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FOREIGN PATENTS

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[54] DIFFERENTIAL SPRING CONDUIT SUPPORT 9 Claims, 5 Drawing Figs.

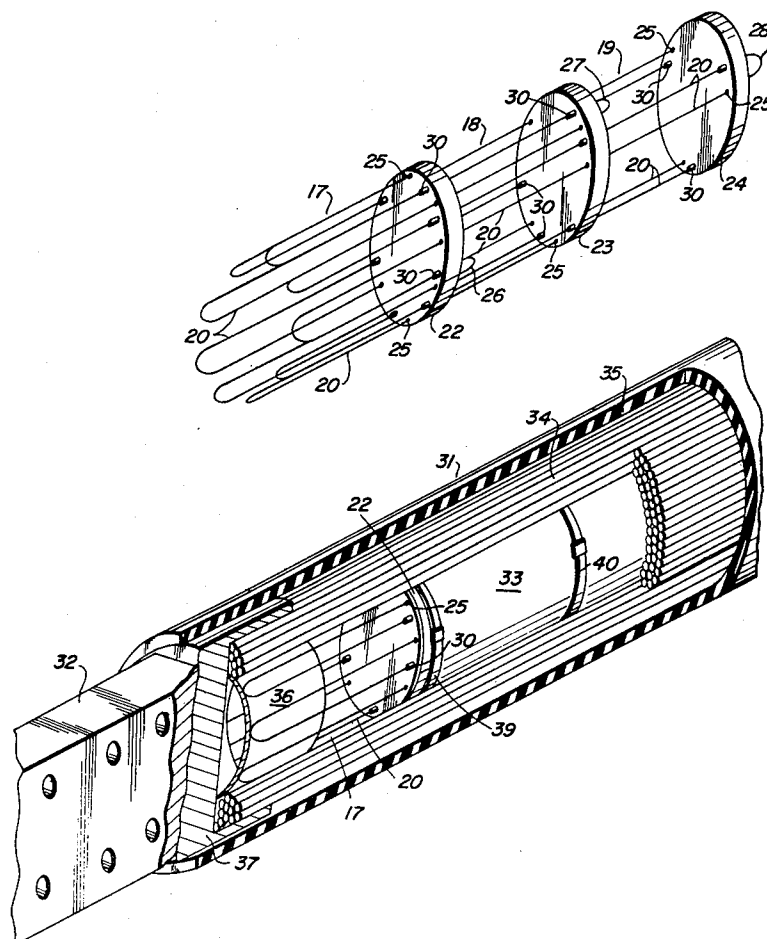
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 103; 13/(Inquired); 219/(Inquired)

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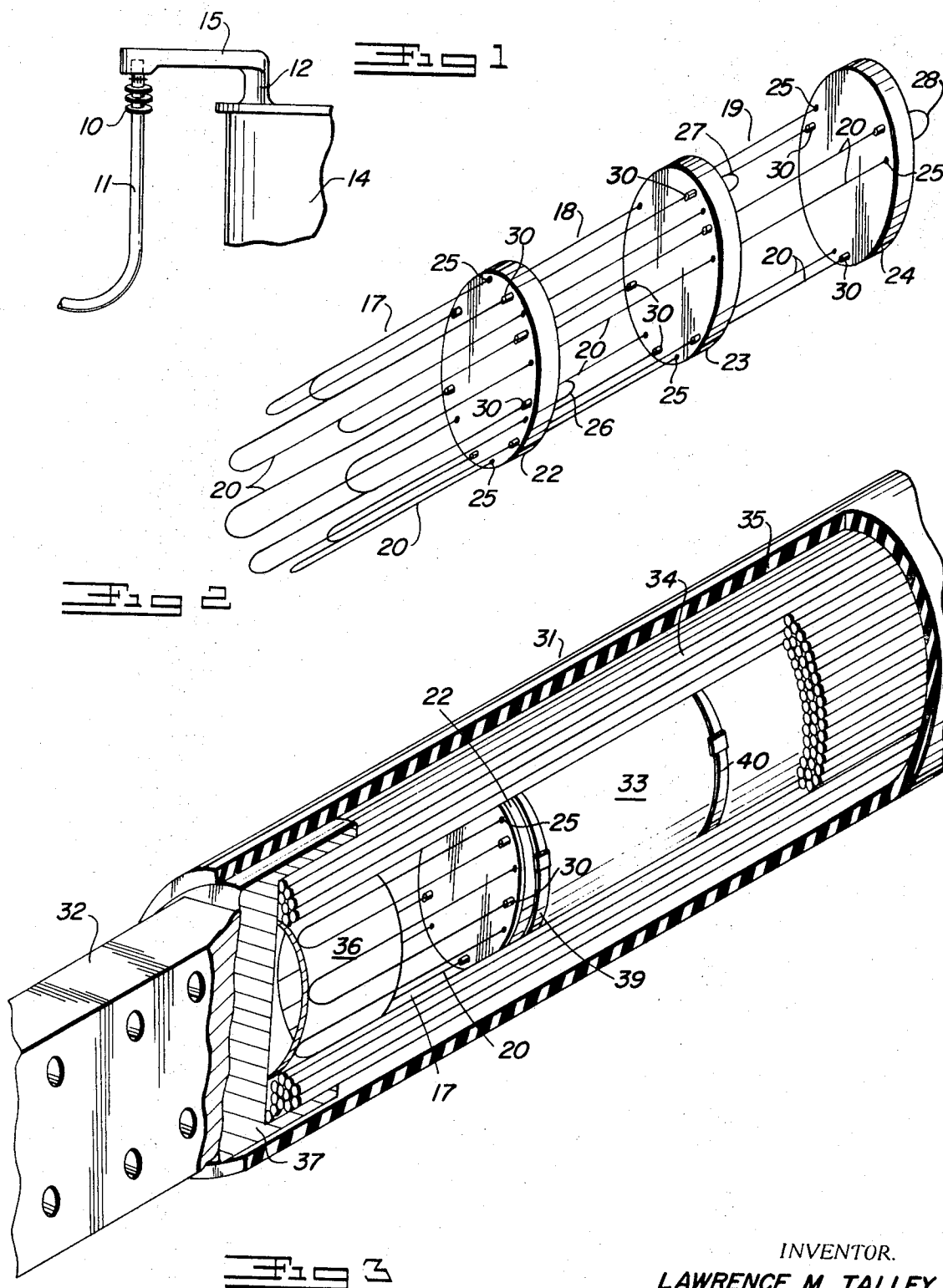
ABSTRACT: A differential spring for supporting a heavy flexible conduit such as a hose or water cooled electrical cable to prevent acute bending stress adjacent a termination. The differential spring comprises a number of hollow cylindrical sections formed of parallel spring wires joined end to end through discs. The size or number of spring wires in the sections decreases from section to section to provide decreasing bending resistance from section to section. The differential spring is placed in the hollow interior or on the exterior of the cable adjacent the end of the cable and has the end of its stiffest section connected to the termination. The differential spring dampens cable sway and offers gradually decreasing support and stiffening to the cable away from the termination.



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SHEET 1 OF 2



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SHEET 2 OF 2

Fig 4

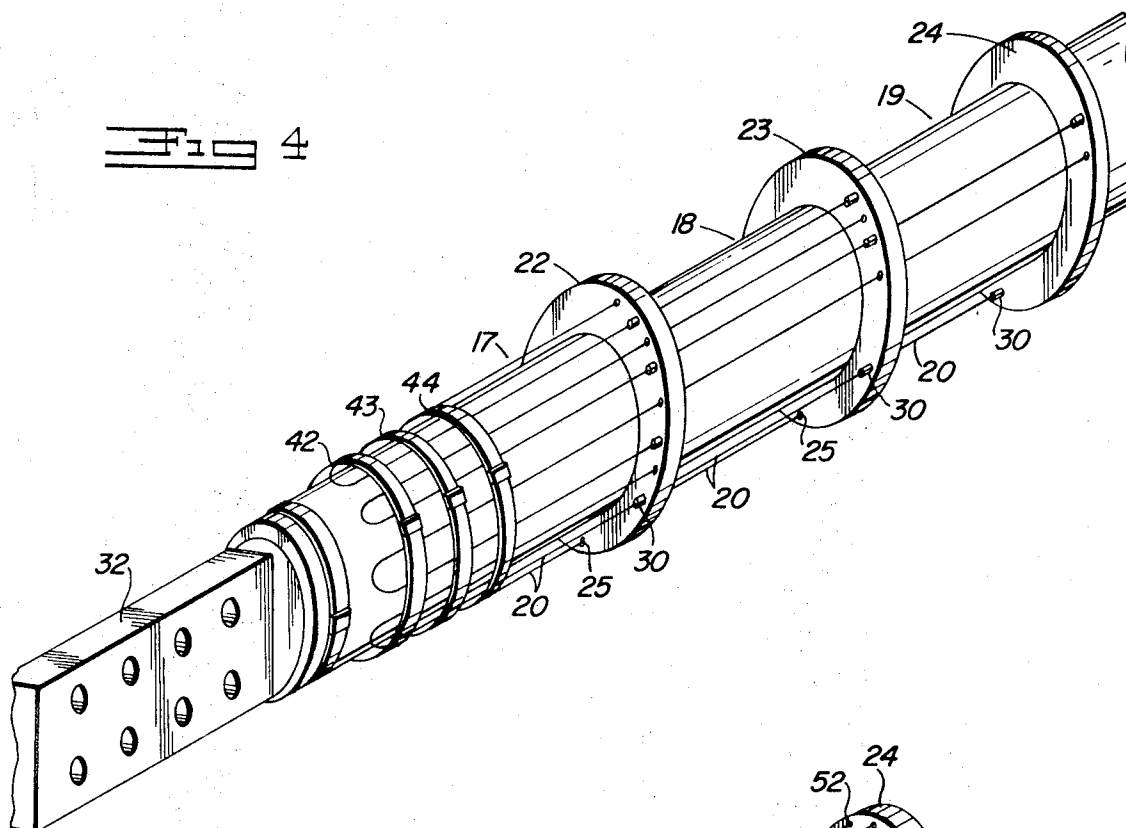
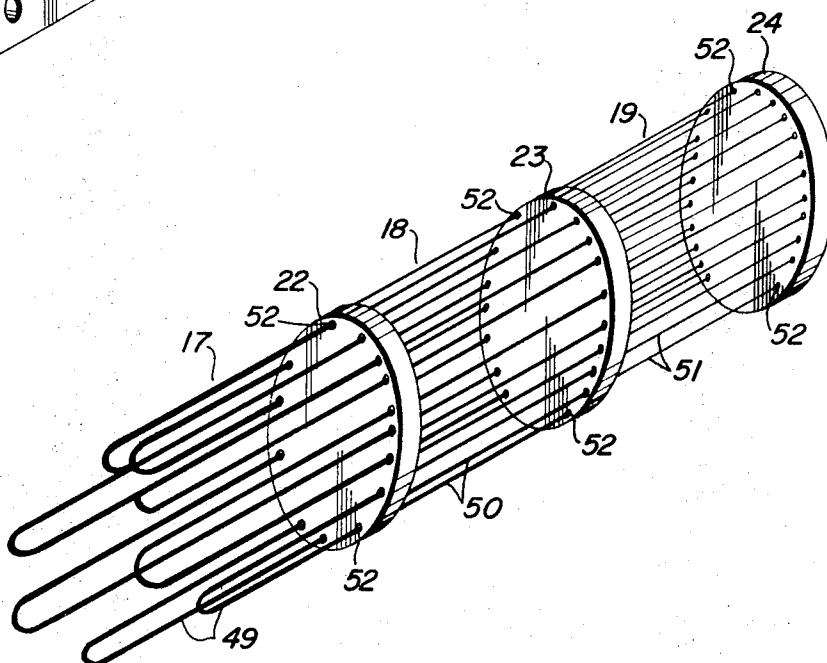


Fig 5

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DIFFERENTIAL SPRING CONDUIT SUPPORT**BACKGROUND OF THE INVENTION**

This invention relates to supports for heavy flexible conduits such as cables, hoses, and the like and more particularly to an improved means for supporting a cable, hose or similar conduit adjacent a termination that provides differential resistance to bending.

Electrical cables of the type that are used to carry large amounts of current, such as those that supply electric arc furnaces, are large and heavy. Many times these cables are water cooled which adds to their weight. The typical water cooled cable comprises a hollow core defined by a hollow tube of rubber or plastic and fabric, copper conductor strands, and an outer jacket which confines the cooling water. In some applications a heat shield is used over the outer jacket.

Cables of this type are terminated by soldering, brazing, or welding the copper or other metallic conductor strands to the terminals. Because of the configuration of the cable the terminated conductor strands are required to carry virtually the entire weight of the cable. A spiral spring or rubber tube defining the hollow core offers little or no support to the cable. The spiral spring is generally attached to the terminals but because of its configuration offers little support or resistance to cable bending. The hollow tube is generally not attached to the terminals, but ends several inches away because of possible damage from the heat generated in soldering or otherwise terminating the copper conductors to the terminal. Neither of the hollow core defining means therefore is of material assistance in stiffening the cable or in assisting the copper strands to carry the weight of the cable.

The problem of supporting the cable is accentuated in applications such as electric arc furnaces where the cables supplying the furnace are in almost continuous motion because of the large varying electric currents and the motion of the furnace electrodes. Also the cables are stretched into a tight catenary when the furnace is tilted to a pouring position.

The cable tension and aggravating motion has been carried by the cable strands alone. The effect of the motion and tension is most severe at the terminals where the cable strands in many cases have been weakened by overheating and oxidation occurring in the terminating process.

Prior cable supports have generally comprised a rigid sleeve or similar device which supports a cable in the area of a splice or adjacent a termination. Such supports do relieve a portion of stress at, for example, the terminations by supporting a small portion of the cable. However, since the rigid sleeve type cable support is generally mounted in a horizontal position to offer maximum support to the cable a sharp bend tends to be produced in the cable at the point where the cable is no longer supported by the rigid sleeve. When the cable is required to hang in a very pronounced arc as, for example, in a cable supplying an electric arc furnace, the terminations are made vertical to avoid sharp bends. In such cases the rigid sleeve support vertically mounted may cause a sharp bend in the cable when the cable is tightened by the furnace being tilted to the pouring position or when cable motion is produced by the large varying electric currents and the motion of the furnace electrodes.

Problems quite similar to those noted above are encountered with hydraulic hoses that carry water and other liquids from place to place for cooling, firefighting and many other purposes.

SUMMARY OF THE INVENTION

A general object of my invention is to provide a support for cables, hoses and similar flexible conduits that solves the problems discussed above. A more particular object is to provide such a support that reduces acute stress at the critical places, such as adjacent a termination, while allowing the conduit to bend in a substantially uniform arc of generous radius. A still more particular object is to provide a support that will dampen conduit motion thereby relieving stress at the terminations.

Another object is the provision of a cable support that may be mounted on the outside of an electrical cable or on the inside of a hollow core electrical cable. Still another object is the provision of a cable support that allows the hollow core defining means of a water cooled electrical cable to be attached to the terminals through the cable support to assist in supporting the cable.

A preferred form and embodiment of my differential spring comprises a plurality of spring wire sections having different flexibilities, and means for joining the sections together to form a series thereof. The series is arranged to have a first end section of minimum flexibility and to increase incrementally in flexibility in each section to a second end section of maximum flexibility.

The differential spring may be on the outside or the inside of a terminated cable, hose, or similar conduit. The section of minimum flexibility is attached to the termination. The section of maximum flexibility may be attached to the conduit, or if the differential spring is placed inside the hollow core of a water cooled electrical cable the maximum flexibility section may have its outer end attached to the hollow core defining means, for example a rubber tube, to enable the tube to assist in supporting the cable.

The differential spring is thus disposed along the flexible conduit in such a manner that maximum support is offered closest the termination and decreases in increments to offer support to the conduit while at the same time allowing it to assume a natural gentle arc as required by the particular application. Because the sections are essentially springs of different strength, conduit motion will be damped in such a manner that maximum damping occurs closest to the termination.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of a water cooled electrical cable connected to an electrode of an electric arc furnace and supported by a preferred form of differential spring;

FIG. 2 is a perspective of a preferred form of differential spring according to my invention;

FIG. 3 is a perspective partially cutaway of a terminated water cooled electrical cable having a rubber tube that defines a hollow core in the cable within which is disposed a differential spring for supporting the cable;

FIG. 4 is a perspective of a terminated water cooled electrical cable having a differential spring disposed about the exterior of the cable; and

FIG. 5 is a perspective of an alternate form of differential spring.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1 a preferred form and embodiment of differential spring 10 according to my invention is shown supporting an electrical cable 11 that supplies current to an electrode 12 of electric arc furnace 14 through a bus 15. The reader is referred to U.S. Pat. No. 3,366,725 assigned to the assignee of this invention for a detailed illustration and description of an electrical transmission system for an electric arc furnace.

A preferred form and embodiment of differential spring 10 is shown in FIG. 2 and comprises in this illustrative embodiment three separate sections 17, 18 and 19. Each section is formed of a plurality of parallel, longitudinally-extending, resilient, spring wires 20. The wires 20 are preferably made of nonmagnetic stainless steel, bronze, brass or other resilient nonmagnetic material for reasons to be disclosed more fully hereinafter.

Separating and defining the sections 17, 18 and 19 are discs 22, 23, 24 which serve to guide and/or terminate the spring wires 20. The sections 17, 18, 19 are made cylindrical in shape to conform to the cable or hose they will support. Sections 17, 18, 19 are constructed to have different numbers of spring wires 20 in each section. In the example of FIG. 2, section 17 is provided with 18 spring wires, section 18 with 12 wires and section 19 with 6 wires. The different numbers of wires in each section is most conveniently provided by passing a length of

wire through one of the openings 25 in the disc 22 and passing the wire back through an adjacent opening 25 in disc 22 to form a loop as at 26. In the same manner the wire is passed through openings 25 in discs 22 and 23 to form loop 27 and then through openings 25 in discs 22, 23 and 24 to form loop 28. The procedure is continued until a differential spring of the desired characteristics is obtained.

The effect of the different numbers of strands of spring wire in each section 17, 18, 19 is a different flexibility or resistance to bending in each of the sections. As shown in FIG. 2 the sections are arranged in order of increasing flexibility or decreasing resistance to bending. The discs 22, 23, 24 are prevented from moving or sliding longitudinally to the right in FIG. 2 with respect to the wires 20 by the loops at 26, 27, 28. To prevent the discs from sliding in the opposite direction blocks are provided in the form of pieces of tubing 30 of larger diameter than the openings 25 welded or otherwise fastened to the spring wires 20 at the face of each disc 22, 23, 24.

In FIG. 3, a preferred form of differential spring is shown disposed within a water cooled cable 31 that is connected to a terminating block 32. The cable is provided with a longitudinally extending tube 33 of rubber or plastic and fabric which defines a hollow core in the cable in which the differential spring is disposed. Surrounding the tube 33 are the stranded conductors 34 that carry the current. A heavy rubber jacket 35 is placed around the conductors to define the outer limits of flow for the cooling water in the cable. The cooling water flows generally over, around and between the copper conductors 34 within the area defined by the tube 33 on the inside and the jacket 35 on the outside.

The copper conductors 34 are terminated between a cylinder 36 and a cup 37 that surrounds the cylinder. The ends of the wires that form the least flexible section 17 of the differential spring are placed between the cup and cylinder along with the conductors 34. The conductors and the end of the differential spring are then soldered or brazed into position. The more flexible sections 18 and 19 of the differential spring are disposed within the tube 33 and are attached thereto by clamps 39 and 40 that clamp the tube 33 to one or more of the discs 22, 23, 24.

When the differential spring is used for supporting electrical cables that carry heavy currents, such as a cable for supplying an electric arc furnace, the spring wires 20 forming the differential spring are preferably made of a nonmagnetic material such as stainless steel to avoid induced heating from the heavy currents carried by the cable. The discs 22, 23, 24 are likewise preferably made of a nonmagnetic material that is also light and durable, for example, Micarta.

When used as illustrated in FIG. 3, the differential spring will furnish decreasing resistance to bending in the sections 17, 18, 19, the maximum resistance occurring in section 17 nearest the termination point, thereby allowing the cable to bend in a more natural arc. The differential spring, by connecting the tube 33 to the termination, also causes the tube to assist in supporting the weight of the cable and cooling water which heretofore has been supported solely by the conductors 34.

Water cooled electrical cables are also made with a spiral spring as a hollow core defining means rather than the tube 33 shown in FIG. 3. The spiral spring is generally attached to the termination. In cables having a spiral spring the differential spring may be routed through the inside or around the outside of the spiral spring. The spiral spring may also be connected to the most flexible section of the differential spring. In that case the spiral spring is connected to the termination through the differential spring.

The differential spring may also be mounted on the outside of the conductors 34. In that case the differential spring would, of course, be of larger diameter and employ discs having a hollow core of appropriate diameter as shown in FIG. 4.

FIG. 4 illustrates my differential spring disposed about the exterior of a water cooled electrical cable substantially the same as that shown in FIG. 3. The ends of the spring wires 20

of the least flexible section 17 are strapped to the cable adjacent the terminating block 32 by straps 42, 43 and 44. With this arrangement, the differential spring again provides differential resistance to cable bending, causes the cable to bend in a more natural gentle arc, and dampens cable sway and flexing. The arrangement shown in FIG. 4 is easily made and the differential spring can be applied to cables previously installed with a minimum of effort and inconvenience.

FIG. 5 illustrates an alternate form of differential spring according to my invention. In this embodiment, each of the sections 17, 18, 19 comprises the same number of spring wires 49, 50, 51 respectively. The differential effect is obtained by using wires 49, 50, 51 of different thickness or diameter in the sections 17, 18 and 19, respectively, the largest diameter wire being used in section 17 to provide the least flexibility or greatest resistance to bending. The spring wires 49, 50, 51 instead of passing through the discs 22, 23, 24 are terminated on the faces of the respective discs by, for example, connection to a pin, staple, or other suitable means anchored to the disc, as shown at 52. With this manner of terminating the spring wires 49, 50, 51, the sections of tubing 30 shown in the embodiment of FIG. 2 are unnecessary since the termination means itself will prevent sliding of the discs 22, 23, 24 with respect to the wires 49, 50, 51.

The embodiment of FIG. 5 is slightly more complex and requires greater assembly time than the embodiment of FIG. 2, but because of the equal number of wires the sections are more balanced and symmetrical in use than those in the embodiment of FIG. 2.

It will be apparent to those skilled in the art that the problems associated with supporting any heavy flexible conduit, for example, a hose that carries cooling water for industrial applications, are quite similar to those encountered in supporting water cooled electrical cables. Accordingly, it will be understood that my invention is intended to encompass the use of my differential spring for supporting flexible conduits other than the water cooled electrical cable specifically described.

While I have specifically illustrated and described a preferred and an alternate form and embodiment of my invention, changes, improvements, and additional uses will occur to those skilled in the art who come to understand its essential principles and accomplishments. I do not, therefore, wish to be confined to the specific forms and uses of my invention herein specifically disclosed, nor in any other way inconsistent with the progress by which my invention has promoted the art.

I claim:

1. In combination, an electrical cable having means defining a hollow core therein and having a terminal and means supporting said cable adjacent said terminal comprising a series of spring wire sections having different flexibilities joined end to end within said cable, said series being arranged to have a first end section of minimum flexibility and to increase in flexibility in each section to a second end section of maximum flexibility, means attaching said first end section to said terminal, and means attaching said second end section to said hollow core defining means, whereby said hollow core defining means is connected to said terminal through said sections to assist in supporting the weight of said cable.

2. The combination of claim 1 wherein said sections are formed of different numbers of parallel spring wires, the number of said spring wires decreasing in said sections from said first end section to said second end section.

3. The combination of claim 1 wherein said sections are formed of equal numbers of parallel spring wires, the thickness of said spring wires decreasing in said sections from said first end section to said second end section.

4. In combination, a flexible conduit having a hollow interior and a differential spring for supporting said conduit adjacent a termination to which it is connected comprising a series of spring wire sections having different flexibilities joined end to end in said conduit, said series being arranged to have a first end section of minimum flexibility and to increase in flexi-

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bility in each section to a second end section of maximum flexibility, said sections having a shape and size throughout their length conforming substantially to the shape and size of said interior, and means attaching said first end section to said termination.

5. The combination of claim 4 wherein said sections are formed of different numbers of parallel spring wires, the number of said spring wires decreasing in said sections from said first end section to said second end section.

6. The combination of claim 4 wherein said sections are formed of equal numbers of parallel spring wires, the thickness of said spring wires decreasing in said sections from said first end section to said second end section.

7. Means for reinforcing a flexible conduit against bending and radial deformation comprising a series of spring wire sections having different flexibilities and means joining said sec-

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tions end to end to have a common longitudinal axis, said series being arranged to have a first end section of minimum flexibility and to increase in flexibility in each section to a second end section of maximum flexibility, each section comprising a plurality of parallel spring wires defining a hollow cylinder and being flexible against radial deformation and against bending in any direction about said longitudinal axis.

8. The means as defined in claim 7 wherein said sections are formed of different numbers of parallel spring wires, the number of said spring wires decreasing in said sections from said first end section to said second end section.

9. The means as defined in claim 7 wherein said sections are formed of equal numbers of parallel spring wires, the thickness of said spring wires decreasing in said sections from said first end section to said second end section.

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