in Figure 2a and 2b, there are four sample connectors. In an ideal case, the sample is connected such that there is no relative movement (or substantially no relative movement) between the sample and the sample connectors. The adaptor is arranged to translate the uniaxial displacement into a first
30 test displacement of a first pair of the sample connectors relative to each other along a first test displacement axis 206a, and a second test displacement of a second pair of the sample connectors relative to each other along a second test displacement axis 206b. The first and second test force axes 206a, 206b define an adaptor plane 208. In this embodiment, the first and second test displacements are perpendicular to each
35 other, but in other embodiments, there may be more than two pairs of sample

connectors whose test displacement axes may have different relative angles, as will be described later.

Throughout the description, any reference to the application of separate test
5 displacements (or deformations) to the sample could also be interpreted as a single
state of deformation acting on the sample, but having displacement (or deformation)
components acting along different axes. For example, the adaptor could equally be
considered to be arranged to transform the driving displacement into a state of
deformation to be applied to the sample, the deformation having components acting
10 along at least two axes.

The adaptor is arranged to translate the uniaxial driving displacement such that the
adaptor plane 208 is parallel to the driving axis 202. In some embodiments, the
adaptor plane 208 and the driving axis 202 may not be exactly parallel. In such
15 embodiments, the adaptor plane 208 may be arranged such that it is angled with
respect to the driving axis 202 by an angle of less than: 5°, 10°, 25°, 30°, 40° 50°, 60°,
or any range of angles defined between these values. The adaptor plane is arranged
such that it is not perpendicular to the driving axis. In all of these embodiments, the
adaptor provides improved access to the sample during the testing process from a view
20 point perpendicular to the adaptor plane relative to known adaptors. An arrangement
in which the adaptor plane and the driving axis are parallel, or substantially parallel,
may be further preferred so as to provide the greatest improvement of access to the
sample along with a simplified form of adaptor. In the embodiment shown in Figures
2a and 2b, the adaptor plane 204 is spaced apart from the driving axis 202 (e.g. the
25 driving axis is not in the adaptor plane 202 – the driving axis is spaced apart from the
adaptor plane 202).

In other embodiments (as described later), the driving axis 202 may lie within the
adaptor plane 208 (e.g. the adaptor plane may overlap the driving plane 203). In the
30 embodiment of Figure 2a, 2b and 2c, the sample is attached to the outside of the body
of the adaptor and so is not in precisely the same plane as the point at which the
driving displacement is applied to the adaptor (e.g. the driving axis). This is illustrated
in Figure 2c, which shows a side view of the adaptor 200. This shows the sample 204
connected so that it rests on the outside of the adaptor body and so is not in precisely
35 the same plane as the adaptor connectors 212a, 212b. In other embodiments, the

sample may be spaced apart from the adaptor body. In yet other embodiments, the sample may be positioned within the adaptor body such that it is in line with the adaptor connectors which are displaced when the adaptor is driven by the uniaxial stress testing device. In this case, the driving axis 202 and adaptor plane 208 will overlap. By translating the uniaxial driving displacement into a test displacement in a parallel plane, the adaptor can provide improved access to the sample 204. This is because the access for a camera view (i.e. the line of sight for a camera), or any other type of access, is left relatively unimpeded compared to a known adaptor that has components that are displaced in a non-parallel plane and thereby obstruct access to a sample.

As can be seen in Figures 2a, 2b and 2c, the adaptor 200 is a planar adaptor i.e. it is generally disposed along or within the adaptor plane 208. The body of the adaptor is therefore generally planar in shape, and does not extend significantly out of the adaptor plane 208. In particular, the adaptor body does not extend out of the adaptor plane 208 in the region surrounding the sample 204. By providing a planar adaptor, the inventor has realised that access to the sample 204 can be improved. This advantageously allows a camera or other device to be directed towards the sample 204 without being blocked by the body of the adaptor 200. In other embodiments, the device may be another type of monitoring device or a device that is arranged to affect the sample in some way, e.g. it may apply heat during stretching.

The adaptor 200 comprises four sample connectors 210a, 210b, 210c, 210d arranged to connect the sample 204 to the adaptor 200. To apply biaxial deformation to the sample, at least three sample connectors are required. In other embodiments, as described later, there may be any other number of sample connectors arranged to provide different deformation of the sample. For example, two sample connectors may be provided to apply a uniaxial deformation, which may be in a different direction to the driving axis 202. Preferably, in some embodiments, more than four sample connectors may be provided to apply test deformations that act along more than two axes. This applies a more uniform state of deformation to the sample and means that a circular shaped sample may be used rather than a cruciform sample. This also means that the size of sample experiencing the biaxial deformation is larger than with a cruciform sample, and hence the measured deformations and forces are larger such that errors are proportionally smaller than with a cruciform specimen.

The sample connectors may comprise any means suitable to connect the sample to the adaptor, and may in particular comprise clamps arranged to grip the sample 204 in some examples. The sample connectors may comprise for example, screw-action grips, self-locking wedge grips, pneumatically actuated grips and the like. In some embodiments, one or more of the sample connectors may comprise a sensor (e.g. a load cell) arranged to measure the force applied to the sample at that sample connector. In other embodiments, a sensor arranged to measure the load applied to the adaptor may be provided as part of the uniaxial testing device, or at one or more of the adaptor connectors. The adaptor 200 further comprises two adaptor connectors 212a, 212b (only one of which is visible in Figures 2a and 2b) arranged to connect the adaptor 200 to the uniaxial stress testing device. This allows the sample connectors to be displaced relative to each other along the driving axis such that the adaptor is moved between the contracted and expanded configurations. The adaptor connectors 212a, 212b may comprise any mechanism suitable for connecting the adaptor to the uniaxial stress testing machine, and in particular may comprise clamps arranged to grip points on the adaptor body. In other embodiments, the adaptor connectors may comprise pivot pins extending through the body of the adaptor. In Figures 2a and 2b the adaptor connectors 212a, 212b are shown connected to a top and bottom edge or surface of the adaptor body. In other embodiments, the adaptor connectors may be connected to any part of the adaptor body.

The uniaxial stress testing machine is arranged to pull the adaptor connectors 212a, 212b apart along the first axis 202 in the direction indicated by arrows A and B in Figures 2a and 2b. When being pulled apart, only one of the adaptor connectors may move, while the other remains stationary, such that the distance between them increases. Displacement is therefore applied to the adaptor 200, which is then translated into displacements in the directions indicated by arrows C, D, E and F. Such displacements may be required, for example, if the sample comprises a flexible material which is to be tested under biaxial tension. Alternatively, the uniaxial stress testing machine may move the adaptor connectors 212a, 212b towards each other along the first axis 202 in directions opposite to arrows A and B. This provides a state of uniaxial compressive deformation to the adaptor 200, which is then translated into a state of biaxial compressive deformation in the opposite direction to arrows C, D, E and F. In this case a modified adaptor connector may be required to maintain the

orientation of the adaptor connector during compression of the sample. The modified adaptor connector of such an example may comprise a slider to maintain the orientation of the grip during the compression.

5 The adaptor 200 is arranged to move between a contracted position, as shown in Figure 2a, and an expanded position as shown in Figure 2b. By moving from the contracted position to the expanded position, the sample connectors 210a, 210b, 210c, 210d move in a known configuration to deform the sample. By moving in a known configuration, which is dependent on the uniaxial driving displacement, a known test
10 displacement of the sample connectors is provided. In the described embodiment, the known configuration comprises a series of circles, one of which is shown in Figure 2a and a second of which is shown in Figure 2b. In between these two positions, the sample connectors are arranged in a series of circles of differing diameters which progressively increase in size when the adaptor 200 moves from the contracted to the
15 expanded position. By moving in a circular configuration, uniform deformations in the adaptor plane are applied to the sample. This means that the magnitude of the deformation applied along the first test displacement axis 206a is the same as that of the second test displacement axis 206b. In other embodiments, the known configuration may comprise a series of ellipses of different eccentricity. This allows
20 non-uniform deformations to be applied to the sample along the first and second test displacement axes 206a, 206b. The deformation applied along one of the first and second test displacement axes may, for example be 2, 3, 4 or more times greater than the deformation along the other. In other embodiments, the deformation along one axis may remain constant while the deformation is applied along the other axis. In yet other
25 embodiments, the known configuration may be a complex shape arranged to provide test deformations which are tailored for any particular testing requirement.

A specific example of an adaptor 300 according to an embodiment of the invention is shown in schematically in Figures 3a, 3b and 3c. This is only one example
30 embodiment of such an adaptor, and demonstrates one of a number of suitable embodiments as will be described later. The adaptor 300 comprises an adaptor portion 302 and a sample portion 304 which is arranged to receive a sample 306 of material which is under test. Although the sample shown in Figures 3a, 3b and 3c is circular, the sample could be any other shape, such as cruciform for example (for example by
35 connecting the sample via only four of the available sample connectors). The sample

304 may be a flexible material, or may in other embodiments be a rigid material, and may be generally of any size and shape, but may preferably be a sheet of flexible material. The adaptor portion 302 comprises a plurality of adaptor members 308. In the embodiment shown in Figures 3a, 3b and 3c, the adaptor members 308 are arranged to surround the sample portion 304 such that the sample portion is generally at the centre of the adaptor 304. In this embodiment, the sample portion 304 comprises an empty area which is surrounded by the adaptor members 308. The sample may be received in the sample portion 304 and attached to the adaptor. In this embodiment, the adaptor plane and the first axis overlap as the sample can be positioned in line (e.g. in the sample plane) with the adaptor connectors. In other embodiments, the sample portion may also comprise adaptor members such that the area of the sample portion is also filled or partly filled with adaptor members 308. In such an embodiment, the sample is attached to the outside of the adaptor (e.g. such that it is on top of the adaptor body or on the surface of the adaptor body, as shown schematically Figure 2c) such that the adaptor plane and the first axis are spaced apart as shown in the embodiment of Figures 2a, 2b and 2c.

In the embodiment shown in Figures 3a, 3b and 3c, the adaptor portion comprises 16 adaptor members 308 (only one of which is labelled in the figures). This is however only one example of such an adaptor, and in other embodiments the adaptor may comprise 8, 10, 12, 14, 18, 20 or more adaptor members as will be described later.

Each adaptor member 308 comprises an element as shown in Figure 3d. In other embodiments, the adaptor members may comprise straight or angled members as described later. The adaptor members are pivotally connected to each other so that they may move with respect to each other. This allows the adaptor 300 to change in shape when it moves between the contracted and the expanded positions as shown by the sequence of Figures 3a, 3b and 3c. As the adaptor 300 changes in shape, a sample rigidly attached to the adaptor will experience a deformation. The adaptor members are preferably rigid so that they do not significantly deform under the action of the driving deformation applied to the adaptor.

In the embodiment of Figures 3a, 3b and 3c, the adaptor members are substantially identical in shape and size. This allows the adaptor 300 to move in a symmetrical configuration, and also means that the adaptor members 308 are more easily

manufactured. In other embodiments, the adaptor members may all be of different sizes or shapes, or some may be a first size or shape, and others may be a second size or shape. This allows the adaptor to move in an asymmetric configuration to apply an inhomogeneous test displacement to the sample. For example, the adaptor members
5 may be shaped such that the known configuration is elliptical rather than circular.

The adaptor members 308 are interconnected by a plurality of pivots points. In the embodiment shown in Figures 3a, 3b and 3c, each adaptor member 308 comprises four pivot points – a first pivot point 310a, a second pivot point 310b, a third pivot point
10 310c and a fourth pivot point 310d. In other embodiments, each adaptor member may comprise three pivot points (as shown in the embodiment of Figures 5a and 5b, and discussed later), or two, or five or more pivot points. The pivot points of each adaptor member 308 are spaced along the length of the respective adaptor member 308 such that the first pivot point 310a is generally at a first distal end of the adaptor member,
15 whilst the fourth pivot point 310d is generally at a second distal end of the adaptor member 308. In the embodiment shown in Figures 3a, 3b and 3c, the pivot points of each adaptor member 308 are equally spaced along its length. In other embodiments, the pivot points may be unequally spaced along the length of each adaptor member.

20 In the embodiment of Figures 3a, 3b and 3c, the adaptor members 308 are interconnected such that the first pivot point 310a of each adaptor member is pivotally connected to the first pivot point 310a of another, neighbouring adaptor member. Similarly, the second pivot point 310b of each of the adaptor members is pivotally connected to the second pivot point of another, neighbouring, adaptor member. The
25 third 310c and fourth 310d pivot points are similarly connected. The pivot points may be connected by pivot pins (e.g. may be pin-joints) or any other suitable connection means such as rotary bearings, flexible joints, or the like.

Each adaptor member 308 may comprise a number of angulated portions. In the
30 embodiment of Figures 3a, 3b and 3c, each adaptor member 308 comprises four such angulated portions 312a, 312b, 312c as shown in Figure 3d. In other embodiments, each adaptor member may be straight, or comprise two or more angulated portions. The angulated portions are separated by the pivot points disposed along the length of each adaptor member as shown in Figure 3d. The inside angle between each angulated
35 portion 312a, 312b, 312c, labelled θ in Figure 3d, is preferably equal such that the

adaptor member is symmetrical in shape. The inside angles of each adaptor member may not be identical in other examples. This may be the case, for example, if equal test displacements are not required.

- 5 The combination of the shape of the adaptor members 308 and the position of the pivot points allows the adaptor members 308 to move with respect to each other such that they remain in the adaptor plane. This means that the adaptor 300 is generally planar in shape and has no significant part of its body extending out of the adaptor plane. This improves the access to the sample 306 during testing as none of the
10 adaptor members are arranged to move out of the adaptor plane and block the view of the sample from a viewing direction substantially perpendicular to the sample.

The adaptor members 308 are arranged such that they extend generally radially out from the sample region 304. The pivot points thus form a first, second, third and
15 fourth set of pivot points (which are connected by the concentric broken circles in Figures 3a, 3b and 3c), with the distance from the adaptor region 304 increasing between each set. The first set of pivot points comprises the first pivot point 310a of each adaptor member, the second set of pivot points comprises the second pivot point 310b of each adaptor member, the third set of pivot points comprises the third pivot
20 point 310c of each adaptor member and the fourth set of pivot points comprises the fourth pivot point 310d of each adaptor member. The first set of pivot points is nearest to the sample portion 304, and in the described embodiment is therefore nearest to the centre of the adaptor 300. The fourth set of pivot points is furthest from the sample region, and therefore the furthest from the centre of the adaptor. In other
25 embodiments, the sample portion 304 may not be at the centre of the adaptor, and so the first set of pivot points may not be closest to the centre of the adaptor.

The pivot points of each set move in a known configuration when the adaptor moves between its contracted and expanded configurations. In the embodiment shown in
30 Figures 3a, 3b and 3c, the known configuration comprises points on a circle. As the adaptor moves from the contracted position in Figure 3a to the expanded position in Figure 3c, these circular known configurations expand in size. A sample 306 connected to the pivot points is therefore stretched as the adaptor moves from the contracted to the expanded position.

In order to connect a sample to the adaptor 300, the adaptor further comprises sample connectors 314 (only one of which is labelled in Figures 3a, 3b and 3c). The sample connectors may comprise a body which comprises a connection to the sample and a connection to the adaptor, such that the test forces are transferred from the adaptor
5 300 to the sample 306. The sample connectors 314 may comprise any mechanism suitable for attaching the sample to a point on the adaptor. In some embodiments, the sample connectors may comprise clamps arranged to grip the sample, and may comprise for example, screw-action grips, self-locking wedge grips, pneumatically actuated grips and the like. In some embodiments, one or more of the sample
10 connectors may comprise a sensor (such as a load cell) arranged to measure the force generated by the displacement of the sample at that sample connector.

The sample connectors are preferably connected to the adaptor 300 at three or more of the pivot points. Each of the sample connectors 314 may be pivotally connected to the
15 pivot points, and may for example be connected via the same pivot pin arranged to interconnect the adaptor members 308. In other embodiments, the sample connectors 314 may be attached to the body of the adaptor members 308, or may be part of the adaptor members themselves. In other embodiments, the sample connectors may be attached to the adaptor members 308 between the pivot points rather than at the pivot
20 points.

At least three sample connectors 314 are required to apply a multi-axial state of deformation to the sample 306, but in some embodiments, more than three sample connectors 314 can be provided to connect the adaptor 300 to the sample 306 at more
25 points. This means that the deformation applied to the sample is more uniform (e.g. is more homogeneous). In yet other embodiments, only two sample connectors 314 may be provided. In this case, a uniaxial deformation is applied to the sample 316, which can be in a different direction to that of driving axis depending on the positioning of the sample connectors 314 on the adaptor 300. As the pivot points move in a known
30 configuration, by attaching the sample connectors 314 to the pivot points, known test deformations can be applied to the sample 306.

The sample connectors 314 are preferably connected to the first set of pivot points as shown in Figures 3a, 3b and 3c. The sample 306 may be connected via sample
35 connectors 314 attached to all of the first set of pivot points. In this embodiment, the

sample is therefore connected via eight sample connectors 314 which are dispersed evenly around the known circular configuration. This provides an even, homogenous state of deformation to be applied to the sample 306. It also means the sample may be generally circular in shape (where a sheet material is being tested, for example), rather than the cruciform sample shape typically used for biaxial stress testing. The use of a circular sample is advantageous because it is more easily manufactured compared to a cruciform sample which must be shaped particularly accurately in order to ensure that a uniform biaxial stress state is generated at the centre of the cruciform sample.

In some embodiments, the sample may be connected via sample connectors 314 attached to some, but not all of, the first set of pivot points. This means that the deformation applied to the sample is less homogenous, but allows samples of different shapes to be tested. In some embodiments, an uneven deformation may be required, in which case the sample can be connected via a number of the sample connectors 314 arranged asymmetrically around the circular known configuration. In yet other embodiments, sample connectors may be provided at each of the first set of pivot points, but can be left unconnected to vary the attachment position to the sample 306.

In other embodiments, the sample connectors may be attached to the second, third or fourth set of pivot points. In yet other embodiments, the sample connectors may be attached to a mixture of pivot points from any number of the first, second, or third or fourth sets of pivot points. This allows a wide range of sample sizes and shapes to be tested.

The adaptor 300 further comprises at least two adaptor connectors 316a, 316b arranged to connect the adaptor 300 to the uniaxial stress testing device. Each of the adaptor members may comprise a rigid body arranged to communicate the driving force from the uniaxial stress testing machine to the adaptor. The adaptor connectors may each comprise a connection mechanism arranged to attach them to the uniaxial stress testing machine at one end, and another connection mechanism arranged to attach them to the adaptor at a second end. In the embodiment of Figures 3a, 3b and 3c, two adaptor connectors are provided to drive the adaptor 300 with a uniaxial drive.

Each of the adaptor connectors 316a, 316b may be connected to one of the pivot points. Similarly to the sample connectors 314, the adaptor connectors 316a, 316b may

be connected via one of the pivot pins connecting two of the adaptor members 308. In other embodiments, each of the adaptor connectors 316a, 316b may be attached to the body of one of the adaptor members 308 or be part of one of the adaptor members. The adaptor connectors 316a, 316b are preferably connected to two of the first set of pivot points as shown in Figures 3a, 3b and 3c. This is advantageous because the movement of the adaptor connectors 316, 316b is then replicated at the other pivot points of the first set. This allows the displacement of the sample connectors, and therefore the deformation state applied to the sample, via the sample connectors attached to the first set of pivot points, to be controlled. In order to reach to the first set of pivot points, the body of each of the adaptor connectors may comprise a slot arranged to receive the adaptor such that each of adaptor connectors fits around the outside of the adaptor. In other embodiments, the adaptor connectors 316a, 316b may be provided at two of the second, third or fourth sets of pivot points. In yet other embodiments, they may be connected to pivot points belonging to different sets of pivot points.

The adaptor 300 shown in Figures 3a, 3b, 3c and 3d is one example of a number of possible arrangements of adaptor members 308. In these other embodiments, the number of adaptor members 308, the shape of the adaptor members 308, or the number of pivot points on each adaptor member 308 may be varied.

By varying the number of adaptor members 308, the number of pivot points in the first set of pivot points (i.e. the innermost pivot points closest to the sample region 304) is varied. The number of pivot points in the first set of pivot points, n , depends on the number of adaptor members, b , according to the expression: $b = 2n$. By increasing the number of adaptor members 308, the number of pivot points to which the sample connectors 314 can be attached is increased. By increasing the number of sample connectors 314, the uniformity of the stress state generated in the sample is increased. For the special case in which the sample connectors move in a circular configuration, the force measured along the driving axis is equal to $n/2$ times the test force measured at each pair of sample connectors. For example, for 8 adaptor connectors, the test force is 4 times the force between each pair of adaptor connectors. An example embodiment of an adaptor 400 in which there are 24 adaptor members 408 and 12 first pivot points 410a in the first set of pivot points is shown in Figure 4a in the contracted position, and Figure 4b in the extended position. The change in position of the first set of pivot points between the contracted and extended position is shown by the arrows

marked A in Figures 4a and 4b. Although increasing the number of adaptor members increases the homogeneity of the stress state, the complexity of the adaptor also increases. The inventor has found that 16 adaptor members (as shown in the embodiment of Figures 3a, 3b and 3c) may provide a balance between these factors, but in other embodiments, there may be other suitable numbers of adaptor members.

Additionally, or alternatively, to varying the number of adaptor members, the size and shape of the adaptor members themselves may also be varied. In particular, the angle between the angulated portions, θ , may be varied. In order to provide an adaptor member which moves in a symmetrical configuration, the angle between the angulated portions, θ may depend on the number of pivot points in the first set of pivot points, n , according to the expression: $\theta = \pi(1 - 2/n)$. For the embodiment shown in Figures 3a, 3b and 3c, this angle is therefore 135° . In the embodiment of Figures 5a and 5b, θ is 150° . The angle between the angulated portions, θ , may however have other dependencies on the number of pivot points, with this being only one such example.

The number of pivot points on each adaptor member may also be varied. Each adaptor member may comprise at least two pivot points so that the adaptor members can move relative to each other in some embodiments. Figures 5a and 5b show an embodiment of an adaptor 500 where there are 16 adaptor members 508, each having three pivot points 510a, 510b, 510c. The number of first pivot points 510a in the first set of pivot points is therefore unchanged from the embodiment of Figures 3a, 3b and 3c. In comparison to the embodiment of Figures 3a, 3b and 3c, the embodiment of Figures 5a and 5b is less restricted in its movement by removing the outer layer (e.g. the fourth set) of pivot points. In the expanded position (shown in Figure 5b) it is therefore expanded to a greater size. This greater range of movement is advantageous because it allows a greater deformation to be applied to the sample.

In another aspect, this invention provides a modified stress testing device 600 comprising the adaptor of any previously described embodiment. A stress testing device 600 is shown in Figure 6a and 6b. The stress testing device 600 has been modified by attachment of the adaptor 300 of the embodiment shown in Figures 3a, 3b and 3c. In Figure 6a the adaptor 300 is in the contracted position, and in Figure 6b it is in the expanded position. In this embodiment, the modified stress testing device 600 comprises a frame 602. A first attachment point 604a and a second attachment point

604b are connected to the frame as shown in Figure 6a and 6b. In this embodiment, the first attachment point 604a is located on a movable member which is arranged to move with respect to the frame to apply a state of deformation to the sample 306. In this embodiment the second attachment point 604b does not move relative to the frame
5 602. In other embodiments, both of the first and second attachment points may be arranged to move with respect to the frame in order to deform the sample. This may be advantageous if the centre of the specimen is required to remain stationary during the test. The adaptor 300 is attached to the stress testing machine 600 by attaching the first adaptor connector 316a to the first attachment point 604a and the second adaptor
10 connector 316b to the second attachment point 604b. By attaching the adaptor of this invention to an existing uniaxial stress testing device, such a device can be modified to allow a multi-axial stress test to be carried out. This advantageously allows a uniaxial device, which is less complex and therefore simpler to use and more widely available, to be used to perform a multi-axial stress test.

15 Such a modified stress testing device may further comprise a camera arranged to monitor the sample during application of the test force. The camera may be directed along a camera axis having at least one component perpendicular to the first axis. By positioning the camera in this way, it has a clear, unobstructed view of the sample. As
20 the adaptor of this invention moves in the adaptor plane as described above, it does not move in such a way as to obstruct the view of the sample.

The camera may also be mounted such that it remains stationary relative to the sample. This is advantageous because the image recorded by a stationary camera will vary
25 only according to the changing size of the sample, not because of the relative distance between the camera and the sample. In the known adaptor described in Figure 1, the camera may be attached to one of the adaptor clamps 102a, 102b because the pivotally connected bars would otherwise obscure the view of the sample. If the camera is located at one of the adaptor clamps 102a, 102b it will move relative to the sample
30 during testing. It will therefore be difficult to distinguish movement of the camera from changes in the size of the sample during testing.

In other embodiments, the camera may be replaced by any suitable monitoring equipment such as an X-ray imaging device, spectrometer, infrared camera, neutron
35 beam etc. In other embodiments, the camera may be replaced by or supplemented by

an instrument arranged to modify the sample, and may for example be a heat source. An external pressure, vacuum, humidity and/or temperature may also be imposed to the sample by, for example, carrying out the test in an atmospheric control chamber.

5 In use, the adaptor of this invention is first connected to a uniaxial stress testing device. As described above, the adaptor is arranged to transform the uniaxial driving displacement provided by the uniaxial stress testing machine into a multi-axial test displacement. Once the adaptor is connected to the uniaxial stress testing device, the sample is connected to the adaptor. This may be done via the sample connectors as
10 described above. Once the sample is connected, the adaptor is driven with a uniaxial driving displacement provided by the uniaxial stress testing device such that multi-axial test displacements are applied to the sample.

An example of a sample connector 700 suitable for use with this invention is shown in
15 Figures 7a, 7b, 7c and 7d. The sample connector 700 comprises a sample attachment portion 702, a sensor portion 704 and an adaptor attachment portion 706. The sample attachment portion 702 comprises a mechanism with which to attach the sample connector 700 to the sample. In this embodiment, the sample attachment portion comprises a pair of opposing grip members 708a, 708b which are arranged to grip the
20 sample such that it is secured to the sample connector. The grip members 708a, 708b may comprise a threaded portion arranged to engage with the body of the sample connector so that when rotated they move with respect to the body of the sample connector 700 in order to grip the sample. In other embodiments, the grip members may be biased towards each other by any other suitable mechanism such as a spring,
25 or a pneumatic or hydraulic actuator for example.

The sensor portion 704 comprises a sensor (such as a load cell) arranged to measure the force acting between the sample attachment portion and the adaptor attachment portion. This provides an indication of the load applied at the sample via the sample
30 connector 700 and may provide an indication of the stress state experienced by the sample.

The adaptor attachment portion 706 comprises a mechanism arranged to attach the sample connector to the adaptor. As discussed above, in some embodiments, the
35 adaptor connector may be attached via the pivot points of the adaptor. The adaptor

attachment portion 706 may comprise a pair of apertures 710a, 710b (only one of which is visible in Figure 7b) which are arranged to receive a pin connecting two of the adaptor members 308.

- 5 In other embodiments the sample connectors may comprise, for example, screw-action grips, self-tightening wedge grips, pneumatically actuated grips and the like.

Various modifications will be apparent to the skilled person without departing from the scope of the claims.

10

In the embodiments described, the adaptor is a non-powered adaptor – that is, its movement does not need an internal power source. It is powered only by the testing device. This simple construction provides an efficient way of achieving multi-axial testing on a uniaxial testing device. In other embodiments, the adaptor may be
15 powered by an internal power source.

CLAIMS

1. A transformable adaptor for a uniaxial stress testing device, the adaptor arranged to move between a contracted and an expanded configuration, and being
5 connectable to the stress testing device via two adaptor connectors such that the adaptor connectors undergo uniaxial displacement relative to each other along a driving axis as the transformable adaptor moves between the contracted and expanded configurations, wherein the adaptor is connectable to the sample via at least three sample connectors, and wherein the adaptor is arranged to translate
10 the uniaxial displacement into a first test displacement of a first pair of the sample connectors relative to each other along a first test displacement axis, and a second test displacement of a second pair of the sample connectors relative to each other along a second test displacement axis, wherein the first test displacement axis and the second test displacement axis define an adaptor plane,
15 the adaptor plane being parallel to the driving axis.
2. An adaptor according to claim 1, wherein the adaptor is a planar adaptor.
3. An adaptor according to claim 1 or claim 2, wherein the adaptor is arranged to
20 move between the contracted position and the expanded position such that the sample connectors move in known configurations when displaced along the first test displacement axis and the second test displacement axis.
4. An adaptor according to claim 3, wherein the known configurations comprise a
25 series of ellipses or circles.
5. An adaptor according to any preceding claim, comprising an adaptor portion which comprises a plurality of adaptor members, and a sample portion arranged to receive the sample.
30
6. An adaptor according to claim 5, wherein the adaptor members are pivotally connected to each other.
7. An adaptor according to claim 6, wherein each adaptor member comprises at
35 least two pivot points.

8. An adaptor according to any one of claims 5 to 7, wherein the adaptor members are arranged to move in the adaptor plane.
- 5 9. An adaptor according to claim 7 or claim 8, wherein each sample connector is connected to one of the pivot points.
10. An adaptor according to any one of claims 7 to 9, wherein each adaptor connector is connected to one of the pivot points.
- 10 11. An adaptor according to any one of claims 7 to 10, wherein the pivot points comprise a first set of pivot points and a second set of pivot points, wherein the first set of pivot points is nearer to the sample portion than the second set of pivot points.
- 15 12. An adaptor according to claim 11, wherein the adaptor portion surrounds the sample portion.
13. An adaptor according to claim 11 or claim 12, wherein each sample connector is connected to one of the first set of pivot points.
- 20 14. An adaptor according to any of claims 11 to 13, wherein each adaptor connector is connected to one of the first set of pivot points.
- 25 15. An adaptor according to any one of claims 5 to 14, wherein the adaptor members are substantially identical in shape and size.
16. An adaptor according to any one of claims 12 to 14, wherein the first set of pivot points comprises innermost pivot points closest to the sample portion and the number of pivot points in the first set of pivot points, n , depends on the number of adaptor members, b , according to the expression: $b = 2n$.
- 30 17. An adaptor according to any of claim 16, wherein each adaptor member comprises two or more angulated portions, and wherein the angle between each

angulated portion, θ , depends on the number of pivot points in the first set of pivot points, n , according to the expression: $\theta = \pi(1 - 2/n)$.

18. An adaptor according to any preceding claim wherein any one or more of the
5 sample connectors comprise a sensor arranged to measure the force applied to the sample via that sample connector.
19. A modified stress testing device comprising an adaptor according to any preceding claim.
- 10 20. A modified stress testing device according to claim 19, further comprising a camera arranged to monitor the sample during use of the modified testing device, wherein the camera is directed along a camera axis having at least one component perpendicular to the driving axis.
- 15 21. A modified stress testing device according to claim 20, wherein the camera is mounted to be stationary relative to the sample.
22. A method of performing a multi-axial stress test, the method comprising:
20 connecting an adaptor to a uniaxial stress testing device via two adaptor connectors;
connecting a sample to be tested to the adaptor via at least three sample connectors; and
driving the adaptor such that the adaptor connectors undergo uniaxial
25 displacement relative to each other along a driving axis and such that the uniaxial displacement is translated by the adaptor into a first test displacement of a first pair of the sample connectors relative to each other along a first test displacement axis, and a second test displacement of a second pair of the sample connectors relative to each
30 other along a second test displacement axis, wherein the first test displacement axis and the second test displacement axis define an adaptor plane, the adaptor plane being parallel to the driving axis.
23. A method according to claim 22, further comprising monitoring the sample
35 during use of the uniaxial stress testing device, wherein the monitoring is carried out

by a camera acting along an axis having at least one component perpendicular to the first axis.

24. A transformable adaptor for a uniaxial stress testing device, the adaptor
5 arranged to move between a first and a second configuration, and being connectable to
the stress testing device via two adaptor connectors such that the adaptor connectors
undergo uniaxial displacement relative to each other along a driving axis as the
transformable adaptor moves between the first and second configurations, wherein the
adaptor is connectable to the sample via at least three sample connectors, and wherein
10 the adaptor is arranged to translate the uniaxial displacement into a first test
displacement of a first pair of the sample connectors relative to each other along a
first test displacement axis, and a second test displacement of a second pair of the
sample connectors relative to each other along a second test displacement axis,
wherein the first test displacement axis and the second test displacement axis define
15 an adaptor plane, wherein the adaptor plane is not perpendicular to the driving axis.

25. An adaptor, a modified stress testing device, and a method substantially as
herein described with reference to any one or more of Figures 2a to 7d.

1/10

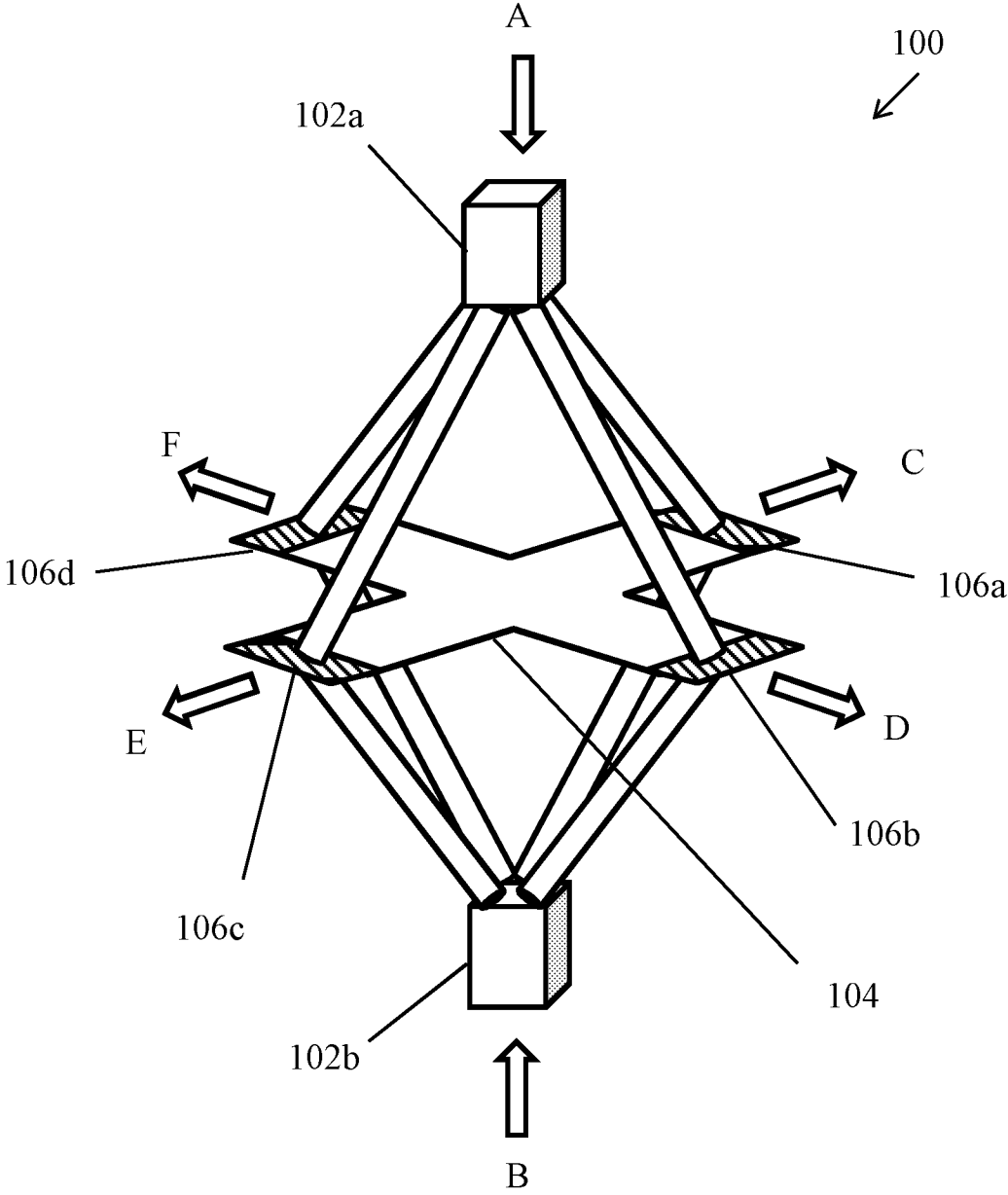


FIG 1 – Prior Art

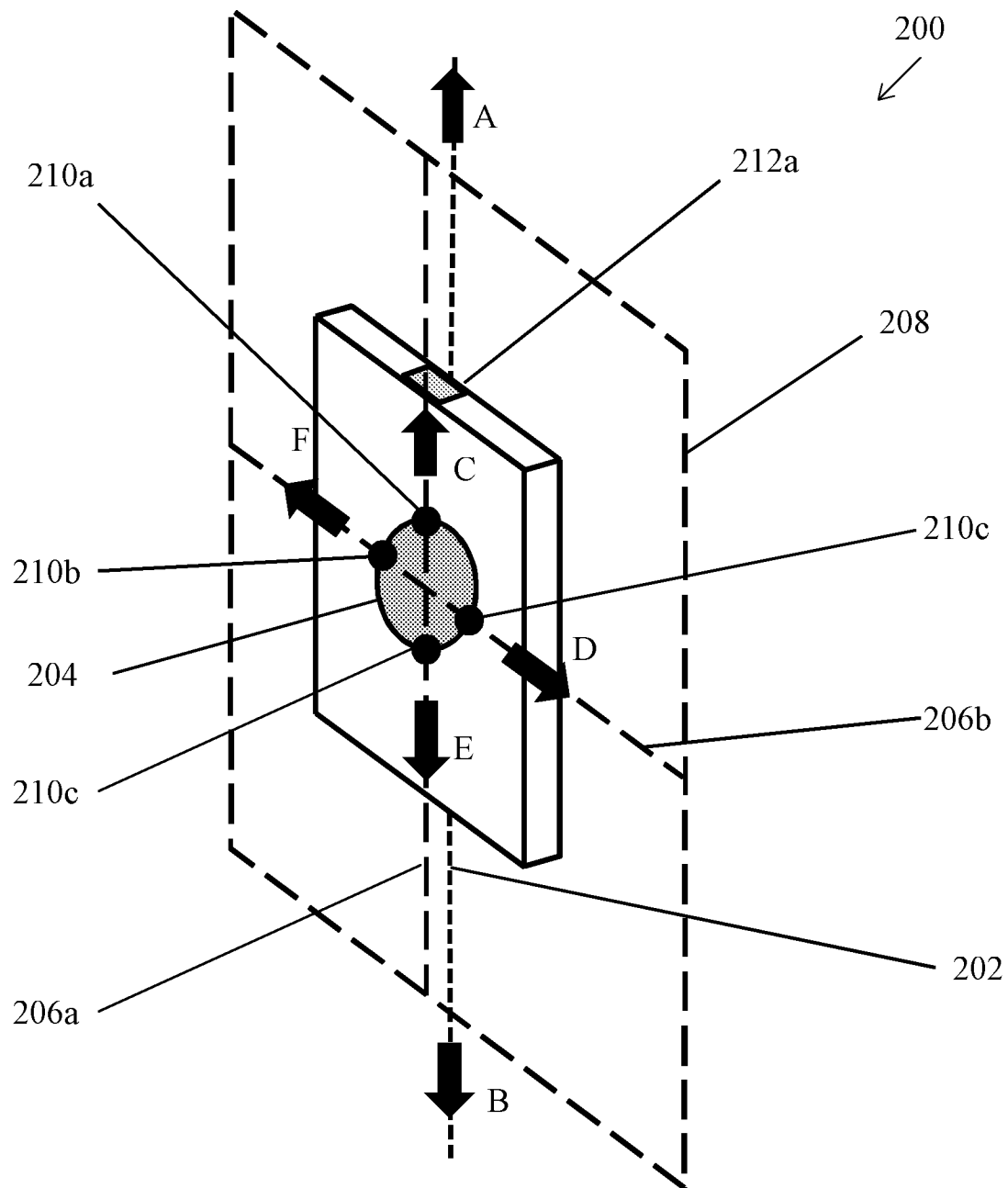


FIG 2a

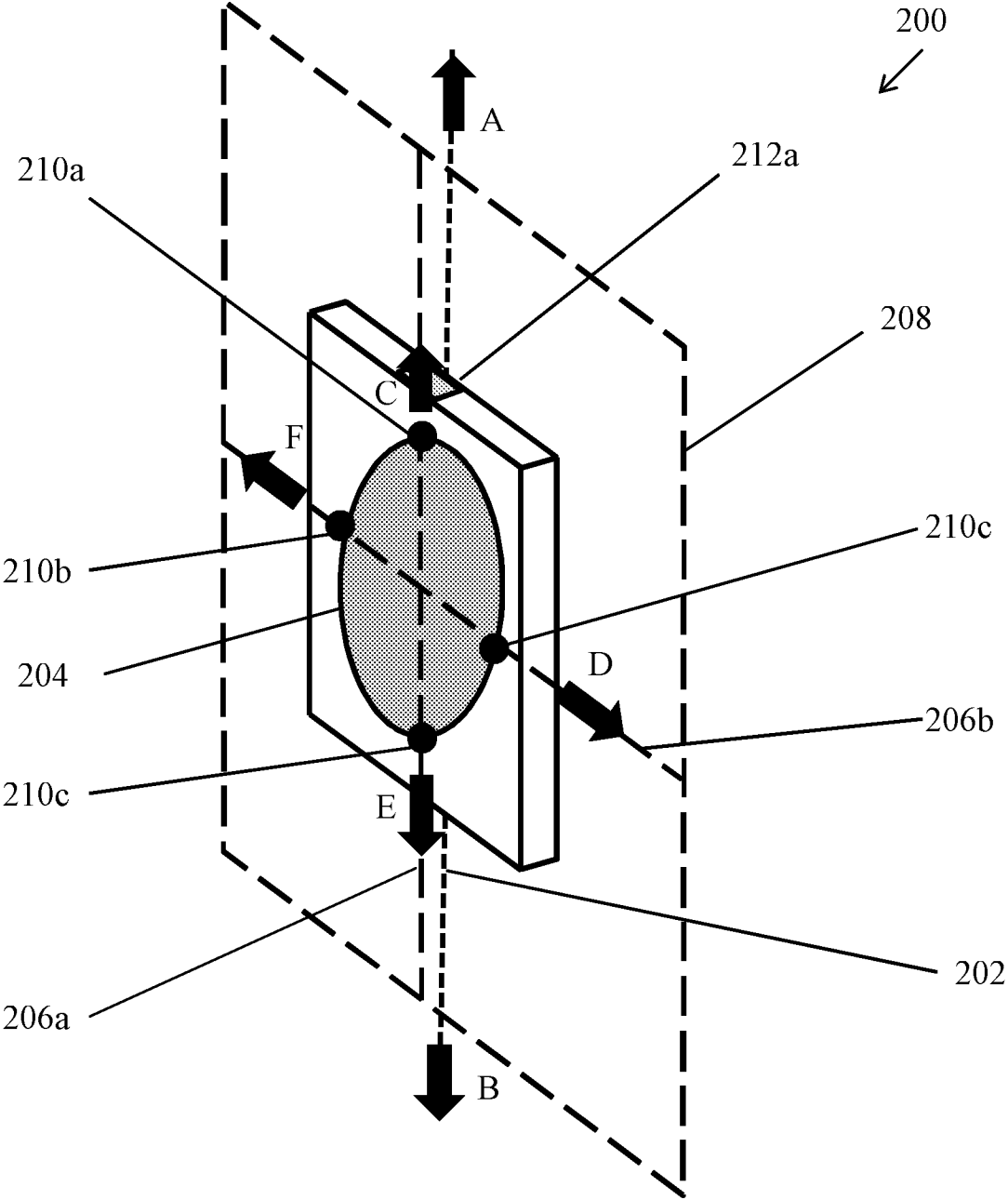


FIG 2b

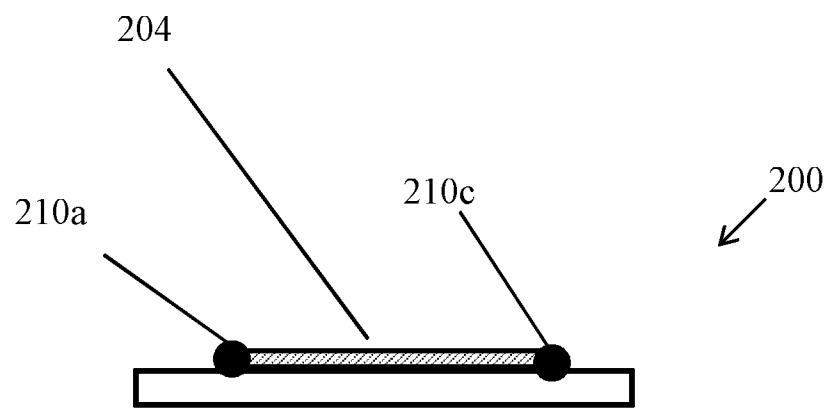
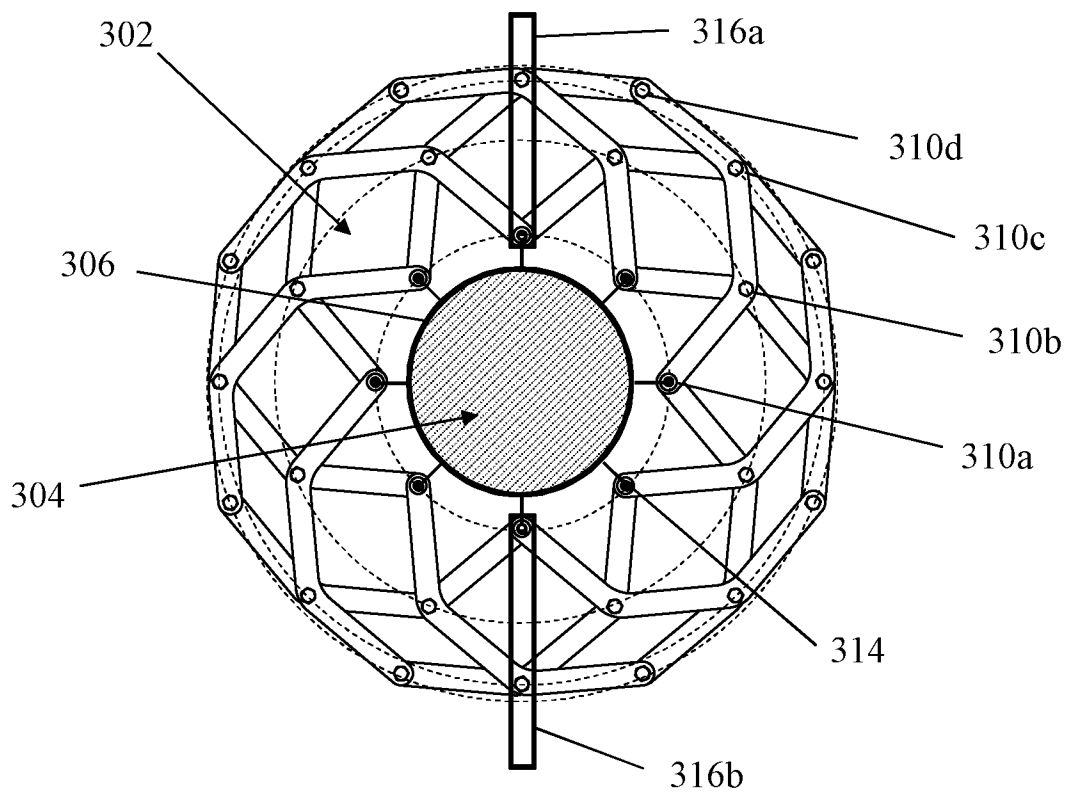
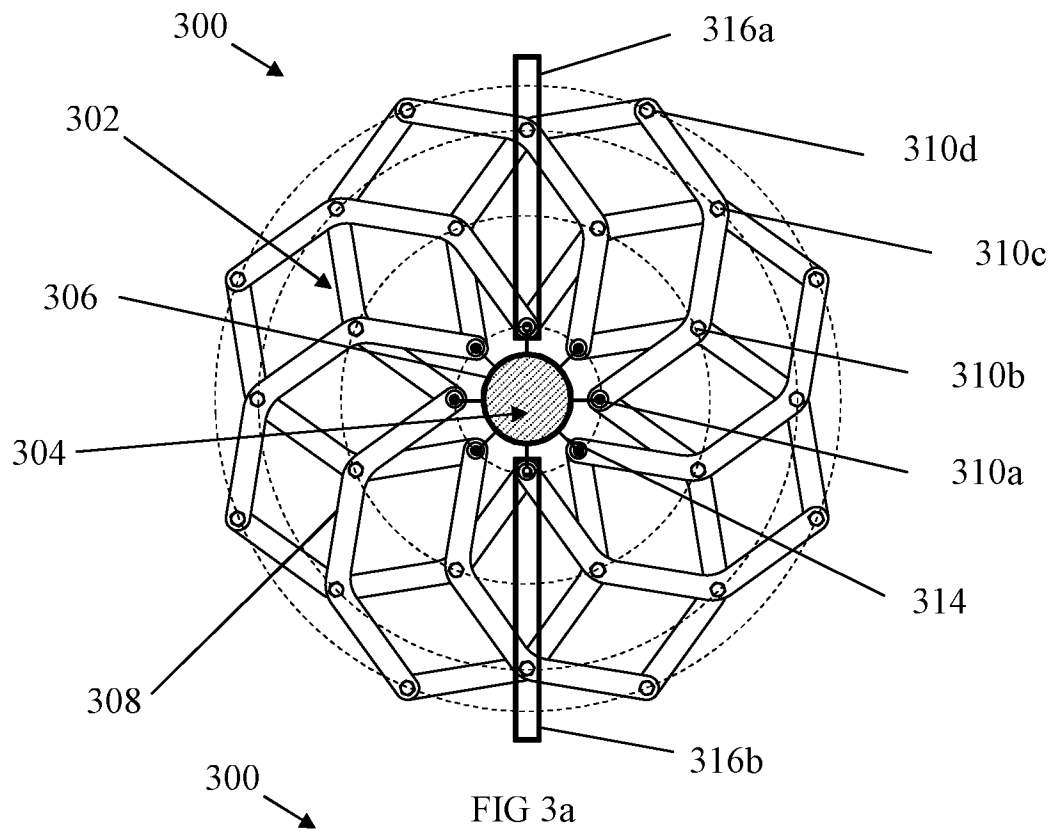


FIG 2c

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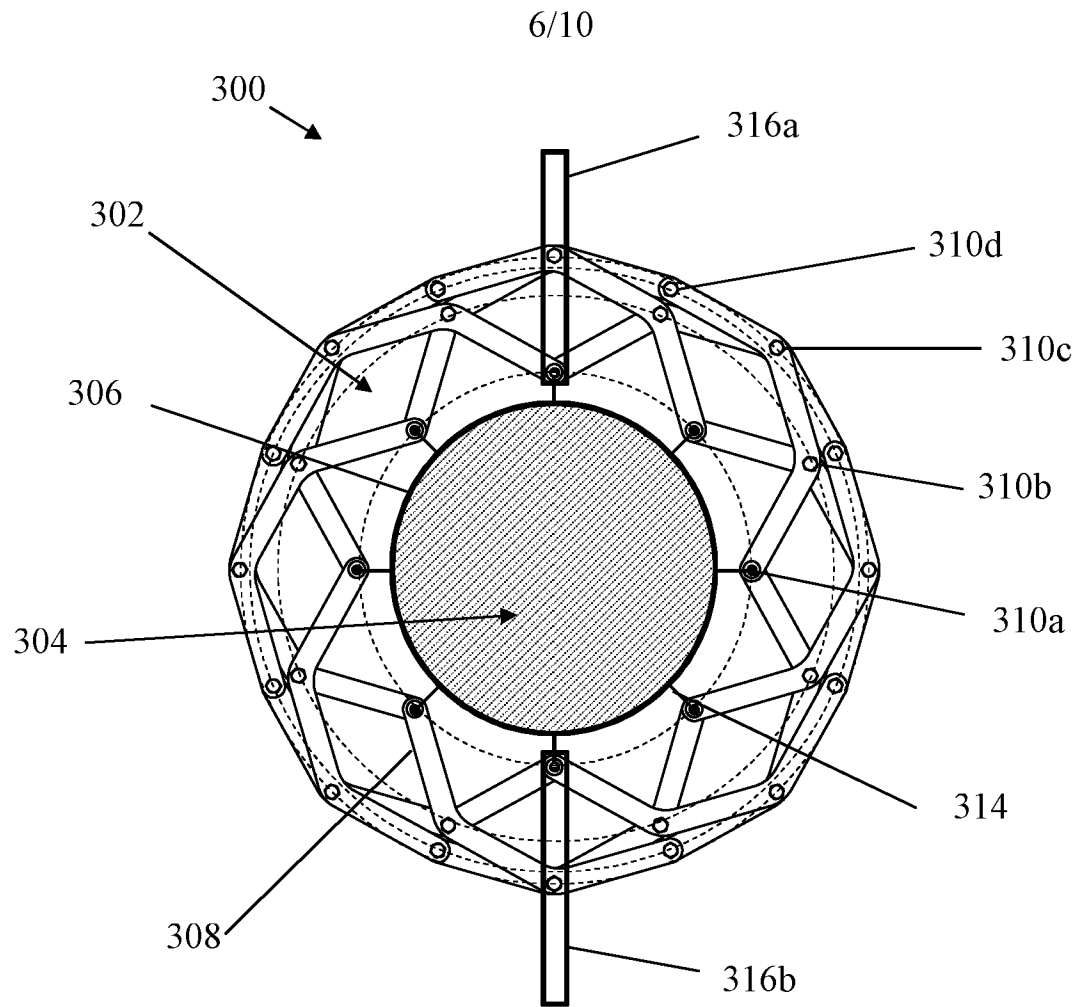


FIG 3c

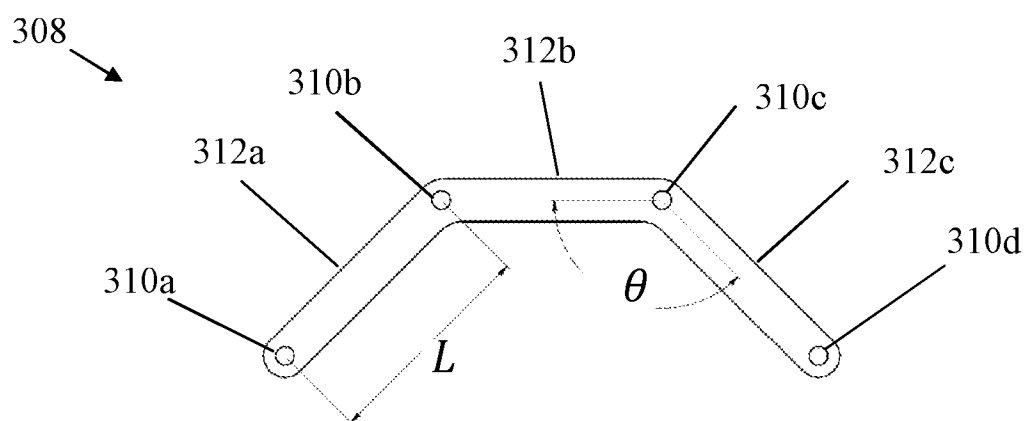


FIG 3d

7/10

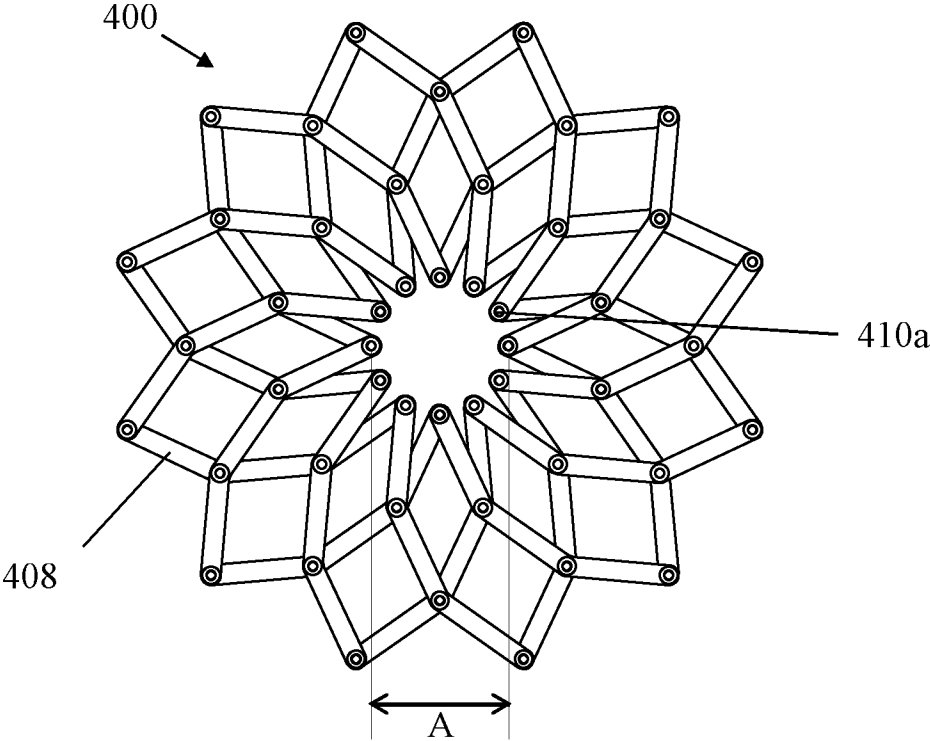


FIG 4a

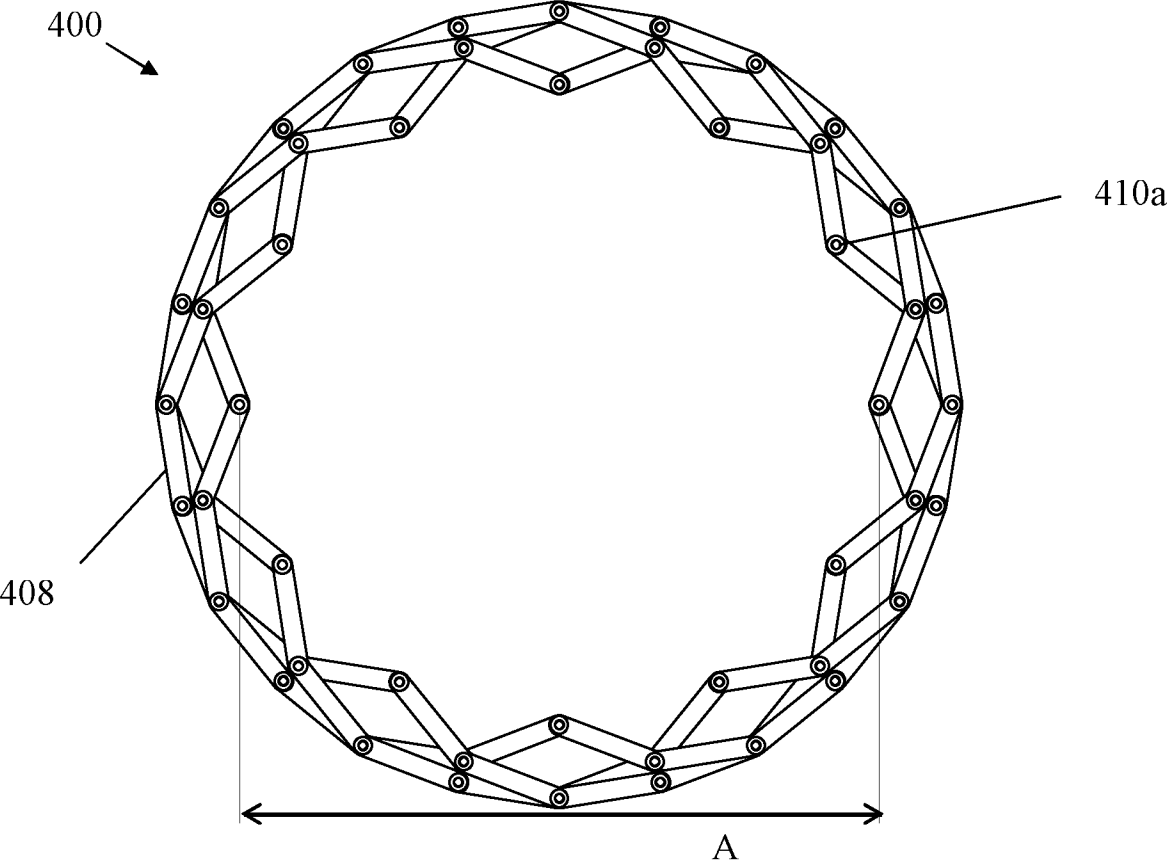


FIG 4b

8/10

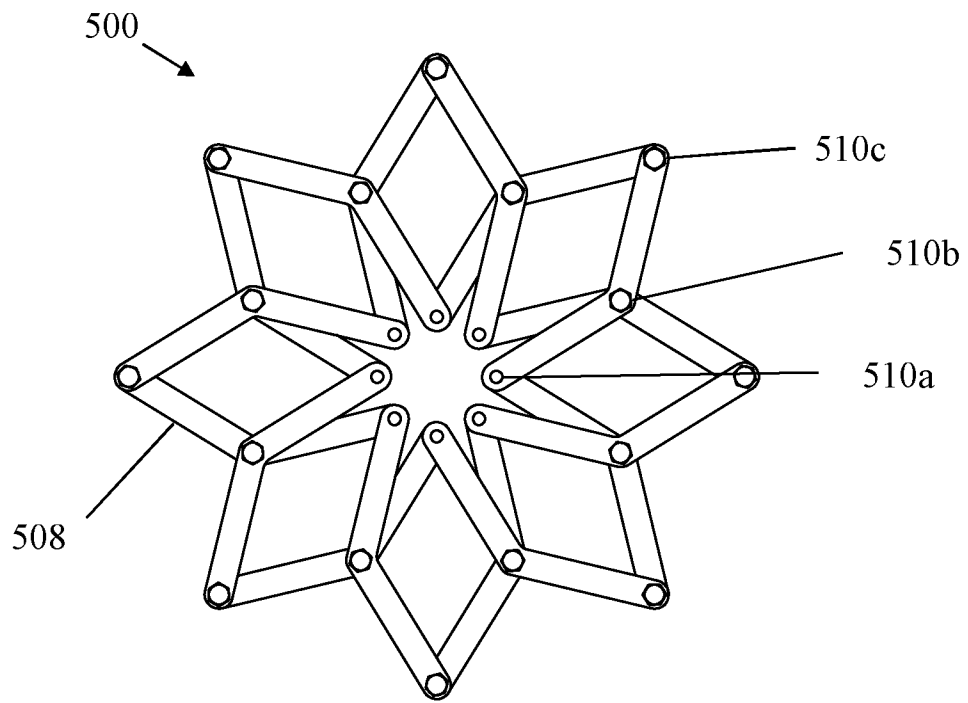


FIG 5a

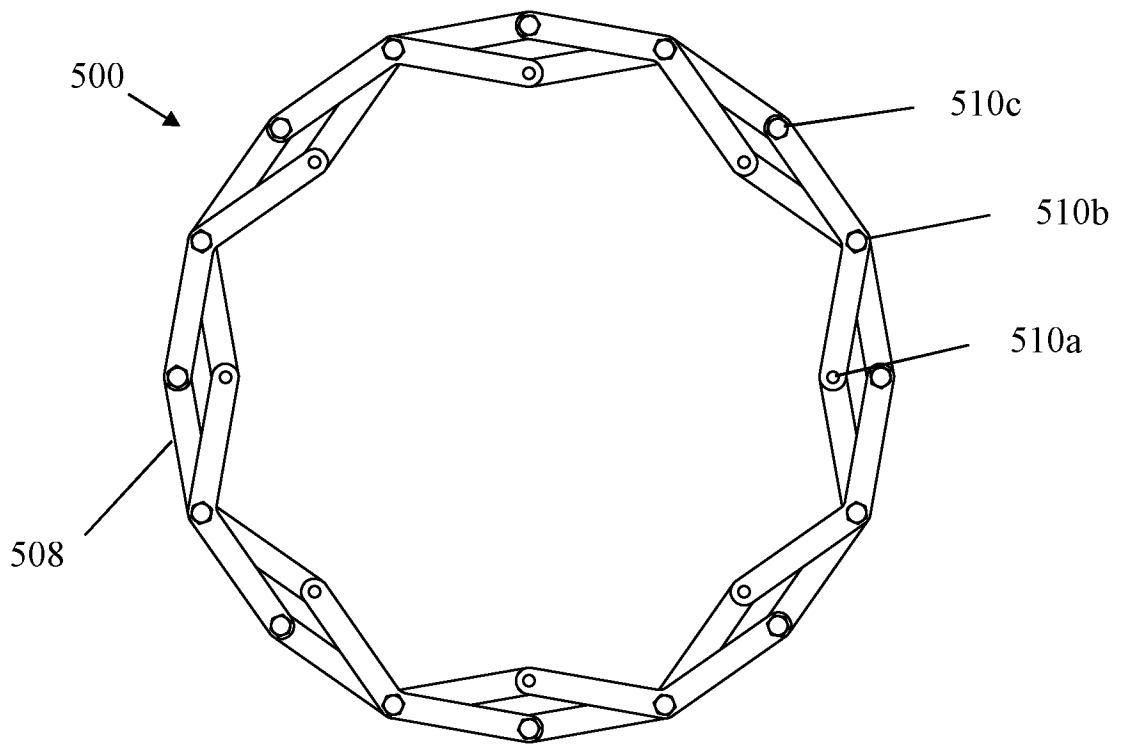
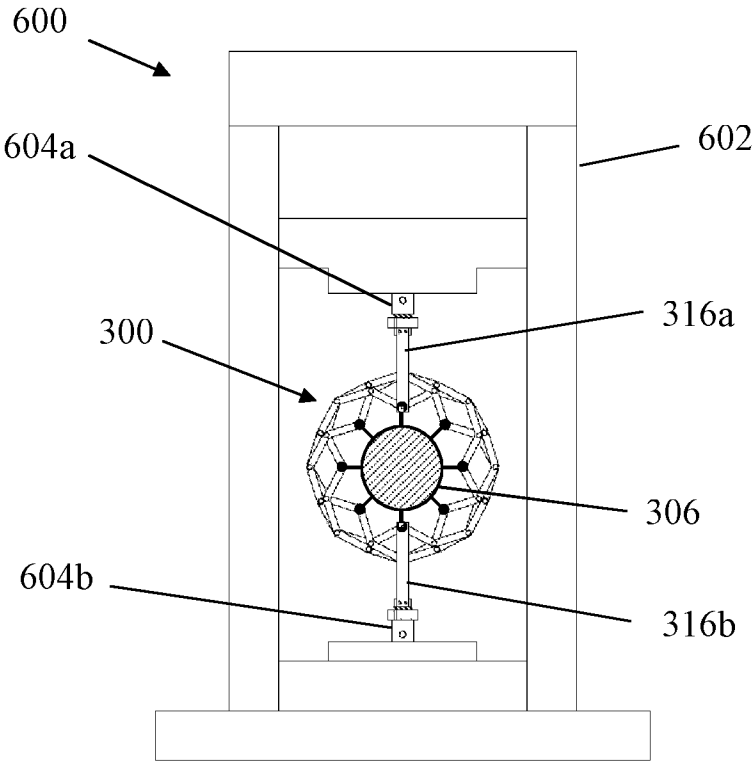
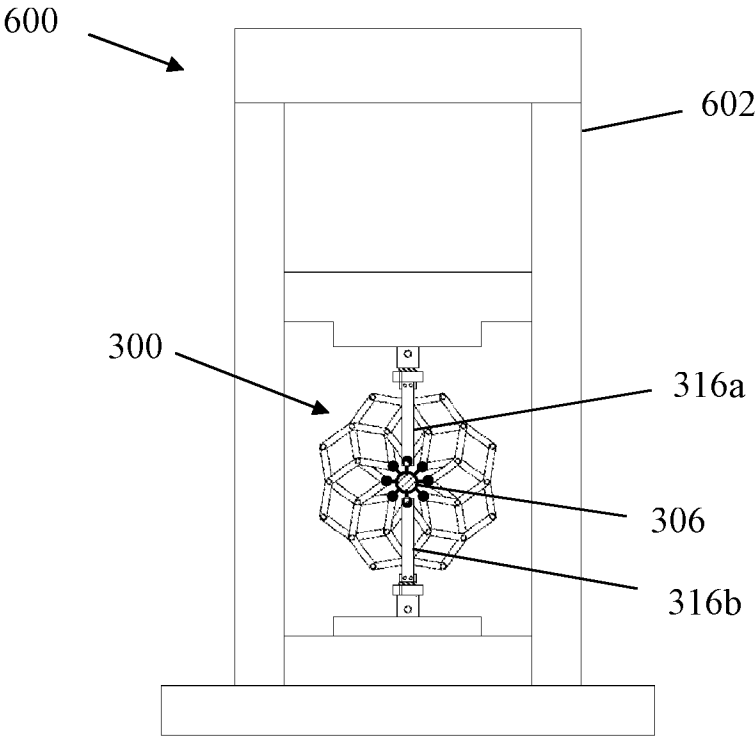


FIG 5b



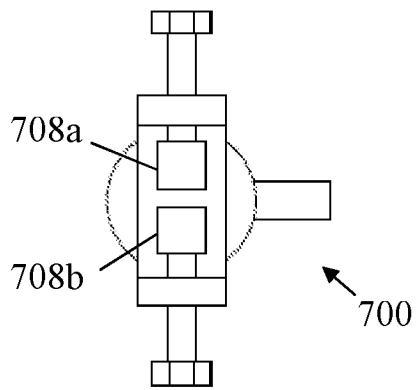


FIG 7a

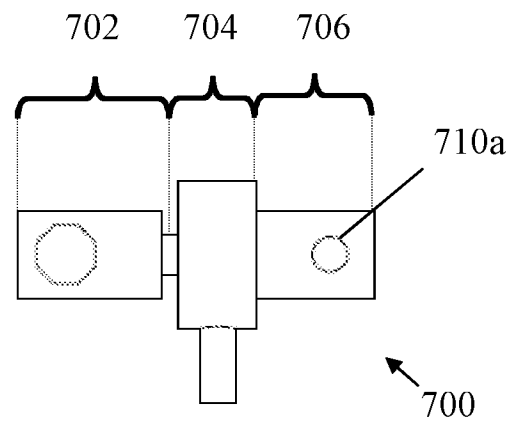


FIG 7b

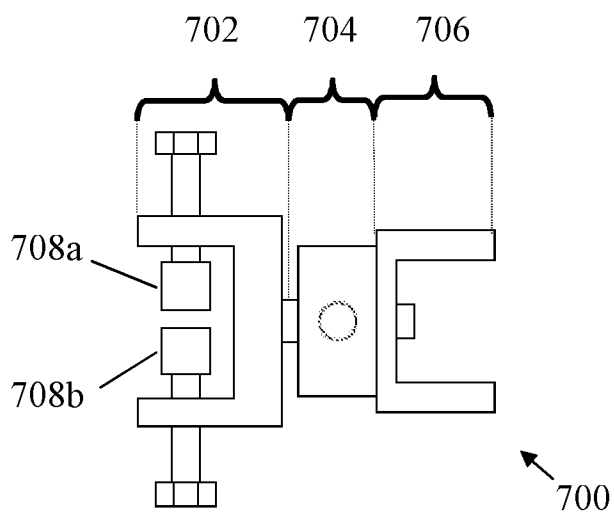


FIG 7c

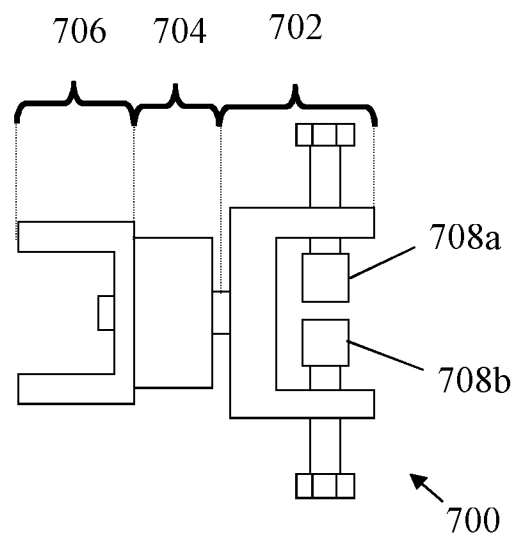


FIG 7d

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2016/050196

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01N3/04 G01N3/08
ADD.

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)
G01N

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 practicable, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/314926 A1 (HANABUSA YASUHIRO [JP]) 29 December 2011 (2011-12-29)	1-25
Y	paragraphs [0029] - [0060]; figures 1-6 -----	20,21,23
X	JP 2009 244183 A (MITSUBISHI MATERIALS CORP; UNIVERSAL SEIKAN KK) 22 October 2009 (2009-10-22) abstract -----	1-25
X	US 5 905 205 A (CLAY STEPHEN B [US]) 18 May 1999 (1999-05-18) column 4, lines 5-61; figures 1, 2 -----	1-25
X	EP 2 570 791 A2 (BAYERN CHEMIE GMBH FLUGCHEMIE [DE]) 20 March 2013 (2013-03-20) paragraphs [0026] - [0042]; figure 1 ----- -/--	1-25



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"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

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INTERNATIONAL SEARCH REPORT

International application No
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