

METHOD OF RESTORING A HOLLOW CYLINDRICAL OBJECT AND
RELATED HOLDING MECHANISM

The present invention relates to a method of restoring a
5 hollow cylindrical object such as, in particular but not
necessarily, a pipe through which liquid (e.g. water or
oil) or gas (e.g. natural gas) flows, and to a related
holding mechanism.

10 BACKGROUND OF THE INVENTION

Pipes for delivering liquid or gas are made for use for an
extended period of time often dozens of years but
deterioration if not damage, or maintenance, calling for
15 restoration (or repair) is inevitable. Replacement of a
defective pipe section is obviously a solution but is
normally not the first choice. There are a lot more
occasions where restoration falling short of repair is
required, e.g. maintenance or overhaul of pipe systems to
20 extend or maximize their life expectance.

The invention seeks to mitigate or at least alleviate such
shortcomings by providing a new or otherwise improved
method of restoring a hollow cylindrical object, and a
25 related holding mechanism.

SUMMARY OF THE INVENTION

According to a first aspect of the invention, there is provided a method of restoring a hollow cylindrical object having an inner surface, comprising the steps of:

- 5 A. providing a holding mechanism which is expandable to attain a relatively larger cross-section and contractible to attain a relatively smaller cross-section, the holding mechanism having an outer surface;
- 10 B. providing a restoring material that includes a curable bonding agent and applying a layer of the restoring material on the outer surface of the holding mechanism;
- C. placing the holding mechanism inside a said cylindrical object;
- 15 D. expanding the holding mechanism to bring and hold the restoring material against the inner surface of a said cylindrical object;
- E. allowing the bonding agent to cure, thereby bonding the restoring material to the inner surface of a said cylindrical object; and
- 20 F. contracting the holding mechanism and then removing the holding mechanism from a said cylindrical object.

Preferably, step B includes preparing the restoring material in the form of a sheet and overlaying the sheet of restoring material onto the outer surface of the holding mechanism.

It is preferred that the restoring material comprises

glass fiber or carbon fiber material.

It is further preferred that the glass fiber material is impregnated with the bonding agent.

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It is yet further preferred that the bonding agent comprises a glue or adhesive material.

10 In a preferred embodiment, the method of restoring a hollow cylindrical object includes step A1, between step A and step B, of applying a release material on the outer surface of the holding mechanism before the layer of restoring material is applied, such that the release material is situated between the layer of restoring
15 material and the holding mechanism.

More preferably, the release material comprises a separation membrane.

20 Preferably, the method of restoring a hollow cylindrical object includes step A2 following step A, of applying a resiliently deformable layer on the outer surface of the holding mechanism.

25 It is preferred that the holding mechanism has a cylindrical configuration for use inside a said hollow cylindrical object with respective axes extending generally parallel to each other.

In a preferred construction, the holding mechanism comprises:

5 a flexible planar member having two, first and second ends and being rollable up, and rolled up in operation, as between the two ends into at least one turn; and

an adjustment device adapted to move the two ends relatively apart for expanding the rolled-up flexible planar member and towards each other for contracting the
10 rolled-up flexible planar member.

More preferably, the adjustment device has first and second parts associated with the first and second ends of the flexible planar member respectively, the first and
15 second parts being in adjustable engagement with each other to determine the relative position between the first and second ends of the flexible planar member.

Further more preferably, the adjustment device comprises a
20 rack-and-pinion as its first and second parts which are in fixed engagement with the first and second ends of the flexible planar member respectively.

Further more preferably, the first and second parts of the
25 adjustment device include a ring of engagement means and a series of engagement means provided at the first and second ends of the flexible planar member respectively, the ring of engagement means being in engagement with the

series of engagement means and being rotatable to cause relative movement between the ring of engagement means and the series of engagement means, thereby determining the relative position between the first and second ends of the flexible planar member.

It is preferred that the flexible planar member comprises a flexible rigid sheet.

It is further preferred that the flexible rigid sheet is made of one of metal and plastic materials.

Preferably, the method of restoring a hollow cylindrical object includes repeating the steps other than step A in succession to restore consecutive sections of a said hollow cylindrical object, with the restoring materials between two adjacent sections overlapped with each other for uninterrupted covering of the inner surface of a said hollow cylindrical object.

Preferably, the hollow cylindrical object comprises a pipe for delivering fluid.

According to a second aspect of the invention, there is provided a holding mechanism for use in a method of restoring a hollow cylindrical object having an inner surface, comprising a body of a cylindrical configuration for use inside a said hollow cylindrical object with

respective axes extending generally parallel to each other. The body has an outer surface for acting upon restoring material. The holding mechanism includes an adjustment device adapted to expand the body to attain a relatively larger cross-section for holding said restoring material against the inner surface of a said hollow cylindrical object and subsequently to contract the body to attain a relatively smaller cross-section for movement relative to a said hollow cylindrical object.

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Preferably, the body comprises a flexible planar member having two, first and second ends and being rollable up, and rolled up in operation, as between the two ends into at least one turn. Also, the adjustment device comprises an adjustment device adapted to move the two ends relatively apart for expanding the rolled-up flexible planar member and towards each other for contracting the rolled-up flexible planar member.

20 More preferably, the adjustment device has first and second parts associated with the first and second ends of the flexible planar member respectively, the first and second parts being in adjustable engagement with each other to determine the relative position between the first and second ends of the flexible planar member.

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Further more preferably, the adjustment device comprises a rack-and-pinion as its first and second parts which are in

fixed engagement with the first and second ends of the flexible planar member respectively.

Further more preferably, the first and second parts of the
5 adjustment device include a ring of engagement means and a
series of engagement means provided at the first and
second ends of the flexible planar member respectively,
the ring of engagement means being in engagement with the
series of engagement means and being rotatable to cause
10 relative movement between the ring of engagement means and
the series of engagement means, thereby determining the
relative position between the first and second ends of the
flexible planar member.

15 It is preferred that the flexible planar member comprises
a flexible rigid sheet.

It is further preferred that the flexible rigid sheet is
made of one of metal and plastic materials.

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BRIEF DESCRIPTION OF DRAWINGS

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

Figure 1 is a perspective view of an embodiment of a
holding mechanism for use in an embodiment of a method of

restoring a hollow cylindrical object, for example a pipe,
both in accordance with the invention;

Figure 2 is a perspective view of the holding mechanism of
5 Figure 1, onto which a release material is applied in an
early step of the restoring method;

Figure 3 is a perspective view of the holding mechanism of
Figure 2, onto which a restoring material is applied in a
10 subsequent step of the restoring method;

Figure 4 is a side view which shows the holding mechanism
of Figure 3 being placed inside the pipe for operation, in
the next step of the restoring method;

15 Figure 5 is a side view corresponding to Figure 4, showing
the holding mechanism being expanded to bring and hold the
restoring material against the inner surface of the pipe,
in the next step of the restoring method;

20 Figure 6 is a side view corresponding to Figure 5, showing
the holding mechanism being placed inside the pipe again
for repeated operation, according to the restoring method;

25 Figure 7 is a perspective view of an end of the holding
mechanism, including adjustment devices operable to expand
or contract the holding mechanism in the pipe; and

Figure 8 is a rear perspective view of one adjustment device of Figure 7.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

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Referring to the drawings, there is illustrated a method, embodying the invention, of restoring a hollow cylindrical object which is, for example, a pipe 100 (i.e. a section of a pipe) for delivering fluid e.g. water or gas. The
10 pipe 100 has a linear central axis X extending along its length and an inner surface 110 that extends cylindrically around the axis X. The restoring method has a number of steps and is suitable for use on most if not all types of pipes (made of metal, concrete or any other materials) for
15 delivering water, steam, gas or oil, etc. The pipe 100 may be buried underground or running underwater or in an open environment, be that indoor or outdoor. The restoring method is applicable to repairing of the inner pipe surface 110, which is accessible via one end of the
20 pipe 100 that is opened for the purpose.

The method of restoring a hollow cylindrical object has a number of steps, including an initial step of providing a holding mechanism 200 (Figures 7 and 8) also embodying the
25 invention, which is broadly stated expandable to attain a relatively larger cross-section and contractible to attain a relatively smaller cross-section. The holding mechanism 200 has a cylindrical configuration, with an outer surface

201, for use in the pipe 100 (which is a cylindrical object) with respective axes extending generally parallel to each other.

- 5 The holding mechanism 200 comprises a flexible planar member 210 and at least one or several adjustment devices 220 operable upon the flexible planar member 210. The flexible planar member 210 is preferably provided by a flexible rigid sheet 210S of a generally rectangular
- 10 shape, which may be made of one of metal and plastic materials, such as galvanized zinc in the described embodiment, hereinafter referred to as the holding sheet 210S.
- 15 The holding sheet 210S has two, opposite first and second ends referred to as head and tail ends 211 and 212, and is rollable up, and rolled up into a scroll in use, as between its two ends 211 and 212 into at least one complete turn, resulting in the aforesaid cylindrical
- 20 configuration. This rolled-up or scroll configuration should stay 360° cylindrical throughout use inside the pipe 100, with the head and tail ends 211 and 212 overlapping with each other. In this regard, the holding sheet 210S should have a length, as measured across its two ends 211
- 25 and 212, longer than the perimeter of the inner cross-section of the pipe 100 so that it can expand to occupy the entire inner cross-section.

The adjustment devices 220 are adapted to move the two ends 211 and 212 relatively apart for expanding or unscrolling the rolled-up holding sheet 210S and towards each other for contracting or scrolling the rolled-up holding sheet 210S. As to construction, each adjustment device 220 has first and second parts 221 and 222 associated, e.g. through fixed engagement, with the head and tail ends 211 and 212 of the holding sheet 210S respectively. The first and second parts 221 and 222 together constitute a rack-and-pinion system, with the second part 222 acting as the "rack" or rack module and the first part 221 acting as the "pinion" or pinion module.

15 The rack module 222 is provided by a blade 222B whose opposite edges are formed with respective series of teeth (i.e. a form of engagement means). The pinion module 221 has a box 221B, a pair of gearwheels 221G mounted therein in a side-by-side manner, and a shaft 221S that extends through the box 221B and on a common side of the gearwheels 221G. Each gearwheel 221G has, as engagement means, a relatively thin lower ring of teeth 221T-1 and a relatively thick upper ring of teeth 221T-2.

25 The blade 222B extends through the box 221B at right angles to the shaft 221S, along a path through the gap between the gearwheels 221G and with its teeth on opposite edges in gear engagement with the lower rings of teeth

221T-1 of the gearwheels 221G respectively. This results in a rack-and-pinion engagement between each gearwheel 221G and the corresponding edge of the blade 222B, on opposite sides thereof.

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Although this is not shown in the drawings, the shaft 221S is rotatable by means of a crank handle connected at one end. The shaft 221S is formed with two consecutive sections over the part of its length within the box 221B, each consisting of a worm gear 221W-1/221W-2. The worm gears 221W-1 and 221W-2 are threaded in opposite directions and are in gear engagement with the upper rings of teeth 221T-2 of the gearwheels 221G respectively, such that upon rotation (e.g. in direction P) the shaft 221S drives the gearwheels 221G in opposite directions which in turn simultaneously slide the blade 222B in one direction (i.e. direction Q).

The adjustment devices 220 are installed on the holding sheet 210S, with the pinion modules 221 mounted on the head end 211 of the holding sheet 210S and the rack modules 222 attached to the tail end 212, both on the inner surface of the rolled-up/scroll structure. The pinion modules 221 are fixed to sit right behind the rim of the head end 211 and in mutual lateral alignment such that one single shaft 221S passes through all of them (Figure 7) for simultaneously operating the same.

The rack modules 222 are fixed to extend inwards from behind the rim of the tail end 212 along part of the circumference of the rolled-up structure. At where the rack modules 222 are, the head end 211 is cut through to
5 form respective slots 213, through which the rack modules 222 or their blades 222B on the tail end 212 are exposed and engaged with the pinion modules 221 on the head end 211.

10 In operation, the pinion and rack modules 221 and 222 are in adjustable engagement with each other for relative movement to determine the relative position between the head and tail ends 211 and 212 of the holding sheet 210S and hence the diameter of the rolled-up holding sheet
15 210S.

Turning back to the subject restoring method, with the provision of the holding mechanism 200 (Figure 1), the method may be carried out with the other steps as now
20 described. First, a restoring material that includes a curable bonding agent is prepared, a layer of which is subsequently applied on the outer surface 201 of the holding mechanism 200 and in particular the rolled-up holding sheet 210S. The restoring material comprises glass
25 fiber material (or carbon fibers) as a preferred choice of material and is in the form of a woven sheet or matt 300 for ease of handling. The glass fiber matt 300 is impregnated with a curable bonding agent which is

preferably a glue or adhesive material for glass fiber.

The glass fiber matt 300 is overlaid onto the cylindrical outer surface 201 of the holding sheet 210S. Depending upon the relative sizes, more than one piece of the glass fiber matt 300 are often required to surround the holding sheet 210S and cover its length.

Prior to placing of the glass fiber matts 300, a release material is preferably applied onto the outer surface 201 of the holding sheet 210S before the glass fiber matts 300 are applied (Figure 3), such that the release material will be situated or sandwiched between the glass fiber matts 300 and the holding sheet 210S to facilitate release the holding sheet 200 from the glass fiber matts 300 at a later stage. The release material may take a physical form for ease of handling, such as a separation membrane 400 (Figure 4) to be wrapped around the pipe 100.

Prior to the application of the separation membrane 400, a sheet of resilient material, for example in the form of a resiliently deformable sheet 401 may be applied on cover or surround the outer surface 201 of the holding sheet 210S. The sheet 401 forms a resiliently deformable layer on the outer surface 201, to be sandwiched between the separation membrane 400 and the holding sheet 210S, for a reason as explained below.

Upon completion of all the aforesaid steps, the holding mechanism 200 may then be moved and placed inside the pipe 100 (Figure 4). The holding mechanism 200 is preferably supported on wheels for mobility, e.g. by including a
5 frame chassis extending through the holding sheet 210S and fitted with wheels 230.

At an appropriate position where restoration is required, the holding mechanism 200 is expanded by operating the
10 adjustment device 220 (Figure 5). More specifically, upon rotation of the shaft 221S, the pinion modules 221 (on the head end 211) are driven to move the rack modules 222 or blades 222B (on the tail end 212) in unison, thereby sliding the head and tail ends 211 and 212 relatively
15 apart and hence expanding or unscrolling the holding sheet 210S until it gets so close upon the inner surface of the pipe 100 that it brings and holds the glass fiber matts 300 (impregnated with bonding agent) round it 360° firmly against the pipe's inner surface.

20 The holding sheet 210S reaches a maximum expanded state in which it attains the largest possible cross-sectional size or diameter within the pipe 100. Subsequently, time (e.g. a few hours) is given to allow the bonding agent to cure,
25 whereby the glass fiber matts 300 are bonded to the inner surface of the pipe 100.

In closing, the holding mechanism 200 is contracted by

reverse turning of the shaft 221S, whereupon the pinion modules 221 move the rack modules 222 in the opposite direction to slide the head and tail ends 211 and 212 relatively towards each other, hence contracting or
5 scrolling the holding sheet 210SF to a relatively smaller diameter or cross-section, for movement relative to the pipe 100. The holding mechanism 200 is finally wheeled back out to be removed from the pipe 100.

10 Whilst the holding mechanism 200 is of a limited length, the pipe 100 is often considerably longer. It is therefore be necessary to conduct the restoration process on one section of the pipe 100 after another, each section being delineated by the length of the holding mechanism 200.

15 Hence, subsequently, the steps as described above, other than the initial step of providing the holding mechanism 200, are repeated in succession to restore consecutive sections of the inner surface of the pipe 100. The
20 restoring materials i.e. glass fiber matts 300 between two adjacent sections should overlap with each other for uninterrupted covering of the pipe's inner surface. Thus, for example, the glass fiber matts 300 for restoring the second section should be placed to overlap with the glass
25 fiber matts 300 previously applied to the first section, as shown in Figure 6.

In practice, the pipe 100 does not have a cross-section

that is perfectly circular (e.g. in terms of ovality) by reason of, for example, manufacturing tolerance or deformation during installation or through use. By virtue of its flexibility, the holding sheet 210S is able to
5 adapt itself, as it is being unscrolled to press radially upon the pipe's inner surface, to match or conform to the non-circular profile or shape of the pipe's inner surface. This ensures complete bonding of the restoring material 300 to the pipe's inner surface 110, particularly over
10 regions of irregularity in terms of ovality and/or general unevenness.

Whilst being flexible is an advantageous characteristic, the holding sheet 210S should also be rigid so that it is
15 sufficiently strong in holding itself up to in turn hold the restoring material 300 firmly against the inner surface of the pipe 100 over a period of time during which the bonding agent cures or hardens.

20 As mentioned above, a resiliently deformable sheet 401 may be used between the separation membrane 400 and the holding sheet 210S. The resiliently deformable sheet 401 may be made of rubber material, etc. and/or in the form of a net. It provides the holding sheet 210S with a
25 resiliently deformable surface or layer with which the holding sheet 210S bears, via the separation material or membrane 400, upon the restoring glass fiber matts 300 to thereby press the glass fiber matts 300 into closer

contact with the inner surface 110 of the pipe 100. Such closer contact is made possible through deformation, upon compression, of the resiliently deformable sheet 401, which adjusts its surface profile to conform to that of
5 the pipe's inner surface 110 in order to overcome or accommodate regions of irregularity in terms of minor unevenness as may be caused by, for example, protuberances and dents and, more often, welding beads.

10 It is envisaged that the subject restoring method is not dependent upon the design or construction of the subject holding mechanism, and vice versa. Thus, for example, the holding mechanism 200 may include a flexible planar member 210 in the form of articulated parts instead of an
15 integral sheet, or the rack module 222 may be replaced by a series of holes or apertures formed in the holding sheet 210S for gear engagement by an associated upwardly-oriented gearwheel of the pinion module 221.

20 As to the restoring material, another choice is carbon fiber, which has roughly comparable mechanical properties to other fibers including glass fiber. Although not as strong or as rigid as carbon fiber, glass fiber is much cheaper and significantly less brittle when used in
25 composites, and is therefore often used as a reinforcing agent for many polymer products to form a very strong and relatively lightweight fiber-reinforced polymer, a composite material called glass-reinforced plastic or

generally known as fiberglass.

It should be noted that the subject restoring method and the subject holding mechanism are applicable to hollow
5 cylindrical objects of all kinds, i.e. not just limited to pipes for delivering fluid, because the nature of the objects to restore is irrelevant to the carrying out of the restoring method.

10 The invention has been given by way of example only, and various other modifications of and/or alterations to the described embodiments may be made by persons skilled in the art without departing from the scope of the invention as specified in the appended claims.

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CLAIMS

1. A method of restoring a hollow cylindrical object having an inner surface, comprising the steps of:

5 A. providing a holding mechanism which is expandable to attain a relatively larger cross-section and contractible to attain a relatively smaller cross-section, the holding mechanism having an outer surface, wherein the holding mechanism has a cylindrical configuration for use inside
10 said hollow cylindrical object with respective axes extending generally parallel to each other, the holding mechanism comprising:

 a flexible planar member having two, first and second ends and being rollable up, and rolled up in
15 operation, as between the two ends into at least one turn; and

 an adjustment device adapted to move the two ends relatively apart for expanding the rolled-up flexible planar member and towards each other for contracting
20 the rolled-up flexible planar member;

B. providing a restoring material that includes a curable bonding agent and applying a layer of the restoring material on the outer surface of the holding mechanism;

25 C. placing the holding mechanism inside said cylindrical object;

D. expanding the holding mechanism to bring and hold the restoring material against the inner surface of said cylindrical object;

30 E. allowing the bonding agent to cure, thereby bonding the restoring material to the inner surface of said cylindrical object; and

F. contracting the holding mechanism and then removing the holding mechanism from said cylindrical object.

2. The method of restoring a hollow cylindrical object as claimed in claim 1, wherein step B includes preparing the restoring material in the form of a sheet and overlaying the
5 sheet of restoring material onto the outer surface of the holding mechanism.

3. The method of restoring a hollow cylindrical object as claimed in claim 1 or claim 2, wherein the restoring
10 material comprises glass fiber or carbon fiber material.

4. The method of restoring a hollow cylindrical object as claimed in claim 3, wherein the glass fiber material is impregnated with the bonding agent.
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5. The method of restoring a hollow cylindrical object as claimed in claim 4, wherein the bonding agent comprises a glue or adhesive material.

20 6. The method of restoring a hollow cylindrical object as claimed in any one of claims 1 to 5, including step A1, between step A and step B, of applying a release material on the outer surface of the holding mechanism before the layer of restoring material is applied, such that the release
25 material is situated between the layer of restoring material and the holding mechanism.

7. The method of restoring a hollow cylindrical object as claimed in claim 6, wherein the release material comprises a
30 separation membrane.

8. The method of restoring a hollow cylindrical object as claimed in any one of claims 1 to 7, including step A2

following step A, of applying a resiliently deformable layer on the outer surface of the holding mechanism.

9. The method of restoring a hollow cylindrical object as
5 claimed in any one of claims 1 to 8, wherein the adjustment device has first and second parts associated with the first and second ends of the flexible planar member respectively, the first and second parts being in adjustable engagement with each other to determine the relative position between
10 the first and second ends of the flexible planar member.

10. The method of restoring a hollow cylindrical object as claimed in claim 9, wherein the adjustment device comprises a rack-and-pinion as its first and second parts which are in
15 fixed engagement with the first and second ends of the flexible planar member respectively.

11. The method of restoring a hollow cylindrical object as claimed in claim 9, wherein the first and second parts of
20 the adjustment device include a ring of engagement means and a series of engagement means provided at the first and second ends of the flexible planar member respectively, the ring of engagement means being in engagement with the series of engagement means and being rotatable to cause relative
25 movement between the ring of engagement means and the series of engagement means, thereby determining the relative position between the first and second ends of the flexible planar member.

30 12. The method of restoring a hollow cylindrical object as claimed in any one of claims 1 to 11, wherein the flexible planar member comprises a flexible rigid sheet.

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13. The method of restoring a hollow cylindrical object as claimed in claim 12, wherein the flexible rigid sheet is made of one of metal and plastic materials.

5 14. The method of restoring a hollow cylindrical object as claimed in any one of claims 1 to 13, including repeating the steps other than step A in succession to restore consecutive sections of said hollow cylindrical object, with the restoring materials between two adjacent sections
10 overlapped with each other for uninterrupted covering of the inner surface of said hollow cylindrical object.

15 15. The method of restoring a hollow cylindrical object as claimed in any one of claims 1 to 14, wherein the hollow cylindrical object comprises a pipe for delivering fluid.

16. A holding mechanism for use in a method of restoring a hollow cylindrical object having an inner surface, comprising:

20 a body of a cylindrical configuration for use inside said hollow cylindrical object with respective axes extending generally parallel to each other, the body having an outer surface for acting upon restoring material, wherein the body comprises a flexible planar member having two,
25 first and second ends and being rollable up, and rolled up in operation, as between the two ends into at least one turn; and

an adjustment device adapted to expand the body to attain a relatively larger cross-section for holding said
30 restoring material against the inner surface of said hollow cylindrical object and subsequently to contract the body to attain a relatively smaller cross-section for movement relative to said hollow cylindrical object, wherein the

adjustment device comprises an adjustment device adapted to move the two ends relatively apart for expanding the rolled-up flexible planar member and towards each other for contracting the rolled-up flexible planar member.

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17. The holding mechanism as claimed in claim 16, wherein the adjustment device has first and second parts associated with the first and second ends of the flexible planar member respectively, the first and second parts being in adjustable engagement with each other to determine the relative position between the first and second ends of the flexible planar member.

18. The holding mechanism as claimed in claim 17, wherein the adjustment device comprises a rack-and-pinion as its first and second parts which are in fixed engagement with the first and second ends of the flexible planar member respectively.

19. The holding mechanism as claimed in claim 17, wherein the first and second parts of the adjustment device include a ring of engagement means and a series of engagement means provided at the first and second ends of the flexible planar member respectively, the ring of engagement means being in engagement with the series of engagement means and being rotatable to cause relative movement between the ring of engagement means and the series of engagement means, thereby determining the relative position between the first and second ends of the flexible planar member.

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20. The holding mechanism as claimed in any one of claims 16 to 19, wherein the flexible planar member comprises a flexible rigid sheet.

21. The holding mechanism as claimed in claim 20, wherein the flexible rigid sheet is made of one of metal and plastic materials.