April 11, 1961 W. D. VAN ZELM ET AL 2,979,163

LOW INERTIA ENERGY ABSORPTION UNIT

Filed May 26, 1958 3 Sheets-Sheet 1

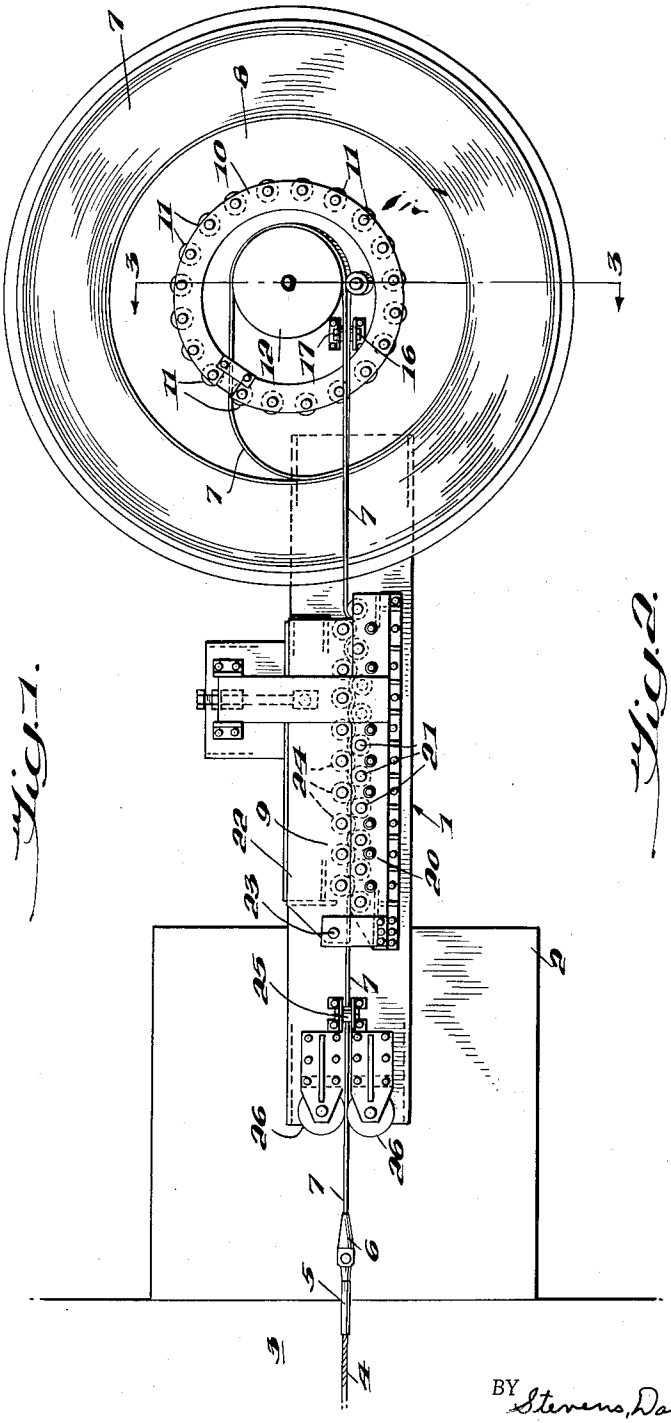


Fig. 1.

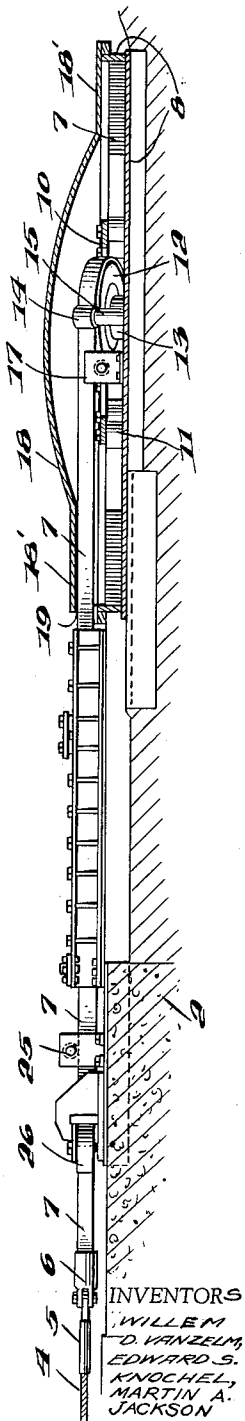


Fig. 2.

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Filed May 26, 1958 3 Sheets-Sheet 2

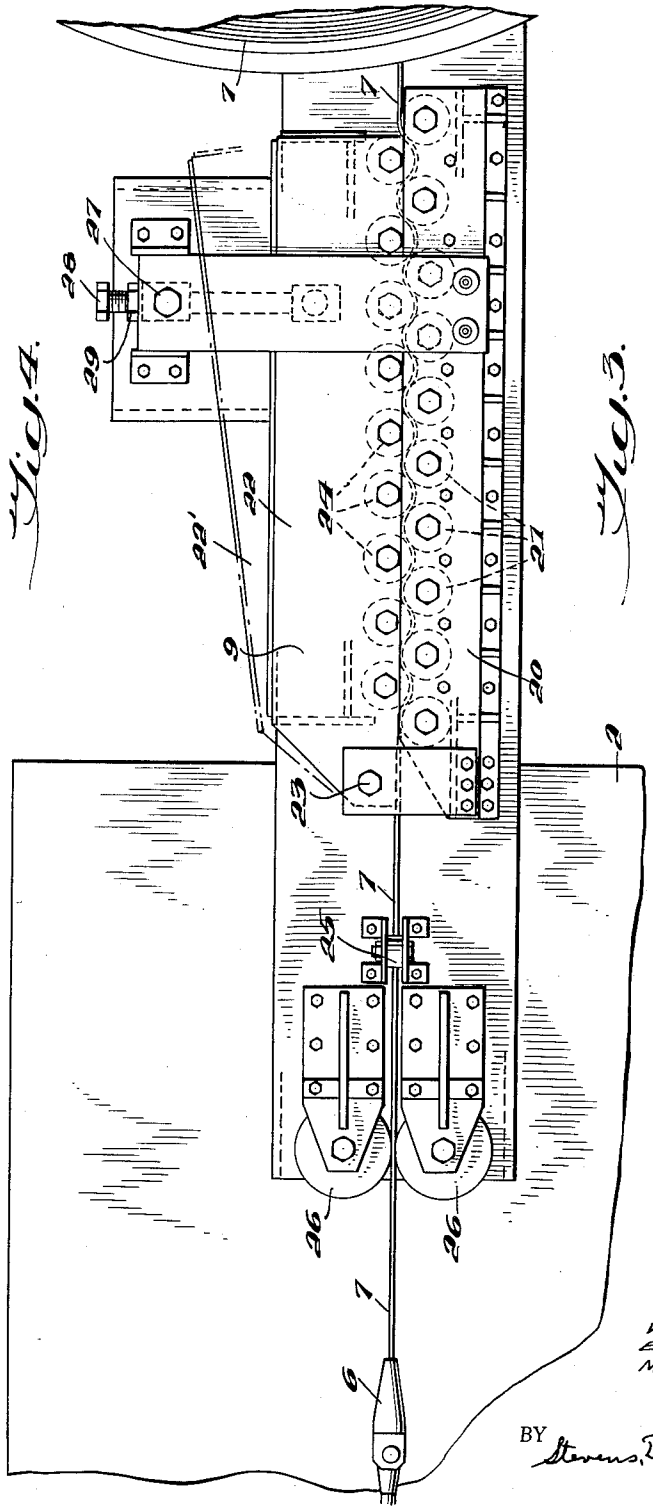


Fig. 4.

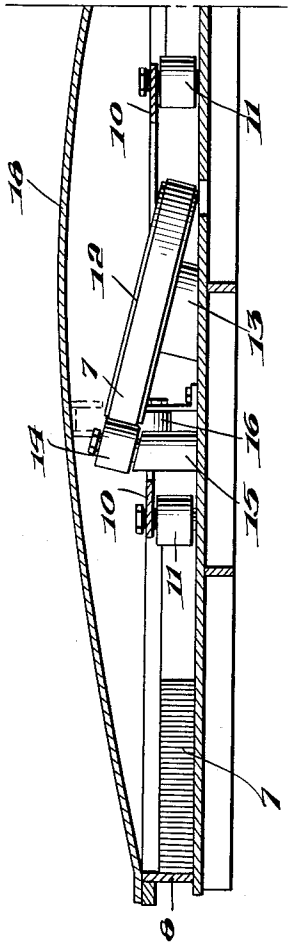


Fig. 3.

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3 Sheets-Sheet 3

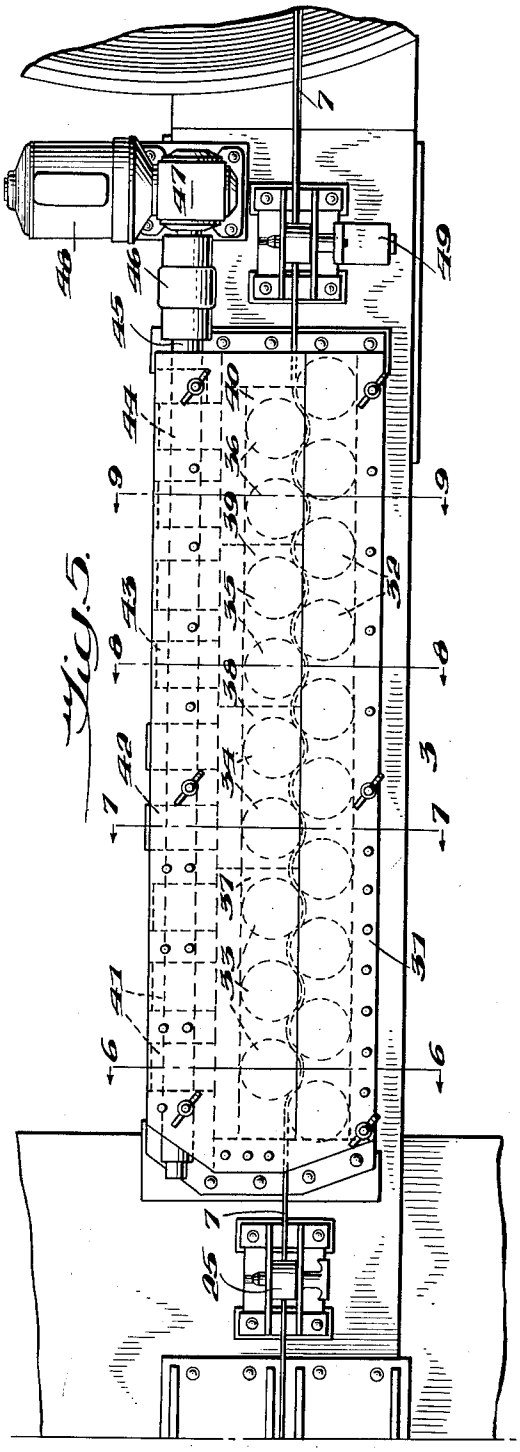


Fig. 5.

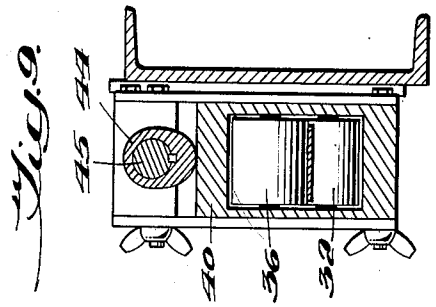


Fig. 9.

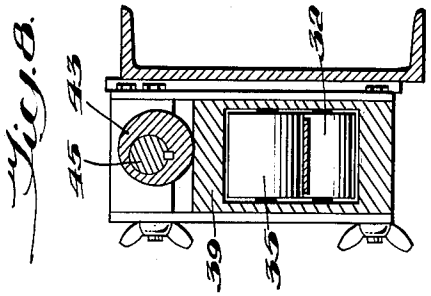


Fig. 8.

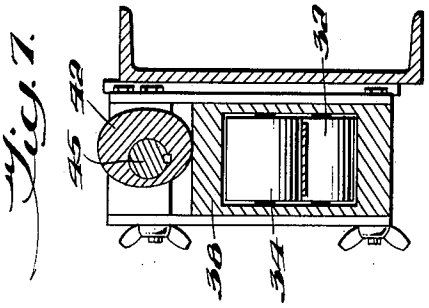


Fig. 7.

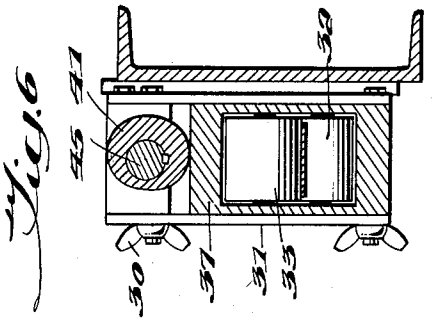


Fig. 6.

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2,979,163

LOW INERTIA ENERGY ABSORPTION UNIT

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Filed May 26, 1958, Ser. No. 737,786
15 Claims. (Cl. 188—1)

This invention relates to a low inertia device for the absorption of kinetic energy at a high rate by the plastic deformation of a strip or bar of metal beyond its yield point.

In a previous embodiment of this invention, a strip of metal was coiled in a reel and in the embodiment illustrated, the strip was fed between two rows of staggered rollers or the like so that as the strip passed between the rollers, as kinetic energy was applied to move the strip therethrough, the kinetic energy was absorbed through the phenomena of deforming the strip of metal progressively and successively in increments. That is, the kinetic energy applied to the strip to move it through the rollers was dissipated in the strip as it passed through the rollers and was bent progressively and successively beyond its yield point or elastic limit in opposite directions. Some of the energy at the initial application to the strip was absorbed in getting the operation under way, that is, overcoming the preload on the strip and the inertia of a large reel of strip metal that might contain several hundred pounds of coiled strip steel. After the reel was accelerated to the speed at which the kinetic energy was to be absorbed, the dissipation of energy would be fairly constant, however, the initial peak of energy required to overcome the inertia of the reel could be very large, for a large unit, and conceivably, might snap the absorbing strip at the outset, thus causing a complete failure of the whole system.

It is a principal object therefore of the present invention to provide an energy absorbing unit having low inertia characteristics, that is, one in which the absorption curve is fairly constant from the start.

It is another object of this invention to provide an absorption unit of the type described in which great lengths of metal strips can be stored in a stationary coil but in which only a small portion or increment of the strip must be accelerated upon the application of kinetic energy to be absorbed.

A further object of this invention is to store the strips for the energy absorbing unit in a non-rotating coil.

It is another object of this invention to provide an energy absorbing unit that is capable of absorbing large quantities of energy at a very high rate without danger of snapping the strip upon the application of the energy due to the low inertia of the reel.

Further and other objects will become apparent from the description of the accompanying drawings in which like numerals refer to like parts in the drawings—

Figure 1 is a top plan view of the arrangement of the energy absorbing unit including the low inertia reel;

Figure 2 is a side elevation thereof partly in section showing a feed arrangement of the reel;

Figure 3 is a fragmentary section through the reel taken on the line 3—3 of Figure 1, slightly enlarged;

Figure 4 is an enlarged plan view of the deforming mechanism showing how the strip may easily be inserted;

Figure 5 shows a modification of the deforming mechanism wherein the loading or energy absorbing capabilities of the mechanism may be varied.

Figures 6, 7, 8 and 9 show sections taken on the lines 6—6, 7—7, 8—8, 9—9 respectively on Figure 5 illustrating the cam arrangement of the variable load applicator.

The energy absorber illustrated in Figures 1 to 4 of the drawings shows the energy absorber generally indicated as 1 including the low-inertia reel, mounted on a concrete pad 2 which is firmly imbedded in the ground along side of a runway 3, for example, at an airport, which is one of the many applications of this device.

The energy to be absorbed at a high rate of a mass moving at a high velocity is imparted to the cable 4. Cable 4 has a terminal 5 secured to one end which is coupled to a fitting 6 on the end of a metal strip or filament 7. Metal strip 7 as shown in Figures 1 to 3, is coiled on edge in a container 8, arranged from the outer periphery of container 8 inwardly so that depending upon the diameter of the container several hundred feet of the strip can be stored and still leave an open space at the center for the mechanism which guides the strip from the inside of the coil outside of the container to the metal bender 9.

In the space within the coil container is located a guide and coil support mechanism comprising a stationary ring 10 having mounted around its periphery a plurality of relatively closely spaced roller bearings 11 the axial length of which is approximately equal to the depth dimension of metal strip 7. Bearings 11 are mounted between ring 10 and the base of container 8 on pivots so that they will rotate freely. Within ring 10 there is a large pivoted guide wheel 12 about the thickness of the depth dimension of strip 7 which is mounted on a pedestal 13, the axis of which is tilted so that the lower side of guide wheel 12 approximately contacts the base or bottom of the container while the upper side of guide wheel 12 is elevated in an amount slightly in excess of the depth dimension of strip 7. A smaller idler roller 14 is also mounted on a pedestal 15 so that its axis is inclined to be parallel to that of guide wheel 12. The outer peripheries of guide wheel 12 and small roller 14 are spaced just sufficiently to permit the passage of the strip 7. Another guide roller 16 mounted on a bracket 17 within ring 10, supports and guides the bottom edge of strip 7 at an elevation to clear the coil of the strip. Should it be found to be desirable it would be perfectly feasible to have a second roller to guide the top edge of strip 7 but it is not found to be necessary. Strip 7 is taken off from the inside of the coil and is passed between the pair of rollers 11 mounted on ring 10 tangent to that part of guide wheel 12 which is closest to the bottom of the container. Strip 7 then passes around the periphery of guide wheel 12 and between guide wheel 12 and small roller 14 and over guide roller 16 mounted on bracket 17 and out through cover 18 of the magazine which cover is formed to afford the passage 19. The cover which is shown at 18' may extend inwardly around a substantial part of its periphery or part way or at preselected locations over the coiled strip to maintain the coiled strip in place until it is withdrawn from the container. As the metal strip is pulled from container 8 (noting Figure 1) the innermost coil, that is, the one adjacent roller supports 11, will be drawn into contact therewith and freely rotate clockwise thereon as successive increments of the strip are withdrawn from the container. A few coils of the strip adjacent to the innermost coil will be drawn in varying degrees toward roller supports 11 as these coils are pulled by the initially moved coil increment and thus likewise be caused to rotate clockwise. This condition may be obtained without any appreciable binding effect inasmuch as these adjacent coils will likewise rotate at substantially the same rate of velocity or acceleration as that of the innermost coil. Thus, the only portion or increment of strip 7 to which

kinetic energy is imparted as it is pulled from casing 8 comprises only a very few of its inner coils that are drawn toward the supporting rollers 11 and rotate in the stationary casing. Since the mass of such a relatively small moving portion of the strip 7 is relatively low it follows that its inertia characteristics are low. By reason of only the relatively small portion of the generally stationary coil that is in motion within casing 8 any time during the operation of the device it follows that this small portion, because of its low inertia characteristics, may be highly accelerated without danger of it being snapped or broken by reason of the acceleration imparted to it.

Strip 7 then passes to the metal bender 9 which consists of a fixed member 20 having a plurality of rollers 21 pivotally mounted along one edge and a movable frame 22 pivoted at 23 at one end which also has a set of pivotally mounted rollers 24 along one edge thereof, staggered in relationship to the rollers of said first member so that as strip 7 passes from the container 8 as described above and through the two sets of rollers 21 and 24, each increment of strip 7 will be progressively and successively deformed beyond its yield point or its elastic limit. Strip 7 as it emerges from the bender 9 passes between another set of guide rollers 25 in contact with the edges of the strip and finally between a pair of guide rollers 26 contacting the face of the strip which allow for the kinetic energy load to be absorbed from any direction over more than 180° in front of rollers 26.

Figure 4 illustrates details of a latching mechanism 27 which permits the movable member 22 to be moved into the dotted line position 22′ shown, to open up the sets of rollers 21 and 24 so that the strip may be set between the rollers quite easily whenever it has to be rethreaded. Fine adjustment is provided by a screw 28 to preload the strip by fixing the spacing between the two sets of rollers 21 and 24 in any predetermined position in which adjustment is secured by the lock nut 29.

Figures 5 to 9 illustrate a modified form of the bender which functions essentially as does the previously described metal bender but has additional features that after threading the metallic strip or tape through the metal bender and adjusting the preloading of the strip, the load may subsequently be varied at will or in response to rate of movement or length of feed of the tape.

The metal bender of Figure 5 is threaded by removing wing nuts 30 and cover plate 31. Rollers 32 correspond to rollers 21 of Figures 1 to 4. Sets of rollers 33, 34, 35 and 36 correspond to the set of rollers 24 of the previous embodiment. Frame members 37, 38, 39, and 40 are capable of moving separately and individually support sets of rollers 33, 34, 35 and 36. Frames 37 to 40 and the rollers 33 to 36 are moved toward the set of rollers 32 by cams 41 to 44 mounted on shaft 45. Shaft 45 is coupled at 46 to gear box 47 and actuator motor 48. Control means 49 generates a signal in response to the rate or length of feed of tape 7 to actuate motor 48. Depending upon the load to be absorbed, the absorption of energy can be adjusted automatically relative to the speed.

When shaft 45 is turned to a position that the cams are inoperative, that is frames 37 to 40 move to disengage rollers 33 to 36 from rollers 32, strip 7 may easily be placed between the sets of rollers and when cover 31 is replaced, the machine is ready for operation. Motor 48 is actuated to turn shaft 45 to move cam 41, frame 37 and rollers 33 to 36 into mesh with rollers 32 to preload the energy absorbing device. Additional preload up to the full capacity may in some cases be desired.

The device is now ready to absorb a predetermined amount of kinetic energy. If it is necessary to absorb a greater or lesser load or to vary the load in operation, motor 48 is actuated by local or remote or automatic control means, such as shown at 49, to rotate shaft 45 to move cams 41 to 44, frames 37 to 40 and rollers 33 to 36 carried thereby into or out of engagement with rollers 32 for variations in energy absorbing capability. Cams 41 to 44 are designed to place and hold a predetermined amount of load in strip 7 by controlling the engagement of selected groups of rollers.

It is to be understood that certain changes, alterations, modifications and substitutions can be made without departing from the spirit and scope of the depending claims.

We claim:

1. A low inertia, energy absorber comprising an elongated strip of metal, said strip of metal formed in a stationary flat coil, means to feed said metal strip from the inside of said flat coil, deforming means to engage and pre-tension said metal strip as it passes from said coil to progressively and successively deform increments of said metal strip by bending beyond the elastic limit of said metal, and means connected to said strip to effect relative motion between said metal strip and said deforming means.

2. A low inertia, energy-absorbing device comprising an elongated strip of metal, said strip of meal formed in a stationary flat coil, means to remove said metal strip in the operation of said device from the inside of said flat coil, frame means mounted on each side of said metal strip, said frame means having means formed thereon to engage said metal strip to progressively and successively deform increments of said metal strip by bending beyond the elastic limit of said metal, means connected to said strip to effect relative motion between said metal strip and said frame means to absorb kinetic energy therebteween, and means on said frame means for pre-loading said metal strip.

3. A low inertia, energy-absorbing device for an arresting gear comprising an elongated strip of metal, said strip of metal maintained in the form of a stationary flat coil, means to remove said metal strip as required from the inside of said flat coil, frame means mounted on each side of said metal strip and having means thereon to adjust the position of one of said frame means relative to the other, said frame means having roller means mounted thereon to engage and pre-tension said metal strip to progressively and successively deform increments of said metal strip by bending beyond the elastic limit of said metal, and means connected to said strip to apply kinetic energy to be absorbed to effect relative motion between said metal strip and said frame means to absorb said kinetic energy therebetween.

4. A low inertia, energy-absorbing device comprising an elongated metal strip, said strip of metal formed in a stationary flat coil, means to remove said metal strip in the operation of said device from the inside of said flat coil, a frame means mounted on each side of said metal strip, said frame means having means mounted on opposite sides of said metal strip to mesh and to effect a progressive and successive deformation of increments of said metal strip by bending beyond the elastic limit of said metal, means to control the relative motion of said deforming means, and means connected to said strip to apply kinetic energy to effect relative motion between said metal strip and said frame means to absorb said kinetic energy therebetween.

5. A low inertia, high rate, energy-absorbing device comprising an elongated metal strip, said strip of metal stored in a stationary flat coil, means to remove said metal strip in the operation of said device from the inside of said stationary flat coil, a frame means mounted on each side of said metal strip, each said frame means having sets of rollers mounted thereon, said two sets of rollers being offset along said metal strip so that the axes of the rollers of one set are positioned between the axes of the rollers of the other set, so that when said rollers are meshed and engage said metal strip, successive increments of said metal strip are progressively deformed by bending beyond the elastic limit of said metal,

and means connected to said strip to apply kinetic energy to effect relative motion between said metal strip and said frame means to absorb said kinetic energy therebetween.

6. A low inertia, high rate, energy absorber comprising an elongated strip of metal, deforming means to engage said metal strip, said strip of metal being stored in a stationary flat coil, means to remove said metal strip from said stationary flat coil from the inside of said coil to pass said metal strip to said deforming means to progressively and successively deform increments of said metal strip by bending beyond the elastic limits thereof, and means connected to said strip to apply kinetic energy to be absorbed to said metal strip to effect relative motion between said strip and said deforming means.

7. A low inertia, high rate, energy-absorbing device comprising an elongated strip of metal, said metal strip mounted in the form of a stationary flat coil, means to remove said metal strip from the inside of said stationary flat coil as said metal strip is moved through said device, frame means mounted on each side of said metal strip, said frame means having staggered laterally extending means formed thereon and meshed to engage said metal strip to progressively and successively deform increments of said metal strip by bending beyond the elastic limit of said metal, and means connected to said strip to effect relative motion between said metal strip and said frame means to absorb kinetic energy therebetween.

8. A low inertia, high rate, energy-absorbing device comprising an elongated strip of metal, said strip of metal being fed from a storage means in the form of a stationary flat coil, said metal strip feeding from the inside of said stationary flat coil as required in the operation of said device, frame means mounted on each side of said metal strip, said frame means having staggered roller means mounted thereon and meshed to engage and initially tension said metal strip to progressively and successively deform increments of said metal strip by bending beyond the elastic limit of said metal, means located adjacent and responsive to the movement of said strip means to apply some kinetic energy to be absorbed to effect relative motion between said metal strip and said frame means to absorb the remainder of said kinetic energy therebetween.

9. A low energy, high rate, energy-absorbing device comprising an elongated metal strip, said metal strip being stored in the form of a stationary flat coil, means to feed said metal strip from the inside of said stationary flat coil as required in the operation of said device, a frame means mounted on each side of said metal strip, said frame means having staggered roller means mounted on opposite sides of said metal strip to mesh and to effect a progressive and successive deformation of increments of said metal strip by bending beyond the elastic limit of said metal, means to control the relative motion of selected groups of said roller means toward one another, and means connected to said strip to apply kinetic energy to effect relative motion between said metal strip and said frame means to absorb said kinetic energy therebetween.

10. An energy-absorbing device comprising a low inertia metal strip, a storage means holding said strip in coiled form, and a metal strip deforming means, said low inertia storage means having means to move successive increments of the inner end portion of said metal strip to said deforming means, said deforming means having means to engage said metal strip to progressively and successively deform increments of said metal strip by bending beyond the elastic limit of said metal, and means located adjacent and responsive to the movement of said strip to apply some of the kinetic energy to be absorbed to effect relative motion between said metal strip and said deforming means, to absorb the remainder of said kinetic energy therebetween.

11. An energy-absorbing device of the type in which kinetic energy is imparted to a moving metal member, said member comprising a bendable, low inertia metal strip, a low inertia metal strip storage means comprising means to store said metal trip in the form of a stationary coil, and means mounted within said strip storage means to feed said metal strip from the inside of said stationary coil in the operation of said device as required in the absorption of the kinetic energy.

12. An energy-absorbing device of the type in which kinetic energy is imparted to a moving metal member, said member comprising a bendable, low inertia metal strip, a low inertia metal strip storage means, said storage means comprising means to store said metal strip in the form of a stationary flat coil, means mounted within said strip storage means to feed said strip from the inside of said stationary flat coil in the operation of said device as required in the absorption of the kinetic energy, and means mounted adjacent said strip storage means to absorb said kinetic energy from said strip as said strip emerges from said stationary coil.

13. An energy-absorbing device of the type in which kinetic energy is imparted to an elongated bendable metal filament, comprising in combination, a low inertia elongated bendable metal filament storage means, an elongated bendable metal filament disposed as a stationary coil in said storage means, and means mounted within said storage means and inwardly of said coil to feed said bendable metal filament from the inside of said stationary coil in the operation of said device as required in the absorption of the kinetic energy.

14. An energy-absorbing device of the type in which kinetic energy is imparted to an elongated bendable metal filament, comprising in combination, a low inertia elongated bendable metal filament storage means, an elongated bendable metal filament disposed as a stationary coil in said storage means, means mounted within said storage means and inwardly of said coil to feed said bendable metal filament from the inside of said stationary coil in the operation of said device as required in the absorption of the kinetic energy, and means mounted adjacent said storage means to absorb said kinetic energy from said bendable metal filament as said bendable metal filament emerges from said storage means.

15. A low inertia, energy absorber of the type in which kinetic energy is imparted to an elongated bendable metal filament, comprising in combination, an elongated bendable metal filament, the innermost end of said filament being adapted for connection to a moving load, the kinetic energy of which is to be absorbed, storage means storing said bendable filament therein as a stationary coil, means mounted within said storage means inwardly of the coil to feed said bendable metal filament from the inside of said stationary coil, deforming means engaged with said metal filament as it is withdrawn from said storage means, said deforming means comprising at least two frame members, each disposed at opposite sides of said meal filament and relatively pivoted together at one end thereof, each frame member having spaced filament engaging surfaces thereon, the said engaging surfaces of one of said frame members offset with respect to the filament engaging surfaces of said opposite frame member whereby they may intermesh, inter-engaging positioning means mounted on the opposite ends of said frame members to position said frame members to preload said metal fiament, said frame filament engaging means progressively and successively deforming increments of said bendable filament by bending the metal of said filament beyond its elastic limit.

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