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Kunczynski

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[54] **FRANGIBLE, FLEXIBLE PRINTED CIRCUIT SENSOR FRACTURABLE BY DERAILED CABLE**

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[51] **Int. Cl.** **H01h 35/00**

[58] **Field of Search**..... 200/61.08, 61.13, 61.18, 200/166 PC; 174/110 SR; 317/101 F; 339/80; 340/222, 419, 303

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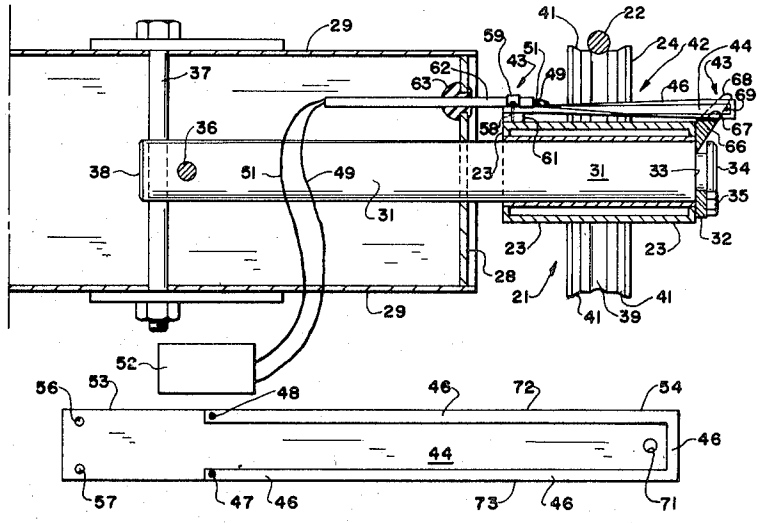
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[57] **ABSTRACT**

A cable derailment sensing device and method for use with pulley means having a cable carried thereby to detect derailment of the cable from the pulley means is disclosed. The sensing device includes a brittle frangible element positioned by mounting means for impact thereof by the cable upon derailment, and the frangible element carries an electrically conductive path thereon which is connected to electrical sensing circuitry. The brittle sensing element is formed of a material which is vibration and fatigue resistant and has sufficient durability to withstand accidental jarring. The electrically conductive path may be formed by printed circuit techniques on a surface of a frangible element such as a printed circuit board. The brittle frangible element is preferably prestressed by the mounting means to insure complete fracturing thereof upon impact by the cable.

11 Claims, 3 Drawing Figures



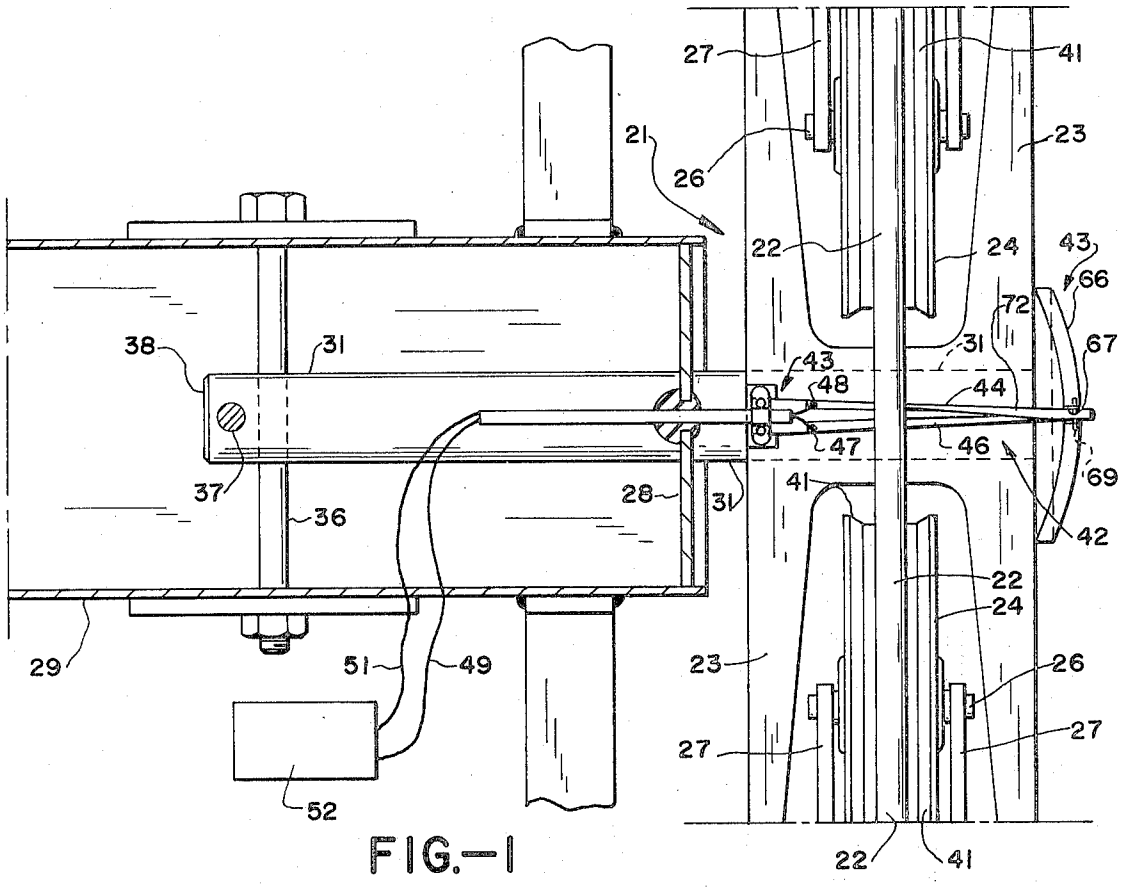


FIG.—1

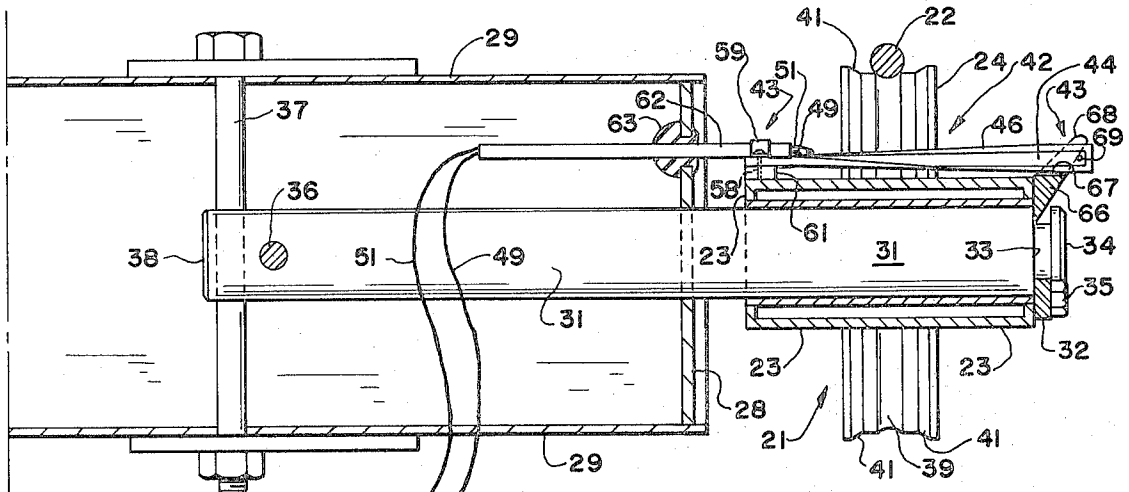


FIG.—2

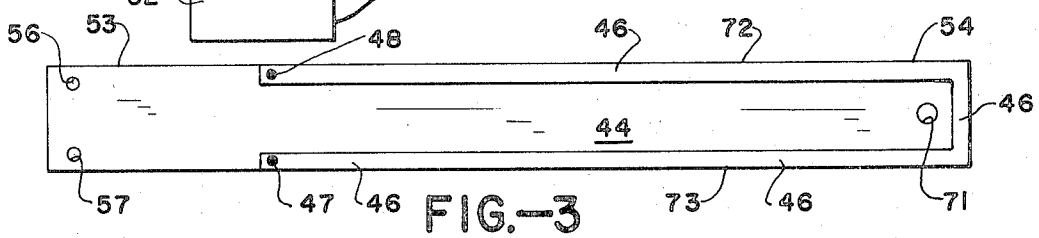


FIG.—3

FRANGIBLE, FLEXIBLE PRINTED CIRCUIT SENSOR FRACTURABLE BY DERAILED CABLE

BACKGROUND OF THE INVENTION

There are numerous systems which employ a cable or flexible tendon which is carried on or driven by pulleys or sheaves. In most of these systems the problem of derailment of the cable from the pulleys is a serious and perplexing one. There are usually numerous safeguards and structures which are employed to attempt to prevent derailment, but these apparatus are not always foolproof.

One system in which derailment of a cable from its carrier sheaves is particularly troublesome and dangerous is in a chairlift of the type employed to transport skiers. Most chairlifts involve several thousand feet of cable stretched over periodically spaced pulleys mounted on towers. Some chairlifts are in excess of 1 mile in length, and constant supervision and observation of the movement of the chair-carrying cable over the pulleys along the entire length of the lift is normally not possible. Moreover, the method of attaching the chairs to the cable inherently prevents the use of cable derailment prevention structures on one side of the cable.

Occasionally, the cable for a chairlift has been known to become derailed from one or more of the pulleys on which it is mounted. Usually the cable will be caught by a supporting structure adjacent the pulleys or sheaves upon derailment so that danger to the passengers of the chairlift is minimized. If the chairlift is not stopped almost immediately after derailment, however, there is some danger that the derailed cable will further be pulled from the supporting structure or entangled in the same. If this should happen, there is a substantial hazard in steep mountainous terrain to personnel riding the chairlift.

In order to increase the safety of the chairlift, attempts have been made to sense derailment of the cable so that the lift can be immediately shut down and the cable replaced on the sheaves. One approach to this problem has been to stretch an electrically conductive wire transversely of and immediately adjacent to the cable in a location which will cause the wire to be severed in the event that the cable is derailed. This wire is then connected to sensing circuitry which can be monitored at a central location to automatically shut down operation of the lift and indicate where the derailment has taken place.

It has been found, however, that sensing devices as above described have not been reliable. Upon derailment of the cable, it will impact the wire, but often the wire merely bends and stretches without becoming severed. In this situation, the sensing circuitry will not detect a derailment, and the lift will continue to operate under the extremely hazardous derailed condition. Additionally, sometimes the cable will impact against the sensing wire and sever the same, but trap the pieces of wire between the cable and supporting structure. When this occurs, the electrical circuit can be completed through the cable, even though the sensing wire is severed. Therefore, a condition again exists in which the sensing circuitry will not shut down operation of the lift. Obviously, when either one of these defects occurs a complete breaking of the wire and circuits may eventually result, but only after the cable has continued to

be advanced for a period of time in the derailed condition.

The reliability of the wire--type sensing devices is further reduced by the adverse environmental conditions in which the sensing device must operate. Thus, in the summer the wire is subject to high temperatures and ultraviolet bombardment at high altitudes, while in the winter extremely cold conditions are encountered. Still further, the build-up of snow on the tower supporting the sheaves may enhance the likelihood that the wire will not be cleanly severed and the circuit broken upon derailment of the cable.

Another approach has been to employ proximity switches to sense the change in or proximity of the cable, for example, when it jumps the sheaves. These switches are often not well suited for the adverse environmental conditions, but more importantly, they must be set at a relatively insensitive level to avoid repetitive false alarms. Thus, the proximity switch cannot sense short duration changes in the location of the cable and usually has a 3 or 4 second built-in delay. This delay, however, can result in an extremely hazardous condition of advancement of the cable while derailed, particularly when the cable cannot be stopped instantaneously even when the proximity switch finally signals to stop.

Finally, some attempts have been made to use cast iron rods as the sensing element by positioning the rods for impact by the cable when it jumps the sheaves. The rods act as an electric conductor, but their brittle nature prevents stretching upon impact. This approach has been found to be unsatisfactory because tower vibration when the cable is running has fatigued and fractured the rods. Additionally, the fragile nature of the rods makes them subject to fracture when bumped during installation or when jarred directly or indirectly by passengers on the chairlift.

Accordingly, it is an object of the present invention to provide a cable derailment sensing device and method which provides improved reliability and safety in connection with sensing the derailment of a cable from pulley means.

Another object of the present invention is to provide a cable derailment sensing device which will reproducibly function in adverse environments, is fatigue and vibration resistant and can withstand accidental impacts upon installation and use.

Another object of the present invention is to provide a cable derailment sensing device which may be readily adapted to a variety of applications, is easy and inexpensive to manufacture, is easy to install, may be readily replaced, and is particularly well suited for use with chairlifts, ski lifts, and the like.

The cable derailment sensing device of the present invention has other objects and features of advantage some of which will be set forth in more detail or will be apparent from the description hereinafter and the accompanying drawing.

SUMMARY OF THE INVENTION

The cable derailment sensing device of the present invention is formed for use with pulley means having a cable carried thereby. The device includes sensing means, mounting means positioning the sensing means adjacent the pulley means for impact by the cable upon derailment from the pulley means, and electrical sensing circuitry connected to the sensing means. The im-

provement of the present invention is comprised, briefly, of the sensing means being formed as a brittle frangible element formed of a fatigue resistant and vibration withstanding material having an electrically conductive path of insubstantial strength carried thereby and electrically connected to the sensing circuitry. The brittle frangible element, preferably a fiberglass printed circuit board, has a strength and brittleness causing complete fracturing of the element at at least one position along the electrically conductive path upon impact of the element by the cable and yet will not fatigue or be severed by vibration or normal operational jarring. The electrically conductive path is preferably printed on a surface of the brittle frangible element by printed circuit techniques, and the brittle frangible element is mounted in a prestressed condition, preferably by twisting, to insure complete fracturing of the electrically conductive path upon impact by the cable.

The method of sensing the derailment of a cable from pulley means of the present invention is comprised of mounting a brittle, frangible and fatigue resistant element, such as a printed circuit board, having an electrically conductive path imprinted thereon adjacent the pulley for impact by the cable, and electrically connecting the path to sensing circuitry.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a top, fragmentary, cross-sectional view of a sensing device constructed in accordance with the present invention and mounted adjacent a set of pulleys.

FIG. 2 is a fragmentary, side elevational view, in cross-section of the sensing device of FIG. 1.

FIG. 3 is a top plan view of a brittle frangible element shown installed in FIGS. 1 and 2 and suitable for use in the sensing device of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIGS. 1 and 2, pulley means or assembly, generally designated 21, is shown with cable or flexible tendon 22 carried thereby. Pulley assembly 21 includes a double-ended yoke 23 to which groove pulley wheels or sheaves 24 are mounted. Sheaves 24 are pivoted by pins 26 for rotation with respect to arms 27. Mounted on the ends of arms 27 (not shown in the drawing) is a second sheave or pulley wheel, and arms 27 are preferably pivotally mounted to yoke 23 by a connection also not shown.

Extending through the end wall 28 of tower arm structure 29 is rod member 31. The double-ended yoke 23 is secured on rod member 31 by block 32 (FIG. 2) which may be selectively inserted in groove 33 at the end 34 of the cylindrical rod and held in place by bolt 35. In order to provide for angular adjustment of the yoke with respect to tower arm structure 29, mutually perpendicular and threaded bolts 36 and 37 are provided and extend through mutually perpendicular openings in end 38 of rod 31. As best may be seen in FIG. 2, pulley wheels or sheaves 24, when employed in a chairlift, preferably are formed with a grooved resilient insert 39, such as a rubber material, on which cable 22 rides and with side flanges 41, which are inwardly tapered to resist derailment of the cable.

As thus far described, the pulley assembly and tower structure are formed in a conventional manner, and further details thereof have been omitted for the sake of simplicity. In the conventional chairlift, the chairs are attached to cable 22 by cable grips, annd the chairs are located periodically over the length of the cable. The chairs and passengers carried thereby exert a considerable downward force on cable 22 as it passes over the sheaves. Additionally, however, considerable lateral forces are exerted on cable 22 by reason of wind loading on the chairs, lateral rocking of the chairs, misalignment of the sheaves from tower to tower, etc., which lateral forces tend to contribute toward and result in occasional derailments.

In order to be able to sense derailment of the cable from the sheaves so that the derailment can be located and the cable motion stopped, sensing means, generally designated 42, is mounted in mounting means, generally designated 43, adjacent pulley means 21 for impact by the cable upon derailment. As shown in FIGS. 1 and 2, sensing means 42 is mounted beneath cable 22 and extends outwardly of both sides of the sheaves. Thus, when cable 22 jumps flanges 41 of the pulleys, the substantial downward force of the weight on the cable will cause the cable to drop downwardly immediately as it passes over the flanges to impact the sensing means adjacent the side walls of the pulleys. It should be noted, however, that there are tower installations in which the pulleys are located in a relatively low position with respect to the cable and in effect hold the cable down against a very substantial upward force. In this situation, the cable would be located on the underside of pulley means 21 as viewed in FIG. 2 with sensing means 42 positioned under yoke carrying arm 31 so as to be impacted by the cable as it snaps upwardly upon derailment.

The improvement of the present invention is comprised of sensing means 42 being formed as a brittle, frangible and fatigue resistant element 44 having an electrically conductive path 46 (best seen in FIG. 3) carried thereby and electrically connected at points 47 and 48 by conductors 49 and 51 to electrical sensing circuitry, generally designated 52. Brittle frangible element 44 has a brittleness selected to cause complete fracturing thereof at at least one position along electrically conductive path 46 and yet is formed of a material which will not fatigue, is impervious to vibration and can withstand accidental jarring or impact. In most chairleft installations cable 22, if derailed from sheaves 24, will apply a minimum downward static force of about 750 to 1,000 pounds. The impulse loading of this downward force on frangible element 44 will, therefore, be relatively high. If frangible element 44 is formed from a board-like strip of material, such as a thermosetting resin or thermosetting plastic having a brittleness which will insure complete fracture of the strip under a load of about 200 to 300 pounds, the sensing strip will be broken in many places along conductor path 46 upon impact by the cable. Many thermosetting resins and plastics have a high resistance to fatiguing and are largely uneffected by vibration. Thus, they are particularly well suited for use in the apparatus and method of the present invention.

It is a feature of the present invention that sensing element or strip 44 have electrically conductive path 46 imprinted thereon using printed circuit techniques so that the conductive path has relatively insubstantial physical strength and will not interfere with or resist complete fracturing of the sensing element. Printed cir-

cuit techniques are particularly well suited for this purpose since they provide the necessary electrically conductive path without adding to the strength of the frangible element. Moreover, stretching of the electrically conductive path, as has been common with wire-type sensors, will not occur.

As best may be seen in FIG. 3, it is preferable that the electrically conductive path be printed as an openended loop connected at open ends 47 and 48 adjacent first end 53 to sensing circuitry 52. The use of the loop is advantageous since it provides a convenient structure for electrical connection to sensing circuitry 52, and severing either branch of the loop will cause an open circuit which can be sensed by circuitry 52. Additionally, the loop at second end 54 passes around a portion of the sensing strip mounting means, as will be set forth in detail hereinafter, which further increases the likelihood of severing conductive path 46. Impact of cable 22 on the sensing strip may pull second end 54 thereof away from mounting means 43, causing the mounting means to sever path 46.

In order to further insure that brittle frangible sensing strip 44 and electrically conductive path 46 are fractured by impact of the cable, it is another important feature of the present invention that the sensing strip is mounted in a prestressed condition. When brittle frangible element 44 is formed as a board-like strip prestressing by mounting means 43 can be accomplished by forming the mounting means to mount strip 44 in a longitudinally twisted orientation between first end 53 and second end 54. This prestressing condition does not introduce a stress which resists fracturing, but instead encourages fracturing. Thus, at first end 53 a pair of openings 56 and 57 may be formed in the frangible sensing strip, and mounting means 43 at end 53 may be comprised of a pair of fasteners 58 passing through clamp 59, and openings 56 and 57 and into block 61 to secure end 53 of the fastening strip in generally horizontal orientation. Clamp 59 further secures a protective sleeve 62 to the sheave supporting yoke 23. Sleeve 62 covers conductors 49 and 51 and passes through grommet 63 into the interior of tower arm structure 29. While the conductors 49 and 51 are shown to pass out to the sensing circuitry through the side wall of the arm structure, this is merely a schematic representation since the conductors would normally extend transversely the length of the arm and pass out of the tower to the sensing circuitry through a grommet similar to grommet 63.

As shown in FIGS. 1 and 2, it is preferable that strip 44 be twisted between ends 53 and 54 by about 90°. Thus, mounting means 43 is further comprised of an upstanding arm 66 formed with a vertically oriented slot or groove 67 dimensioned for receipt of second end 54 of the sensing strip. Slot 67 opens to the top 68 of arm 66 so that strip 44 may be inserted in the slot from the top thereof. This is particularly convenient when the sensing strips must be replaced. In order to hold the sensing strip in arm 66, a pin 69 is positioned through opening 71 in second end 54 of the frangible strip. Pin 69 engages the outwardly sloped underneath surface of arm 66 beyond the slot and prevent upward displacement of the strip out of slot 67. Pin 69, moreover, is in a position with respect to conductive path 46 to break the conductive path in the event that cable 22 pulls the sensing strip inwardly from arm 66.

Since the grips which secure the chairs to the cable must pass over and beyond the sheaves, it is not possible to provide a structure which will prevent derailment of the cable outwardly of the tower. Thus, there is a greater likelihood of cable derailment over the side of the sheaves away from the tower than derailment of the cable toward the tower. Thus, it is a further feature of the present invention that strip 44 is positioned in mounting means 43 with the portion of the strip most likely to be impacted upon derailment of the cable oriented with one of side edges 72 or 73 positioned to be impacted first by the cable. Edge 72, therefore, is oriented upwardly on the side of sheaves 24 away from tower arm structure 29 since this is the area in which derailment is most likely to occur. Orientation of strip 42 in an edgewise manner in this area further enhances the likelihood of complete severing of the conductive path carried thereby by concentrating the impact of the cable on a small area of the brittle strip and maximizing the elongation of the lower edge 73 of the strip for any downward deflection upon a cable impact. Since the strip is a brittle material, any substantial elongation of edge 73 will start fracturing. The likelihood of fracturing beginning at the edge of the strip 44 makes it further advantageous and a feature of the present invention to position conductive path 46 to extend along the opposite edges 72 and 73 to maximize the chance of severing upon cable impact.

The combination of providing a brittle, frangible and fatigue resistant sensing strip having an electrically conductive, looped path of insubstantial strength mounted in mounting means in a prestressed condition, which includes edgewise orientation of the strip, affords a highly reliable sensing means and safety device. The sensing strip will be impervious to normal tower vibration and yet will virtually shatter and fly apart upon impact by the cable. Thus, stretching of the conductive path or trapping the path between the cable and the supporting structure of the sheaves is not possible when the strip fragments upon impact, and false alarms from vibration, fatigue and jarring will not occur.

The brittle frangible element 44 of the present invention may be conveniently formed of a number of different materials. An epoxy glass, without fiber reinforcing, commonly employed in circuit boards and having a thickness of about 0.100 inches has been found to be advantageous. Path 46 may be formed of copper and coated with a solder to afford protection against the adverse weather conditions in which the sensing strip must operate. The length of the strip will vary depending upon the expected paths through which cable 22 might travel upon derailment. The length and brittleness of the material employed will determine the degree of twist which will provide prestressing of the strip. Numerous forms of electrical sensing circuitry can be employed in connection with the sensing device of the present invention. It is only necessary that the circuitry be able to differentiate between a closed looped circuit when the strip is intact and an open circuit upon fracturing of the same. Normally the circuitry would include visual or audio alarms and would be connected to shut down the power driving the cable. These types of circuits are well known in connection with the operation of ski lifts and other apparatus.

I claim:

1. In a cable derailment sensing device for use with pulley means having a cable carried thereby and including sensing means, mounting means positioning said sensing means adjacent said pulley means and for impact by said cable upon derailment from said pulley means, and electrical sensing circuitry connected to said sensing means, the improvement comprising:

said sensing means being formed as a brittle, frangible and fatigue resistant element formed from an electrically insulating material and having an electrically conductive path carried thereby, said electrically conductive path being formed as an open ended loop of electrically conductive material printed on said sensing means and electrically connected at the open end thereof to said sensing circuitry, said element having a brittleness causing complete fracturing thereof at at least one position along said electrically conductive path upon impact of said element by said cable upon derailment from said pulley means, and said mounting means supporting said sensing means adjacent a first and a second end of said sensing means.

2. In a cable derailment sensing device as defined in claim 1 wherein,

said loop commences and terminates and is electrically connected to said sensing circuitry adjacent said first end of said strip, and said loop is formed to pass around a portion of said mounting means adjacent said second end of said strip.

3. In a cable derailment sensing device as defined in claim 1 wherein,

said mounting means is formed to position said element for impact by said cable with said element in a prestressed condition.

4. In a cable derailment sensing device as defined in claim 3 wherein,

said element is formed as a board-like strip, and said strip is secured in said mounting means adjacent the ends of said strip, and said mounting means is formed to mount said strip in a longitudinally twisted orientation between said ends.

5. In a cable derailment sensing device as defined in claim 4 wherein,

said strip is formed from a resin-based material and is secured in said mounting means in a substantially horizontal plane adjacent a first end thereof, and said strip is secured in said mounting means in a substantially vertical plane adjacent a second end thereof to provide substantially a 90° twist intermediate said ends to prestress said strip.

6. In a cable derailment sensing device as defined in claim 5 wherein,

said strip is formed with an opening adjacent said second end dimensioned for receipt of a pin forming a portion of said mounting means,

said electrically conductive path is formed as an electrically conductive material printed on a surface of said strip in an open ended loop extending from said first end of said strip along an edge of said strip and around said opening and along an opposite edge of said strip back to said first end;

said mounting means is formed with a slotted portion dimensioned for receipt of said strip and formed for demountable securement of said strip in said slotted portion by positioning of a removable pin through said opening and into engagement with said mounting means adjacent said slotted portion.

7. In a cable derailment sensing device as defined in claim 6 wherein,

said strip is positioned in said mounting means with the portion thereof most likely to be impacted upon derailment of said cable oriented with an edge thereof positioned to be impacted first by said cable.

8. A method of sensing the derailment of a cable from pulley means carrying said cable comprising:

mounting in a prestressed manner a brittle, frangible, and fatigue resistant printed circuit board having an electrically conductive path imprinted thereon adjacent said pulley means for impact thereof by said cable upon derailment from said pulley means;

electrically connecting said electrically conductive path to external electrically sensing circuitry formed to sense cable derailment upon breaking of said electrically conductive path by said cable; and

fracturing of said printed circuit board and said electrically conductive path by impacting said printed circuit board with said cable upon derailment of said cable from said pulley means.

9. In a cable derailment sensing device for use with pulley means having a cable carried thereby and including sensing means, mounting means positioning said sensing means adjacent said pulley means and for impact by said cable upon derailment from said pulley means, and electrical sensing circuitry connected to said sensing means, the improvement comprising:

said sensing means being formed as a brittle, frangible and fatigue resistant element formed from an electrically insulating material and having an electrically conductive path of insubstantial strength imprinted thereon, said path being electrically connected to said sensing circuitry, said element having a brittleness and being mounted in said mounting means to cause complete fracturing thereof at substantially any position along said electrically conductive path impacted by said cable.

10. In a cable derailment sensing device as defined in claim 9 wherein,

said mounting means is formed to position said element for impact by said cable with said element in a prestressed condition.

11. In a cable derailment sensing device for use with pulley means having a cable carried thereby and including sensing means, mounting means positioning said sensing means adjacent said pulley means and for impact by said cable upon derailment from said pulley means, and electrical sensing circuitry connected to said sensing means, the improvement comprising:

said sensing means being formed as a brittle, frangible and fatigue resistant printed circuit board formed of an electrically insulating material and having an electrically conductive path of insubstantial strength imprinted thereon, said path being electrically connected to said sensing circuitry.

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