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(54) **AXIAL BUFFER DEVICE AND FALL PROTECTION DEVICE HAVING THE SAME**

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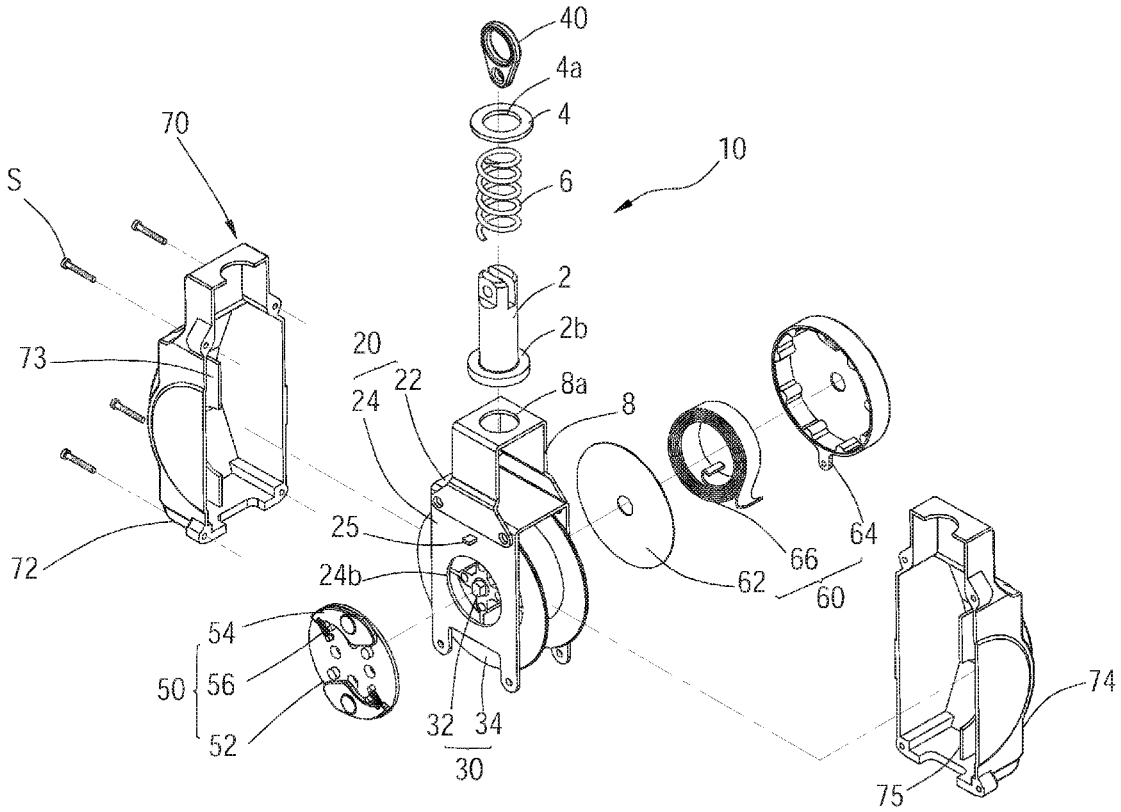
CPC ***A62B 1/10*** (2013.01); ***A62B 35/0075*** (2013.01)

(57) **ABSTRACT**

An axial buffer device and a fall protection device including the axial buffer device are disclosed. The axial buffer device includes a buffer rod having a first friction surface; and a buffer member having a second friction surface which contacts the first friction surface. When any one of the buffer rod and the buffer member is pulled by a force which is greater than a default value to overcome a maximum friction between the buffer member and the buffer rod, the buffer member would slide on the buffer rod with friction to cushion the pulling force. The fall protection device includes a frame, a rotary member disposed in the frame and adapted to roll up a safety belt, and the axial buffer device. One of the buffer rod and the buffer member is connected to a hanging point and the other one is connected to the frame.



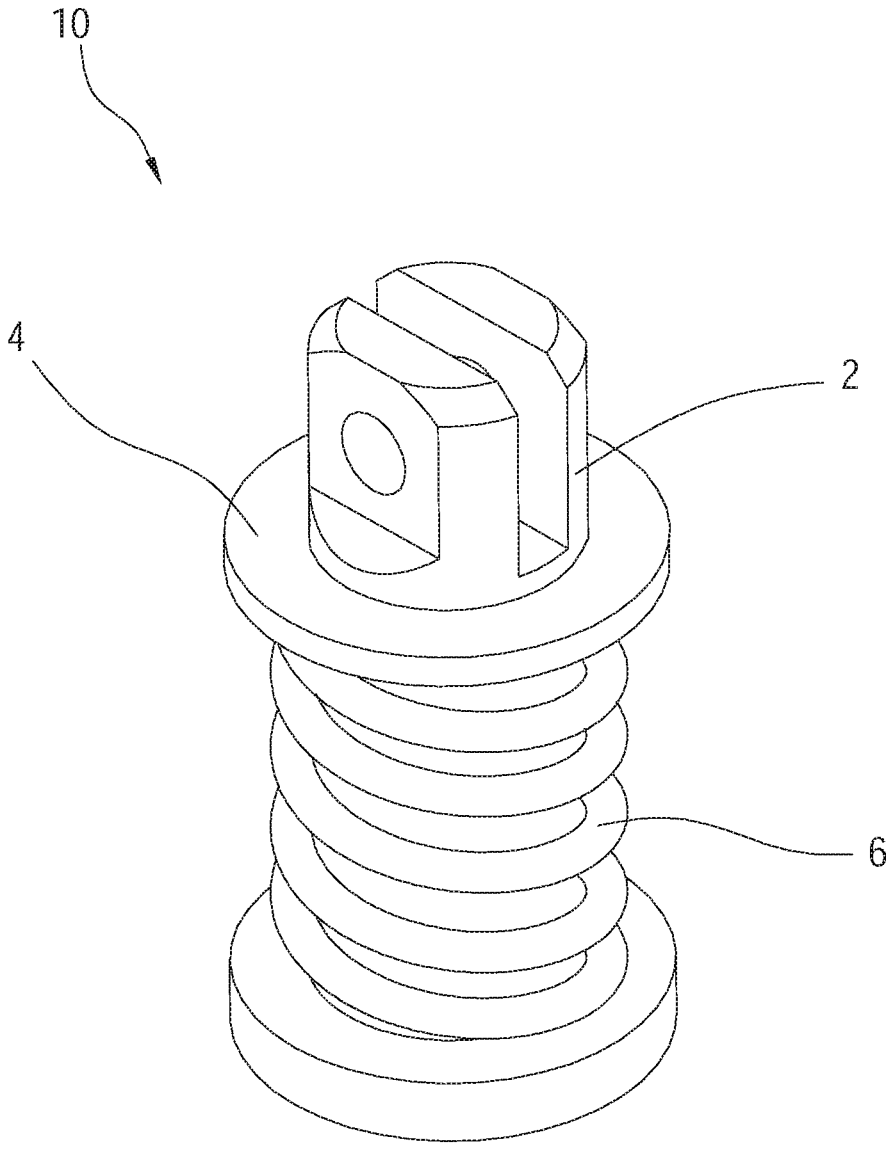


FIG. 1

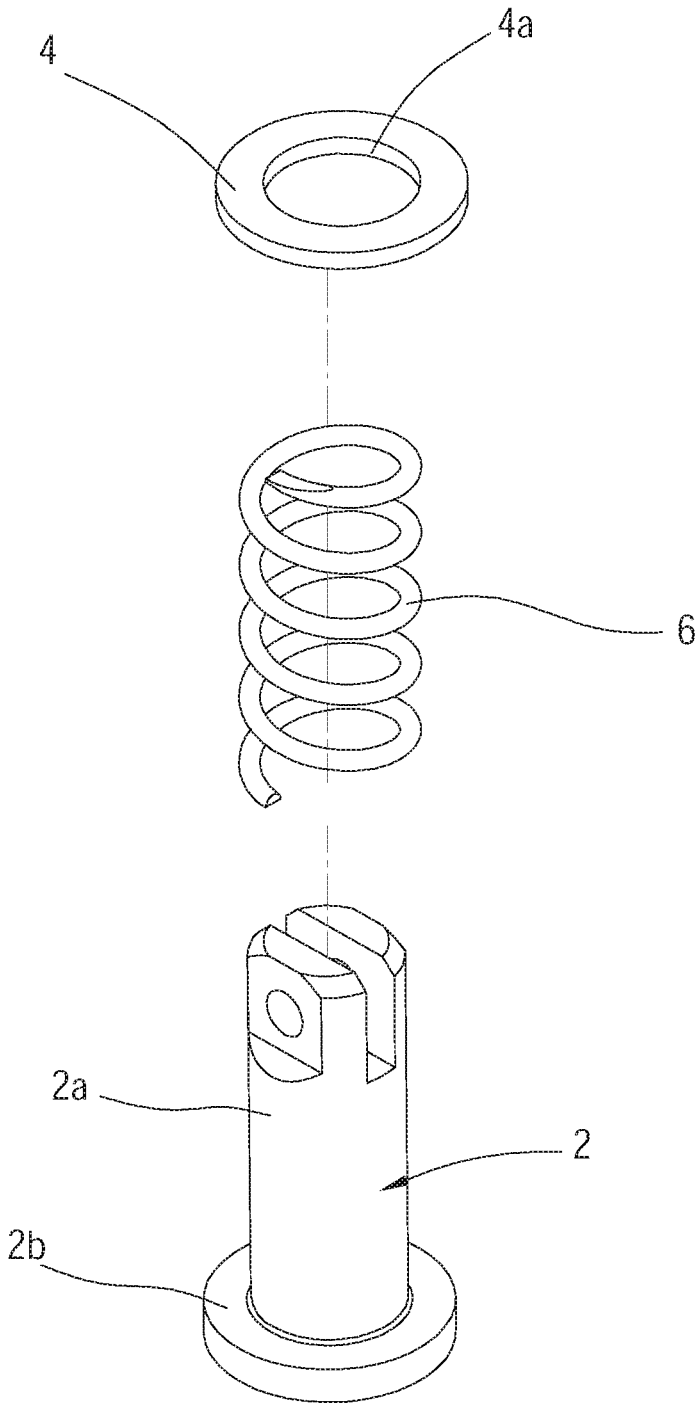


FIG. 2

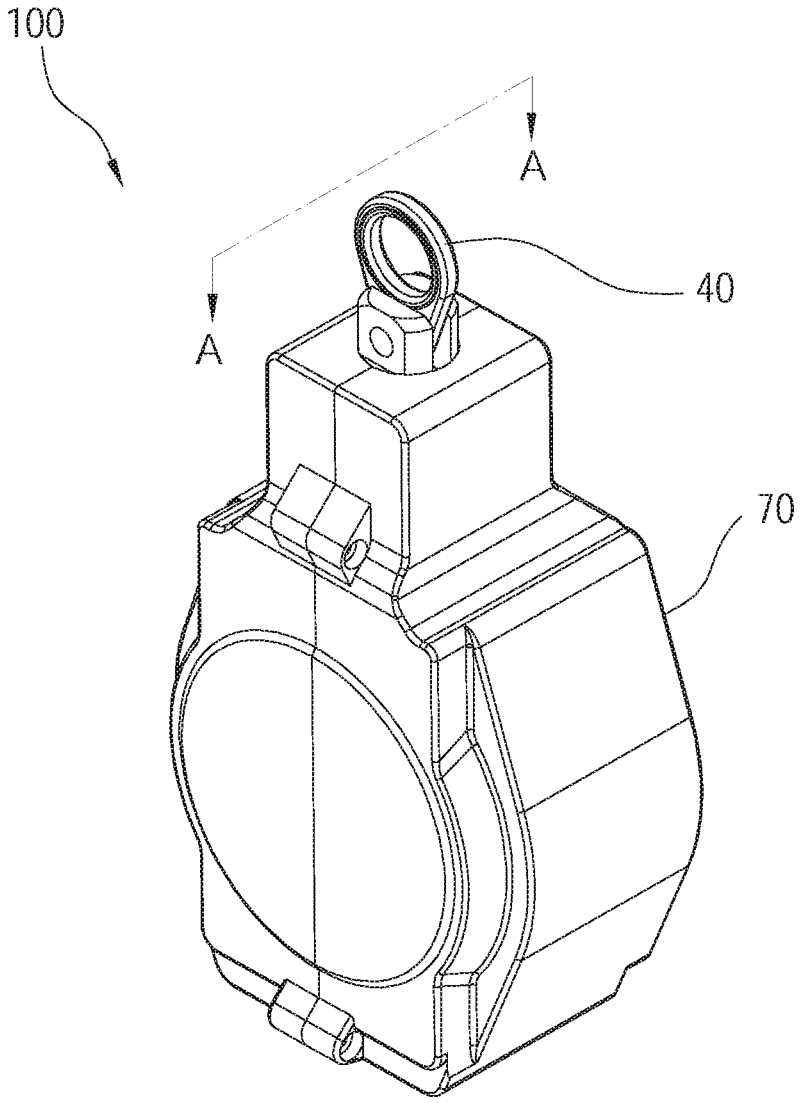


FIG. 3

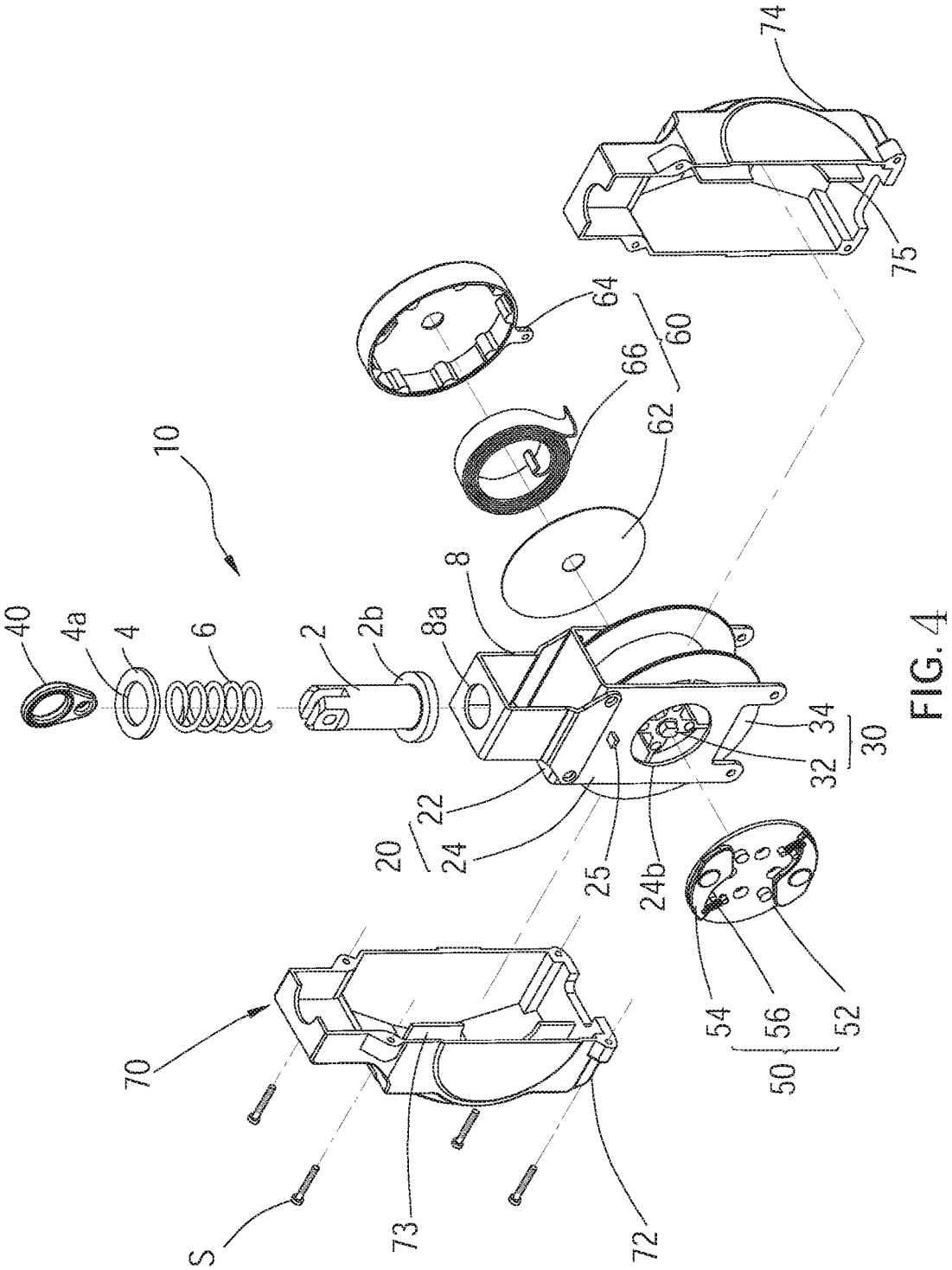

74
75
64
60
66
62
10
8
40
4a
4
6
2
2b
8a
34
30
32
22
20
24
25
24b
54
56
52
50
70
S
73
72

FIG. 4

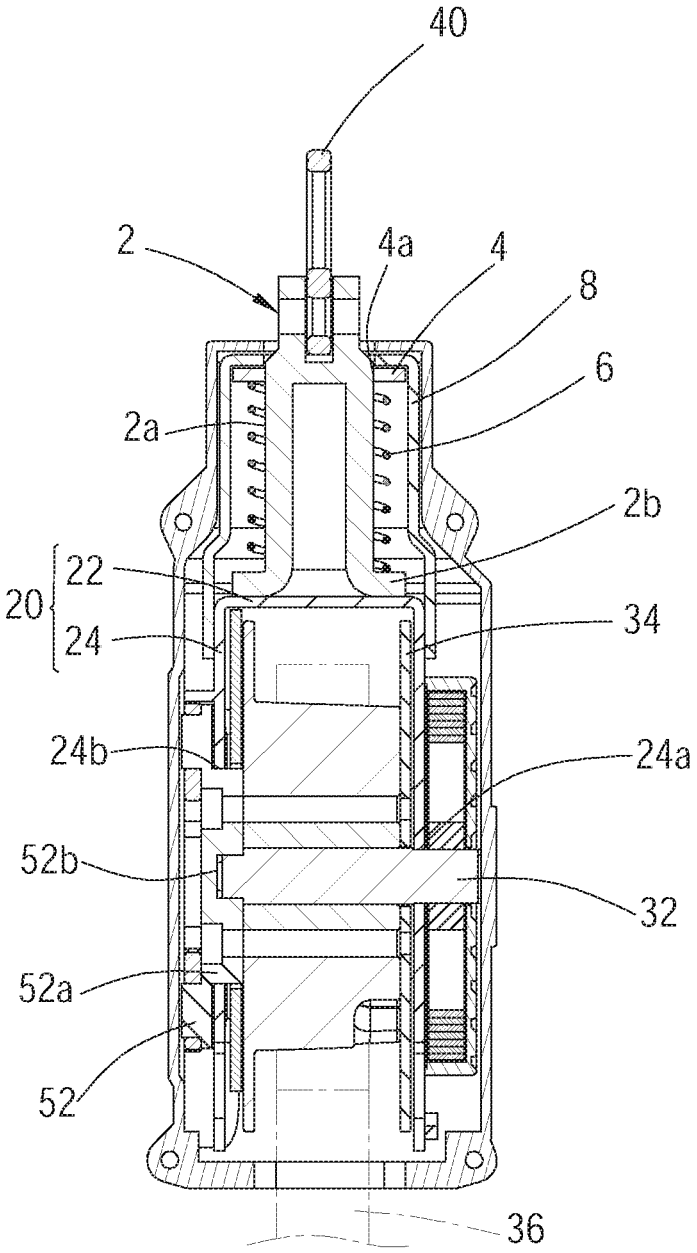


FIG. 5

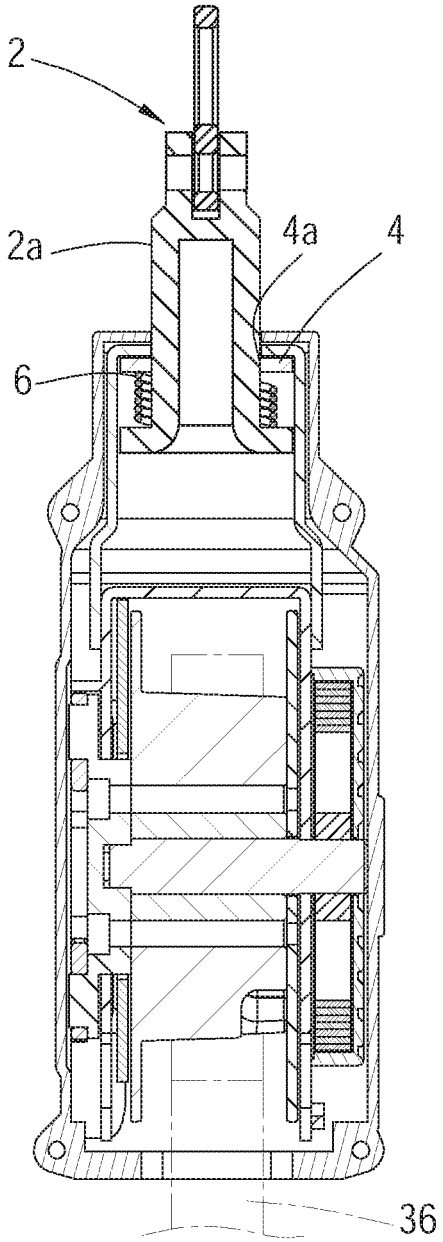


FIG. 6

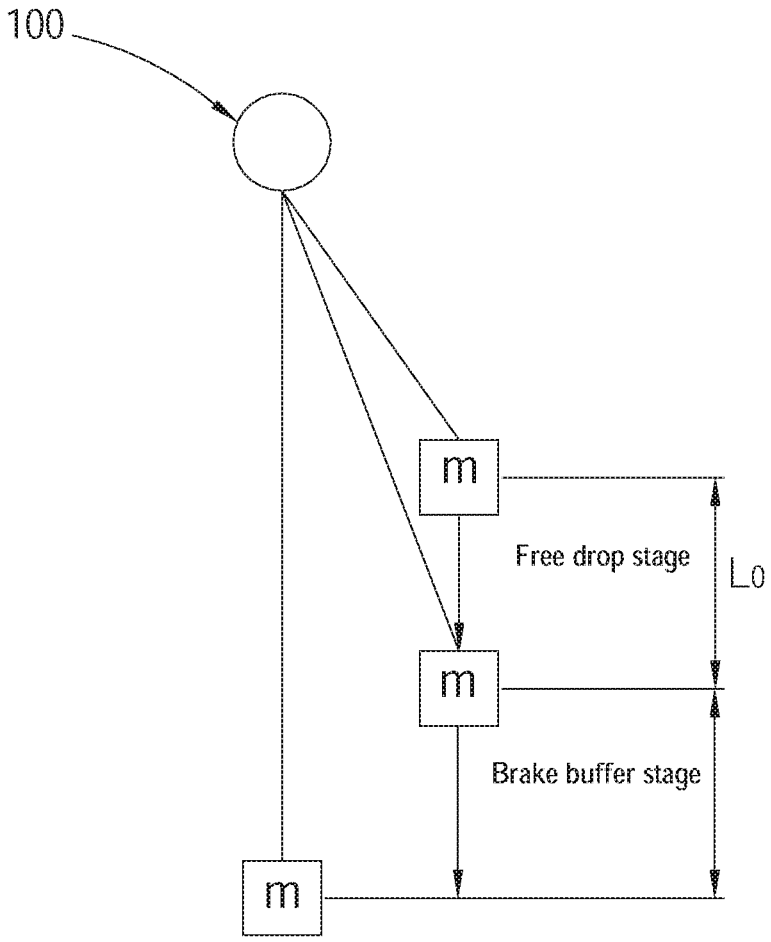


FIG. 7

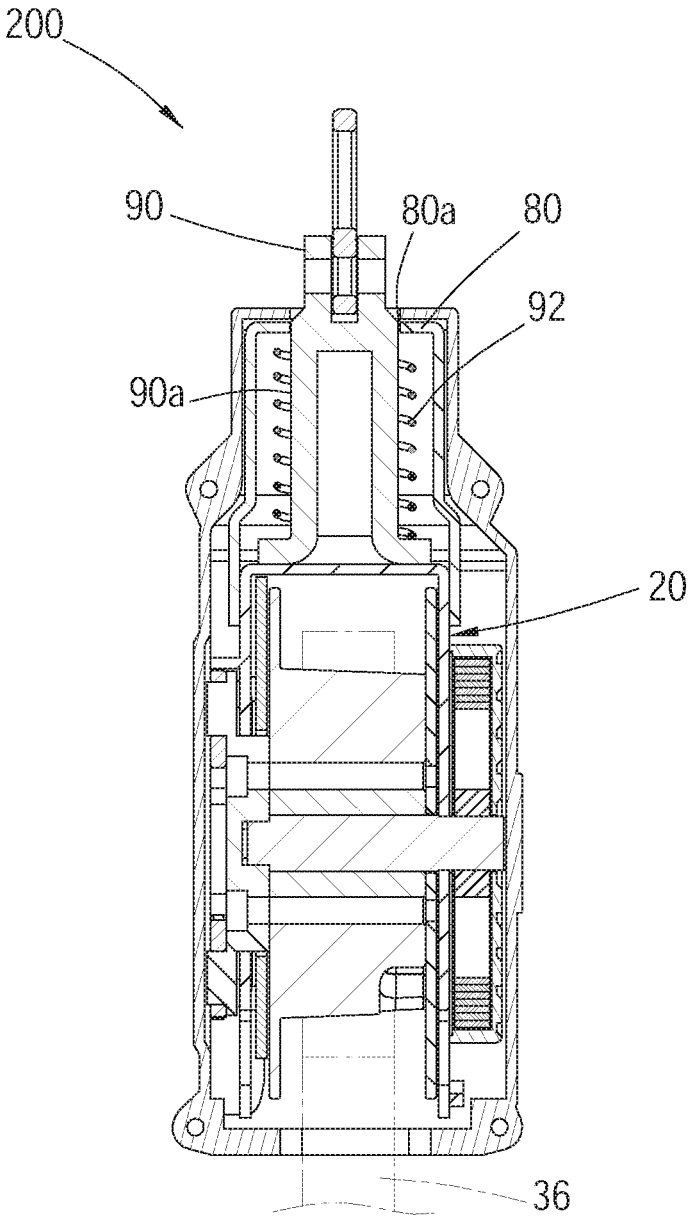


FIG. 8

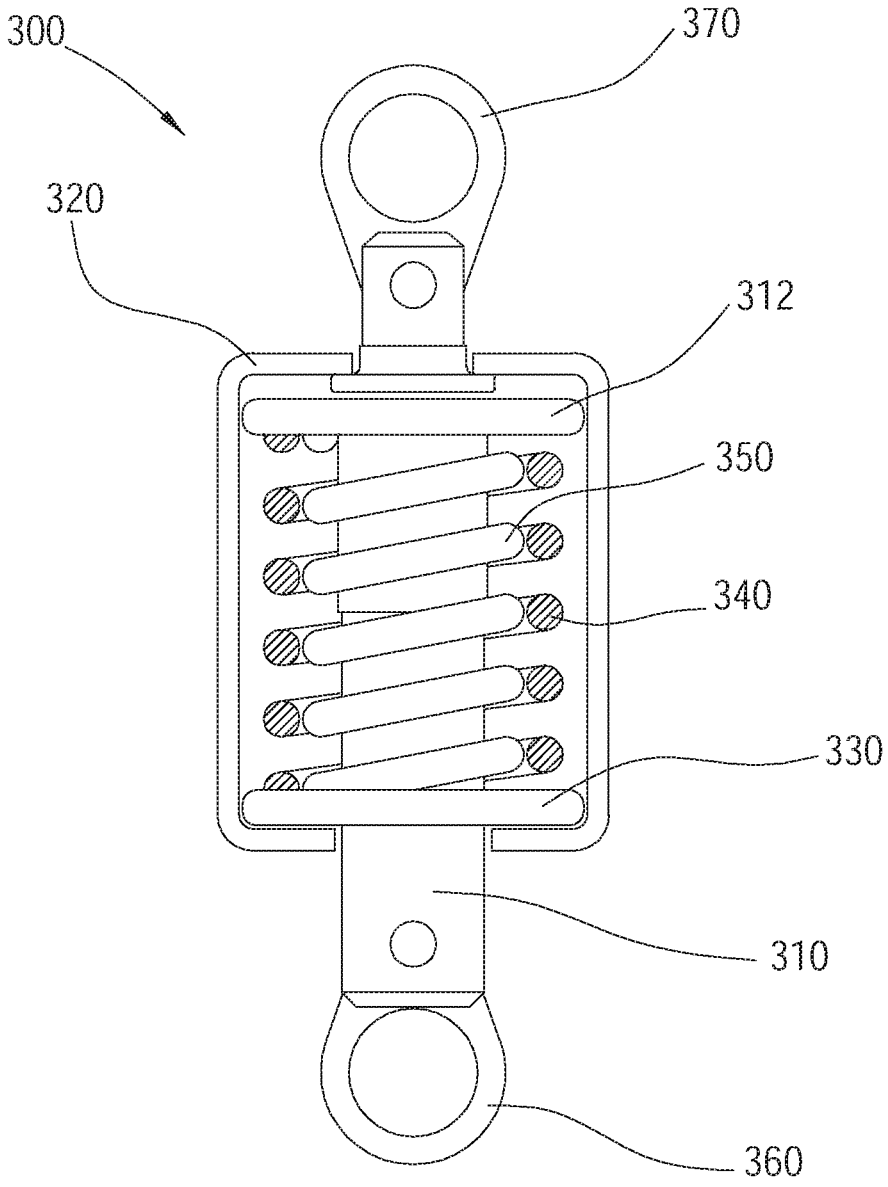


FIG. 9

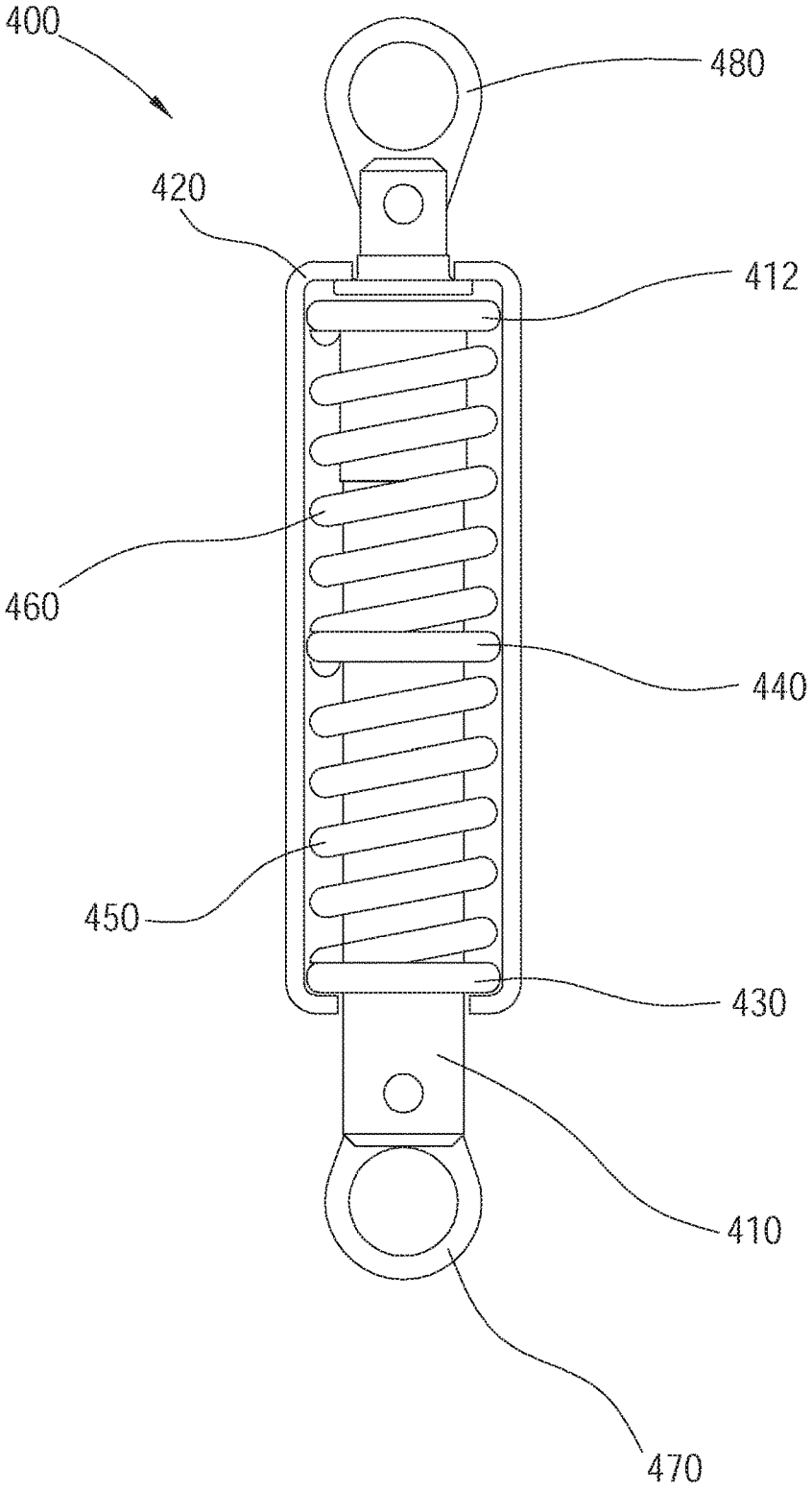


FIG.10

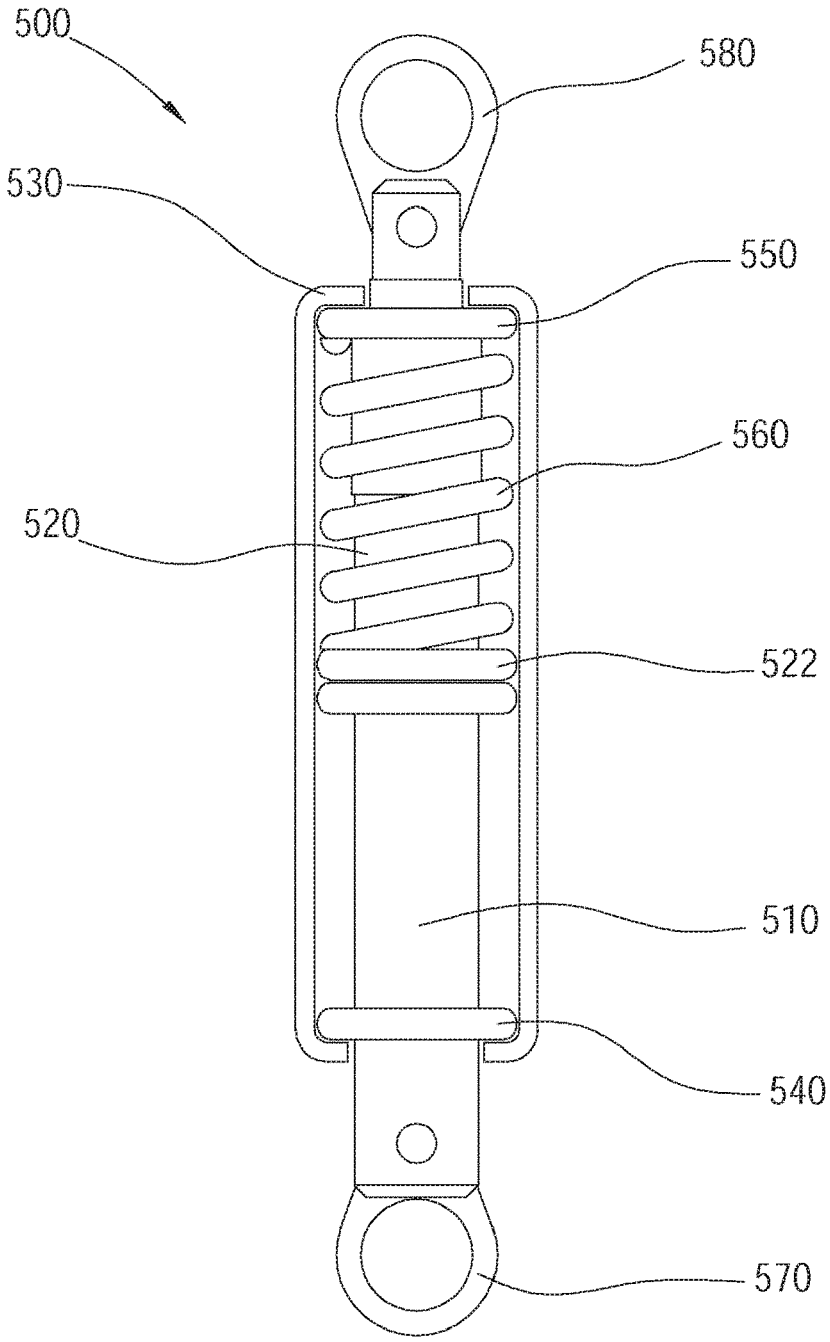


FIG.11

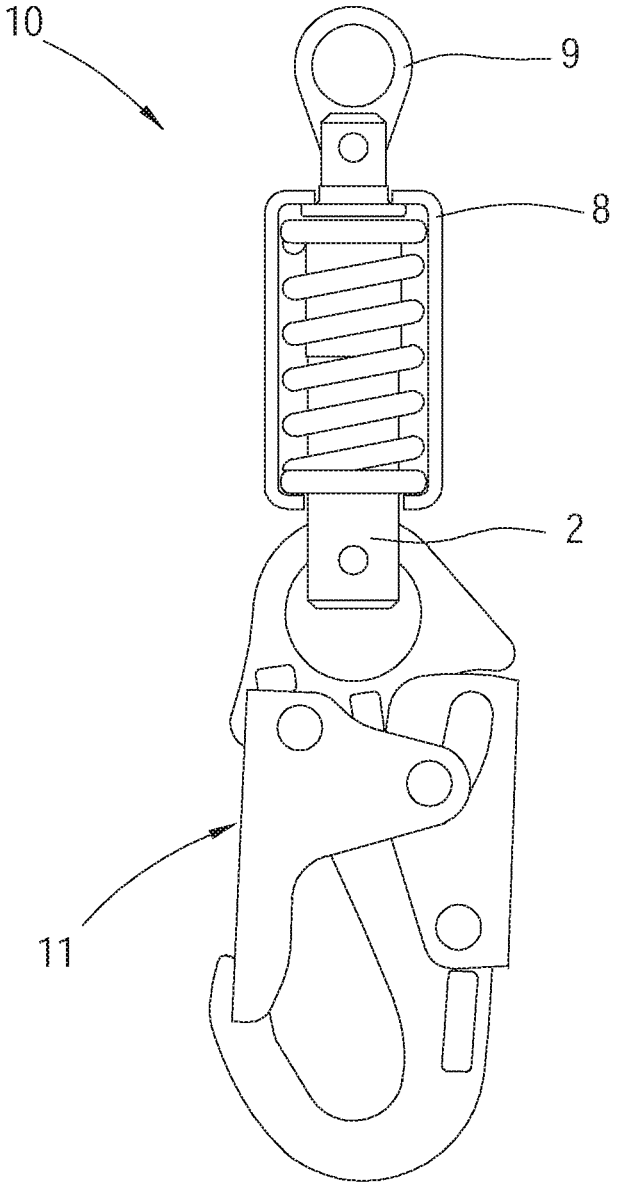


FIG.12

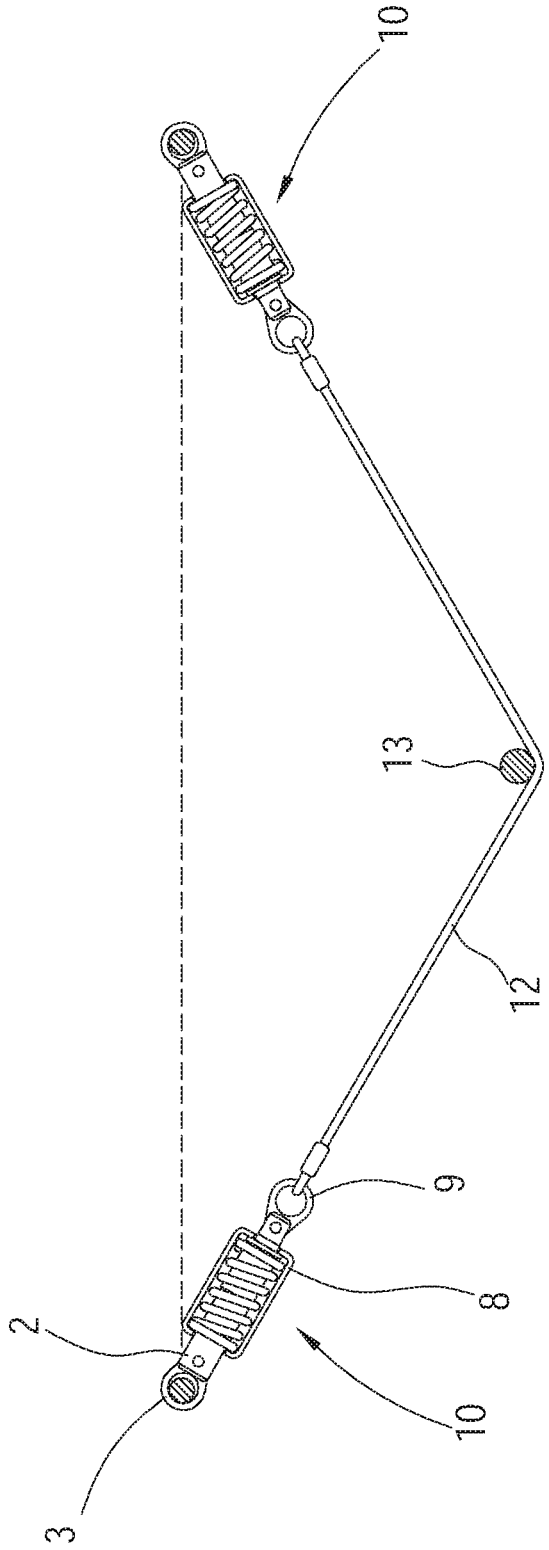


FIG.13

AXIAL BUFFER DEVICE AND FALL PROTECTION DEVICE HAVING THE SAME

BACKGROUND OF THE INVENTION

1. Technical Field

[0001] The present invention is related to a buffer device, and more particularly to an axial buffer device and a fall protection device.

2. Description of Related Art

[0002] Working in elevated environments like roofs, factories, construction sites, aerospace bases, or in the situations like elevator repairing or shipbuilding, workers are usually required to wear safety equipment like fall protection device when they are working. The fall protection device is adapted to be connected with a safety belt, and the safety belt is fastened to the worker. When the worker falls from an elevated site accidentally, the fall protection device can stop or buffer the safety belt to prevent the worker continue to fall or slow down the falling speed of the worker to secure the safety of the worker.

[0003] Conventional fall protection devices may include an elastic stretch design for the safety belt, with this design as the worker attached with the safety belt falls, this stretchable safety belt can buffer or slow down the falling speed of the worker. However, the length, the elastic modulus, the height of the work site, also the weight of the worker, all of them must be considered when designing the safety belt. In the case that the length of the safety belt is too long, once the worker falls without the rebounding of the safety belt and hits the ground, injuries may occur.

[0004] There is another fall protection device having a portion of the safety belt with an overlay-sewing design. With this design on the safety belt, when the worker attached with the safety belt falls, the overlay-sewing portion of the safety belt would be ripped by the downward force, absorb the downward impulsive force of the worker, thereby providing the cushion effect. However, this design may damage the structure of the safety belt, affect its strength, and lower the load-bearing capacity, which may result in a dangerous situation.

[0005] Besides, there is also a fall protection device with a rapid lock-up design. As the worker falls, the pulling force will make the fall protection device lock up the safety belt immediately so as to prevent the worker from continuing to drop. However, this design may cause an instant impact force (like G-Force) and a counter force which may cause organ injuries or bone fractures to the worker.

BRIEF SUMMARY OF THE INVENTION

[0006] In view of the above, an object of the present invention is to provide an axial buffer device and a fall protection device having the axial buffer device. By utilizing the design of the axial buffer device, it is favorable to buffer a falling speed or shorten a falling distance of an object which the axial buffer device is applied to. For example, when the axial buffer device is applied to the fall protection device, it is favorable to buffer a falling speed or shorten a falling distance of a worker or an object which is attached to the fall protection device. In addition, the axial buffer device could be applied to other objects, such as a pull ring, a hoist ring, a hook, a cord, etc. to provide a good buffer mechanism.

[0007] The present invention provides an axial buffer device, including a buffer rod having a first friction surface; and a buffer member having a second friction surface which contacts the first friction surface; when any one of the buffer rod and the buffer member is pulled by a force which is greater than a default value to overcome a maximum friction between the buffer member and the buffer rod, the buffer member would slide on the buffer rod with friction.

[0008] In one embodiment, the axial buffer device further includes a first spring, wherein the first spring is connected to the buffer rod to provide an elastic force to the buffer rod.

[0009] In one embodiment, the first spring is fit around the buffer rod; one of two ends of the first spring is connected to the buffer rod, and another one of the two ends of the first spring is connected to the buffer member.

[0010] In one embodiment, the axial buffer device further includes a second spring, wherein the second spring is fit around the buffer rod and interposed between the first spring and the buffer rod; one of two ends of the second spring is adapted to connect to the buffer rod, and another one of the two ends of the second spring is adapted to connect to the buffer member.

[0011] In one embodiment, an outer peripheral surface of the buffer rod forms the first friction surface; a through hole is disposed on the buffer member and includes an inner peripheral surface which forms the second friction surface; a fitting relation between the second friction surface and the first friction surface is an interference fit.

[0012] In one embodiment, the buffer member comprises a holder and a first buffer ring; the first buffer ring and the buffer rod are disposed within the holder; the first buffer ring is fit around the buffer rod and includes the second friction surface.

[0013] In one embodiment, the axial buffer device further includes a first spring, wherein the first spring is fit around the buffer rod; one of two ends of the first spring is connected to the buffer rod, and another one of the two ends is connected to the first buffer ring.

[0014] In one embodiment, the axial buffer device further includes a second spring, wherein the second spring is fit around the buffer rod and interposed between the first spring and the buffer rod; one of two ends of the second spring is connected to the buffer rod, and another one of the two ends of the second spring is connected to the first buffer ring.

[0015] In one embodiment, the buffer member further includes a second buffer ring; the second buffer ring is fit around the buffer rod and includes a third friction surface which faces the first friction surface of the buffer rod; the axial buffer device further comprises a first spring and a second spring; the first spring is fit around the buffer rod and disposed between the first buffer ring and the second buffer ring; two ends of the first spring respectively connect to the first buffer ring and the second buffer ring; the second spring is fit around the buffer rod; two ends of the second spring respectively connect to the second buffer ring and the buffer rod.

[0016] In one embodiment, the axial buffer device further includes another buffer rod, wherein the two buffer rods are disposed coaxially; the buffer member includes a holder, a first buffer ring, and a second buffer ring; the two buffer rods, the first buffer ring and the second buffer ring are disposed

within the holder; the first buffer is fit around the buffer rod and includes the second friction surface; the second buffer ring is fit around the other buffer rod and includes a third friction surface which contacts a fourth friction surface on the other buffer rod.

[0017] In one embodiment, the axial buffer device further includes at least one spring, wherein the at least one spring is fit around one of the two buffer rods.

[0018] The present invention also provides a fall protection device adapted to connect to a safety belt. The fall protection device includes a frame, a rotation member disposed in the frame and adapted to roll up the safety belt, and the aforementioned axial buffer device, wherein one of the buffer rod and the buffer member is adapted to connect to a hanging point, and the other one is adapted to connect to the frame.

[0019] In one embodiment, the fall protection device further includes a brake unit and a housing, wherein the brake unit is disposed on the rotation member to restrict a rotation of the rotation member; the housing includes a first half housing and a second half housing which are opposite and joined to each other; a first division plate is disposed in the first half housing and a second division plate is disposed in the second half housing which is opposite to the first division plate; the rotation member is disposed in one part of the housing which is at one side of the first division plate and the second division plate, and the brake unit is disposed in another part of the housing which is at another side of the first division plate and the second division plate.

[0020] In one embodiment, the rotation member includes a shaft lever and a rotary drum; the brake unit is mounted on the shaft lever; the rotary drum is fit around the shaft lever to be rotated with the shaft lever coaxially.

[0021] In one embodiment, a fitting relation between the rotary drum and the shaft lever is an interference fit.

[0022] The advantage of the present invention is that: by utilizing the friction surfaces of the buffer rod and the buffer member of the axial buffer device which face to each other, the sliding friction generated between the buffer rod and the buffer member could cushion a force (or an impulsive force) when the force applied to the buffer rod or the buffer member is greater than a default value, whereby to buffer and absorb a falling force of the worker, and slow down a falling speed of the worker, which could avoid an injury to the worker. In addition, the probability of rebounding which makes a secondary damage to the worker also could be decreased.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0023] The present invention will be best understood by referring to the following detailed description of some illustrative embodiments in conjunction with the accompanying drawings, in which

[0024] FIG. **1** is a perspective view of an axial buffer device of a first embodiment according to the present invention;

[0025] FIG. **2** is an exploded view of the axial buffer device of the first embodiment;

[0026] FIG. **3** is a perspective view of a fall protection device of an embodiment according to the present invention;

[0027] FIG. **4** is an exploded view of the fall protection device of FIG. **3**;

[0028] FIG. **5** and FIG. **6** are cross-sectional views of the fall protection device of FIG. **4** as viewed along line A-A of FIG. **4** which show relative positions of the buffer rod and the buffer member before and after the relative movement;

[0029] FIG. **7** is a schematic view showing a falling test of the fall protection device;

[0030] FIG. **8** is a cross-sectional view of a fall protection device of another embodiment according to the present invention;

[0031] FIG. **9** is a cross-sectional view of an axial buffer device of a second embodiment according to the present invention;

[0032] FIG. **10** is a schematic view of an axial buffer device of a third embodiment according to the present invention;

[0033] FIG. **11** is a schematic view of an axial buffer device of a fourth embodiment according to the present invention;

[0034] FIG. **12** is a schematic view showing the axial buffer device of an embodiment is applied to a hook according to the present invention; and

[0035] FIG. **13** is a schematic view showing the axial buffer device of an embodiment is connected to a cord according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0036] The following illustrative embodiments and drawings are provided to illustrate the disclosure of the present invention, these and other advantages and effects can be clearly understood by persons skilled in the art after reading the disclosure of this specification. As illustrated in FIG. **1** and FIG. **2**, an axial buffer device **10** of a first embodiment according to the present invention includes a buffer rod **2** and a buffer member.

[0037] The buffer rod **2** includes a first friction surface **2***a*. In the current embodiment, an outer peripheral surface of the buffer rod **2** forms the first friction surface **2***a*. In addition, the buffer rod **2** further includes a flange **2***b*, wherein the flange **2***b* is disposed at one end of the buffer rod **2** and protruded from the outer peripheral surface of the buffer rod **2**.

[0038] The buffer member includes a second friction surface facing to the first friction surface **2***a*. In the current embodiment, the buffer member includes a first buffer ring **4**. The buffer ring **4** includes a through hole, and an inner peripheral surface of the through hole forms the second friction surface **4***a*, wherein the first buffer ring **4** is adapted to be fit around the buffer rod **2** and contacts with the first friction surface **2***a*. Preferably, the fitting relation between the first buffer ring **4** and the buffer rod **2** is an interference fit (or a tight fit). In addition, in other applications, the fitting relation also could be a transition fit or a clearance fit, etc. Whereby, when a force applied to the buffer rod **2** or the first buffer ring **4**, such as a component of an external force which is parallel to the axial direction of the buffer rod **2**, is greater than a default value, the first buffer ring **4** would slide with friction on the buffer rod **2** by the force against to the maximum friction force between the first buffer ring **4** and the buffer rod **2** so as to buffer, absorb or offset the force.

[0039] Moreover, the axial buffer device **10** can further include a first spring **6**. The first spring **6** is adapted to be connected to the buffer rod **2** to provide an elastic force for increasing the buffering effect of the buffer rod **2**. In the current embodiment, the first spring **4** is fit around the buffer rod **2**, wherein one of the two ends of the first spring **4** is

adapted to be connected to the flange **2***b* of the buffer rod **2**, and another of the two ends of the first spring **4** is adapted to be connected to first buffer ring **4**. In more details, in the current embodiment, the first spring **4** is a compressed spring as an example, wherein two ends of the compressed spring abut against the flange **2***b* of the buffer rod **2** and the surface of the first buffer ring **4** respectively. Whereby, when the first buffer ring **4** slides with friction on the buffer rod **2** to be close to the flange **2***b*, the first spring **6** would be compressed to form an elastic force which could be used to buffer the force.

[0040] Referring to FIG. **3** and FIG. **4**, a fall protection device **100** of an embodiment according to the present invention is illustrated. The fall protection device **100** includes a frame **20**, a rotation member **30** and an axial buffer device. The frame **20** includes a top plate **22** and two lateral plates **22**. The top plate **22** is connected between the two lateral plates **14**, and the top plate **12** and the two lateral plates **14** constitute a containing space for containing the rotation member **30**. One of the lateral plates **24** includes a through hole **24***a*, and the other lateral plate **24** includes a through hole **24***b*, wherein the through hole **24***a* and the through hole **24***b* are disposed coaxially.

[0041] The rotation member **30** includes a shaft lever **32** and a rotary drum **34**. The shaft lever **32** penetrates through the through hole **24***a*, and the rotary drum **34** is mounted on the shaft lever **32** to be rotated with the shaft lever **32** coaxially. The rotary drum is adapted to roll up a safety belt **36**, wherein one end of the safety belt **36** is adapted to be connected to a worker or a hanging point of a safety equipment wearing by the worker. In one embodiment, a fitting relation between the rotary drum **34** and the shaft lever **32** includes an interference fit (or a tight fit), such as a transition fit or a clearance fit, whereby a rotational friction would be generated between the rotary drum **34** and the shaft lever **32** due to the tight fit design of the rotary drum **34** and the shaft lever **32** when the shaft lever **32** stops rotating, which enables a slowing down of the falling speed of the safety belt **36** while being stretched out and deceleration of the falling speed of the worker worn with the safety belt **32**. However, in other applications, the fitting relation of the shaft lever **32** and the rotary drum **34** is not limited to the above embodiment.

[0042] In the current embodiment, the axial buffer device includes a structure of the axial buffer device of the aforementioned embodiment. Therefore, the detailed description thereof is omitted here. The buffer member of the axial buffer device **10** further includes a holder **8**. The holder **8** is disposed on the frame **20**. In the current embodiment, a plurality of positioning holes are provided at a bottom of the holder **8**, wherein the plurality of positioning holes could be penetrated with a plurality of bolts to fasten the holder **8** on the frame **20**. However, in other applications, other fastening methods also could be utilized.

[0043] One of the buffer rod **2** and the buffer member is adapted to be connected to a hanging point, and the other is connected to the frame **20**. In the current embodiment, the buffer rod **2** is disposed on the frame **20**, and one end of the buffer rod **2** penetrates through a through hole **8***a* of the holder **8** to be connected to a hanging point. A hanging ring **40** is connected to one end of the buffer rod **2**, and is adapted to hang on or fix to a hanging point. Alternatively, the hanging ring **40** also could be utilized together with a cord to connect to the hanging point. Wherein, the hanging point includes, for example, a steel reinforcing bar, a pillar, a steel cord or a cable rope which enables the buffer rod **34** to indirectly or directly connect to the hanging point, but it is not limited thereto. In addition, the hanging point is not limited to a fixed point or an anchoring point. For example, the hanging point could be a hanging member which is connected to a cord which could slide along a longitudinal direction of the cord. In another embodiment, the buffer rod **2** could be connected to the frame directly or indirectly and the holder **8** could be connected to the hanging point directly or indirectly. It is not limited thereto.

[0044] Furthermore, in the current embodiment, the fall protection device **100** further includes a brake unit **50**, a rewinding unit **60** and a housing **70**.

[0045] The brake unit **50** is disposed on the rotation member **30**. As shown in FIG. **4** and FIG. **5**, the brake unit **50** of the current embodiment includes a braking plate **52**, two braking parts **54**, and two restoring springs **56**. The braking plate **52** includes a protrusion part **52***a*. The protrusion part **52***a* is fit into the through hole **24***b* of the lateral plate **14**. A recess **52***b* is formed on the protrusion part **52***a* and is adapted to be engaged with the shaft lever **32**, and the braking plate **52** could be rotated with the shaft **22** coaxially. The two braking parts **54** are pivotally connected to the braking plate **52** respectively. One end of each of the two restoring springs **56** is connected to one of the braking parts **54**, and another end is connected to the braking plate **52**, which provides an elastic force to each of the two braking parts **54** to keep each of the braking parts **54** in a retracted position.

[0046] The rewinding unit **60** includes a first cover **62**, a second cover **64** and a spiral spring **66**. Wherein, the first cover **62** is combined with the second cover **64** to form a containing space for receiving the spiral spring **66** which coils up normally One end of the spiral spring **66** is connected to the shaft lever **32**, and another is connected to the second cover **64**.

[0047] The housing **70** is adapted to receive the axial buffer device **10**, the frame **20**, the rotation member **30**, the brake unit and the rewinding unit **60**. The housing **70** includes a first half housing **72** and a second half housing **74** which are joined to each other, wherein a first division plate **73** is provided in the first half housing **72**, and a second division plate **75** is provided in the second half housing **74**; the first division plate **73** and the second division plate **75** are opposite to each other. The first half housing **72** and the second half housing **74** could be combined together by positioning members such as bolts S, whereby the first division plate **73** and the second division plate **75** could be joined to each other to divide the containing space of the housing **70** into two parts. One part of the containing space which is located at one side of the first division plate **73** and the second division plate **75** is adapted to receive the frame **20** and the rotation member **30**, and another part of the containing space which is located at the other side of the first division plate **73** and the second division plate **75** is adapted to receive the brake unit **50**. With the design of the first division plate **73** and the second division plate **75**, the rotation member **30** could be isolated from the brake unit **50** and thereby to prevent small objects such as dust particles carried by the safety belt **36** which is wound around the rotation member **30** being entered or adhered to the brake unit **50** and decrease the interference to the operation of the brake unit **50**. Besides, the spiral spring **66** is received in the

first cover **62** and the second cover **64**, which is capable of avoiding the intrusion of the small objects such as dust particles as well. Moreover, the axial buffer device **10** is isolated with the top plate **22**, which is also favorable to avoid the intrusion or adhesion of small objects such as dust particles carried by the rotation member **30** and the safety belt **36**. In addition, in one embodiment, the axial buffer device **10** is not limited to be enclosed by the housing **70**, and could be exposed on an exterior of the housing **70**.

[0048] With the above-mentioned design, in a normal situation, for example, as a worker walks normally on a working platform or a pallet, the rotation unit **30**, the brake unit **50**, and the rewinding unit **60** rotates coaxially (or synchronous rotary). When the safety belt **36** bears a pulling force smaller than a default value, for example, the worker attached with the safety belt **36** is away from the fall protection device **100** and the safety belt **36** is being pulled, the spiral spring **66** of the rewinding unit **60** stretches and stores a restoring force (or elastic force) for coiling because of the pulling from the safety belt **36**. On the contrary, when the worker approaches the fall protection device **100**, the force to pull the safety belt **36** would decrease to a value lower than the elastic force of spiral spring **66** such that the elastic recovery appears and the spiral spring **66** coils back so as to drive the safety belt **36** to wind around the rotary drum **34** again.

[0049] In another situation that the safety belt **26** is being pulled rapidly at a moment, such as a worker attached with the safety belt **26** falls from an elevated site accidentally, the safety belt **26** would be pulled out rapidly by a pulling force which is greater than the default value, whereby the braking parts **54** of the brake unit **50** would be spun out by overcoming the elastic force of the restoring spring **56**. Then, the braking parts **54** would engage with a stopper **25** disposed on the frame **20**, which fixes the braking plate **52**, as well as the shaft lever **32** which is connected to the braking plate **52**. Referring to FIG. **4** and FIG. **5**, because of the engagement of the brake unit **50** and the secure fixation of the shaft **22**, the pulling force applied to safety belt **26** would also pull the frame **20** together with the holder **32**, which is connected to the frame **20**, to move downwardly. Meanwhile, the holder **8** would bring the first buffer ring **4** to move downward, which overcomes the maximum friction between the second friction surface **4***a* of the first buffer ring **4** and the first friction surface **2***a* of the buffer rod **2** disposed at the hanging point, and makes the first buffer ring **4** to slide on the buffer rod **2** with friction to generate a relative movement as shown in FIG. **6**. Wherein, the sliding friction generated between the first friction surface **2***a* of the buffer rod **2** and the second friction surface **4***a* of the first buffer ring **4** could cushion the falling force (or impulsive force) of the safety belt **26** and the worker attached with the safety belt **26** so as to buffer and absorb the falling force of the worker, and slow down the falling speed of the worker, thereby avoiding injury to the worker. In addition, the occurrence of the rebounding of safety belt **26** and the secondary damage to the worker also could be reduced.

[0050] As shown in FIG. **5** and FIG. **6**, it is worth mentioning that in this embodiment, the elastic force provided by abutting the first spring **6** against the buffer rod **2** and the first buffer ring **4** could be combined with the sliding friction between the buffer rod **2** and the first buffer ring **4** to improve the performance of buffering and offsetting the falling force of the safety belt **36** and the worker. For example, when the safety belt **36** is being pulled down to rotate the rotation member **30** and the frame **20**, the first buffer ring **4** would be driven to slide on the buffer rod **2** to generate a relative movement which compresses the first spring **6** disposed therebetween, whereby the elastic force generated by compressing the first spring **6** in the opposite direction could be utilized to cushion the falling force of the safety belt **36**. Besides, in a situation when the falling force is removed, the restoring elastic force of the first spring **6** also could be utilized to restore the buffer rod **2** and the first buffer ring **4** to the initial state as shown in FIG. **5**. It is worth mentioning that it is not limited to be provided with the first spring **6**. In one embodiment, the first spring **6** could be omitted, and only the sliding friction generated between the buffer rod **2** and the first buffer ring **4** is utilized to cushion the falling force of the safety belt **36**.

[0051] Furthermore, the first spring **6** is not limited to the compressed spring. In one embodiment, the first spring **6** could be a tension spring to be connected between the frame **20** and the buffer rod **2**, which provides an elastic force for restoring the buffer rod **2** to its initial position. In addition, in other applications, other types of springs also could be utilized. In one embodiment, two ends of the tension spring could be connected to the holder **8** and the first buffer ring **4** respectively to provide a restoring elastic force to cushion the falling force.

[0052] As illustrated in FIG. **7**, a free drop stage of a test weight refers to a period between releasing from a static state and an initiation of a brake unit (e.g. the brake unit **50**), while a brake buffer stage of the test weight refers to a period between the initiation of the brake unit and being held as static again. Wherein, a physical model equation of a fall protection device which utilizes conventional linings or woven type energy absorbers to provide the brake buffer effect is as follows: m*g* (L_0+X) =f_s*X, wherein m is mass of the test weight; g is gravitation acceleration; L**0** is a distance of free drop; fs is a brake buffer force; X is a brake bufferdistance. In contrast, a physical model equation of the fall protection device having the axial buffer device according to the present invention is as follows: m*g* (L**0**+X) =1/2*k*X^2+f_s*X, wherein k is elastic coefficient; f_s=μ_s*P*A; ·s is a friction coefficient of a contact surface; P is a surface pressure of an interference fit; A is a contacting area of a buffer ring (e.g. the first buffer ring) and a buffer rod. It would be understood from the two physical model equation mentioned above, the fall protection device having the axial buffer device of the present invention could have a shorter brake bufferdistance X due to being disposed with the spring (e.g. the first spring).

[0053] As illustrated in FIG. **8**, a fall protection device **200** of another embodiment according to the present invention is different from the fall protection device **100** of the aforementioned embodiment in that: an axial buffer device of the fall protection device **200** further includes a buffer member **80** and a buffer rod **90**. Wherein, the buffer member **80** is disposed on the frame **20**, wherein a through hole is formed on the buffer member **80**, and an inner surface of the through hole forms a second friction surface **80***a*. The buffer rod **90** is disposed between the frame **20** and the buffer member **80**. One end of the buffer rod **90** penetrates through the through hole, and an outer peripheral surface of the buffer rod **90** forms a first friction surface **90***a*, which faces the second friction surface **80***a*. Whereby, the sliding of the buffer member **80** on the buffer rod **90** with friction also could be

utilized to cushion the falling force of the safety belt and the worker so as to slow down the falling speed. In addition, a spring **92** also could be disposed in the axial buffer device to be connected to the buffer rod **90** so as to provide a suitable elastic force for the buffer rod. For example, in the current embodiment, the spring **92** is a compressed spring to be fit around the buffer rod **90**, wherein one end of the spring **92** abuts against the buffer rod **90** and another end abuts against the buffer member **80**, which provides a good buffering performance additionally. Furthermore, in one embodiment, the spring **92** could be other types of springs, such as a tension spring to be connected between the buffer rod **90** and the frame **20**, and is not limited to the above example.

[0054] It is worth mentioning that a default value whether the pulling force applied to the safety belt is greater enough is used as a reference to determine whether a buffering effect of the axial buffer device is initiated or not. In practice, the default value could be different values according to a degree of the interference fit and a contacting area between the buffer rod and the buffer member, an elastic coefficient of the spring, or the arrangement of the fall protection device for different applications. For example, the default value is mainly determined by the friction between the buffer rod and the buffer member. However, when the axial buffer device further includes a spring, the default value would be further adjusted by an elastic force provided by the spring. In addition, in one embodiment, the brake unit or the rewinding unit could be omitted. For example, when the safety belt wound on the rotation member is being pulled out until the rotation member stops rotating, such as a full length or nearly a full length of the safety belt is pulled out, the force applies to the rotation member through the safety belt would be greater than a default value, and the buffer member of the axial buffer device would be pulled to slide on the buffer rod with friction, which could cushion the falling force.

[0055] As illustrated in FIG. **9**, an axial buffer device **300** of a second embodiment according to the present invention has almost the same structure with the axial buffer device **10** mentioned above, which includes a buffer rod **310**, a buffer member including a holder **320** and a first buffer ring **330**, and a first spring **340**. Particularly, the axial buffer device **300** further includes a second spring **350**. Wherein, the buffer rod **310** is disposed in the holder **320**; the first buffer ring **330** is fit around the buffer rod **310** and disposed in the holder **320**; the first spring **340** is fit around the buffer rod **310**, wherein one of the two ends of the first spring **340** is adapted to be connected to the buffer rod **310**, such as being connected to a flange **312** of the buffer rod **310**, and the other of the two ends of the first spring **340** is adapted to be connected to the first buffer ring **330**; the second spring **350** is fit around the buffer rod **310**, and is interposed between the first spring **340** and the buffer rod **310**, wherein one of the two ends of the second spring **350** is adapted to be connected to the buffer rod **310**, such as being connected to a flange **312** of the buffer rod **310**, and the other of the two ends of the second spring **350** is adapted to be connected to the first buffer ring **330**. In practical application, the axial buffer device **300** could be connected to a hanging point via the buffer rod **310** or the holder **320**, while the other one could be adapted to be connected to an object, wherein the object includes, but is not limited to, a hook, a hoist ring, a lifting hook, a cord, etc. For example, in the current embodiment, one end of the buffer rod **310** is connected to a hoist ring **360**, and one end of the holder **320** is connected to another hoist ring **370**, whereby the buffer **310** and the holder **320** could utilize the hoist rings **360**, **370** to indirectly connect to the hanging point or the object respectively. In addition, by utilizing the parallel type spring buffer member having the first spring **340** and the second spring **350**, the axial buffer device **300** could provide a good buffer performance For example, when the pull ring **360** on the buffer rod **310** is pulled by a force which is greater than a default value, the flange **312** of the buffer rod **310** would be moved toward the first buffer ring **330** to compress the first spring **340** and the second spring **350**, and the first buffer ring whose one end abuts against the holder **320** and another end abuts against the first spring **340** and the second spring **350** with elasticity would slide on the buffer rod **310** with friction, whereby the sliding friction and the elastic force of the springs would cushion the pulling force. In addition, when the pull ring **370** on the holder **320** is pulled upward by a force which is greater than a default value as shown in FIG. **9**, the holder **320** would abut against the first buffer ring **330** and push the first buffer ring **330** toward the flange **312** of the buffer rod **310**, which makes the first buffer ring **330** to slide on the buffer rod **310** with friction and to compress the first spring **340** and the second spring **350**, whereby the sliding friction and the elastic force of the springs could be utilized to cushion the pulling force. Furthermore, in other applications, it is not limited to be disposed with two springs. In one embodiment, the axial buffer device could include a combination of three or more springs.

[0056] As illustrated in FIG. **10**, an axial buffer device **400** of a third embodiment according to the present invention includes a buffer rod **410**, a buffer member including a holder **420**, a first buffer ring **430** and a second buffer ring **440**, a first spring **450**, and a second spring **460**. The buffer rod **410** which includes a first friction surface is disposed in the holder **420**. The first buffer ring **420** is fit around the buffer rod **410**, wherein the first buffer ring **430** includes a second friction surface which faces and contacts the first friction surface, and preferably, a fitting relation between the first buffer ring **430** and the buffer rod **410** is an interference fit. The second buffer ring **440** is fit around the buffer rod **410**, wherein the second buffer ring **440** includes a third friction surface which faces and contacts the first friction surface, and preferably, a fitting relation between the second buffer ring **440** and the buffer rod **410** is an interference fit. The first spring **450** is fit around the buffer rod **410** and is located between the first buffer ring **430** and the second buffer ring **440**, wherein two ends of the first spring **450** are adapted to connect to the first buffer ring **430** and the second buffer ring **440** respectively. The second spring **460** is fit around the buffer rod **410**, wherein two ends of the second spring **460** are connected to the buffer rod **420** and the second buffer ring **440** respectively, such as one end of the second spring **460** abuts against a flange **412** of the buffer rod **410** and another end of the second spring **460** abuts against the second buffer ring **440**. In practical application, the axial buffer device **400** could be connected to a hanging point via the buffer rod **410** or the holder **420**, while another one is adapted to connect to an object. In addition, in the current embodiment, a hoist ring **470** is connected to one end of the buffer rod **410**, and another hoist ring **480** is connected to the holder **420**, whereby the buffer rod **410** and the holder **420** could be indirectly connected to the hanging point or the object via the hoist rings **470**, **480** respectively. By utilizing

the double buffer rings and the serial type spring buffer member having the two springs, the axial buffer device **400** could provide a good buffer performance For example, when the hoist ring **480** on the holder **420** is connected to a hanging point and the hoist ring **470** on the buffer rod **410** is pulled by a force which is greater than a default value, the flange **412** of the buffer rod **410** would compress the second spring **460**, and the second buffer ring **440** which is respectively pushed by elastic forces of the second spring **460** and the first spring **450** would slide on the buffer rod **410** with friction; meanwhile, the second buffer ring **440** would compress the first spring **450**, which applies a force onto the first buffer ring **430** to make the first buffer ring **430** to slide on the buffer rod **410** with friction, whereby the sliding friction between each of the buffer rings and the buffer rod, and the elastic force of each of the springs could be utilized to cushion the pulling force. In addition, in other applications, it is not limited to be disposed with two springs and two buffer rings. In one embodiment, the axial buffer device could be disposed with three or more springs and buffer rings. However, it is not limited thereto.

[0057] As illustrated in FIG. **11**, an axial buffer device **500** of a fourth embodiment according to the present invention includes two buffer rods, a buffer member, and at least one spring. The two buffer rods are a first buffer rod **510** and a second buffer rod **520**, wherein the first buffer rod includes a first friction surface, and the second buffer rod **520** includes a fourth friction surface. The buffer member includes a holder **530**, a first buffer ring **540** and a second buffer ring **550**, wherein the two buffer rods **530**, **540**, the first buffer ring **540** and the second buffer ring **550** are disposed within the holder **530**. The first buffer ring **540** is fit around the first buffer rod **510**, wherein the first buffer ring **540** includes a second friction surface which faces and contacts the first friction surface, and preferably, a fitting relation between the first buffer ring **540** and the first buffer rod is an interference fit. The second buffer ring **550** is fit around the second buffer rod **520**, wherein the second buffer ring **550** includes a third friction surface which faces and contacts the fourth friction surface, and preferably, a fitting relation between the second buffer ring **550** and the second buffer rod **520** is an interference fit. In addition, the axial buffer device **500** could further include at least one spring **560** which is fit around one of the two buffer rods. For example, in the current embodiment, the spring **560** is fit around the second buffer rod **520**, wherein two ends of the spring **560** are adapted to connect to the second buffer ring **550** and the second buffer rod **520** respectively, such as one end of the spring **560** abuts against the second buffer ring **550**, and another end abuts against a flange **522** of the second buffer rod **520**. In practical application, the first buffer rod **510** or the second buffer rod **520** is adapted to connect to a hanging point, and another one is adapted to connect to an object. Furthermore, in the current embodiment, a hoist ring **570** and another hoist ring **580** are connected to the first buffer rod **510** and the second buffer rod **520** respectively, whereby the first buffer rod **510** and the second buffer rod **520** could be indirectly connected to the hanging point or the object respectively. By utilizing the separate type spring buffer member having double buffer rods, it is favorable to provide a good buffer performance. Whereby, when the hoist ring **580** on the second buffer rod **520** is connected to a hanging point and the hoist ring **570** on the first buffer rod **510** is pulled by a force which is greater than a default value, the first buffer rod **510** would drive the first buffer **540** to apply a pressure to the holder **530**, and then the holder **530** would apply a pressure onto the second buffer ring **550**; meanwhile, when the second buffer slides on the second buffer rod **520** with friction, the spring **560** would be also compressed. Therefore, the sliding friction between each of the buffer rings and the second buffer rod **520**, and the elastic force of the spring could be utilized to cushion the pulling force. In addition, in other applications, the spring **560** could be disposed on the first buffer rod **510** or each of the first buffer rod **510** and the second buffer rod **520** could be mounted with a spring respectively.

[0058] Referring to FIG. **12**, it is a schematic view of an application of the axial buffer device of one embodiment according to the present invention with a hook. Wherein, the axial buffer device could be any one of the axial buffer devices of the first to the fourth embodiments as described above. In the current embodiment, the axial buffer device **10** of the first embodiment is utilized as an example. Particularly, a hoist ring **9** is connected to a top of the holder **8**, which is adapted to connect to a hanging point, and the buffer rod **2** is adapted to connect to a hook **11**. Whereby, the hook **11** could be adapted to hang an object, an apparatus or a worker; especially when the hook **11** is pulled by a force which is greater than a default value, the axial buffer device **10** could provide a brake buffer effect correspondingly.

[0059] Referring to FIG. **13**, it is a schematic view showing a cord is connected between two axial buffer devices of an embodiment according to the present invention. Wherein, the axial buffer device could be any one of the axial buffer devices of the first to the fourth embodiments. In the current embodiment, for example, the axial buffer device **10** of the first embodiment is utilized as the two buffer devices. Particularly, two hoist rings **3** are respectively connected to each of the buffer rods **2** of the two axial buffer devices **10**, wherein each of the other ends of the two hoist rings **3** is connected to a hanging point. Two hoist rings **9** are respectively connected to each of the holders **8** of the two axial buffer device **10**, wherein each of the other ends of the two hoist rings **9** is respectively connected to one of the two ends of the cord **12**. An object **13** could be hung on the cord **12**, wherein a weight of the object **13** would apply a pressure on the cord **12**, which makes the cord **12** to pull the axial buffer device **10**; when the force applied to any one of the two axial buffer devices is greater than a default value, the axial buffer device **10** would provide a corresponding brake buffer effect.

[0060] It shall be understood that two ends of each of the springs, the first spring or the second spring of each of the above embodiments are not necessary to abut against the flange of the buffer rod or the buffer member at an initial state but are spaced apart with a predetermined distance when the axial buffer device is not initiated or does not cushion. Until the buffer member slides on the buffer rod with friction, the two ends of the spring would be connected or abut against the buffer rod and the buffer member to provide an elastic force to the cushioning process.

[0061] It is worth mentioning that the aforementioned axial buffer device is not limited to the axial buffer device of the first embodiment, and could be any one of the axial buffer devices of the second to the fourth embodiments.

[0062] It must be pointed out that the embodiments described above are only some embodiments of the present invention. The fall protection device is not only adapted to attach to a worker to provide a protection when the worker

accidentally falls, but also could be adapted to hang on an object such as working material or a machine tool, which could also avoid a rapid falling of the working material or the machine tool. All equivalent structures which employ the concepts disclosed in this specification and the appended claims should fall within the scope of the present invention.

What is claimed is:

1. An axial buffer device, comprising:

a buffer rod, including a first friction surface; and

a buffer member, including a second friction surface which contacts the first friction surface; when any one of the buffer rod and the buffer member is pulled by a force which is greater than a default value to overcome a maximum friction between the buffer member and the buffer rod, the buffer member would slide on the buffer rod with friction.

2. The axial buffer device of claim **1**, further comprising a first spring, wherein the first spring is connected to the buffer rod to provide an elastic force to the buffer rod.

3. The axial buffer device of claim **2**, wherein the first spring is fit around the buffer rod; one of two ends of the first spring is adapted to connect to the buffer rod, and another one of the two ends of the first spring is adapted to connect to the buffer member.

4. The axial buffer device of claim **3**, further comprising a second spring, wherein the second spring is fit around the buffer rod and interposed between the first spring and the buffer rod; one of two ends of the second spring is adapted to connect to the buffer rod, and another one of the two ends of the second spring is adapted to connect to the buffer member.

5. The axial buffer device of claim **1**, wherein an outer peripheral surface of the buffer rod forms the first friction surface; a through hole is disposed on the buffer member and includes an inner peripheral surface which forms the second friction surface; a fitting relation between the second friction surface and the first friction surface is an interference fit.

6. The axial buffer device of claim **1**, wherein the buffer member comprises a holder and a first buffer ring; the first buffer ring and the buffer rod are disposed within the holder; the first buffer ring is fit around the buffer rod and includes the second friction surface.

7. The axial buffer device of claim **6**, further comprising a first spring, wherein the first spring is fit around the buffer rod; one of two ends of the first spring is adapted to connect to the buffer rod, and another one of the two ends is adapted to connect to the first buffer ring.

8. The axial buffer device of claim **7**, further comprising a second spring, wherein the second spring is fit around the buffer rod and interposed between the first spring and the buffer rod; one of two ends of the second spring is adapted to connect to the buffer rod, and another one of the two ends of the second spring is adapted to connect to the first buffer ring.

9. The axial buffer device of claim **6**, wherein the buffer member further comprises a second buffer ring; the second buffer ring is fit around the buffer rod and includes a third friction surface which faces the first friction surface of the buffer rod; the axial buffer device further comprises a first spring and a second spring; the first spring is fit around the buffer rod and disposed between the first buffer ring and the second buffer ring; two ends of the first spring respectively connect to the first buffer ring and the second buffer ring; the second spring is fit around the buffer rod; two ends of the second spring respectively connect to the second buffer ring and the buffer rod.

10. The axial buffer device of claim **1**, further comprising another buffer rod, wherein the two buffer rods are disposed coaxially; the buffer member includes a holder, a first buffer ring and a second buffer ring; the two buffer rods, the first buffer ring and the second buffer ring are disposed within the holder; the first buffer is fit around the buffer rod and includes the second friction surface; the second buffer ring is fit around the other buffer rod and includes a third friction surface which contacts a fourth friction surface on the other buffer rod.

11. The axial buffer device of claim **10**, further comprising at least one spring, wherein the at least one spring is fit around one of the two buffer rods.

12. A fall protection device including an axial buffer device as in claim **1** and adapted to connect to a safety belt, further comprising:

a frame; and

a rotation member disposed in the frame and adapted to roll up the safety belt; wherein one of the buffer rod and the buffer member is adapted to connect to a hanging point, and the another one is adapted to connect to the frame.

13. The fall protection device of claim **12**, further comprising a brake unit and a housing, wherein

the brake unit is disposed on the rotation member to restrict a rotation of the rotation member;

the housing includes a first half housing and a second half housing which are opposite and joined to each other; a first division plate is disposed in the first half housing and a second division plate is disposed in the second half housing which is opposite to the first division plate;

the rotation member is disposed in one part of the housing which is at one side of the first division plate and the second division plate, and the brake unit is disposed in another part of the housing which is at another side of the first division plate and the second division plate.

14. The fall protection device of claim **13**, wherein the rotation member includes a shaft lever and a rotary drum; the brake unit is mounted on the shaft lever; the rotary drum is fit around the shaft lever to be rotated with the shaft lever coaxially.

15. The fall protection device of claim **14**, wherein a fitting relation between the rotary drum and the shaft lever is an interference fit.

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