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(71) Applicant: **Rossini, Ettore**
23845 Costa Masnaga (LC) (IT)

(72) Inventor: **Rossini, Ettore**
23845 Costa Masnaga (LC) (IT)

(74) Representative: **Rustichelli, Monica**
Brand & Patent
Via Ganaceto, 123
41100 Modena (IT)

(54) Stiffening fabric or band in pseudoelastic material to dump vibrations in elements subject to them

(57) Stiffening fabric or band in pseudoelastic material to damp vibration in elements subject to it, comprising a layer of material of thread(s) of pseudoelastic material, or SMA, with thread(s) arranged in the plane of the layer; characterised by the fact that the thread(s) in pseudoelastic material are arranged in strips of volutes, orientated with the pitches (L) of the volutes in the direction of the warp (O) and the amplitude of the volute (F) in the direction of the weft (T). Advantageously the fabric or band has at least one layer of support material and the volute strips, advantageously placed in the plane, are produced with different threads and the volutes are separate from each other.

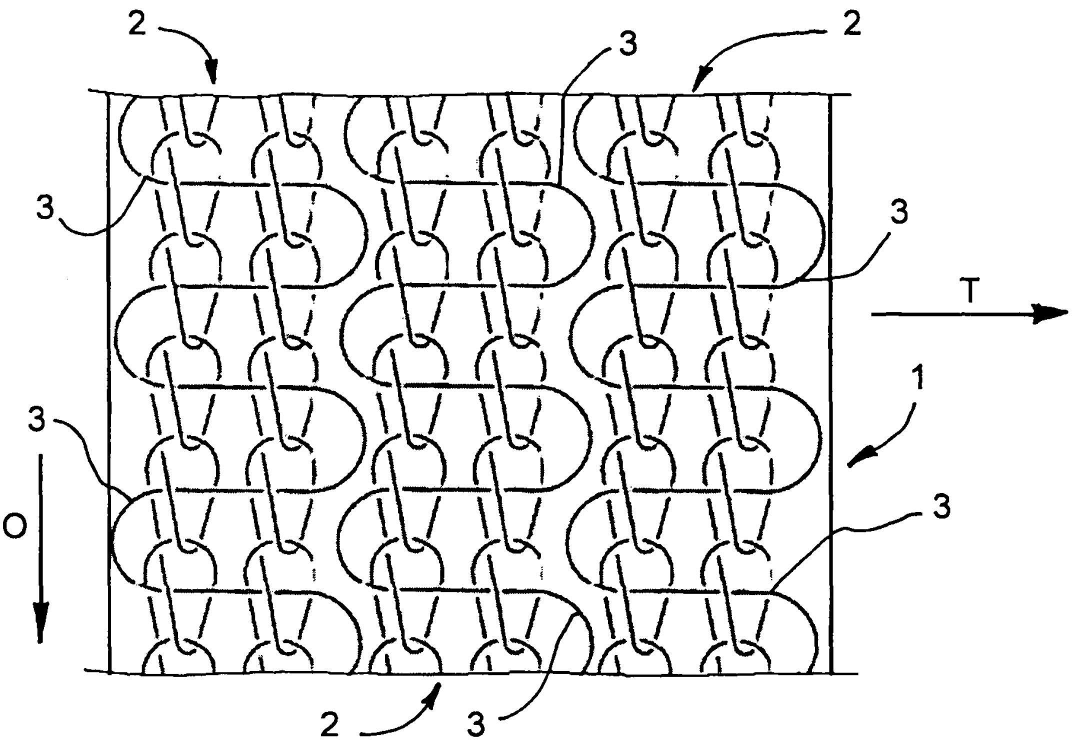


Fig. 1

EP 2 028 309 A1

Description

Technical field

[0001] The present invention relates to a stiffening fabric or band in pseudoelastic material to damp vibration in elements subject to it, or rather a fabric or band that contains pseudoelastic material which, thanks to its particular positioning and application in an element of an object subjected to vibration allows the said vibration to be damped internally, thereby making the object more advantageously usable in the specific application or use required.

Prior art

[0002] The prior art already includes more or less rigid materials that oppose internal vibration within the thickness of the material itself and respond to the laws of elasticity and known coefficients, such as the specific elastic module of each, even if composite, material.

[0003] In technological development, such design levels have been reached that the constructive elements of the object are subject to stress that causes vibration to be applied to the object itself, therefore in-depth study to find a way to damp this vibration without changing the dimensions of the element is required. This is a design path, which is well-known due to the analysis of stress and strain in the construction engineering field, that leads to the use of diverse multi-layered materials impregnated with internal mechanical stiffening elements applied externally to the element or products with the element itself.

[0004] Therefore, the effect of damping the vibration is known in the prior art with the use of stiffening layers made of rigid material, prevalently impregnated and applied with thermosetting resins, so the rigid material and the resin that are always rigid determine a variable elastic module inside the elements, which does provide adequate vibration damping; on the other hand, the greater the rigidity of the material (high elastic module), the greater the vibration frequency of the element itself, such that the element may be subject to higher resonant frequency.

[0005] In the prior art, there are also so-called "shape memory" materials, known by the acronym SMA, or which may also have "superelasticity" or "pseudoelasticity", that is, metal alloys in which the components cause structural martensitic-austenitic transformation at temperatures near to room temperature, making use of its trigger transformation characteristic both in the change from martensite to austensite, on heating, and in the opposite change from austenite to martensite, on cooling.

[0006] The best known of these alloys is NiTiNOL which has enabled the manufacture of the so-called shape memory materials used in a wide range of technological applications, including surgical prosthetics devices, as well as devices where stress induces controlled strain of the object to the maximum value permitted for that object, so as to make use of the elastic, or rather pseudoelastic, return, which recovers the shape of the object itself to avoid excessive strain and prevent it from breaking.

[0007] Finally, in the prior art there are specifically designed materials or elements that are applied for damping vibration that use the said pseudoelastic materials, where SMA threads are placed longitudinally to the stress-strain direction, and which have high quantities of SMA thread, even up to 100% in weight with regard to the weight of the support material, that is, in high quantities in order to achieve a significant damping response.

[0008] This prior art is subject to considerable improvement with regard to the definition of materials using components in such pseudoelastic alloys that may be advantageously used to damp vibration in elements subject to it, when such materials are closely connected to the said elements subject to vibration.

[0009] From what has been described above, it is clear that it is necessary to solve the technical problem, which is the basis of the present invention, by creating a device for the component element, the fabric or band in pseudoelastic alloy, which enables the control and direction of the known pseudoelastic effect that the said fabric or band can transmit to the element of the object subject to vibration, with the principal aim of containing and/or eliminating the said vibration.

[0010] Another aim of the invention is to create a device for the element in pseudoelastic alloy of the fabric or band which enables the intensity and direction of the vibration damping intervention to be controlled, by using limited quantities of pseudoelastic material.

[0011] A last but not least aim of the present invention is to control the vibration damping intervention frequency, whether or not linked to the required vibration damping intensity value.

Summary of the invention

[0012] The invention solves the above-mentioned technical problem, by using a stiffening fabric or band in pseudoelastic material to damp vibration in elements subject to it, comprising a layer of material of thread(s) of pseudoelastic material, or SMA, with thread(s) arranged in the plane of the layer; characterised by the fact that the thread(s) in pseudoelastic material are arranged in strips of volutes, orientated with the pitches of the volutes in the direction of the warp and the amplitude of the volute in the direction of the weft.

[0013] An advantageous embodiment has at least one layer of stiffening fabric or band support material; also the volute strips placed in the plane may be produced with different threads and each volute may be separate.

[0014] Further embodiments of the invention are summarised in the enclosed claims.

[0015] Furthermore, the fabric or band advantageously has the volute strips with the volute pitch or wavelength of between 2 and 20mm. Besides, the volute strips have a volute amplitude (F) of between 3 and 20mm. Besides, the thread(s) in pseudoelastic material, or SMA, of the said fabric or band, composing the volutes, have a diameter of between 0.050 and 0.250mm.

[0016] In a further advantageous embodiment, the invention comprises a composite band, with a layer of stiffening material to provide resistance to the vibration of the application element, which has a thread or threads in pseudoelastic material, or SMA, placed in the plane(s) of the layer; characterised by the fact that the thread(s) in pseudoelastic material are arranged in strips of volutes, orientated uniformly with each other in the plane (s) of the layer. Advantageously, the composite band has a thread or threads in pseudoelastic material, or SMA, arranged in the plane(s) of the layer by means of a band or fabric.

[0017] Finally, in another embodiment, the invention advantageously comprises a composite structural element, with a layer of stiffening material to provide resistance to the vibration in the machine device that it is to be used in, where there is a thread or threads in pseudoelastic material, or SMA, placed in the plane(s) of the layer; characterised by the fact that it has thread(s) in pseudoelastic material arranged in strips of volutes, orientated uniformly with each other in the plane(s) of the layer. Advantageously, the composite structural element has the thread or threads in pseudoelastic material, or SMA, placed in the plane(s) of the layer by means of a fabric or band.

[0018] The characteristics and advantages of the present invention, with the production of a stiffening fabric or band, with components in pseudoelastic material, to damp vibration in elements subject to it, shall be made clearer by the description below of an example embodiment, given as a non-limitative indication with reference to the enclosed drawings.

Brief description of the drawings

[0019] An embodiment of the invention is illustrated, purely in the form of examples, in the five drawings enclosed, where Figure 1 is a limited schematic representation of a fabric or band, in accordance with the invention, where the material with pseudoelastic properties and the method of fixing it to the other components of the band are highlighted; Figure 2 is a schematic plan view of a thread volute in pseudoelastic material; Figure 3 is a perspective schematic view of a band in pseudoelastic material in accordance with the invention; Figure 4 is a schematic view of a first arrangement of volute strips placed in a plane of the fabric or band in accordance with the invention; Figure 5 is a schematic view of a second arrangement of volute strips staggered by a quarter of a volute and slightly overlapping in a plane of the fabric or band in accordance with the invention; Figure 6 is a schematic view of a third arrangement of volute strips staggered by half a volute, aligned and slightly overlapping in a plane of the fabric or band in accordance with the invention; Figure 7 is a schematic view of a fourth arrangement of matched volute strips, subdivided into two overlapping planes, each with the arrangement shown in Figure 4; the volutes on the two planes are staggered by a quarter of a volute and slightly overlapping; these planes of volute strips are inserted facing each other into an internal plane of the fabric or band in accordance with the invention; Figure 8 is a schematic view of a fifth arrangement of matched volute strips, subdivided into two overlapping planes, each with the arrangement shown in Figure 4; the volutes on the two planes are staggered by half a volute and aligned with each other; these planes of volute strips are inserted facing each other into an internal plane of the fabric or band in accordance with the invention; Figure 9 is a schematic view of a sixth arrangement of matched volute strips on two overlapping planes, each with the arrangement shown in Figure 4; the volutes on the two planes are staggered by an eighth of a volute; these planes of volute strips are inserted facing each other into an internal plane of the fabric or band in accordance with the invention; Figure 10 is a schematic view of a seventh arrangement of matched volute strips, subdivided into three overlapping planes, each with the arrangement shown in Figure 4; the volutes on the three planes are staggered by a third of a volute and slightly overlapping; these planes of volute strips are inserted facing each other into an internal plane of the fabric or band in accordance with the invention; Figure 11 is a representation in a schematic diagram of the structural transformation of the formation network of the pseudoelastic material alloy, which shows the trigger strain between two slightly different stresses and the corresponding large strain due to a phenomenon known for the above-mentioned alloy.

Detailed description of a preferred embodiment

[0020] Figure 1 shows a band 1, in accordance with the invention, on which three strips 2 of volutes 3 with a thread in pseudoelastic material are arranged; each strip is attached in the formation position of the volutes 3 with a simple chain stitch 4, to keep the volutes 3 in position during the production of the band 1. The warp O indicates the production direction of the band/fabric, while the direction T of the weft indicates the direction of the stress in the band/fabric and the subsequent strain.

[0021] In Figure 2, where a single volute 3 of a strip 2 is shown, L indicates the pitch and F indicates the amplitude of the volute obtained by folding the thread in pseudoelastic material.

[0022] Figure 3 shows the layers of band/fabric on which the strips of volute shown in Figure 1 are applied. The layers are composed of a first layer 4 of stiffening fibres longitudinally to the warp; a second layer 5 of stiffening fibres 5 in the direction of the weft is applied to the previous one; when the band/fabric is completed there may be a further layer or core 6 which, when a composite material is produced directly, may be omitted.

[0023] In Figures 4 to 10 the various arrangements of the strips 2 of volutes 3 are differentiated according to the quantity and partial overlapping of the strips and/or volutes.

[0024] Indeed, Figure 4 is a layout of strips 2 with volutes 3 like the one shown in Figures 1 and 3.

[0025] Furthermore, in Figure 5 two rows of matched strips 7 are staggered by Q, that is, a quarter of the pitch L of a volute.

[0026] Furthermore, in Figure 6 two rows of matched strips 8 are staggered by M, that is, half of the pitch L of a volute.

[0027] Furthermore, in Figure 7 two rows of strips 9a in one plane and 9b in the other are staggered by Q, that is, a quarter of the pitch L of a volute.

[0028] Similarly to Figure 6, in Figure 8 two rows of strips 10a in one plane and 10b in the other are staggered by M, that is, half of the pitch L of a volute.

[0029] Similarly to Figure 7, in Figure 9 two rows of strips 11 a in a plane and 11 b in the other are staggered by V, that is, an eighth of the pitch L of a volute.

[0030] Similarly to the previous Figures, in Figure 9 three rows of strips 12a in one plane, 12b in a second plane and 12c in a third one are staggered by Z, that is, a third of the pitch L of a volute.

[0031] Finally, in the diagram in Figure 11 there is a layout for loading the metal threads of the volute. During loading, from s to s', the stress in the thread of the pseudoelastic material varies little, whereas the strain is much greater than e. During the variation of the stress, which is typical of stress strain with vibration, the material is subjected to constant strain and slack, so the metal thread must achieve several cycles, equal to the vibration frequency, and on every cycle dissipate the energy stored from the strain in the phase transformation, thus drastically reducing their amplitude.

[0032] The band/fabric in accordance with the invention is produced by "overlapping" the metal thread in pseudoelastic material onto other stiffening fibres (glass, carbon, aramides, etc.), arranged longitudinally and fixed there with the help of other threads that are inserted transversally (without over-under crossing or crimping among the threads). In producing a composite, the direction of the fibres is usually that of maximum strain (under compression or traction) and it follows that the volutes 3 are aligned in the same direction T, which may be prevalently the optimal one for maximising the absorption of the vibration that is produced.

[0033] However, it must be pointed out that the arrangement similar to the sinusoid shown (which is actually less precise than what is shown in the figures) almost "isotropically" covers the whole surface of the fabric or band and therefore the above-mentioned drawbacks are minimised.

[0034] In tests carried out, the diameter of the thread was advantageous if compressed between 0.050 and 0.250mm, while the volutes were formed with amplitudes (F) of between 3 and 20mm and wavelengths (L) of between 2 and 20mm.

[0035] The production of the fabrics or bands may take place with widths of between 3 and 1600mm and (theoretically) infinite lengths.

[0036] Normal thermosetting resins (epoxy resins, polyesters, vinyl resins, furan resins, etc.) are used to impregnate the band or fabric and make it work in synchrony with the object to which it is to be applied.

[0037] The resin impregnation may be done either by direct manual application (paintbrush, roller etc.) or by infusion or extrusion using traction, thus achieving a rigid band which will then be attached to the final object. The band or fabric may be inserted as they are or with other stiffening fabrics into the structure of the article or object for which it is designed to damp vibration, and then impregnated with resin as previously mentioned.

[0038] In a different application, the band or fabric may be inserted as they are or with other stiffening fabrics between sheets of thermoplastic material and then moulded to obtain the article or object in which it is designed to damp vibration.

[0039] The main advantages in damping vibration are obtained by using thermosetting materials (high module), which are good at transferring energy to the thread in pseudoelastic material, enabling its dissipation, whereas with thermoplastic materials (low elastic module) they have been tested and do not ensure the same damping effect, almost as if the thread in pseudoelastic material had not been adequately stressed.

[0040] In testing the application of the band, it was used in the manufacture of a pair of skis, by inserting it into both the traction axis and the compression axis of the stress, longitudinally to the ski. The results obtained were reassuring and, when they were subjected to laboratory tests, the absence of vibration was highlighted, and furthermore, when tested on the ski slope, there was also considerable stability in the holes that are formed near to the doors.

[0041] The advantages obtained by this invention are: the band/fabric 1, in accordance with the invention, with threads in pseudoelastic metal thread organised and arranged in strips of orientated volutes, makes almost full use of the characteristic of the material used, making it work in the field at marked hysteresis between stress and strain, dissipating energy during stress and reducing the subsequent elastic response that is typical of the materials with high elastic module, which notoriously also have good mechanical characteristics in response to stress. This is a great advantage with respect to the use of threads arranged just longitudinally to the prevalent stress/strain direction known in the prior art. The strain previous to the composition of the band/fabric or composite material leads to the insertion of the thread itself, the stress which is exploited in the pseudo-sinusoidal structure, to cause the material to work and dissipate energy in the optimal area of the stress/strain graph.

[0042] The band/fabric is produced using the chain knitting technique (advantageously with crochet machine technology) which enables the production of fabrics where the various layers are not weaved as in traditional fabric, but simply placed onto each other and then linked to each other by a chain thread. This effect is advantageous as, in the field of composite materials, the absence of crimps between layers reduces the de-lamination phenomenon of the composite.

[0043] In practical implementation, the materials, dimensions and realisation details may be different from those indicated, but technically equivalent to them, all of which, however, are included within the scope of protection of the present invention as defined by the following claims.

Claims

1. Stiffening fabric or band in pseudoelastic material to damp vibration in elements subject to it, comprising a layer of material of thread(s) of pseudoelastic material, or SMA, with thread(s) arranged in the plane of the layer; **characterised by** the fact that the thread(s) in pseudoelastic material are arranged in strips of volutes, orientated with the pitches (L) of the volutes in the direction of the warp (O) and the amplitude of the volute (F) in the direction of the weft (T).

2. Fabric or band, as described by claim 1, wherein there is at least one layer of supporting material to stiffen the fabric or band.

3. Fabric or band, as described by one of claims 1 or 2, wherein the strips of volute placed in the plane are produced with different threads and the volutes are separate from each other.

4. Fabric or band, as described by one of claims 1, 2 or 3, wherein the strips of volutes in the plane are interpenetrated in the respective volute vertices between the positioned strips.

5. Fabric or band, as described by one of claims 1, 2 or 3, wherein the strips of volutes in the plane are overlapping in the respective volute vertices between the positioned strips.

6. Fabric or band, as described by one of claims 1, 2 or 3, wherein the strips of volutes in the plane are overlapping and staggered in the respective volute vertices between the positioned strips.

7. Fabric or band, as described by one of claims 1, 2, or 3, wherein the strips of volutes in the plane are interpenetrated, overlapping and staggered in the respective volute vertices between the positioned strips.

8. Fabric or band, as described by one of claims 1, 2 or 3, wherein the strips of volutes subdivided into two planes are interpenetrated and staggered, with respect to the ones in the other plane in the respective volute vertices between the positioned strips.

9. Fabric or band, as described by one of claims 1, 2 or 3, wherein the strips of volutes subdivided into two planes are interpenetrated, overlapping and staggered, with respect to the ones in the other plane in the respective volute vertices between the positioned strips.

10. Fabric or band, as described by one of claims 1, 2 or 3, wherein the strips of volutes subdivided into two or three planes are interpenetrated, overlapping and staggered, with respect to the ones in the other planes in the respective volute vertices between the positioned strips.

11. Fabric or band, as described by one of claims 1, 2 or 3, wherein the strips of volutes have a volute or wavelength (L) of between 2 and 20mm.

12. Fabric or band, as described by one of claims 1, 2 or 3, wherein the strips of volutes have a volute amplitude (F) of between 3 and 20mm.

13. Fabric or band, as described by any of the previous claims, wherein the thread or threads in pseudoelastic material, or SMA, comprising the volutes has/have a diameter of between 0.050 and 0.250mm.

14. Composite band, with a layer of stiffening material to resist vibration in the application element, wherein there is a thread or threads in pseudoelastic material, or SMA, arranged in the plane(s) of the layer, as described in one of the above claims; **characterised by** the fact that it has a thread or threads in pseudoelastic material arranged in strips of volutes, orientated uniformly with respect to each other in the plane(s) of the layer.

15. Composite structural element, with a layer in stiffening material to resist vibration in he machine device for which it is designed, wherein there is a thread or threads in pseudoelastic material, or SMA, arranged in the plane(s) of the layer, as described in one of the above claims; **characterised by** the fact that it has a thread or threads in pseudoelastic material arranged in strips of volutes, orientated uniformly with respect to each other in the plane(s) of the layer.

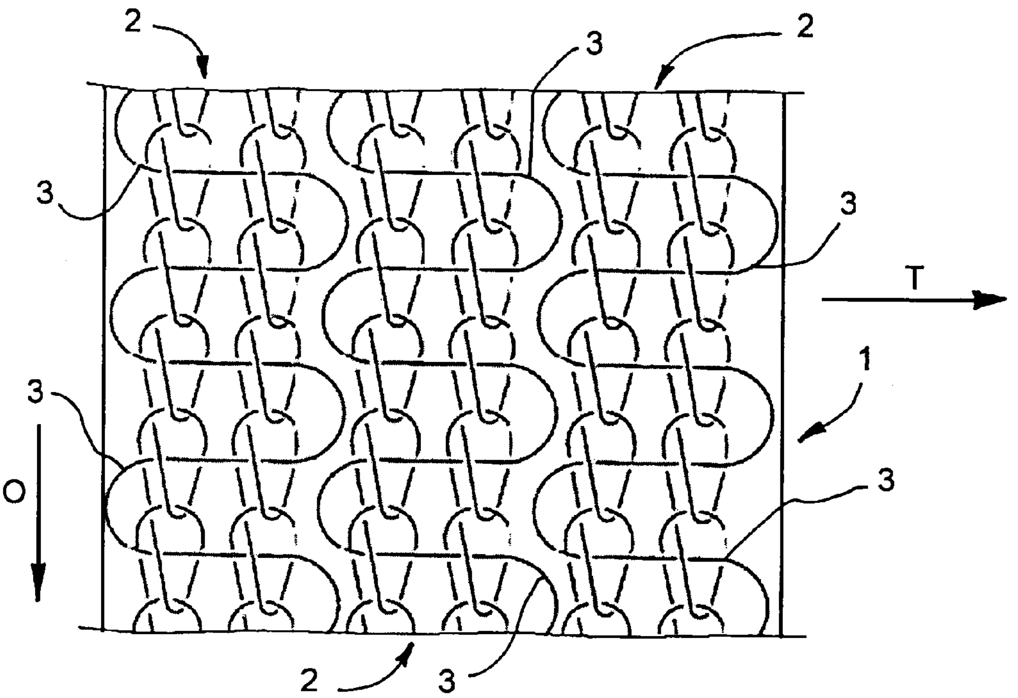


Fig. 1

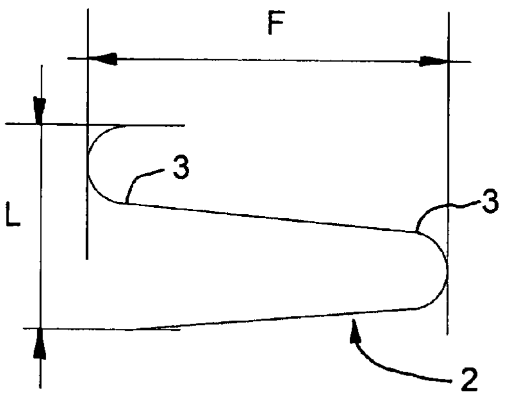
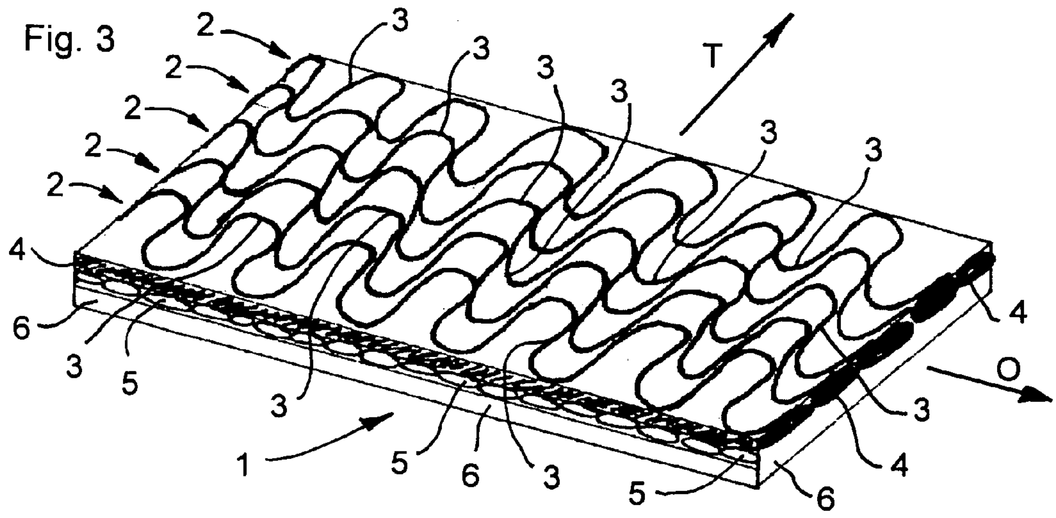


Fig. 2

Fig. 3



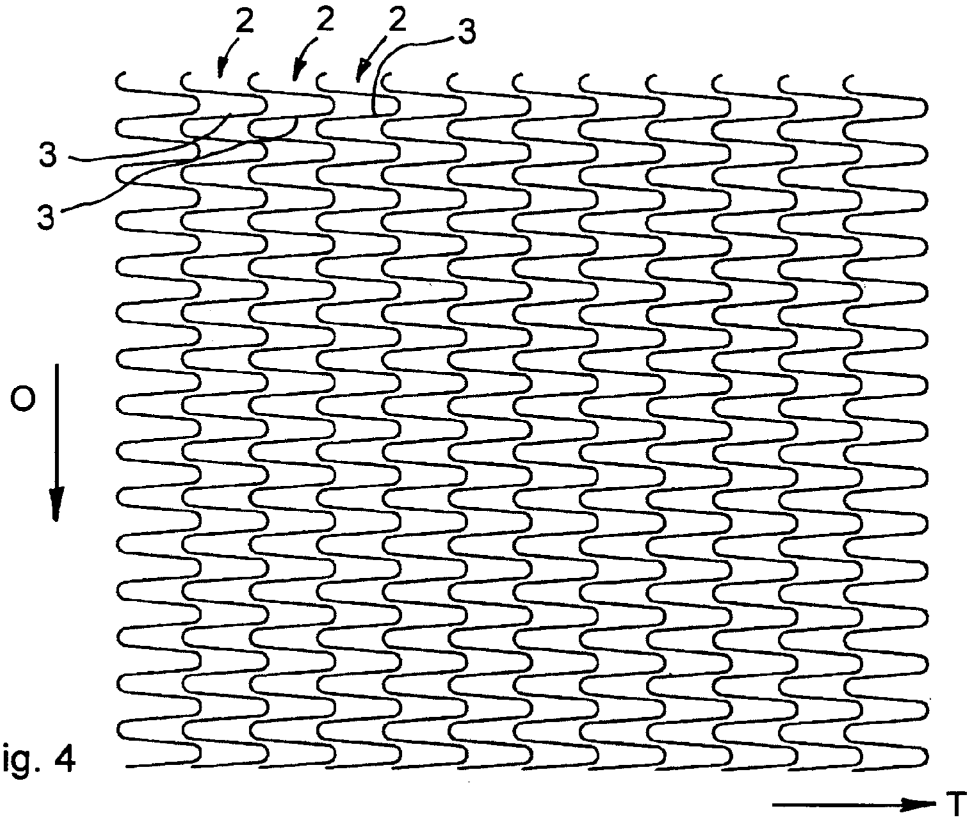
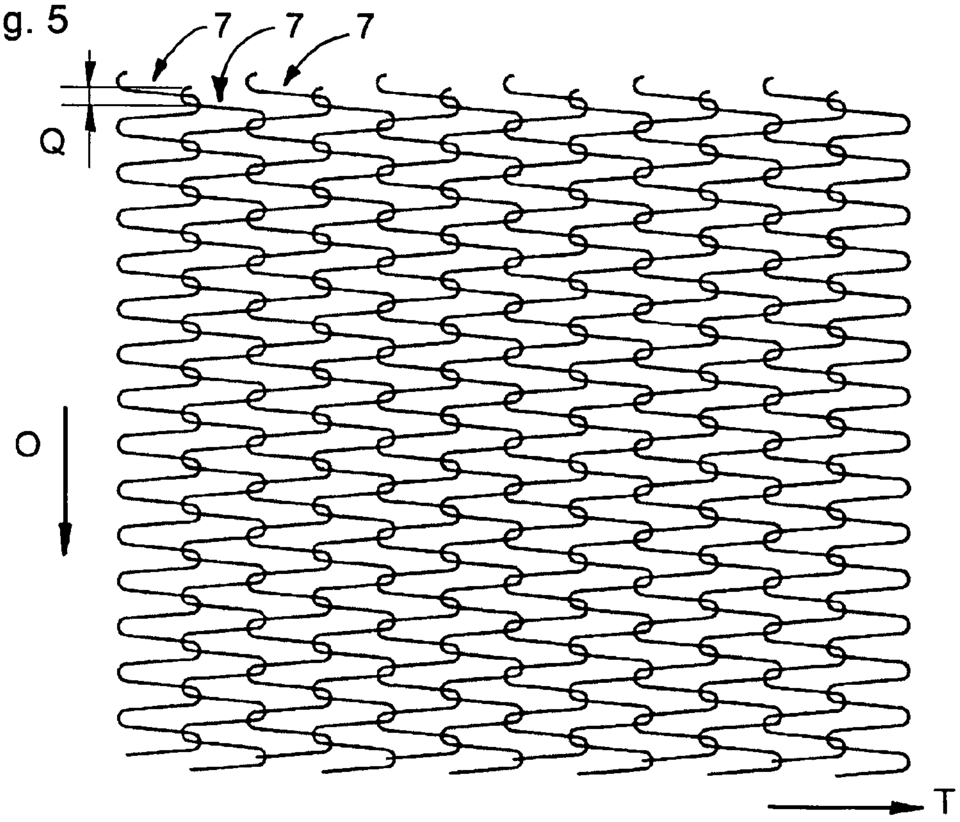


Fig. 4

Fig. 5



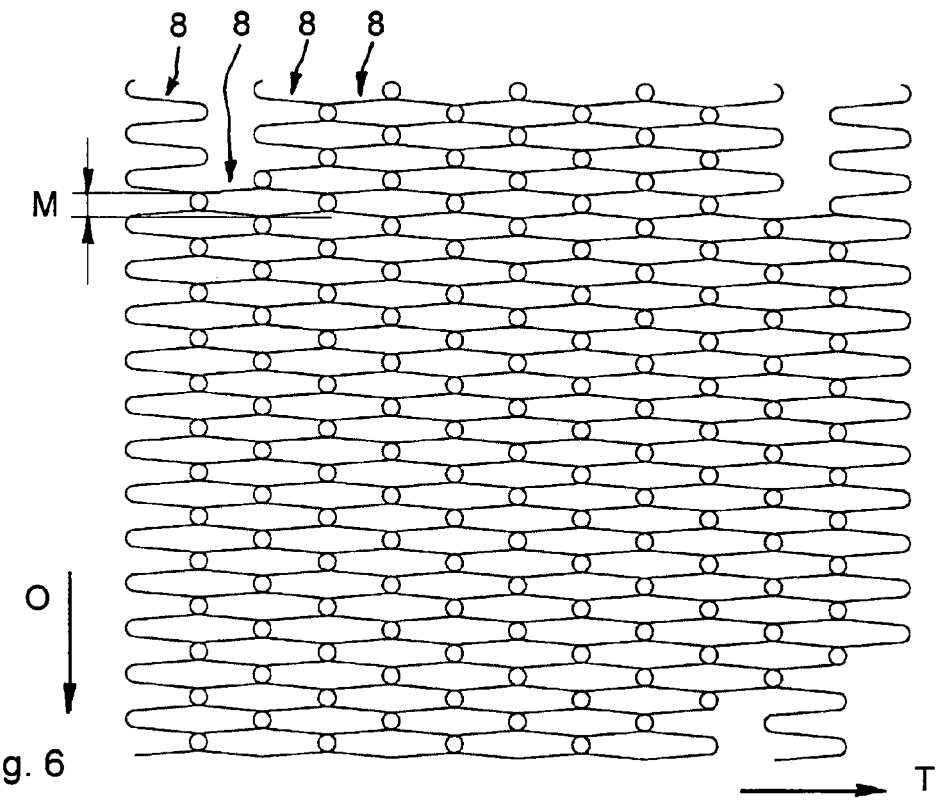
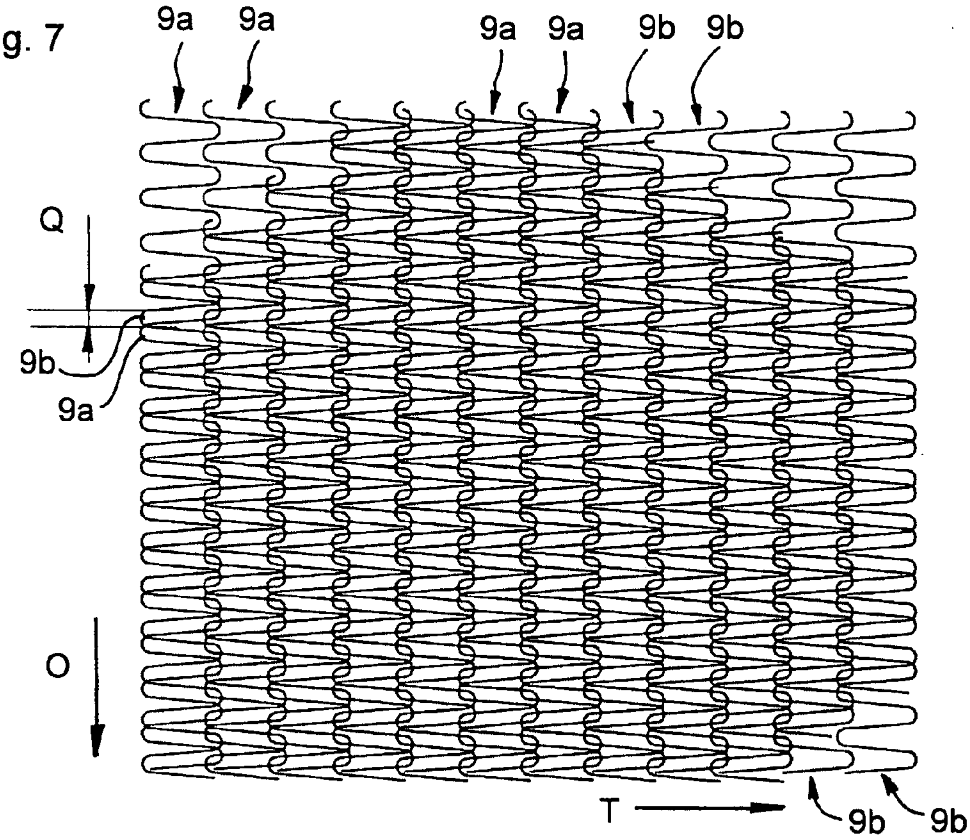


Fig. 6

Fig. 7



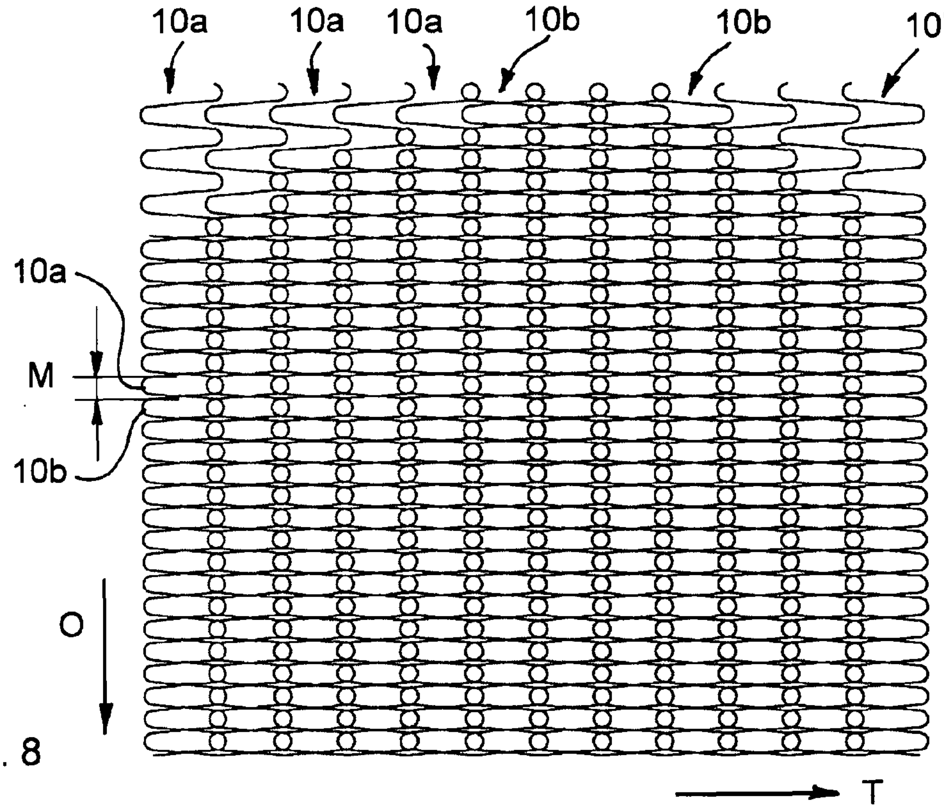


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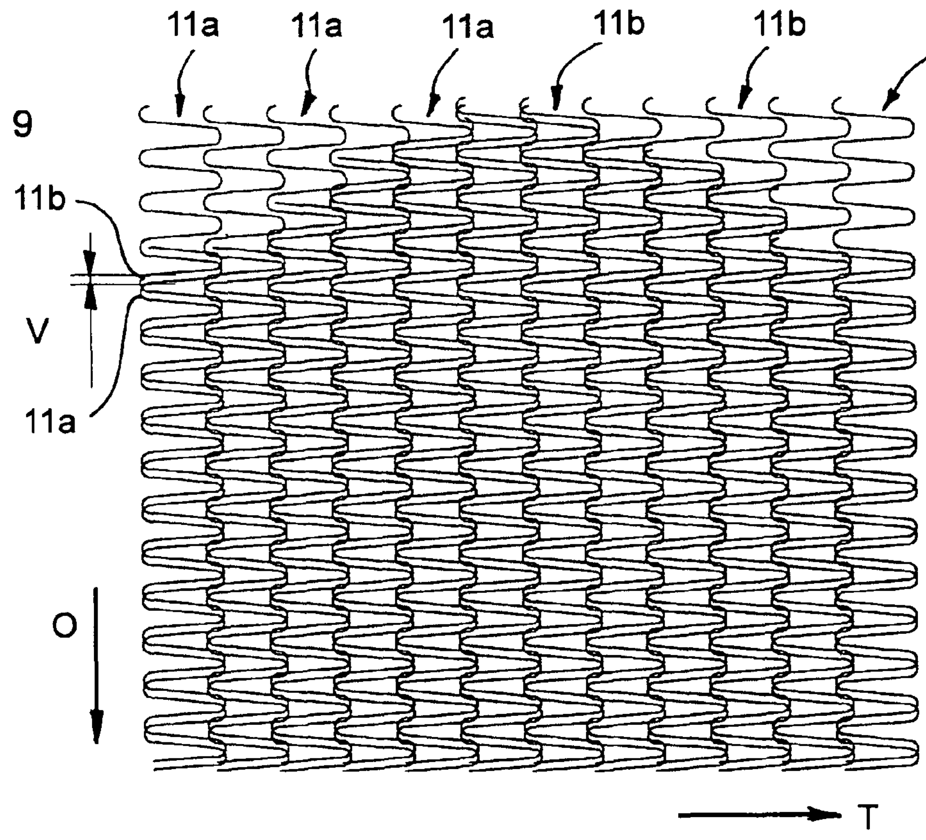
Fig. 8

Fig. 9



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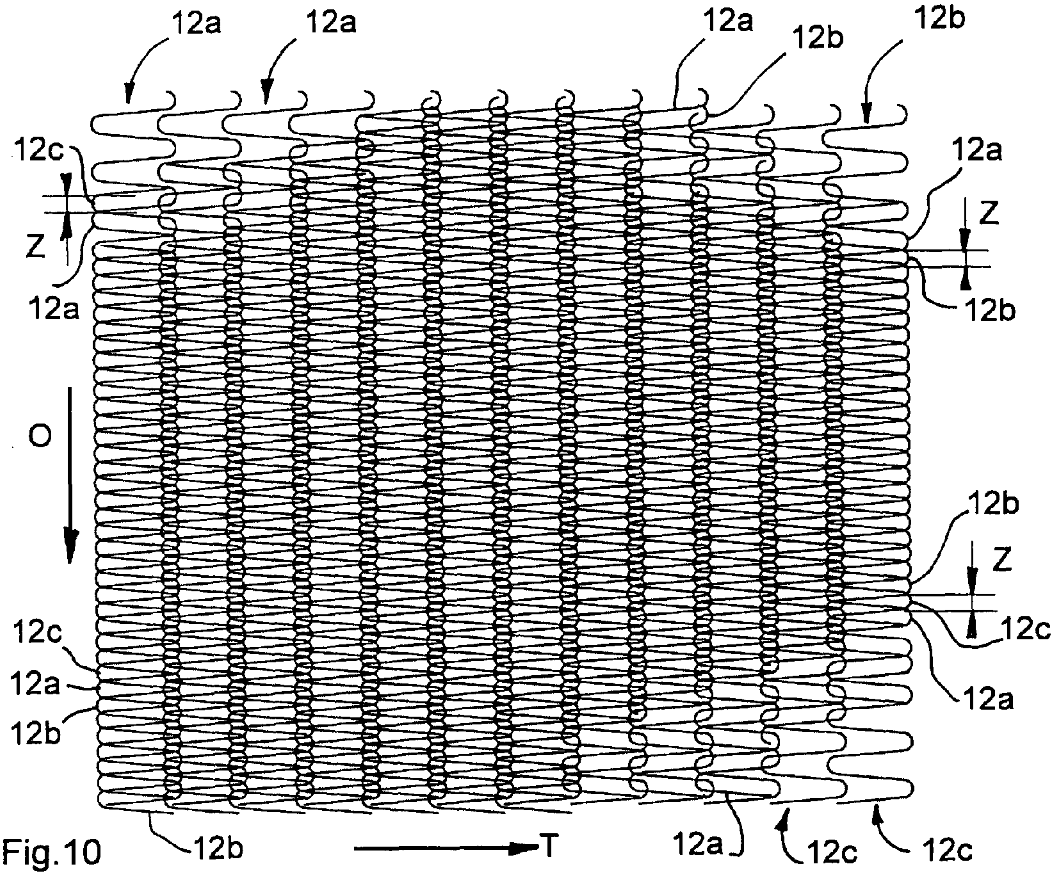
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Fig.10

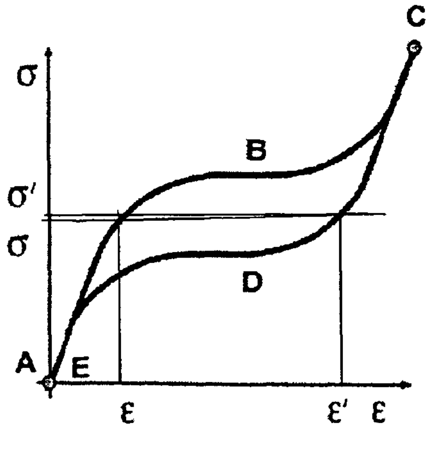
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Fig. 11

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EUROPEAN SEARCH REPORT

Application Number
EP 08 01 4752

DOCUMENTS CONSIDERED TO BE RELEVANT

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	15 January 2009	Demay, Stêphane

CATEGORY OF CITED DOCUMENTS

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