



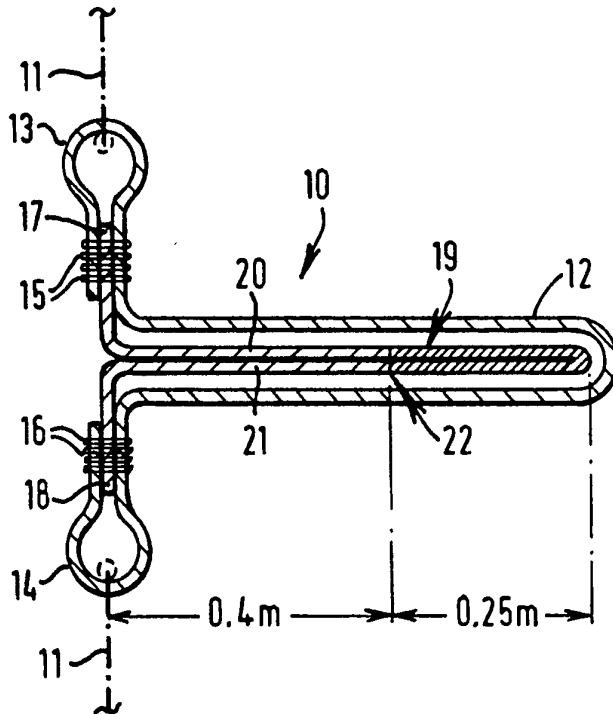
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(54) Title: ENERGY ABSORBING FALL ARREST DEVICE

(57) Abstract

An energy absorbing fall arrest device comprises fall arrest means adapted to be secured at one end to anchorage means and at the other end to a load, and an energy absorber (10) responsive to a sudden increase in tensile loading of said fall arrest means. The device has a multiple stage tensile energy absorber (10) comprising a plurality of energy absorbing elements (20, 21, 22) in series. A first stage (20, 21) of the energy absorber (10) is arranged to extend and absorb energy in response to a predetermined tensile load. Each successive stage (22, only one shown) is arranged to extend and absorb energy in response to a progressively higher tensile load.



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ENERGY ABSORBING FALL ARREST DEVICE

The present invention relates to fall arrest apparatus and, in particular, to a fall arrest device incorporating an energy absorber.

5 An example of a fall arrest device to which the present invention might be applied is disclosed in the Applicants' published European Patent Application No. 0 272 782 A1.

Typically, the energy absorber may be constructed to form part of a lanyard which can be used to connect a personnel safety harness to a fixed point whilst the wearer is working
10 in a high place. In some situations, personnel safety harness may be the only practicable safety means available, for example, where the provision of scaffolding or comparable support is not feasible. Examples of users who might wear such apparatus include window cleaners, fire brigade personnel and
15 rescue personnel.

Although the energy absorbing fall arrest device is primarily intended for use in personnel safety equipment, it will be appreciated that such apparatus has applications in other fields, for example supporting loads from cranes and the
20 like. If a load moves or tilts when supported from a crane by slings, high sudden loads may often be imposed on the remaining slings. Such shock loading can cause sling failure and the incorporation of an energy absorber so as to gradually absorb the load applied can be a great advantage in preventing the
25 failure of additional slings. The skilled reader will appreciate that there are numerous comparable circumstances in which an energy absorber is useful for attenuating the sudden loads encountered in fall arrest situations.

In their primary role as components of personnel safety
30 harness, energy absorbers are usually called into operation when the wearer falls. Studies of typical falls over the years suggest that the majority of falls are of less than two metres. In some countries, regulations stipulate that the maximum fall for which protection is needed is two metres. Falls for

industrial workers who are attached to fall-arrest systems can usually be minimised by careful design of the fall-arrest equipment. In many instances, standards are set for the minimum amount of energy which must be absorbed upon operation
5 of the energy absorber. Current European Standard EN355 stipulates a minimum energy absorption of about 6,000 J for a 4 m free-fall of a 100 kg mass and a shock absorber maximum extension of approximately 1.75 m for an effective free unloaded length of 2.0 m.

10 Typical known energy absorbers in fall arrest apparatus have force/extension characteristics of the form shown in figure 1, in which the force applied both to the anchorage and to the user in kilonewtons (kN) is plotted against the extension in metres. The area under the curve corresponds to
15 approximately 8,000 J and this is more than adequate to exceed the desired standard limit of 6,000 J. Under the aforementioned current European Standard, the maximum load which should be applied to the user and the anchorage is typically set at 6 kN. Again, this limit is not exceeded, even
20 though there will usually be a slight peak at B as indicated. This known energy absorber therefore operates within current standards, but nevertheless has certain disadvantages.

The main drawback is that, even when the fall is less than two metres, the force applied to the user is typically of the
25 order of 5 kN. This can be relatively uncomfortable for the user and puts unwarranted strain on the anchorage. Since the majority of falls are of less than two metres, it is desirable if such falls can be arrested whilst applying much lower loads on the user and on the anchorage. Desirably, of course, this
30 would be achieved without exceeding the limits set by standards currently in force defining the minimum energy absorption, the maximum force applied and the maximum extension of the energy absorber. However, the relationship between absorber operating force and absorber extension means that a simple reduction in
35 the operating force to a more acceptable lower value would result in an extension value which exceeds current standards.

It is therefore an object of the present invention to provide an energy absorbing fall arrest device which meets all dynamic and other requirements of standards currently in force.

The invention is an energy absorbing fall arrest device comprising fall arrest means adapted to be secured at one end to anchorage means and at the other end to a load, and an energy absorber responsive to a sudden increase in tensile loading of said fall arrest means; characterised in that;

10 said energy absorber is a multiple stage tensile energy absorber comprising a plurality of energy absorbing elements in series, wherein a first stage of the energy absorber is arranged to extend and absorb energy in response to a predetermined tensile load and wherein each successive stage

15 is arranged to extend and absorb energy in response to a progressively higher tensile load.

In its simplest form, the device includes a two-stage energy absorber in which the first energy-absorbing element can, whilst it is absorbing energy, extend to a first distance and the second element can extend to a second distance during operation. Desirably, the sum of the two extensions is less than, say, 1.3 metres when incorporated in a lanyard of 2 metres length.

25 The energy absorbing arrangement can be a single component or can be a combination of elements using different energy-absorbing mechanisms.

The energy absorbing elements will normally be disposed in parallel with a flexible backing member which does not extend significantly and which does not break even when all the energy absorbing elements have been fully extended.

30 When applied to a 2 metre lanyard, the first energy absorbing element of a dual-element arrangement is desirably constructed and arranged to operate when the force applied thereto is commensurate with a fall of up to and including

35 2 metres. In such an arrangement, the second energy absorbing

element is adapted to operate after a fall greater than 2 metres.

The respective extensions of the multiple energy absorbing elements, together with their operating forces, are chosen so
5 that the total area under the force/extension curve of the device is sufficient to absorb all the energy necessary to comply with the requirements of current standards.

The energy absorbing element may be a tear ribbon which comprises a folded web whose two parts are connected together
10 either by sewing or warp, weft or other threads, the size/construction of the threads interconnecting the two parts of the web being such as to yield at a specific tension applied in opposite directions to free ends of the web.

To form the respective energy absorbing elements, tear
15 ribbons of different strengths can be used in series. Alternatively, a single tear ribbon can be constructed to have a first portion which tears at a first force and subsequent portions which tear at progressively higher forces. The lengths of the first and subsequent portions can be chosen so
20 as to total a desired maximum extension when used in a lanyard.

Another possibility for the energy absorbing mechanism is a combination of a member and a friction block, the energy absorbing force being provided by the friction required to draw the member through the block. For multiple stage operation,
25 either multiple friction blocks could be provided or the member could change in dimension to be drawn through a single friction applying portion of the friction block. This could be achieved where the flexible member is a web and is drawn through a tight slot in the friction block, the post-first stage web being of
30 relatively thicker material and therefore requiring greater force to pull it through the slot.

Yet another form of energy absorbing device suitable for use in the present invention uses longitudinal destructive failure of a length of webbing. In this arrangement, a length
35 of webbing is folded over on itself a number of times to form a series of loops, each of which is pierced centrally by a coil

of metal such as steel. This so-called "splitter coil" is arranged to cause the webbing to split axially when a fall-arrest load is applied to opposite ends of the webbing. The cross-section of the coil may be round, square or any other shape suitable to achieve rending of the webbing. To assist in maintaining the direction of the split, guide attachments may be included to feed web past the coil in a desired orientation as the webbing splits.

Single stage energy absorbers of this type are known and exhibit force/extension characteristics similar to those shown in Figure 1. A multiple stage device is therefore possible by reinforcing the webbing at suitable positions along its length, force levels being determined by the strength characteristics of the webbing and its reinforcements.

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

- Figure 1 is a force/extension graph illustrating the performance of a known energy absorber (not illustrated);
- Figure 2 is a cross-sectional view through a preferred energy absorber for use in the present invention;
- Figure 3 is a force/extension diagram of the energy absorber of figure 2;
- Figure 4 is a view similar to figure 2 but showing a second embodiment of energy absorber;
- Figure 5 is a force extension diagram of the energy absorber of figure 4;
- Figure 6 is a cross-sectional view illustrating a third embodiment of energy absorber, and
- Figure 7 is a perspective view of another form of energy absorber suitable for use in the present invention.

In the text which follows, the invention will be described in relation to a typical 2-metre lanyard for use by window cleaners and similar high-level workers who use the lanyard to

connect a body harness to an anchorage point on a building or comparable structure.

Referring now to Figure 1, it will be seen that a fall arrest device incorporating the known single stage energy absorber has an energy absorption capacity of about 8,000 J. This is ample to meet the 6,000 J standard and, even with the possibility of a force peak at B, the maximum force applied to either the user or the anchorage is lower than the 6 kN limit. Whilst this known energy absorber meets current European standards, it suffers from the disadvantage that, even after a relatively short fall of less than 2 metres, a high force of 5 kN or even greater is applied to both the user and the anchorage. This can be uncomfortable for the user and may serve to weaken a less than perfect anchorage.

There are substantial advantages to using "low-force rated" energy absorbers on flexible horizontal lifelines, as they can considerably reduce the all-important end-anchorage loadings.

Figure 2 shows a first preferred energy absorber (10) for use in the fall arrest device of the invention. This is incorporated in a lanyard indicated at (11) which may be connected to the absorber (10) by sewing or by linking rings or buckles. In use, one extremity of the lanyard (11) is attached to fall arrest means (not shown) and the other extremity is attached to a user's safety harness (not shown). The absorber (10) is typically made from 50 mm-wide backing webbing (12) which is of significant strength and constructed so that it does not break, even under high loads.

The backing web (12) has two loops (13, 14) by which it is connected to the lanyard (11) and which are formed by sewing at (15) and (16). The sewing (15) also secures respective upper and lower ends of a tear ribbon having separable webs united by integrally formed threads during manufacture, for example, by sewing threads. Of course, an adhesive or other interconnection could be used provided that the separation force thereof can be precisely controlled.

As will be seen in Figure 2, the two webs (20, 21) are differently cross-hatched to the left and to the right of a transition indicated at (22). To the left of the transition (22) there is a relatively weak interconnection between the two webs which will separate when a tensile force of about 3.4 kN is applied to the two ends (17) and (18). Over the portion of the interface to the right of transition (22) the webs (20, 21) will separate with an applied force of 5 to 5.5 kN.

In use, if the user should fall, force will be applied to the ends (17, 18) which will be drawn apart. When the force reaches approximately 3.4 kN, the webs (20) and (21) will start to separate, absorbing energy as they do so. It will be appreciated, of course, that the interconnection between the two webs from the left hand end to the transition (22) has to be an even interconnection so that the separation force remains generally constant whilst the two webs are being separated. The length of the first portion to the left of transition (22) is about 0.4 metres and, as will be apparent from Figure 3, this gives a total extension of 0.8 metres to the lanyard.

When the fall is less than 2 metres, the force applied to the lanyard (11) will be insufficient to take the separation past the transition (22) and therefore the portion of the webs (20, 21) to the right of the transition will not separate.

As will be appreciated in combination with Figure 2 and Figure 3, the force applied to the falling user will be reduced compared with the prior art and similarly the force applied to the anchorage in the case of a slight fall will not be so high as to cause potential damage or weakening, particularly in connection with horizontal, flexible lifelines.

A further significant advantage is that, if the fall is greater than 2 metres, the second portion of the tear ribbon (19), to the right of the transition (22) in Figure 2 will be torn. However, both the anchorage and the user will experience a two-stage application of force. Firstly, at approximately 3.4 kN, the first portion of the tear strip applies a force which retards the fall and absorbs a certain amount of energy.

After an extension of approximately 0.8 metres, the second portion of the tear strip comes into operation and applies a higher force, followed by a halt after a fall of approximately 1.4 metres. This has the added advantage that any faller who enters the second stage of energy absorption is not suddenly subjected to a high force of 5 or 5.5 kN, but has such high force applied in two stages. In addition to being less uncomfortable, this causes less shock and therefore the user may have more time in which to be alert and take action to minimise further possible injury.

Referring now to Figures 4 and 5, there is shown a second embodiment of energy absorber (25) which is again incorporated as part of a lanyard (26). The absorber (25) includes a packing web (27) which can be in a continuous length sewn at (28). The backing web (27) is formed into upper and lower connection loops (29) (30) by respective sewing (31, 32). To the right as shown in the drawing, the packing web (27) is formed into a slack loop (33) which surrounds a loop of a first tear ribbon (34) whose ends are secured by sewing (31) and (32). Tear ribbon (34) operates in exactly the same way as the tear ribbon (19) of Figure 2 except that it has a single separation load and is not a two-stage ribbon as the ribbon of Figure 2. To the left as shown in the drawing, the backing web (27) has a pair of slack loops (35, 36) and a further loop (37) which embraces a second tear ribbon (38). Second tear ribbon (38) is comparable to ribbon (34) but has a shorter length and higher tear strain. Tear ribbon (38) has its ends (39, 40) secured by sewing (28, 41).

Referring now to Figures 4 and 5 together, it will be seen that the absorber (25) operates in practice very similar to the absorber (10) of Figure 2. Tear ribbon (34) has a tear strain of approximately 3.4 kN. In the event that the stress in the lanyard reaches this figure, the two webs of tear ribbon (34) begin to separate. The extension is accommodated by loops (35) and (36).

When tear ribbon (34) is fully extended, tear ribbon (38) begins to separate, provided that a force greater than approximately 5 to 5.5 kN is present in the lanyard. Again, extension of the second tear ribbon (38) continues until the maximum total extension of roughly 1.3 metres has been achieved and over 6,000 J energy has been absorbed.

The performance is very much along the lines of the energy absorber shown in Figure 1 but simple tear strips (34) and (38) can be used.

Figure 6 shows a third embodiment of absorber (45) which is shown incorporated in a lanyard (46). The absorber has a backing web (47) which is formed into anchorage loops (48, 49) by sewing (50, 51). Also connected between the loops (48, 49) by means of sewing (50, 51) is an energy absorbing arrangement which comprises a flexible member (53) which in this case is in the form of a length of webbing or a comparable strap having two end portions (56, 57) of reduced width compared to a central section (58). The two end portions (56, 57) pass through respective slots (59, 60) in a friction body (61) which can be a piece of plastics material.

The slots (59, 60) are arranged to apply a grip to the end portions (56, 57) and to yield only when a desired load, for example of about 3.4 kN is exerted across the end portions (56, 57). This can be arranged by moulding the body (61), or by forming the body (61) in two parts and clamping them in relation to the webs or other comparable elongate flexible member (53). In view of the size of the slots (59, 60), it will be appreciated that the thicker central portion (58) of the member (53) will only be able to pass through the slots (59, 60) upon application of a higher force. The respective dimensions of the slots (59, 60) and the thickness of the web portion (58) is chosen such that the force required to draw the central portion (58) through the slot is approximately 5 to 5.5 kN. Of course, the respective lengths of the end portions (56, 57) and the central portion (58) are chosen so that, during the first stage of energy absorption, an extension of

about 0.8 metres is effected and the total extension upon operation of both stages of the absorber amounts to about 1.3 metres.

5 Again, the absorber (45) of Figure 6 operates in a manner comparable to the absorbers of Figures 2 and 4 and has a comparable characteristic force/extension curve.

10 Instead of a strap or webbing being used in the member (53) of Figure 6, member (53) could be a rope or cable passing through circular apertures rather than slots (59) (60) in a friction member. The shape and form of the friction member (52) can also vary widely.

Referring now to Figure 7, a perspective view is shown of yet another form of energy absorber (75) suitable for use in the present invention. In this arrangement, a length of webbing (76) is folded over on itself a number of times to form a series of loops (78, 80), each of which is pierced centrally by a metal coil (85). Coil (85) is the so-called "splitter coil" and is arranged to cause longitudinal splitting of the webbing (76) when a fall-arrest load is applied to the opposite ends (79, 81) of the webbing. The dotted line (82) indicates the path along which splitting occurs. The cross-section of coil (85) as shown here is circular, but any other cross-sectional shape may be used which is suitable to effect the desired longitudinal rending of the webbing.

25 The second stage of energy absorption is effected by a thickening of the webbing (76) in the portion denoted by the reference numeral (77). A more complex multiple stage device based on this principle could be formed by further reinforcing the webbing (76) at suitable positions along its length.

30 Although the invention has been specifically described in relation to a fall-arrest device having a two-stage energy absorber, it will be appreciated that the same principle can be applied to provide a fall arrest device including an energy absorber having three or more stages of operation if this should be desirable.

35

As mentioned previously, the invention is not limited to the application of personnel safety in the workplace. It may also be used in relation to cranes and other lifting and suspension devices in which animate or inanimate loads are suspended by slings, ropes, wires, and comparable flexible elements. The invention may also be used in climbing and similar outdoor sports where protection against falls or after falling is desirable.

Many other variations will be apparent to persons skilled in the art without departing from the scope of the claims which follow.

CLAIMS

1. An energy absorbing fall arrest device comprising fall arrest means adapted to be secured at one end to anchorage means and at the other end to a load, and an energy absorber responsive to a sudden increase in tensile loading of said fall arrest means;

characterised in that:

said energy absorber is a multiple stage tensile energy absorber comprising a plurality of energy absorbing elements in series, wherein a first stage of the energy absorber is arranged to extend and absorb energy in response to a predetermined tensile load and wherein each successive stage is arranged to extend and absorb energy in response to a progressively higher tensile load.

2. An energy absorbing fall arrest device as claimed in claim 1 wherein the respective energy absorbing elements are comprised in a single component.

3. An energy absorbing fall arrest device as claimed in claim 1 or claim 2 wherein the energy absorbing elements are disposed in parallel with a flexible backing member which does not break or extend when the energy absorbing elements have been fully extended.

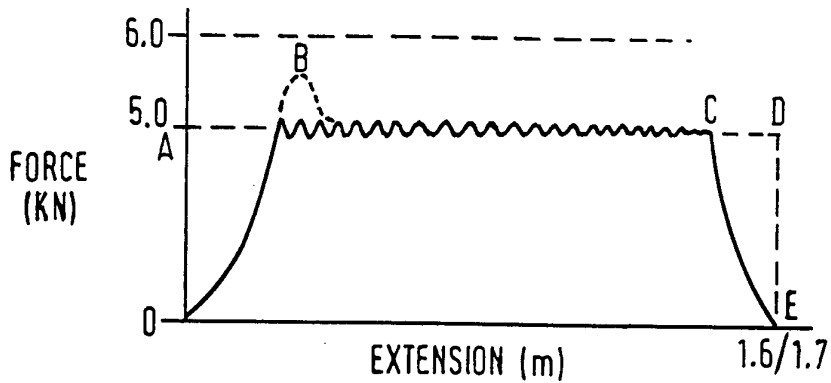
4. An energy absorbing fall arrest device as claimed in any preceding claim wherein the total energy absorption is greater than 6,000 J.

5. An energy absorbing fall arrest device as claimed in any preceding claim comprising a tear ribbon constituted by a folded web the parts of which are connected together by threads, the threads interconnecting the parts of the folded web being arranged to yield in response to predetermined tensile loads applied in opposite directions to the free ends of the web.

6. An energy absorbing fall arrest device as claimed in any one of claims 1 to 4 wherein energy absorption is achieved by means of multi-thickness webbing and a friction block through which said multi-thickness webbing is drawn in response to the application of a predetermined tensile load.

7. An energy absorbing fall arrest device as claimed in any one of claims 1 to 4 wherein energy absorption is achieved by means of an arrangement which involves longitudinal splitting of an elongate web of a material having different degrees of reinforcement along its length.

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FIG. 1
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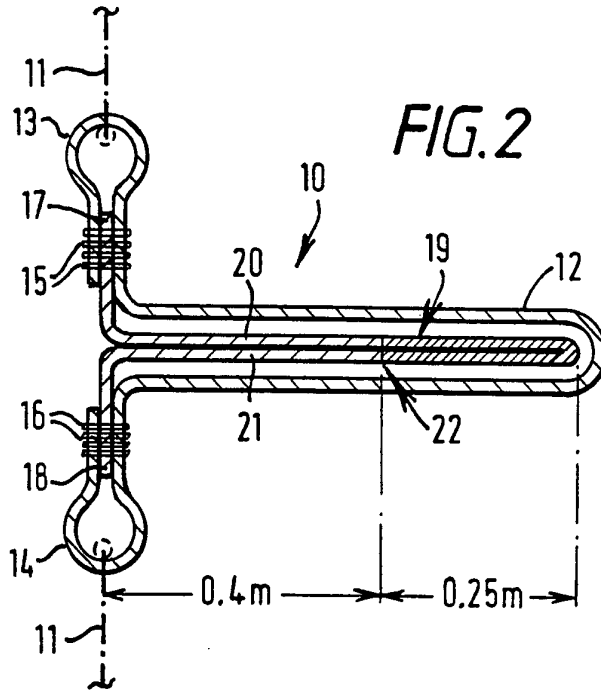


FIG. 2

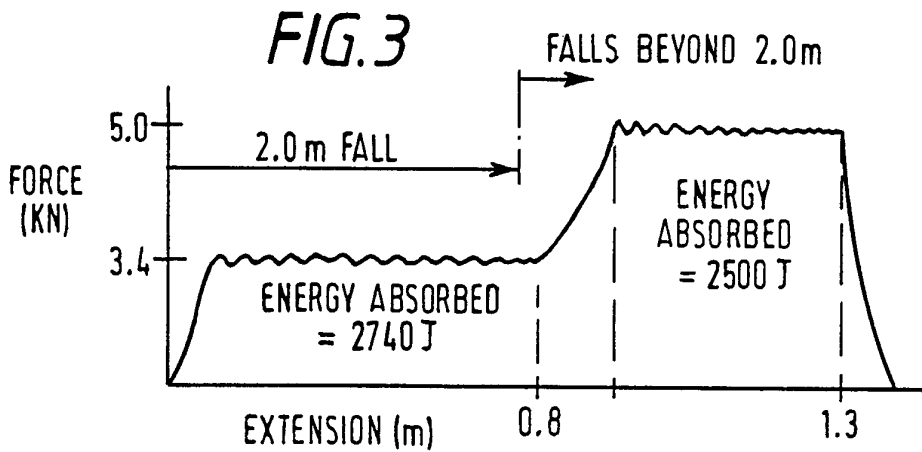


FIG. 3

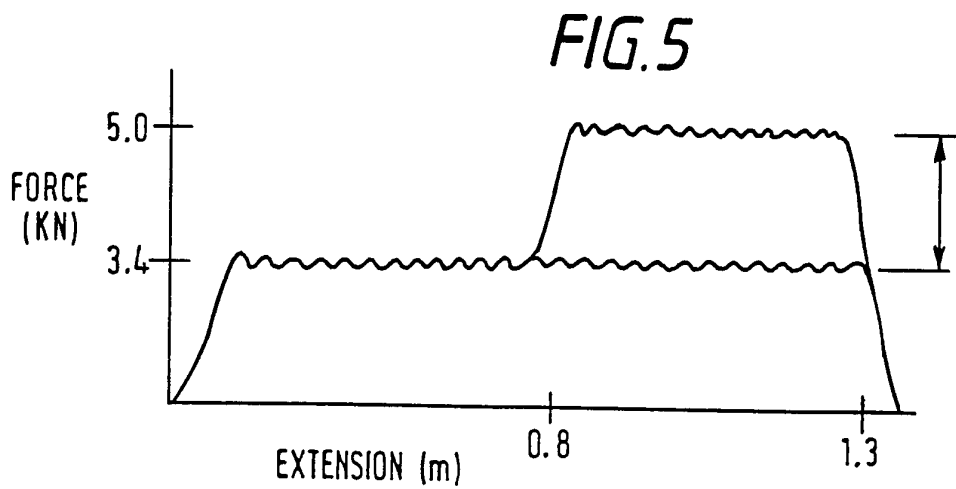
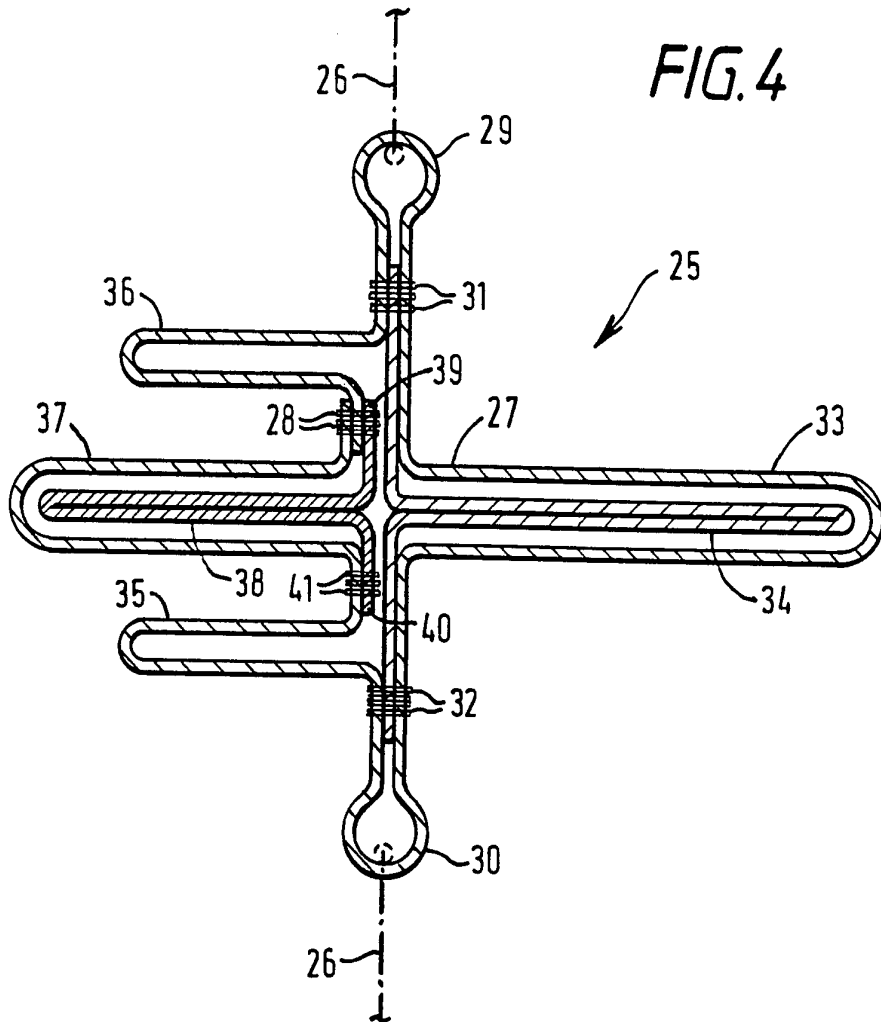


FIG. 6

