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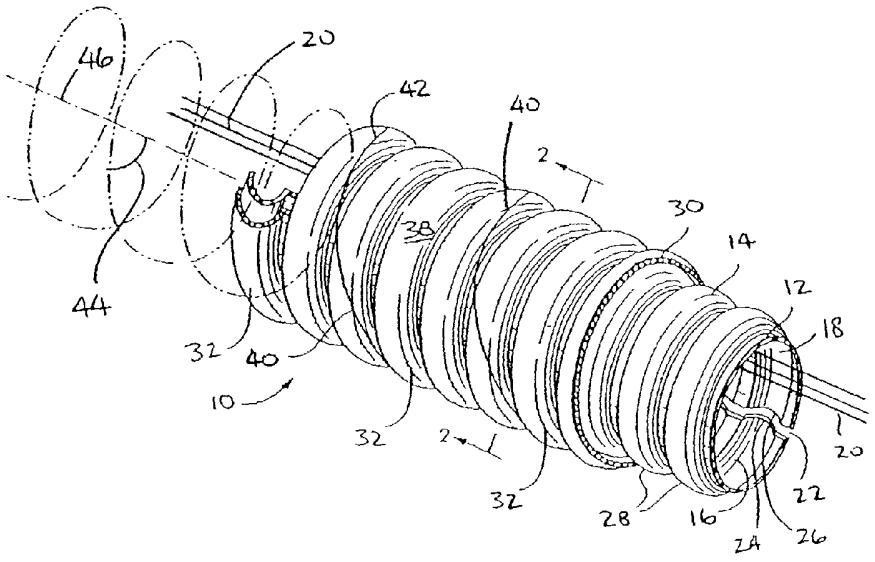
(54) Title: VIBRATION DAMPING CORRUGATED FLEXIBLE SLEEVING



(57) Abstract: A flexible sleeve for damping vibrations and supressing noise is disclosed. The sleeve is corrugated for radial stiffness and bending flexibility and has one or more damping layers of non-woven felt adhered to a flexible, resilient tubular support layer. The damping layers may be on both the inside and outside surfaces of the support layer. The support layer defines an interior space for receiving elongate substrates, the sleeve being slit to provide access to the interior space. Manufacture of the sleeve is by wrapping elongate multilayer strips combining the damping and support layers helically around a convoluted mandrel and applying heat and pressure to join the strips and force them to conform to the convoluted shape of the mandrel.

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VIBRATION DAMPING CORRUGATED FLEXIBLE SLEEVING

Related Application

This application is based on and claims the benefit of U.S. Provisional Application No. 60/311,291, filed August 9, 2001.

Field of the Invention

This invention concerns sleeving for encasing and protecting elongated substrates, such as wiring harnesses, and for reducing rattle noise from such substrates when they are used in a high vibration environment.

Background of the Invention

Elongated substrates, such as wiring harnesses, fluid conduits, such as brake lines and fuel lines, and optical fiber bundles are often used in automotive, aerospace and marine environments where they are subjected to significant ambient vibration. In automotive applications, wiring harnesses in particular are pernicious sources of unwanted "rattle noise" due to their propensity to resonate in response to structure borne vibration caused by engine operation or irregularities of the road surface over which the vehicle is passing. Wiring harnesses typically extend substantially throughout the vehicle's passenger compartment where they distribute power and control signals from the engine compartment to the dashboard instruments, interior lights, radio, speakers, electric windows, electric door locks, the window defogging element and on to the trunk to power the tail lights and often an electric fuel pump which may be positioned in the fuel tank. Although the harness is intermittently attached to the vehicle structure, the lengths of the harness between attachment points will often resonate and rattle against the structure in response to relatively low-

frequency vibrations within the range of human hearing and provide a source of noise, which is both annoying and a cause of concern to the vehicle occupants. Aside from the noise annoyance, vibration of wiring harnesses will cause fatigue failures of the wiring, solder joints or mechanical connectors, leading to electrical malfunctions, such as short circuits, which could result in a vehicle fire. The failure due to vibration and fatigue of other elongate substrates, such as fuel lines or brake lines, also has catastrophic potential. There is clearly a need for a device which will help damp vibration of elongated substrates and thereby reduce sympathetic vibration of the substrates and its resultant rattle noise and associated fatigue failures.

Summary and Objects of the Invention

The invention concerns a vibration damping sleeve adapted to receive and protect elongate substrates. The sleeve comprises an elongate tubular support layer formed of a flexible, resilient polymeric material, preferably polyester. The support layer has circumferential corrugations providing radial rigidity and bending flexibility. The support layer has an outwardly facing surface and an inwardly facing surface surrounding and defining an interior space adapted to receive the substrates. A damping layer of energy absorbing material is positioned in facing relationship with one of the surfaces of the support layer, the damping layer being substantially co-extensive with the one surface and having corrugations matching the corrugations of the support layer. The damping layer is preferably a non-woven polyester felt positioned on the outwardly facing surface of the support layer. The same material, i.e., polyester, is preferred for both the support and damping layers because it simplifies production of the sleeve and recycling at the end of its life.

A second damping layer may be positioned between the inwardly facing surface of the support layer and the interior space to provide additional damping to the elongate substrates received within the interior space. Preferably, the second damping layer is substantially co-extensive with the inwardly

facing surface and has corrugations matching the corrugations of the support layer.

It is an object of the invention to provide a sleeve for protecting elongate substrates from vibration.

It is another object of the invention to provide a protective sleeve using a non-woven felt as a damping material.

It is yet another object of the invention to provide a sleeve which is easy to manufacture and recycle.

It is again another object of the invention to provide a sleeve having different components made from the same material.

These and other objects and advantages of the invention will become apparent upon consideration of the following drawings and detailed description of preferred embodiments.

Brief Description of the Drawings

Figure 1 is a partial cut-away perspective view of an embodiment of a sleeve according to the invention;

Figure 2 is a cross-sectional view taken along lines 2-2 of Figure 1;

Figure 3 is a partial cut-away perspective view of another embodiment of the sleeve according to the invention; and

Figure 4 is a flow chart describing a method of manufacture of the sleeve according to the invention.

Detailed Description of the Preferred Embodiments

Figures 1 and 2 show a flexible protective sleeve 10 according to the invention. Sleeve 10 has a flexible, resilient elongate tubular support layer 12 with an outwardly facing surface 14 and an inwardly facing surface 16. Inwardly facing surface 16 surrounds and defines an interior space 18 adapted to

receive elongate substrates 20, which could be, for example, a wiring harness. Support layer 12 has a slit 22 defined by adjacent sleeve edges 24 and 26, the slit providing access to the interior space 18. The support layer 12 may be biased into a shape which normally closes the slit by keeping the edges 24 and 26 in contact, or even in overlapping relationship. The flexibility of the support layer, however, allows the edges 24 and 26 to be easily separated and the slit 22 opened to provide access to the interior space 18 for inserting the elongated substrate 20, effecting repairs or developing breakout branches.

Support layer 12 has circumferential corrugations 28 which provide the sleeve with increased radial strength against collapse, as well as relatively great bending flexibility. This enables the sleeve to readily follow paths through the vehicle having relatively sharp bends and compound curves as required to route the harness or other substrate without kinking.

Support layer 12 is preferably formed of polymer sheet or film, such as polyester, polypropylene or nylon. Such materials are inexpensive, readily available and adaptable to a wide variety of different manufacturing methods.

A damping layer 30 of energy absorbing material is shown positioned in facing relation with the outwardly facing surface 14 of the support layer 12. The damping layer 30 is co-extensive with the surface, having corrugations 32 matching those of the support layer. Preferably, the damping layer 30 is adhered to the support layer 12 substantially continuously over the entire outwardly facing surface 14. By providing a corrugated damping layer, the bending flexibility of the sleeve is not significantly altered as it would be if the damping layer were smooth and only attached to the crests of the corrugations. A smooth layer would increase the bending stiffness, since the layer would resist expanding when the sleeve was bent or curved.

Damping layer 30 is preferably formed from a non-woven felt due to felt's excellent ability to absorb and dissipate vibration energy. The preferred material for the damping layer 30 is a

polyester felt for its damping characteristics as well as its durability and resistance to fire as well as to attack by molds, mildew, bacteria and other agents of decay. Other felts, made of materials such as polypropylene or nylon, are also feasible. It is, however, preferred to make the damping layer 30 from the same material (i.e., polyester) as the support layer 12. Using the same materials simplifies production, since the layers are readily compatible and may be adhered by a variety of different techniques such as heat fusing by ultrasonic welding or by adhesives. Recycling of the sleeve 10 is also simplified when the various component layers are of the same material.

The damping layer 30 may also be made of other damping materials such as foam rubber or foamed synthetic material, as well as soft thermoplastic elastomers. Woven, braided or knitted fabrics may also be used to provide an energy absorbing layer.

In one specific example of a sleeve according to the invention, support layer 12 is a 0.24mm thick polyester film to which a damping layer 30 of non-woven flame-retardant polyester fiber having an areal density of 7.25 ounces per square yard is adhered.

As shown in Figure 3, sleeve 10 may also include a second damping layer 34 positioned between the inwardly facing surface 16 and the interior space 18. Damping layer 34 provides additional protection to substrates 20, preventing them from rattling within the support layer 12 and, thus, further reducing noise and damage from mutual abrasion of the substrate and the sleeve. Preferably damping layer 34 is substantially co-extensive with and adhered to the inwardly facing surface 16 and also has corrugations 36 matching the corrugations 28 of the support layer 12.

The second damping layer 34 is preferably a non-woven polyester felt similar to the outer damping layer 30, although other materials and configurations, such as foam rubber or foamed synthetic material, as well as soft thermoplastic elastomers and

woven, braided or knitted fabrics, may also be used to provide an energy absorbing layer.

As described in the flow chart of Figure 4, the sleeve 10, shown in Figure 1, may be manufactured by first adhering a sheet of the damping material (e.g., polyester felt) to a sheet of flexible, resilient polymeric material (e.g., polyester film or sheet) to form a single sheet having a damping layer adhered to a support layer. Adherence of the sheets together is preferably by means of adhesive but could also be by fusing via heat and pressure, for example, by ultrasonic welding. The adhered sheets which will form the support layer 12 and damping layer 30 of sleeve 10 are then cut into strips, for example 51mm wide and helically wrapped at a predetermined helix angle around a shaped mandrel having convolutions. The strips are wrapped so that their edges butt against each other or even overlap. Heat and pressure are then applied to the strips joining them along the abutting edges and forcing the damping and support layers to conform to the convolutions, thereby providing the corrugations 28 in the sleeve 10. Vestiges of strips 38 are indicated in Figure 1 by their edges 40 which form a helical seam 42, characteristic of this particular manufacturing method. Seam 42 describes a helix angle 44 measured relative to the longitudinal axis 46 of the sleeve 10, the corrugations 36 on the damping layer 30 being oriented at an angle to the helix angle sufficient to conform to the corrugations 36 to the corrugations 28 on the support layer 12.

In an alternate manufacturing process, the damping layer 30 is "cigarette wrapped" around a thin tubular polymer melt stream which will become the support layer 12, thereby forming a multilayer tubular feed stock which is then fed into a corrugating machine. The term "cigarette wrapped" refers to a type of wrapping wherein an elongated flat strip of sheet material is formed into a tube by bringing the edges of the sheet together parallel to one another forming a substantially straight seam lengthwise along the length of the tube, much as cigarette paper is wrapped around tobacco to form a cigarette. Such a seam

48 is shown in Figure 3, indicating the alternate method of manufacture for the embodiment shown.

In yet another alternate forming process, corrugations are added to a flat, multi-layer sheet material comprising a damping layer and a polymer sheet layer. The flat, corrugated sheet is then curled to a final tubular shape and heat set to permanently assume the tubular shape.

The flexible protective sleeve according to the invention is effective at reducing rattle noise of elongated substrates such as wiring harnesses due to the noise and vibration damping characteristics of the non-woven felt damping layer. When such a layer contacts a neighboring structure, it tends to deaden any sound that would normally be produced by the vibration of the substrate against the structure. Energy of the vibration will also be absorbed by the felt, thus, damping the vibration and increasing the fatigue life of the items surrounded by the sleeve. Use of the sleeve will result in decreased noise from sympathetic vibrations, as well as decreased failures due to fatigue.

CLAIMS

What is claimed is:

1. A vibration damping sleeve adapted to receive and protect elongate substrates, said sleeve comprising:

an elongate tubular support layer formed of a flexible, resilient polymeric material and having circumferential corrugations providing radial rigidity and bending flexibility, said support layer having an outwardly facing surface and an inwardly facing surface surrounding and defining an interior space adapted to receive the substrates; and

a damping layer of energy absorbing material positioned in facing relationship with one of said surfaces of said support layer, said damping layer being substantially co-extensive with said one surface and having corrugations matching said corrugations of said support layer.

2. A vibration damping sleeve according to Claim 1, wherein said damping layer is positioned on said outwardly facing surface of said support layer.

3. A vibration damping sleeve according to Claim 2, wherein said damping layer is adhered to said support layer substantially continuosly over said outwardly facing surface.

4. A vibration damping sleeve according to Claim 2, wherein said damping layer comprises an elongated strip of said energy absorbing material adhered to an elongated strip of said support layer and helically wrapped at a predetermined helix angle relatively to the sleeve, the corrugations on the damping layer being oriented at an angle to the helix angle sufficient to conform to the corrugations on the support layer.

5. A vibration damping sleeve according to Claim 2, wherein said damping layer comprises a sheet of said energy absorbing material cigarette wrapped around said support layer.

6. A vibration damping sleeve according to Claim 1, wherein said support layer is formed from a polymeric material selected from among the group consisting of polyester, polypropylene and nylon.

7. A vibration damping sleeve according to Claim 1, wherein said damping layer comprises a non-woven felt material.

8. A vibration damping sleeve according to Claim 7, wherein said felt material is selected from among the group consisting of polyester, polypropylene and nylon.

9. A vibration damping sleeve according to Claim 7, wherein said damping layer is formed from substantially the same material as said support layer.

10. A vibration damping sleeve according to Claim 9, wherein said damping layer and said support layer comprise polyester.

11. A vibration damping sleeve according to Claim 2, further comprising a second damping layer positioned between said inwardly facing surface of said support layer and said interior space.

12. A vibration damping sleeve according to Claim 11, wherein said second damping layer is substantially co-extensive with said inwardly facing surface and has corrugations matching said corrugations of said support layer.

13. A vibration damping sleeve according to Claim 12, wherein said second damping layer is adhered to said support layer substantially continuously over said inwardly facing surface.

14. A vibration damping sleeve according to Claim 1, wherein said damping layer comprises a foamed material.

15. A vibration damping layer according to Claim 14, wherein said damping layer comprises foam rubber.

16. A vibration damping layer according to Claim 1, wherein an elongated substrate is received within said interior space.

17. A vibration damping layer according to Claim 1, wherein said elongated substrate comprising a wiring harness.

18. A vibration damping sleeve adapted to receive and protect elongate substrates, said sleeve comprising:

a flexible resilient elongate tubular support layer comprising polyester and having circumferential corrugations providing radial rigidity and bending flexibility, said support layer having an outwardly facing surface and an inwardly facing surface surrounding and defining an interior space adapted to receive the substrates; and

a damping layer of polyester felt positioned overlying one of said surfaces of said support layer, said damping layer being substantially co-extensive with said one surface and having corrugations matching said corrugations of said support layer.

19. A vibration damping sleeve according to Claim 18, wherein said damping layer is adhered to said support layer substantially continuously over said outwardly facing surface.

20. A vibration damping sleeve according to Claim 19, further comprising a second damping layer positioned between said inwardly facing surface of said support layer and said interior space.

21. A vibration damping sleeve according to Claim 20, wherein said second damping layer is substantially co-extensive with said inwardly facing surface and has corrugations matching said corrugations of said support layer.

22. A vibration damping sleeve according to Claim 21, wherein said second damping layer is adhered to said support

layer substantially continuously over said inwardly facing surface.

23. A vibration damping sleeve according to Claim 22, wherein said second damping layer comprises polyester felt.

24. A method of making a vibration damping sleeve having a tubular support layer formed of a flexible, resilient polymeric material and a damping layer formed of a non-woven felt, said method comprising the steps of:

adhering a sheet of said felt to a sheet of said polymeric material;

cutting said adhered sheets into a plurality of strips having longitudinal edges;

wrapping said strips helically around a mandrel having a plurality of corrugations while positioning said edges in abutting relationship; and

applying heat and pressure to said strips thereby forcing them to conform to said corrugations of said mandrel and causing said longitudinal edges to adhere to one another and form a helical seam along said sleeve.

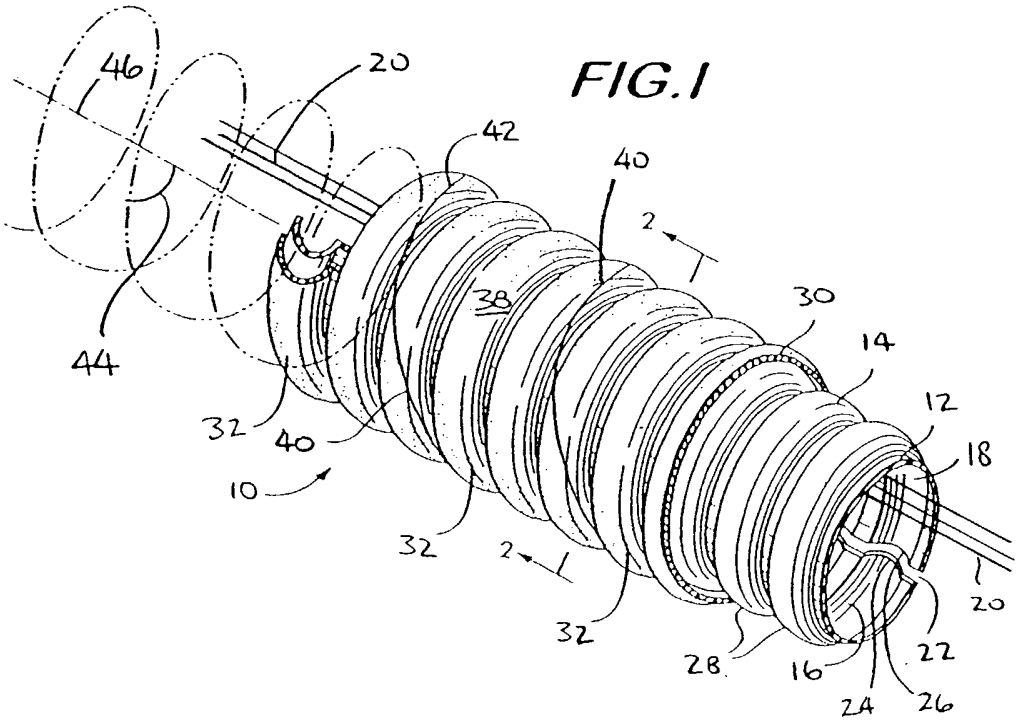
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FIG.1

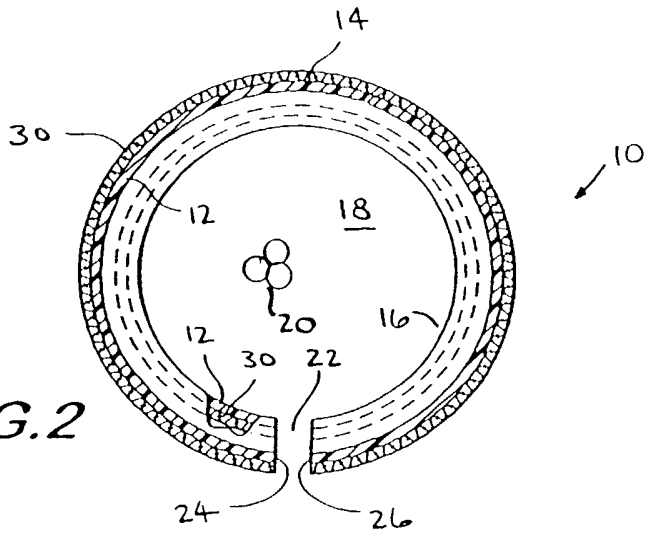
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FIG.2

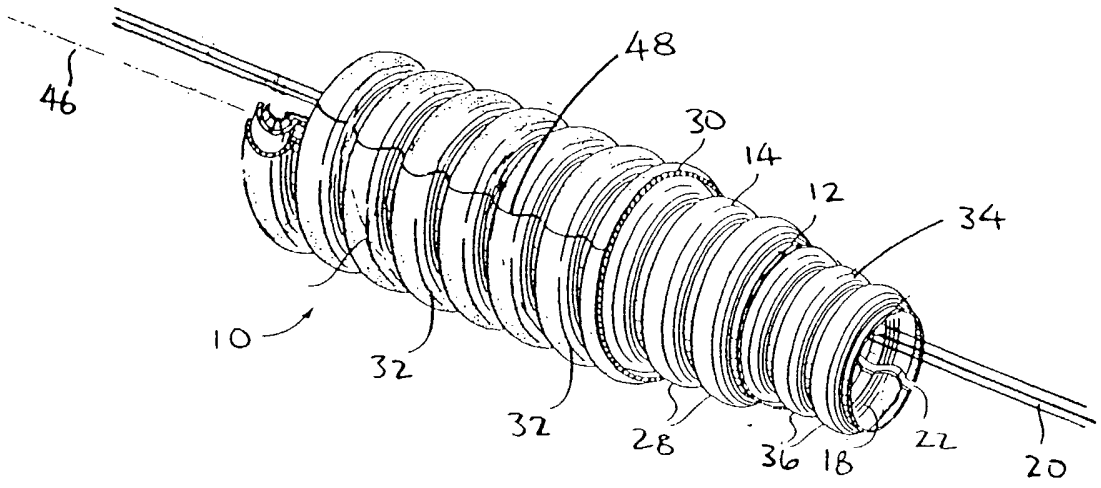

FIG. 3

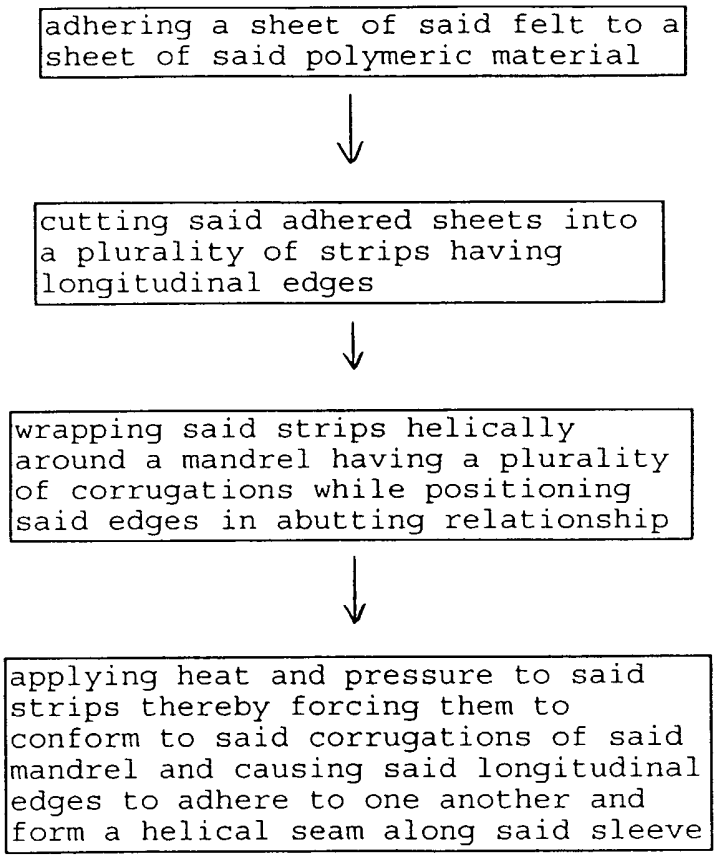
adhering a sheet of said felt to a sheet of said polymeric material
cutting said adhered sheets into a plurality of strips having longitudinal edges
wrapping said strips helically around a mandrel having a plurality of corrugations while positioning said edges in abutting relationship
applying heat and pressure to said strips thereby forcing them to conform to said corrugations of said mandrel and causing said longitudinal edges to adhere to one another and form a helical seam along said sleeve

FIGURE 4