Title: ENERGY ABSORBING ANCHOR

Abstract: An energy absorber comprises means for attaching the energy absorber to a supporting structure, means for attaching the energy absorber to a load element, and orienting means. The energy absorber further comprises at least one deformable element responsive to a predetermined tensile load applied to the means for attaching to deform the at least one deformable element and to change the orientation of the energy absorber towards the direction of an applied load. The energy absorber further comprises a store of flexible elongate material and friction deployment means arranged to deploy the store of flexible elongate material and to provide resistance during said deployment and thereby absorb energy.
Energy Absorbing Anchor

This invention relates to an energy absorbing anchor and in particular to an energy absorbing anchor intended for use with height safety systems whereby it is attached to relatively fragile structures.

Height safety equipment is used to prevent personnel working at height from falling to the ground below. A typical arrangement is where personnel wear harnesses attached to one end of a lanyard and the other end of the lanyard is attached to a cable such that it is free to move along the length of the cable. The cable is fixed between anchors that are attached to a structure and personnel can then move freely along the length of the cable in order to access work areas that need attention such as maintenance. More sophisticated cable systems are intended for long lengths of cable where access is required over a large area often requiring deviations in the line of the cable. These systems tend to use intermediate anchor points through which the cable passes in order to limit cable spans between anchors and to allow deviations such as corners and angle changes, often to follow deviations in a structure surface. Sophisticated traveller devices have been developed to travel along the cable and pass over intermediate anchors, without any need to be detached from the cable. A person can then attach their lanyard to such a traveller device and move along the length of the cable across intermediate anchors.

Some cable systems are positioned to stop personnel from gaining access to the edge of a building and therefore avoid the possibility of falling. The problem with such cable systems is that many maintenance tasks such as gutter clearing require access at the edge of buildings and so they are too restrictive. The more usual cable systems allow personnel access to the edge of building but arrest a fall safely in the unfortunate event that someone should accidentally fall. These systems are known as fall arrest systems. The loading on end and corner anchors on such systems can be high depending on the distance through which someone falls and whether there are falls by multiple personnel.

Safety regulations have led to cable systems being fitted increasingly to roofs including many different lightweight fragile types such as those made from thin steel sheet or
plastic membrane. Early cable system anchors were attached to these roofs by securing the anchors to the underlying framework rather than directly to the roof sheeting. However, these anchors were difficult to install, restricted the anchor location to suitable parts of the underlying framework and had to pass through the roof skin thereby compromising weatherproofing and often, insurance cover.

Cable system anchors, particularly those fitted to fragile roofs, typically perform two basic functions. The first is to hold the cable clear of the roof surface in normal access use by personnel so that the cable, particularly in mid span where it tends to sag, cannot scratch the roof protective coating. Also, the travellers that are attached to the cable and to personnel and which are free to move along the cable length to allow access along the cable system must be prevented from hitting the roof surface. The second basic function is to withstand loading transmitted through the cable in a fall without over loading the anchor fixings to the roof surface, particularly with respect to tensile loading on the fixings and also damaging the roof to which the system is attached. Such over loading of the fixings, and/or damage to the roof would compromise the safety of the cable to which a faller or a number of fallers is attached before and after a fall event.

One known anchor that can be attached directly and safely to the surface of a fragile roof is disclosed in UK Patents GB 2370089B and GB 2362448B. This anchor can be used in any end or intermediate position in a cable system and has the ability to lie down close to the plane of the roof when loaded beyond a predetermined level and also to absorb significant amounts of energy whilst also limiting loading on the fixings to the roof and on the roof itself.

Fixings in relatively fragile roof sheeting are significantly stronger when loaded in shear than when loaded in tension. Therefore, the ability of the anchors to lie down in the plane of the roof is essential to enable the fixings to be loaded primarily in shear and therefore to maximise the safe loading limit on the fixings to the roof and the roof itself. This type of anchor also has an inbuilt energy absorber that extends under a resisting load that does not exceed the said safe loading limit so that load transmitted through the cable and applied to the anchor is also maintained within the said safe loading limit. The energy absorber is capable of relatively large extensions due to the plastically deformable material being held within the
anchor as a coiled store. Key requirements for this absorber are that it should absorb as much energy as possible within the limitations of the strength of the roof fixings and the roof itself and that it should extend as little as possible to limit movement in the cable and therefore the distance through which fallers fall. The distance through which a faller falls and the weight of the faller are components of energy being put into the system and therefore a large fall distance requires more energy absorption and so it is important to minimise the fall distance during the process of energy absorption. This type of anchor tries to achieve this by maintaining the force resisting extension of the absorber close to the said safe loading limit as far as is practicable bearing in mind the limitations of the absorbing mechanism itself.

The energy absorbing mechanism in this type of anchor utilises plastic deformation of a store of plastically deformable material. However, there are several problems with using plastic deformation and these are addressed by the present invention. Firstly, the load at which plastic deformation takes place is hard to predict with accuracy because it depends on the exact mechanical condition and chemical composition of the plastically deformable material before plastic deformation. Secondly, the choice of plastically deformable material for the energy store, particularly in terms of cost and weight, is limited because the material needs to be both strong but also ready to yield and plastically deform. Thirdly, the plastic deformation process itself changes the mechanical condition of the plastically deformable material tending to make it more brittle and this can affect the load required to plastically deform it and also reduce the ultimate braking load where there is likely to be a concentration of stress in the material that would otherwise migrate to other parts in a material which will yield more readily. Fourthly, the plastic deformation process is irreversible in that the plastically deformable material cannot be re-used.

There are various materials that have been developed to act as friction linings to give a predictable resistance to load in a wide variety of environmental conditions such that their coefficient of friction when in contact with other materials is consistently reproducible in manufacture and in use. These developments are helped as a result of continual search for more reliable friction lining materials, particularly those used in a wide variety of vehicle braking systems.
Accordingly, one object of this invention is to provide an energy absorbing anchor that is capable of functioning in any anchor position in a cable fall arrest system whether as an end anchor or an intermediate anchor.

Another object of this invention is to provide an energy absorbing anchor that supports the cable in normal access use of a cable fall arrest system (not involving a fall situation), so that the cable is held clear from the surface of the roof and traveller devices used by personnel to remain attached to the cable across intermediate anchors are also held clear of the roof surface. Support to the cable should be maintained without any permanent deflection of the energy absorbing anchor until loading on the anchor transmitted through the cable exceeds a predetermined level, such as would typically occur in a fall event. Ultimately, this predetermined level is limited by the strength of the fixings between the energy absorbing anchor, particularly the tensile component of loading on the fixings, and also the strength of the roof itself. In order to establish a safe limit, it is typical to apply an additional safety margin of about 100%. However, the limit should also be sufficiently high to avoid, as far as is practical, the energy absorbing anchor from deflecting prematurely as a result of accidental pulling on a fall arrest system cable during normal access use rather than during and after a fall event.

A further objective of this invention is to provide an energy absorbing anchor that orients towards the load applied through the cable when the said predetermined level of load is exceeded such that the loading on the fixings of the energy absorbing anchor to the roof surface is substantially in shear and therefore capable of sustaining a higher level of load, and whereby the energy absorbing anchor has an energy absorbing mechanism that uses friction to resist deployment of a flexible elongate in order to absorb energy such that the resisting load does not exceed the safe limit applied to anchor fixings to the roof and the roof itself when the said fixings are loaded substantially in shear.

In a first aspect, this invention provides an energy absorber comprising: means for attaching the energy absorber to a supporting structure, means for attaching the energy absorber to a load element, and orienting means comprising at least one deformable element and responsive to a predetermined tensile load applied to the means for attaching to a load.
element to deform the at least one deformable element and to change the orientation of the energy absorber towards the direction of an applied load, and further comprising a store of flexible elongate material and friction deployment means to deploy the store of flexible elongate material and to provide resistance during said deployment and thereby absorb energy.

In a second aspect, this invention provides an energy absorber comprising means for attaching the energy absorber to a supporting structure, means for attaching the energy absorber to a load element, a store of flexible elongate material and friction deployment means to deploy the store of flexible elongate material and to provide resistance during said deployment and thereby absorbing energy, a casing around the store of flexible elongate material and said friction deployment means, and further comprising orientation means including said casing and responsive to deployment of said flexible elongate material to change the orientation of the energy absorber by rotation about a lower rim of the casing towards the direction of the applied load.

In a third aspect, this invention provides an energy absorber comprising means for attaching the energy absorber to a supporting structure, means for attaching the energy absorber to a load element, a substantially cylindrical casing, a store of flexible elongate material and friction deployment means to deploy the store of flexible elongate material and to provide resistance during said deployment and thereby absorb energy, further comprising orientation means including said casing and at least one deformable element responsive to a predetermined tensile load applied to the means for attaching to a load element to deform the at least one deformable element and to change the orientation of the energy absorbing anchor towards the direction of the applied load by rotation about a lower rim of the casing and whereby there is at least some deployment of the flexible elongate material during orientation.

In practice it has been typically found that the cable is held at about 200mm above the roof surface in normal access use of a fall arrest system (preceding a fall event), and that it is preferable orientation begins when the applied load on the said load element is about 2.5kN. Lower loads initiating orientation can lead to the anchor being oriented accidentally during
normal use of a fall arrest system rather than in the event of a fall accident. In some applications, fragile roof sheets may fail by buckling if orientation is initiated at applied loads of more than 5kN and the fixings to the roof may become overloaded in tension tending to pull the fixings out of the roof. Therefore, a figure of 2.5kN offers a 100% safety margin.

It has also been found in practice that the maximum load that most fragile roofs and the fixings into the roof surface can withstand when the energy absorbing anchor has completed orientation towards the applied load and the fixings are load substantially in shear, is approximately 20kN and so it is preferred to limit this to 10kN in order to maintain a 100% safety margin. It is therefore desirable that the applied load on the load element after orientation should not exceed the maximum safe limit that in practice has been found to be about 10kN.

The invention will now be described by way of example only with reference to the accompanying diagrammatic figures, in which:

Figure 1 shows a partially cut away view of an energy absorbing anchor according to a first embodiment of the invention;

Figure 2 shows an elevation partially cut away view from a direction perpendicular to Figure 1;

Figure 3 a partially cut away plan view of Figure 1;

Figure 4 shows a partially cut away view of Figure 1 in operation;

Figure 5 shows a partially cut away view of an energy absorbing anchor according to a second embodiment of the invention;

Figure 6 shows a partially cut away view of Figure 5 in one level of operation;

Figure 7 shows a partially cut away view of Figure 5 in a second level of operation;
Figure 8 shows a partially cut away view according to a third embodiment;

Figure 9 shows a detail of the embodiment in Figure 8;

Figure 10 shows a partially cut away view according to a fourth embodiment of the invention;

Figure 11 shows a partially cut away plan view of Figure 10;

Figure 12 shows a partially cut away view of Figure 10 in operation;

Figure 13 shows a plan view of a typical base plate.

Referring to Figures 1 to 4, a first embodiment of the invention is shown.

In the energy absorbing anchor of the first embodiment a length of flexible elongate material 1 is located around axial guide 2 dividing the length of the elongate material equally and each end of elongate material 1 is then coiled in the same rotational direction around cylindrical drum 3. One end of elongate material 1 is then passed through drum 3 and around axle 4 and swaged to the other end of elongate material 1 by swage means 5 such that the ends of elongate material 1 are effectively joined. Swage means 5 is located to the drum 3 such that it cannot move with respect to drum 3. Drum 3 is located on axle 4 such that its central axis is coaxial with the central axis of axle 4 and is free to rotate about axle 4.

Base plate 7 is substantially rectangular with fixing positions such as 46 shown in Figure 13 at each corner and with a formed shape about its centre to provide stiffening such that when base plate 7 is fixed at each fixing position to a structure such as a fragile roof surface, loading on the fixings is, as far as is practicable, equally distributed across all fixings. The type of fixings used is ideally a type that is readily available and easy to install such as stitching screws that can be pierced into a fragile roof surface and tightened in one operation.
After base plate 7 is fixed to the surface of a fragile structure such as a roof sheet, base plate 7 is substantially parallel to the plane of the fragile structure surface.

The use of a rectangular base plate 7 is preferred, but other shapes can be used.

The axial guide 2 is attached to a U bolt 6 which is attached in turn to the base plate 7. The axial guide 2 is arranged such that it can orientate in all directions in the plane of base plate 7 with respect to U bolt 6. U bolt 6 is fastened with nuts 47 and 48 to the centre of base plate 7 such that axial guide 2 is effectively connected to base plate 7.

Bracket 8 consists of two parallel plates held apart and joined at one end to form a U shape. Said one end of the bracket 8 is rigidly attached to load element 9 and casing 10. Axle 4 is located in locating holes in both parallel plates of bracket 8 such that its central axis is parallel to the plane of base plate 7 and perpendicular to the plane of the parallel plates. Drum 3, located on axle 4, is positioned between the parallel plates of bracket 8. Friction discs 11 and 12 are located at either end of drum 3 and with their disc axes coaxial with the central axis of axle 4 and with interlocking means between the friction discs 11 and 12 and drum 3 that constrains the said friction discs to rotate with drum 3. Friction discs 11 and 12 are made of a friction lining material that has a relatively consistent coefficient of friction between itself and the material from which bracket 8 is made. The parallel plates of bracket 8 are then urged together, and against the friction discs 11 and 12, by spring discs 13 and 14 and bolts 15 and 16 such that the urging force generates a frictional resisting loading, resisting rotation of drum 3 with respect to bracket 8. Spring discs 13 and 14 are intended to provide some axial elastic movement to ensure that compression between the parallel plates of bracket 8, and thus the urging force, can be maintained over a prolonged period.

Guide 18 is fixed by means of fastenings 49 and 50 to bracket 8 such that guide 18 cannot rotate with respect to bracket 8. The purpose of guide 18 is to constrain the path of flexible elongate material from drum 3 to axial guide 2 such that it is aligned between load element 9 and U bolt 6 and remains aligned in the event of tensile loading between load element 9 and U bolt 6.
Casing 10 is cylindrical with a closed domed portion at its upper end, as shown in Figures 1, 2 and 4. Other types could be used, but a cylindrical casing is desirable for symmetry to ensure that the performance of the anchor is consistent regardless of the direction of the tensile load applied to load element 9.

Along the length of casing 10 there are various weakening grooves shown as 20a to 20d that enable the casing to plastically deform when a sufficient predetermined compression load is applied between load element 9 and the lower rim of casing 10. When a load is generated in a fall situation transmitted through fall arrest system cable 40 typically in a direction parallel to the plane of base plate 10, casing 10 is urged to rotate about its lower rim. The rotational moment about the rim of casing 10 is resisted by the connecting components between base plate 7 and load element 9 including the frictional resistance resisting rotation of drum 3 due to compression loading between the parallel plates of bracket 8 resisting deployment of elongate material 1. Below a predetermined level of applied load at load element 9 casing 10 remains rigid and resists rotation. However, as the level of load increases to reach a first predetermined level, casing 10 plastically deforms in the region of the weakening grooves 20a to 20d, as shown in Figure 4, such that load element 9 rotates in the plane orthogonal to and with respect to base plate 7 and in a direction typically in the plane of base 7 towards the direction of the applied load at load element 9. Rotation in the plane orthogonal to base plate 7 will then continue until the rim of casing 10 slips away from base plate 7, whereupon, the energy absorbing anchor lies in an orientation substantially in the plane of base plate 7.

Further increase of load applied to load element 9 will eventually reach a second predetermined level with a magnitude whereby the applied load at load element 9 is sufficient to overcome the friction resistance between bracket 8 and friction discs 11 and 12 thereby allowing drum 3 to rotate and to deploy flexible elongate material 1. The combined effect of deployment of elongate material 1 and such deployment being resisted by the resisting load between friction discs 11 and 12 and bracket 8, provides energy absorption. Drum 3 will continue to turn until the applied load at load element 9 in no longer sufficient to overcome the load resisting deployment of elongate material 1.
It should be understood that for geometric reasons the first predetermined level of load is lower than the second.

The friction discs 11 and 12 provide a consistent and known coefficient of friction with respect to bracket 8, as a result the load resisting rotation of drum 3 will be largely predictable and consistent. Therefore, by controlling frictional resistance through the choice of material for friction discs 11 and 12 and also the compression loading between the parallel plate of bracket 8 including the design and material specification for spring discs 13 and 14 and the torque applied on tightening bolts 15 and 16, the load applied at load element 9 can be effectively limited such that it does not exceed the safe limit for the strength of the fixings between base plate 7 and a fragile structure surface such as a roof sheet and also the safe limit for the strength of the fragile structure itself.

Referring to Figures 5 to 7, a second embodiment is shown.

In Figures 5 to 7, the energy absorbing anchor has a rigid substantially cylindrical casing. The casing is shown in Figure 5 as comprising a dome 41, cylinder 42 and interlinking discs 43 and 44 to represent a casing construction that is easy to manufacture. However, the casing could equally be one component including a domed portion at its upper end and a cylindrical body portion. The casing, being rigid, is not intended to substantially plastically deform.

When a load is generated through fall arrest system cable 40 and applied to load element 9 this will usually be in a direction that is substantially parallel to the plane of base plate 7, said casing comprising dome 41, cylinder 42 and interlinking discs 43 and 44 is urged to rotate about its lower rim with respect to base plate 7. Below a predetermined level of applied load at load element 9, the rotational moment tending to rotate the casing about its lower rim is resisted by the components connecting load element 9 to base plate 7 and in particular, by the friction resistance resisting rotation of drum 3 with respect to bracket 8. However, when the level of load applied at the load element 9 reaches a first predetermined level, the load resisting deployment of elongate material 1 acting between load element 9 and base plate 7 exceeds the frictional resistance between friction discs 11 and 12 and bracket 8.
such that flexible elongate material 1 is deployed. Such deployment allows the casing to rotate with respect to base 7, as shown in Figure 6, until the rotation reaches an angle with respect to base 7 sufficient for the lower rim of the casing to slip away from base plate 7 and the energy absorbing anchor assumes an orientation substantially in the plane of the roof, as in Figure 7. Deployment of elongate material will cease after the rim of the casing has slipped away from base 7 and then recommence when the load applied to load element 9 increases to a second predetermined level that is sufficient to overcome the load resisting deployment of the elongate material 1. In this embodiment therefore, energy is typically absorbed by means of deployment of flexible elongate material both during at least part of the orientation process and also after orientation of the energy absorbing anchor. After orientation, deployment of elongate material 1 will cease when the load applied to load element 9 is insufficient to overcome the load resisting deployment of flexible elongate material 1.

It should be noted, that during orientation of the energy absorbing anchor, as shown in Figure 6, the applied load at load element 9 transmitted through fall arrest system cable 40 and sufficient to deploy elongate material, is typically significantly less than the load resisting deployment of elongate material 1 between load element 9 and base 7. That is, the first predetermined load level is smaller than the second predetermined load level. This is because of the geometry of the casing in terms of the proportion of its height to the radius of its base. Hence, the reason why deployment stops temporarily after the lower rim of the casing, shown as 45 in Figure 6, slips away from base 7.

Figures 8 and 9 show the same embodiment as in Figures 5 to 7 except spacer plates 24 and 25 have been added. One problem that can be encountered with a friction device of this kind is that when load is maintained between the friction lining discs 11 and 12 and bracket 8 over a long period of time, the load required to overcome the frictional resistance and initiate rotational movement of drum 3 can be greater than the load required to overcome frictional resistance whilst drum 3 is already rotating. This effect is often referred to as stiction. Therefore spacer plates 24 and 25 are intended to hold the parallel sides of bracket 8 apart and thereby release compression loading between discs 11 and 12 and bracket 8 until frictional resistance is required in a fall event.
When load transmitted through fall arrest system cable 40 applied at load element 9, typically in a direction parallel to the lane of base plate 7, is below a predetermined level, the casing, comprising dome 41, cylindrical body 42 and interlinking discs 43 and 44, is urged to rotate about its rim whilst at the same time being resisted by the spacer plates connected between bracket 8 and bolt 6 as shown in Figure 9. However, when the level of load applied at load element 9 reaches a predetermined level such as in a fall event, tab portions 51 and 52 in spacer plate 25 and similar tab portions in spacer plate 24 deform and break away from bracket 8 such that the load generated between load element 9 and U bolt 6 is transferred to flexible elongate material 1. Flexible elongate material is then deployed without any frictional resistance until the parallel plates of bracket 8 are able to be compressed together by spring discs 13 and 14 and bolts 15 and 16 bearing on friction discs 11 and 12 and drum 3 thereby causing further deployment of flexible elongate material 1 to be resisted and enabling the anchor to function thereafter as in Figures 5 to 7.

Referred to in Figures 10 to 12, a third embodiment is shown.

In Figures 10 to 12, the energy absorbing anchor has two drums 27 and 28, both cylindrical and with the same cylindrical outer diameter. Both drums 27 and 28 are located on axle 4 such that their central axes are coaxial with the axis of axle 4 and such that they are each free to rotate independently with respect to axle 4 and each other. Flexible elongate material 29 is passed around axial guide 2 dividing the length of the elongate material equally. One end of the elongate material is coiled around drum 27 in one rotational direction and the other end of elongate material 29 is coiled around drum 28 in the opposite rotational direction. Each end is then looped around axle 4 and secured back on itself by means of swaging means 32 and 33 such that each loop is free to rotate about axle 4.

Friction disc 11 is located between drum 27 and one parallel plate of bracket 8 and friction disc 12 is located between drums 28 and the other parallel plate of bracket 8, whereby friction disc 11 is constrained to rotate with drum 27 and friction disc 12 is constrained to rotate with drum 28. A further friction disc 30 is located between drums 27 and 28 and constrained to rotate with drum 28. Disc 31 has similar radial dimensions to friction disc 30, is ideally made of a material similar to bracket 8 and is constrained to rotate with drum 27.
The parallel plates of bracket 8 are then urged together by spring discs 13 and 14 and bolts 15 and 16 such that the urging force generates a frictional force which resists rotation of both drums 27 and 28. When a load is applied between load element 9 and U bolt 6 that is sufficient to overcome the resistance provided by the compression of friction discs 11 and 12 against bracket 8 and friction disc 30 against disc 31, drums 27 and 28 rotate in opposite directions deploying elongate material 29 equally from each drum. The benefit of this arrangement is that it avoids the need for guide 18, shown in Figures 1 and 2, such that the resultant of the load on the elongate material 29 either side of axial guide 2 is aligned between load element 9 and axial guide 2. It also avoids the possibility of the flexible elongate material being damaged whilst bearing on guide 18, as shown in Figure 1, during deployment and avoids any undesirable effects as a result of friction between the flexible elongate material and guide 18.

The features of the embodiments shown in Figures 8 and 9 and Figures 10 to 12 could be applied to any of the other embodiments, or vice versa.

In all embodiments, it can be beneficial to tighten bolts 47 and 48, as shown in Figure 1, after assembly of the energy absorbing anchor so that a pre-tension load can be applied between the load element 9 and base plate 7. This helps to ensure that there is no deflection of the energy absorbing anchor in normal use, without a fall event, up to a predetermined level of load applied to load element 9. Without the pre-tension loading, the energy absorbing anchor may be loose between the load element 9 and base plate 7 particularly if these is elastic stretching of the flexible elongate material or scope for further tightening of the coiled flexible elongate material on drum 3.

The above embodiments specify that the friction discs 11 and 12, and also 30 in respect of Figure 11, are constrained to rotate with the drum (or drums). This can be achieved in various ways such as applying an interlocking surface form to the adjacent surface of both the friction disc and drum. Alternatively, the friction discs could be adhered to the drum (or drums) by adhesive or some other means of surface bonding. Whilst the embodiments describe the friction discs being constrained to rotate with the drum or drums, the invention could also function if the friction discs are constrained to bracket 8 whereby the drum or
drums effectively rotate against friction discs that are static with respect to the drum or drums.

It has been found that the flexible elongate material can be multi-stranded steel cable such as galvanised steel cable or stainless steel cable and that the cable diameter can be about 5mm in diameter in order withstand expected loading during and after a fall event. However, the flexible elongate may take any form provided that it has sufficient tensile strength and that this strength is not unacceptably compromised as a result of being coiled around a drum.

The drum (or drums as in Figures 10 to 12) may be made of a reinforced plastic because the loading applied through the flexible elongate material tends to be distributed over a relatively large area. However, it could also be made from a variety of other materials and may be constructed of more than one component such as being made in two halves and joined. Construction from more than one component may be necessary in order for the drum to be readily manufactured. The other components are ideally made from steel, treated and coated to protect against prolonged exposure to a variety of outside environmental conditions or else made of stainless steel.

The casing in all the above embodiments is shown as having a cylindrical body with a closed and domed upper end and with the cylindrical central axis aligned between the load element 9 and U bolt 6. This central positioning of the cylindrical body enables the moment resisting its orientation to be the same irrespective of the direction in the plane of base plate 7 that it is tending orientate towards a load applied at the load element 9 typically as a result of a fall event. However, the casing could have any other cross sectional geometry as may be beneficial particularly if the direction of the load applied at load element 9, typically in the plane of base plate 7, can be predicted. For example, the casing could have a rectangular base if the direction of the applied load at load element 9 could be predicted to be in either of two perpendicular directions with respect to the plane of the base plate 7. Also, a rectangular base could be arranged such that it could provide greater resistance to orientation in one direction as compared to another direction by arranging the distance between its rim and the line of load between the load element 9 and U bolt 6 to provide different resisting moments depending on the direction of the applied load at load element 9.
The casing could be an open structure but whereby it is sufficiently rigid to withstand typical compressive loading between load element 9 and U bolt 6 or, with respect to Figures 1 to 4, the casing could use some other means to plastically deform when the compressive loading between load element 9 and U bolt 6 reaches a predetermined level. For example, it may be that a thinner walled casing could be arranged to beneficially buckle when a predetermined compressive loading is applied between load element 9 and U bolt 6.

In the embodiment in Figures 1 to 4, there is no deployment of the flexible elongate material until the energy absorbing anchor has completed its orientation with respect to base plate 7. Whilst this is preferred, this embodiment of the invention could also be arranged to orientate whilst undergoing both plastic deformation in the casing and also some deployment of the flexible elongate material 1.

The method shown in Figure 9, using spacer plates 25 and 24 is a typical example of how the parallel plates of bracket 8 could be held apart to release compression loading between friction discs 11 and 12 and bracket 8 until a fall event. However, any other method may be used to release compression loading between friction discs 11 and 12 and bracket 8, typically until a fall event has occurred.

All the above references to predetermined loads mean loads that are ideally predetermined with a consistent degree of accuracy although the degree of accuracy will depend on numerous factors such as consistency of materials, dimensional accuracy of components and variations in assembly methods and procedures. The degree of accuracy may also depend on variations in environmental conditions and whether the energy absorbing anchor is a recent installation or has been installed for a longer period.

In all the above embodiments, if the flexible elongate material should ever be fully deployed, the swaging means for connecting the ends of the elongate such that the elongate is securely looped about axle 4 provides a secure attachment between load element 9 and base plate 7. In order to comply with regulatory standards, this attachment between load element 9 and base plate 7 should be capable of withstanding a load of at least twice the maximum load.
applied at load element 9 during deployment of the flexible elongate material. However, it is important that the energy absorbing anchor should have a sufficient store of coiled flexible elongate material to absorb all the foreseen energy that could be generated in the worst case fall scenario within the scope of the fall arrest system and its installation.

The use of a rotating friction resisted deployment means allows the energy absorbing anchor to provide a relatively large extension by deployment of the elongate material without having to be excessively large. In order to provide a similar degree of extension by linear frictionally resisted movement a very long device would be required.

As explained above, in the energy absorbing anchors according to the second and third embodiments the first predetermined level of load required to change the orientation of the energy absorbing anchor can be set by the amount of tightening of the bolts 15 and 16, which controls the compression loading between the relatively rotating parts of the energy absorbing anchor. Further, in all of the embodiments the tightening of the bolts 15 and 16 controls the second predetermined level of load required to begin deployment of the flexible elongate material from the drum or drums.

Accordingly, the present invention provides the advantage that the predetermined levels of load at which the energy absorbing anchor will change orientation or begin deployment can be set to a desired one of a range of possible predetermined loads by appropriate tightening of the bolts 15 and 16 without requiring changes in the components of the anchor. In contrast, a device using plastic deformation to absorb energy will change orientation and begin deployment at a fixed level of applied load. In order to change the load levels for such a known energy absorber it is necessary to change the material, cross-section or geometry of the plastically deformable material.

Accordingly, an energy absorbing anchor according to the present invention has improved flexibility regarding the applied load levels to which it responds.

In practice it will usually be preferred to tighten the bolts 15 and 16 before the anchor is installed, for example on a roof. However, it will be possible to tighten the bolts after
installation of the anchor if desired.

As explained above, in the first and second embodiments of the invention the first predetermined load at which the change of orientation of the anchor begins will be smaller than the second predetermined load at which deployment of the material from the store takes place for geometrical reasons. Although in the first embodiment it is intended that the change of orientation should be enabled and the first predetermined load set by deformation of the casing, it will be understood that there is an upper limit to the first predetermined load level because if the load level at which deformation of the casing occurs is set too high the change of orientation will take place without deformation of the casing, similarly to the second embodiment.

This geometric relationship between the first and second predetermined load is a consequence of the shape of the energy absorbing anchor. If the anchor was sufficiently short relative to its diameter or width, the first and second predetermined loads could be the same or the second predetermined load smaller than the first. However, in practice it is usually preferred for the energy absorbing anchor to have a post like profile with a height considerably greater than, and usually several times greater than, its diameter.

However, in the arrangement shown in figures 8 and 9, the first predetermined level of load at which the change in orientation begins is set by the release of spacer plates 24 and 25 from between the parallel plates of bracket 8. This release is unrelated mechanically to the deployment of the elongated material and accordingly the first predetermined load level at which the change in orientation begins can be arranged to have any desired value relative to the second predetermined level of load at which the elongate material begins deployment.

Preferably, the first and second predetermined levels of load are arranged to be substantially the same in order to maximize the amount of energy absorbed relative to the degree of movement of the load element 9.

As explained above, in the arrangement of figures 8 and 9 the frictional loading resisting deployment of the elongated material is zero until the plates 24 and 25 are removed.
from between the parallel plates of the bracket 8. Preferably the release mechanism is arranged to reduce the length of this frictionally unreisted movement as far as possible.

The description given above is of preferred embodiments of the invention only. The skilled person will be able to make numerous changes to these embodiments which will fall within the scope of the invention, which is defined in the attached claims.
CLAIMS

1. An energy absorber comprising: means for attaching the energy absorber to a supporting structure, means for attaching the energy absorber to a load element, and orienting means comprising at least one deformable element and responsive to a predetermined tensile load applied to the means for attaching to a load element to deform the at least one deformable element and to change the orientation of the energy absorber towards the direction of an applied load, and further comprising a store of flexible elongate material and friction deployment means arranged to deploy the store of flexible elongate material and to provide resistance during said deployment and thereby absorb energy.

2. An energy absorber according to claim 1, and further comprising a casing around the store of flexible elongate material and the friction deployment means.

3. An energy absorber according to claim 2, in which the casing is substantially cylindrical.

4. An energy absorber according to claim 2 or claim 3, in which the deformable element of the orienting means is the casing.

5. An energy absorber comprising:
   means for attaching the energy absorber to a supporting structure, means for attaching the energy absorber to a load element, a store of flexible elongate material and friction deployment means to deploy the store of flexible elongate material and to provide resistance during said deployment and thereby absorbing energy, a casing around the store of flexible elongate material and said friction deployment means, and further comprising orientation means including said casing and responsive to deployment of said flexible elongate material to change the orientation of the energy absorber by rotation about a lower rim of the casing towards the direction of the applied load.

6. An energy absorber according to claim 5, in which the casing deforms to change the orientation of the energy absorber.
7. An energy absorber according to claim 5 or claim 6, in which the casing is substantially cylindrical.

8. An energy absorber comprising means for attaching the energy absorber to a supporting structure, means for attaching the energy absorber to a load element, a substantially cylindrical casing, a store of flexible elongate material and friction deployment means to deploy the store of flexible elongate material and to provide resistance during said deployment and thereby absorb energy, and further comprising orientation means including said casing and at least one deformable element responsive to a predetermined tensile load applied to the means for attaching to a load element to deform the at least one deformable element and to change the orientation of the energy absorbing anchor towards the direction of the applied load by rotation about a lower rim of the casing and whereby there is at least some deployment of the flexible elongate material during orientation.

9. An energy absorber according to claim 8, in which the casing deforms to change the orientation of the energy absorber.

10. An energy absorber according to any preceding claim, in which the friction deployment means comprises at least one drum having the flexible elongate material wound around the drum such that deployment of the material rotates the drum, the friction means being arranged to provide resistance to rotation of the drum.

11. An energy absorber according to claim 10 comprising two drums having a common axis of rotation, the flexible elongate material being wound around the drums such that deployment of the material rotates the drums in opposite directions, the friction means being arranged to provide resistance to relative rotation of the drums.

12. An energy absorber according to claim 11, in which a single flexible elongate material is wound around both drums.

13. An energy absorber according to any one of claims 10 to 13, in which the flexible elongate material is wound through more than one complete turn around the or each drum.
14. An energy absorber according to any preceding claim, in which the change in the orientation of the energy absorber rotates it from an orientation substantially orthogonal to the plane of the supporting structure to an orientation substantially parallel to the plane of the supporting structure.

15. An energy absorber according to any preceding claim, in which the friction deployment means include adjustment means which can be used adjust said predetermined tensile load.

16. An energy absorber according to any preceding claim, in which the orienting means includes a release means which maintains the friction deployment means in a released state in which engaging surfaces of the friction deployment means are out of contact, the release means responding to the predetermined tensile load by changing the friction deployment means into an engaged state in which said engaging surfaces are in contact.

17. An energy absorber according to any preceding claim, in which the energy absorber is an energy absorbing anchor for use in a height safety system.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A22B35/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A62B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<tr>
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<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
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<tr>
<td>Y</td>
<td>WO 01/87420 A (KEYGUARD LIMITED; RENTON, JULIAN) 22 November 2001 (2001-11-22) page 6, line 25 – page 11, line 12; figure 3</td>
<td>1-3, 10, 13-15, 17</td>
</tr>
<tr>
<td>Y</td>
<td>EP 0 373 328 A (VERARDO, SERGIO) 20 June 1990 (1990-06-20) column 2, line 32 – column 3, line 18</td>
<td>1-3, 10, 13-15, 17</td>
</tr>
<tr>
<td>A</td>
<td>WO 03/039680 A (ARGOUD, RODOLPHE) 15 May 2003 (2003-05-15) the whole document</td>
<td>1-17</td>
</tr>
<tr>
<td>A</td>
<td>GB 2 240 757 A (* DENIS FERRANTI METERS LIMITED) 14 August 1991 (1991-08-14) the whole document</td>
<td>1-17</td>
</tr>
</tbody>
</table>

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Date of the completion of the international search: 20 May 2005

Date of mailing of the international search report: 17/06/2005

Name and mailing address of the ISA
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<table>
<thead>
<tr>
<th>Patent document cited in search report</th>
<th>Publication date</th>
<th>Patent family member(s)</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>CA 2409112 A1</td>
<td>22-11-2001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GB 2362448 A, B</td>
<td>21-11-2001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WO 0187420 A1</td>
<td>22-11-2001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GB 2370089 A, B</td>
<td>19-06-2002</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 2003151180 A1</td>
<td>14-08-2003</td>
</tr>
<tr>
<td>EP 0373328 A</td>
<td>20-06-1990</td>
<td>IT 1226190 B</td>
<td>21-12-1990</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AU 4479589 A</td>
<td>24-05-1990</td>
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<tr>
<td></td>
<td></td>
<td>CA 2001519 A1</td>
<td>18-05-1990</td>
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<tr>
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<td></td>
<td>EP 0373328 A2</td>
<td>20-06-1990</td>
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<tr>
<td></td>
<td></td>
<td>JP 2224673 A</td>
<td>06-09-1990</td>
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<tr>
<td></td>
<td></td>
<td>EP 1441814 A1</td>
<td>04-08-2004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US 2004256176 A1</td>
<td>23-12-2004</td>
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<tr>
<td>GB 2240757 A</td>
<td>14-08-1991</td>
<td>AU 7072691 A</td>
<td>21-08-1991</td>
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<tr>
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<td></td>
<td>WO 9111217 A1</td>
<td>08-08-1991</td>
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