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(71) Applicant: **Manufatti Plastici Traversa Ezio S.n.c.
22075 Lurate Caccivio (Como) (IT)**

(72) Inventors:
• **Ricca, Giovanni**
I-20147, Saronno (MI) (IT)
• **Ambrosetti, Maria Rita**
I-28831, Baveno (VB) (IT)
• **Bessegghini, Stefano**
I-23037, Tirano (SO) (IT)

(74) Representative: **Zanoli, Enrico et al**
Zanoli & Giavarini S.r.l.
Via Melchiorre Gioia, 64
20125 Milano (IT)

(54) **Hinge made of a shape memory material**

(57) Hinge for connection of parts with freedom of angular movement about the axis (X) of the hinge, characterized in that it comprises a pin (10) made of shape memory material, to which said parts with freedom of

angular movement are rigidly constrained in at least two regions (12, 12a) spaced along said axis (X), so that said angular movement determines application of a torsional moment on said shape memory pin.

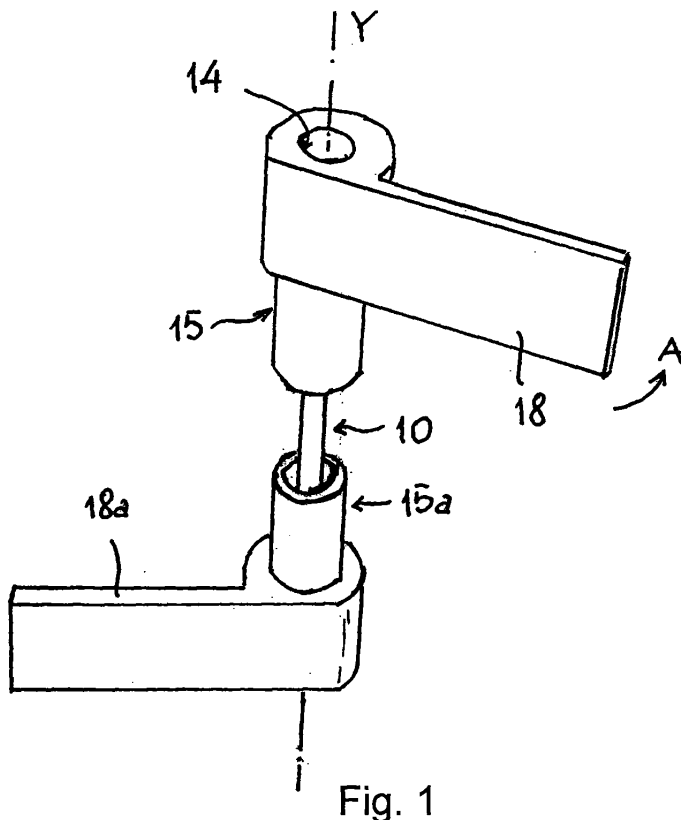


Fig. 1

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Description

[0001] The present invention relates to a hinge made of shape memory material. More specifically, the invention relates to a shape memory hinge which operates with torsion. The invention also extends to a pivot for doors, door panels, windows and the like incorporating said shape memory hinge.

[0002] The use of shape memory materials, in particular bi- or tri-metallic alloys such as Ni-Ti (nitinol) alloys is known and documented to make various elements or devices in the mechanical, space and biomedical fields. In many cases activation of the shape memory material requires a difference in temperature, while in other cases activation is obtained through mechanical stress, or with a combination of mechanical and thermal stresses.

[0003] In general, shape memory materials have the characteristic of showing a pseudo-permanent state of deformation, and they are capable of returning, after undergoing deformation, to the shape and dimension of the condition prior to deformation. Shape memory materials also present a superelastic or pseudo-elastic effect, the stress/deformation diagram of which shows a hysteresis cycle, with a deformation limit of around 8%.

[0004] The memory effect can be one-directional, when only the high temperature shape in the martensitic phase is memorized; in this case to obtain the low temperature shape it is necessary to apply external mechanical stress.

[0005] The memory effect can also be bi-directional, when two shapes are memorized, one at low temperature and one at high temperature, transition between the two shapes taking place solely through heat, without applying external mechanical stress.

[0006] Various hinge structures made of shape memory material are known, some of which are intended for aeronautical and/or space applications, where the aspect concerning cost does not need to be of primary importance.

[0007] The patent application WO 99/60860 relates to a hinge structure for the deployment of instrumentation in a spacecraft. The hinge consists essentially of an element made of shape memory material, with a flattened configuration, which operates with flexure and which can change from a substantially folded position, i.e. hinge closed, to a substantially straightened or extended position, i.e. hinge open. The hinge in shape memory material described in this document also functions as an actuator of the deployment of instrumentation connected thereto, as the flexural movement can be determined by a martensitic transformation undergone by the shape memory material as a function of the temperature.

[0008] The patent application US 2003/0196298 relates to another hinge structure for aerospace application, consisting of a shape memory material such as nitinol, a nickel and titanium alloy. Also in this case the hinge is composed of a flat element operating by flexure and acting as an actuator for the deployment of equipment

and/or instrumentation mounted on the spacecraft. Moreover, the hinge can be conductive to perform the following functions: a) to allow current and/or electrical signals to pass from the instrumentation connected to the hinge to one or more different units on board the spacecraft; b) to allow phase transition due to the heating determined by the passage of current, and thereby determine the flexural movement.

[0009] The Japanese patent JP 7264274 by Nippon Electric Co. illustrates a mobile telephone of the type formed of two halves that fold against each other in the idle position and can be opened by rotation about a hinge made of shape memory material capable of memorizing the degree of extension of the open position, optimizing the aperture angle as a function of the preferences of the user. The shape memory hinge is composed of a pair of elongated cylindrical elements 4, fastened at the ends thereof to the two halves of the mobile telephone, which flex in the central region thereof. This is therefore a hinge that operates by flexure.

[0010] In the prior art embodiments described above the kinematically active part of the shape memory material is always composed of a portion, at times very small, of the material of which the hinge is actually composed. This is determined by the fact that the flexural movement substantially only involves the part of the hinge located in proximity to the axis about which rotation takes place, whether determined by a thermal effect or by mechanical stress. The rest of the material forming the hinge acts simply as an element for fastening to the parts connected by the hinge, both in the case of hinge in the form of a flat element and in the case of hinge in the form of cylindrical element. Considering the noteworthy costs of shape memory materials, this prior art solution is not efficient.

[0011] Moreover, the concentration of flexural stress on a reduced portion of the shape memory material increases wear and reduces the number of hysteresis cycles that the shape memory material can undergo; in essence, it reduces the life thereof.

[0012] An object of the present invention is to eliminate or reduce the aforesaid drawbacks of prior art shape memory hinges, by providing a hinge in which the shape memory material can be used in a more efficient manner, and in particular in which the active portion of the shape memory material is increased and the concentration of mechanical stress per unit of volume is decreased with respect to the situation characterizing hinges operating with flexure.

[0013] The aforesaid and other objects and advantages of the invention, which will be apparent from the description hereunder, are attained with a hinge for connection of parts with freedom of angular movement about the axis of the hinge, characterized in that it comprises a pin made of shape memory material, to which said parts with freedom of angular movement are rigidly constrained in at least two regions spaced along said axis, so that said angular movement determines application

of a torsional moment on said shape memory pin.

[0014] Some preferred embodiments of the invention, provided by way of non-limiting examples, will now be described with reference to the accompanying figures, in which:

- Figure 1 is a perspective schematic view of a shape memory element which is part of the hinge according to the invention;
- Figure 2 is a partly exploded perspective schematic view of a hinge according to the invention;
- Figure 3 is a stress-deformation diagram of a shape memory material utilized in the hinge according to the invention.

[0015] With reference to the figures, 10 indicates the element made of shape memory material which forms the pin of the hinge according to the invention. In this embodiment, the pin 10 has a cylindrical shape and is provided with two enlarged heads 12, 12a at the ends thereof. With reference also to Figures 2, 3 and 4, the pin 10 is inserted at one end into a corresponding hole 14 of an element 15, provided with a bracket 18 which extends perpendicularly and externally with respect to the axis of the hinge, for connection, for example, to the panel of a door, not shown. The diameter of the hole 14 corresponds to the outer diameter of the head 12 of the pin 10, so that the head 14 can be forced into the hole 14 and rigidly constrained to the element 15. In the same way the head 12a of the pin 10 is rigidly constrained inside a corresponding hole of an element 15a, also provided with a bracket 18a, which extends perpendicularly and externally with respect to the axis of the hinge, for connection, for example, to the frame of a door, not shown. The method of fastening the heads 12, 12a to the parts 15, 15a can differ from fastening obtained by forcing the heads 12, 12a into corresponding holes. For example, fastening can be obtained by means of an adhesive, or by means of mechanical constraining elements such as pins, screws, etc.

[0016] Operation of the hinge according to the invention is as follows. Assuming that the bracket 18a is fastened to the frame of a door and the bracket 18 to the panel of a door, rotation of the panel, for example in the direction of the arrow A in Figure 4 to open the door, will determine application of a torsional moment on the pin 10, which is made of a nickel-titanium alloy called nitinol. The behavior of the material to torsional stress is described by the diagram in Figure 5.

[0017] As can be seen in said figure, upon application of the torsional moment a small but proportional deformation occurs, until reaching a plateau. This first area of the diagram corresponds to the force required to start the initial angular movement of the hinge, that is, to start opening the door. Upon reaching the plateau, maximum deformation corresponds to a minimum force, thereby obtaining almost total opening of the door, with the exception of the final portion which requires a certain

amount of residual force to be applied. Closing of the door is described by the reverse cycle, with a hysteresis, as can be seen in the figure. The hinge made of shape memory material described above is particularly advantageous for use in wardrobes, lockers, furniture units and the like. Therefore, one aspect of the invention is constituted by a door or panel structure which is part of a furniture unit, characterized by the use of a hinge made of shape memory material as described above.

[0018] The elements 15, 15a provided with brackets for fastening to the parts to be connected can advantageously be made of plastic material with suitable properties of mechanical resistance, such as polyethylene, polypropylene, polyamide and the like, as is known in the field. Differently, they can be made of metal or other equivalent materials, and can be produced in one piece or in several connected pieces.

[0019] According to another embodiment, not shown, the pin 10 can be formed with parts suitable to be fastened directly to the parts to be connected, without the need for separate fastening means 15, 15a.

[0020] The degree of angular movement between the parts to be connected depends on the specific application.

[0021] In the case of doors for furniture units and the like, the degree of the rotation angle will vary as a rule between 95° and 180°, corresponding respectively to the door position more or less orthogonal to the aperture plane and to the door position more or less parallel to the aperture plane, but fully open. Opening positions of intermediate degrees to those above are as a rule 100°, 110° (most used), 120° and 165°.

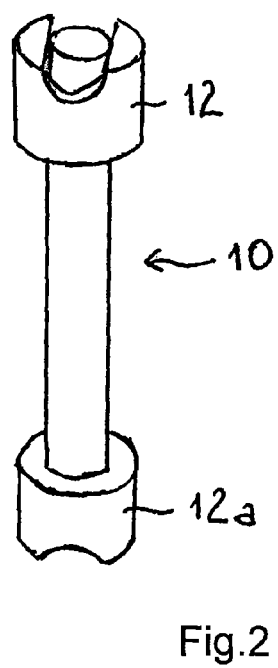
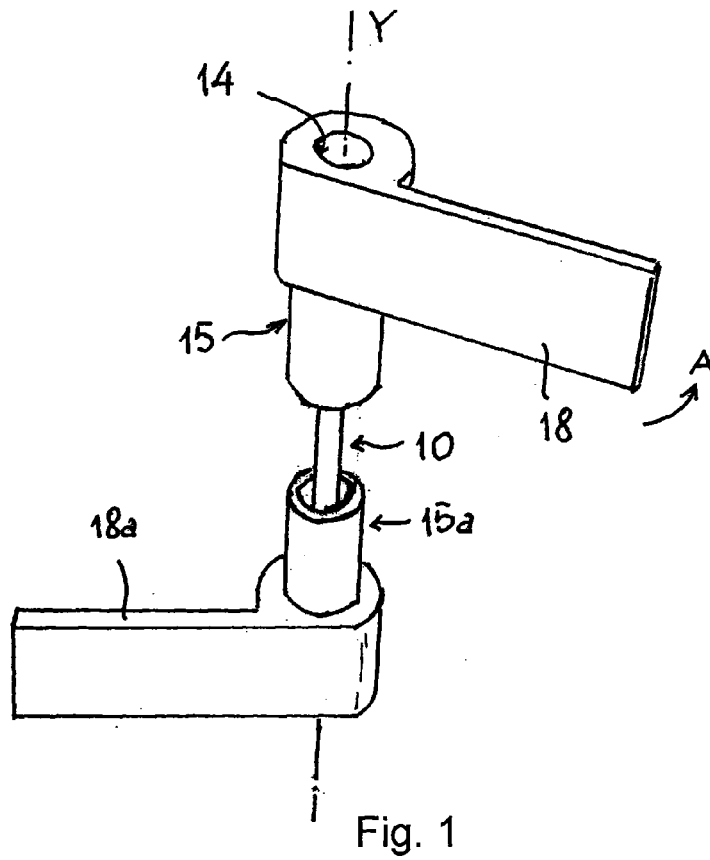
[0022] As is apparent from the above description, production of a hinge with element made of shape memory material which operates with torsion, i.e. of the pin type, allows use of this material to be confined to the kinematically active part of the device only, avoiding waste of this material to make purely connection parts which are therefore kinematically inactive. Moreover, substantially the entire mass of the pin existing between the spaced regions of application of the torsional moment are involved by the stress, which allows the performances and the duration of the hinge to be improved.

[0023] Although some preferred embodiments of the invention have been described, it is susceptible to numerous modifications and variants within the scope of the same inventive idea defined in the appended claims.

Claims

1. Hinge for connection of parts with freedom of angular movement about the axis (X) of the hinge, **characterized in that** it comprises a pin (10) made of shape memory material, to which said parts with freedom of angular movement are rigidly constrained in at least two regions (12, 12a) spaced along said axis (X), so that said angular movement determines ap-

- plication of a torsional moment on said shape memory pin.
2. Hinge according to claim 1, **characterized in that** said pin (10) is cylindrical in shape. 5
 3. Hinge according to claim 1, **characterized in that** said parts with freedom of angular movement are rigidly constrained to said pin by means of elements (15, 15a) rigidly constrained to spaced regions (12, 12a) of said pin (10). 10
 4. Hinge according to claim 3, **characterized in that** said elements (15, 15a) are provided with holes (14) in which said spaced regions (12, 12a) of said pin (10) are housed and fastened. 15
 5. Hinge according to claim 4, **characterized in that** said spaced regions (12, 12a) of said pin (10) comprise heads mounted rigidly thereon. 20
 6. Hinge according to claim 3, **characterized in that** said elements (15, 15a) are provided with brackets (18, 18a) for fastening to said parts with freedom of angular movement. 25
 7. Hinge according to claim 6, **characterized in that** said brackets (18, 18a) for fastening to said parts with freedom of angular movement extend perpendicularly and externally with respect to the axis (X) of the hinge. 30
 8. Hinge according to any one of the previous claims, **characterized in that** said pin (10) is made of nickel-titanium alloy. 35
 9. Hinge according to claim 3, **characterized in that** said elements (15, 15a) are made of plastic material.
 10. Furniture unit or furniture unit component comprising a door or panel that can be opened and closed with a hinge, **characterized in that** said hinge comprises a pin (10) made of shape memory material in which at least two fastening regions (12, 12a) are defined, a first region being suitable for fastening to the fixed part of said unit furniture and a second region being suitable for fastening of said panel, said regions being spaced along the axis (X) of said pin, so that said opening and closing movement of said panel determines the application of a torsional moment on said shape memory pin. 40 45 50
 11. Furniture unit according to claim 10, **characterized in that** said panel and said fixed part of said furniture unit are rigidly constrained to said pin (10) by means of elements (15, 15a) rigidly constrained to spaced regions (12, 12a) of said pin (10). 55
 12. Furniture unit according to claim 11, **characterized in that** said elements (15, 15a) are provided with holes (14) in which said spaced regions (12, 12a) of said pin (10) are fastened.
 13. Furniture unit according to claim 12, **characterized in that** said spaced regions (12, 12a) of said pin (10) are comprised of heads rigidly mounted thereon.
 14. Furniture unit according to claim 11, **characterized in that** said elements (15, 15a) are provided with brackets (18, 18a) for fastening to said parts with freedom of angular movement.
 15. Furniture unit according to claim 14, **characterized in that** said brackets (18, 18a) for fastening to said parts with freedom of angular movement extend perpendicularly and externally with respect to the axis (X) of the hinge.
 16. Furniture unit according to claim 10, **characterized in that** said pin (10) is made of nickel-titanium alloy.
 17. Furniture unit according to claim 10, **characterized in that** said elements (15, 15a) are made of plastic material.



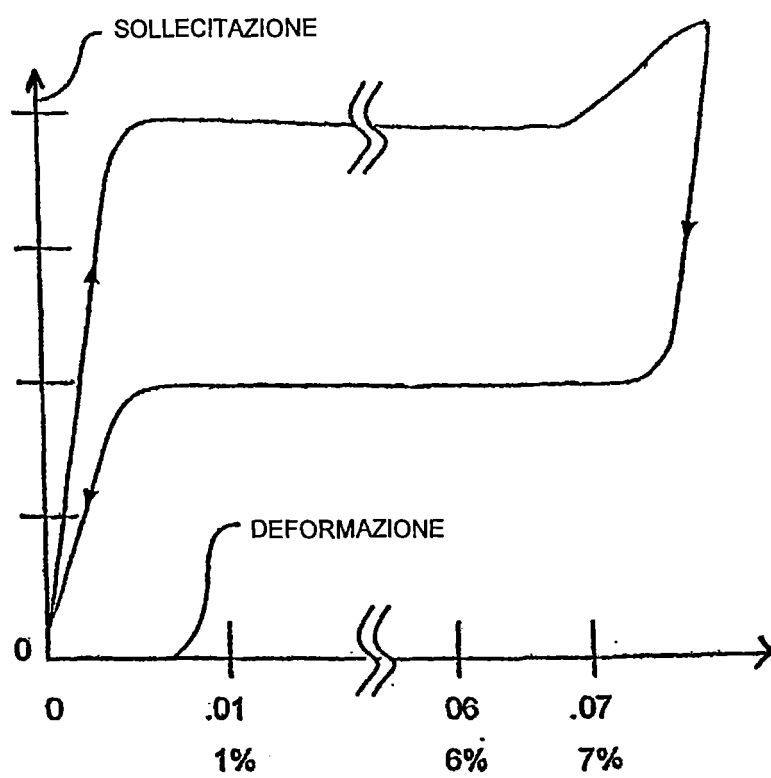


Fig. 3

REFERENCES CITED IN THE DESCRIPTION

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