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[54] **ELECTRICAL CONNECTOR**
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174/28, 174/88
 [51] Int. Cl..... **H01b 9/06**
 [50] Field of Search..... **174/13, 14,**
28, 29, 15C, 88B, 21.4, 99E; 339/9E

ABSTRACT: A connector for electrically connecting associated ends of a pair of elongated electrical conductors while allowing relative movement therebetween and an electrical power transmission system using such connector.

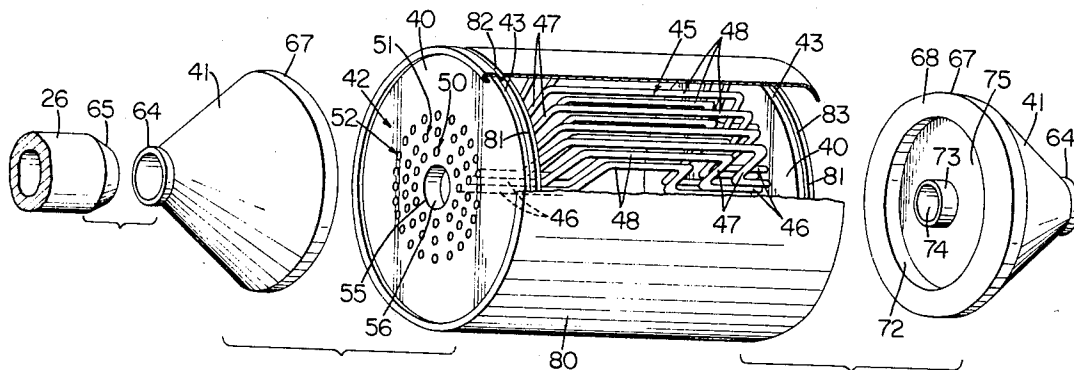
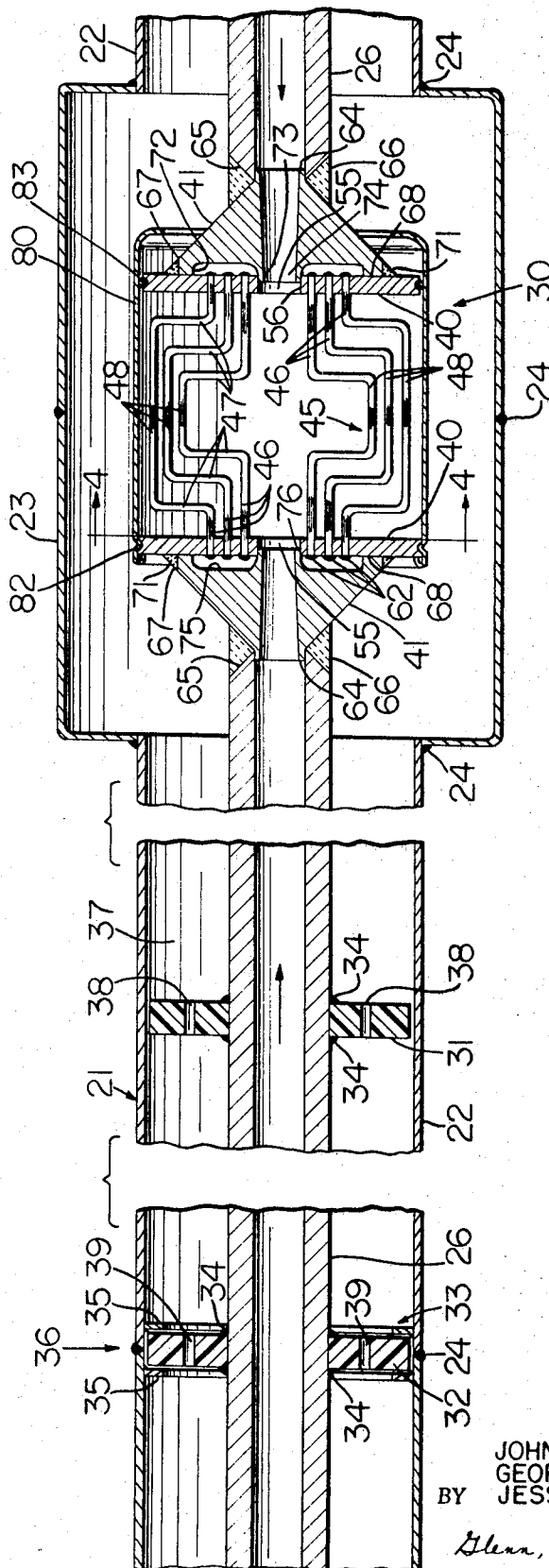


FIG-3



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FIG-4

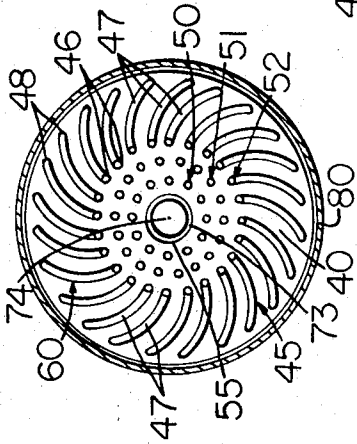


FIG-5

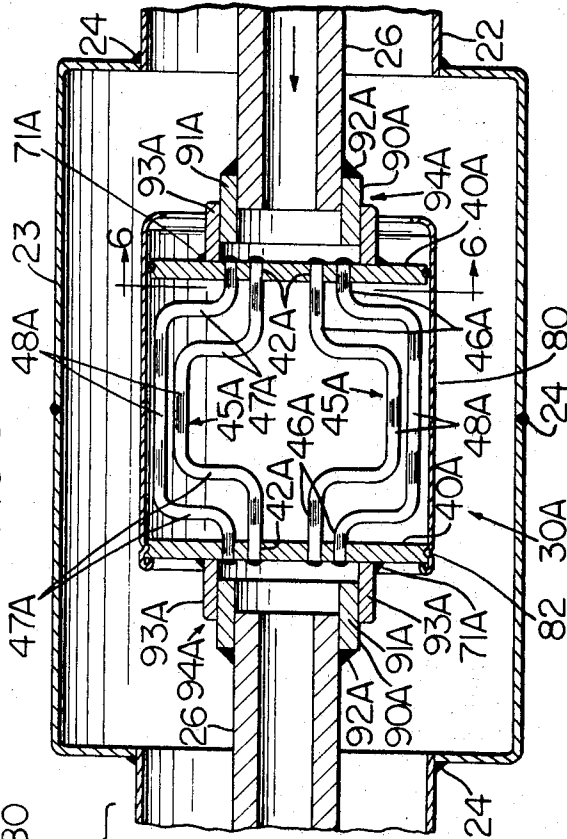
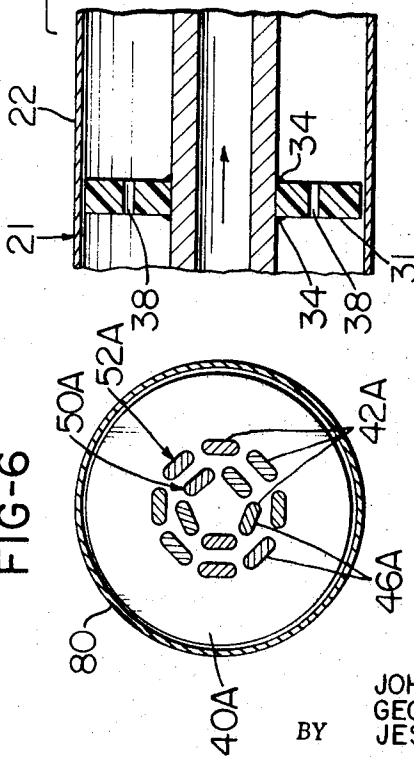


FIG-6



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ELECTRICAL CONNECTOR

BACKGROUND OF THE INVENTION

Electrical power transmission conductors used transmit electrical power over great distances are subject to a wide range of temperatures causing large expanding and contracting movements thereof. In underground systems, for example, the conductors must be supported laterally within confined limits and such conductors expand and contract comparatively large amounts along their lengths. Accordingly, it is necessary to provide suitable connectors, commonly referred to as expansion joints, between adjoining end-to-end underground conductors to compensate for the large amounts of longitudinal expansion and contraction mentioned above. Each of the previously proposed expansion joints used in association with housed conductors is deficient in one or more of the following respects in that it is too expensive to produce and install, occupies too much space, does not provide an adequate current carrying capacity across the expansion joint, and has great rigidity which results in heavy loads in an associated system due to expansion and contraction.

SUMMARY

This invention provides an improved connector, i.e., expansion joint, for electrically connecting associated ends of a pair of elongated electrical conductors which is of simple and economical construction, occupies a comparatively small volume, provides conductivity which is no less than the conductivity of its associated electrical conductors, and is comparatively freely expandable and contractible in response to contraction and expansion of its associated electrical conductors. This invention also provides an improved housed electrical power transmission system which provides efficient electrical power transmission while substantially eliminating undue stresses in the end-to-end electrical conductors relative to their associated protective conduit or housing.

Other details, uses, and advantages of this invention will become apparent as the following description of the exemplary embodiments thereof presented in the accompanying drawings proceeds.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings show exemplary embodiments of this invention, in which

FIG. 1 is a view with parts in section and parts broken away illustrating a plurality of electrical conductors suitably fastened in end-to-end relation and with an exemplary expansion joint of this invention fastened in position between each adjoining pair of electrical conductors and illustrating such conductors and expansion joints carried within an associated protective conduit of the type used in housed power transmission systems;

FIG. 2 is an exploded perspective view with parts in section and parts broken away particularly illustrating the component parts of the exemplary electrical expansion joint of FIG. 1;

FIG. 3 is an enlarged cross-sectional view with parts broken away particularly illustrating the expansion joint of FIG. 1 installed in position between a pair of associated electrical conductors and showing two types of spacers which may be used to support an electrical conductor substantially centrally within its associated protective conduit;

FIG. 4 is a view taken on the line 4-4 of FIG. 3 particularly illustrating the arcuate configuration of the outwardly extending legs of a plurality of outer U-shaped leads comprising the expansion joint of FIG. 1;

FIG. 5 is an enlarged cross-sectional view with parts broken away illustrating another exemplary embodiment of the expansion joint of this invention; and

FIG. 6 is a view taken on the line 6-6 of FIG. 5.

DESCRIPTION OF ILLUSTRATED EMBODIMENTS

Reference is now made to FIG. 1 of the drawings wherein one exemplary embodiment of an electrical power transmission system of this invention is illustrated and designated generally by the reference numeral 20. The power transmission system 20 may be used in any application where it is desired to transmit electrical power through housed conductors and comprises an outer protective conduit or housing which is designated generally by the reference numeral 21 and is defined by a plurality of substantially identical cylindrical conduit sections 22 and a plurality of cooperating comparatively large diameter cylindrical sections 23 suitably fixed in position at predetermined intervals and such comparatively large diameter cylindrical portions 23 are adapted to receive an expansion joint of this invention therewithin.

The sections 22 and 23 of conduit 21 may be fastened together in any suitable manner so as to provide a fluidtight connection therebetween; however, in this example of the invention such conduit sections are shown as being welded together so as to provide a fluidtight connection of high quality and optimum structural strength between adjoining conduit sections and a representative few of such welds have been designated by the same reference numeral 24 in FIG. 1 of the drawings.

The exemplary electrical power transmission system 20 shown in FIG. 1 has a plurality of elongated electrical conductors 26 carried within the conduit 21 and each conductor 26 of this example of the invention has a cylindrical configuration. The power transmission system 20 uses an embodiment of an electrical expansion joint which is designated generally by the reference numeral 30 and provided for electrically connecting associated ends of each pair of electrical conductors 26.

The power transmission system 20 has a plurality of electrical insulating spacers 31 fixed to each electrical conductor 26 at spaced intervals and the spacers support their associated lead within the conduit 21 while allowing axial sliding movement of the electrical conductors 26 within the conduit 21. The power transmission system 20 also has a plurality of dual-purpose spacers 32; and, in this example of the invention each dual-purpose spacer is fixed to an associated elongated electrical conductor 26 along the central portion thereof. Each dual-purpose spacer 32 supports its associated conductor 26 within the conduit 21 in a similar manner as each spacer 31; however, each spacer 32 is also anchored or fixed to the conduit 21 as shown at 33 to assure that axial expansion and contraction of the associated conductor 26 due to temperature changes occurs only on opposite sides of the dual-purpose spacer 32 to thereby prevent the associated conductor 26 from "creeping" or "walking" axially along the conduit 21.

The spacers 31 and 32 are made of an electrical insulating material so as to electrically insulate the conductors 26 from the conduit 21. Further, each spacer 31 and 32 may be fixed to its associated electrical conductor 26 in any suitable manner such as by a suitable cement, by welding a bead adjacent each side of each spacer 31 and 32 and as shown at 34, or by fixing a pair of annular bands to an associated conductor 26 and on opposite sides of a particular spacer, for example.

Each dual-purpose spacer 32 of this example of the invention is attached or anchored axially along conduit 21 by welding a pair of annular flanges 35, see FIG. 3, adjacent associated terminal ends of a pair of conduit sections 22 which are to be placed in abutting end-to-end relation. The conduit sections 22 with their flanges 35 fixed in position are then placed together as shown at 36 so that an associated spacer 32 is sandwiched between the flanges 35 whereupon the abutted ends of conduit sections are welded together to thereby fix the central portion of the associated conductor 26 within the housing 21 to prevent excessive creeping or walking of the conductor in either direction within the conduit 21.

The power transmission system 20 utilizing the exemplary expansion joint 30 preferably utilizes an electrically noncon-

ductive (i.e., electrical insulating) fluid such as an inert gas, for example, under pressure which is carried within the conduit 21 so that it fills the volume between each electrical conductor 26 and expansion joint 30 and the outside conduit 21. This utilization of an inert gas under pressure helps to assure the provision of maximum electrical insulation along the full length of each electrical conductor 26. Further, the use of an electrical insulating fluid also serves to dissipate heat away from the conductors 26 and expansion joints 30 and thereby helps to cool these components.

To assure that the inert gas indicated by the reference numeral at 37 in FIGS. 1 and 3 is free to flow along the full length of the conduit 21 each spacer 31 and 32 has a plurality of openings 38 and 39 respectively provided therein and the openings 38 and 39 assure unobstructed flow of inert gas along the full length of the conduit 21. The openings 38 and 39 in each insulating spacer 31 and 32 respectively may be provided in any desired pattern.

Having described in general terms the electrical power transmission system 20 with its conduit 21, electrical conductors 26, spacers 31 and 32, and expansion joints 30 between each adjoining pair of conductors 26, the description will now proceed with a detailed description of the exemplary expansion joint 30 illustrated in FIG. 1.

The expansion joint 30 comprises a pair of spaced circular plates or supports 40 each fixed to an associated electrical conductor 26 through the use of a transition member 41. Each plate 40 has a plurality of openings 42 provided therein and the openings 42 are arranged inwardly of its peripheral outline indicated at 43. The plates 40 of this example of the invention are substantially identical and the openings 42 in one plate 40 are arranged opposite corresponding openings 42 in the other plate 40 so as to define a plurality of cooperating sets or pairs of openings in such plates. Further, each cooperating set of openings is arranged so that a straight line through the center of each set is arranged parallel to the central axis of the expansion joint 30.

The expansion joint 30 also has a plurality of substantially U-shaped axially flexible electrical leads 45 extending between the plates 40 and the leads 45 have the same length. Each substantially U-shaped lead 45 has identical opposite end portions 46 which are arranged in aligned relation on a common axis, i.e., end portions 46 are arranged in a rectilinear path. Each U-shaped lead also has a bight 48 and a pair of substantially parallel legs 47 extending outwardly therefrom and the end portions 46 extend in opposite directions from the terminal outer ends of the legs 47. The opposite end portions 46 extend through an associated set of cooperating openings 42 in the plates 40 and each end portion 46 is fixed to its associated plate so that with movement of the plates 40 toward and away from each other the U-shaped leads 45 deflect or flex to compensate for movement of the plates 40.

Each of the plates 40 has its openings 42 formed therein so that they are arranged on a plurality of concentric circles and in this example of the invention a plurality of three concentric circles designated generally by the reference numerals 50, 51 and 52 are illustrated. If desired, the openings 42 in each plate 40 may be arranged so that a radial line extending from the center of the concentric circles 50-52 outwardly along the plate 50 will not intersect openings 42 provided in two immediately adjacent concentric circles to thereby assure maximum spacing is provided between each immediately adjacent pair of openings 42 arranged on different concentric circles.

The plates 40 illustrated in this example of the invention have a circular peripheral outline and each plate has a comparatively large central opening 55 extending therethrough and defined by a substantially right circular cylindrical surface 56. As previously mentioned the U-shaped leads 45 have the same overall length and such leads have all been designated by the reference numeral 45 for convenience and ease of presentation; however, it will be appreciated from FIGS. 2 and 3 of the drawings and the presentation to be made subsequently

that although all of the leads 45 have similar configurations, all leads 45 do not have identical configurations.

The U-shaped leads 45 are fixed at their opposite ends 46 to the plates 40 so that the bight 48 of each lead 45 extends toward the outer periphery, i.e., circumference 43 of the circular plates 40. The U-shaped leads 45 associating with openings 42 arranged on the innermost concentric circles 50 each have a narrow bight 48 and comparatively long end portions 46. The U-shaped leads 45 associating with the outermost concentric circles 52 each have a comparatively wide bight 48 and comparatively short end portions 46. Similarly, the intermediate U-shaped leads 45 associating with the intermediate concentric circles 51 each have a bight 48 of intermediate width and end portions 46 of intermediate length.

With this arrangement it will be seen that a maximum number of U-shaped electrical leads 45 that are axially flexible are provided between the plates 40 to, in effect, provide an axially flexible electrical expansion joint 30 wherein the combined conductivity or current carrying capacity of the U-shaped leads 45 is not less than that of each conductor 26. In fact, the combined conductivity of the U-shaped leads 45 is generally greater than the conductivity of either of the conductors 26 so as to provide an electrical connection providing optimum performance.

From the illustration presented in FIGS. 2-4 of the drawings, it will also be seen that the size and arrangement of the plates 40 and U-shaped leads 45 enable the provision of flexible leads having maximum length for easy flexing yet in a comparatively small volume as determined by the circumference 43 of each plate 40 and the distance between such plates. To help assure that each substantially U-shaped lead 45 has a maximum length and therefore is easier to flex, the outwardly extending legs 47 of each U-shaped lead are preferably arranged to extend in an arcuate path as illustrated at 60, see FIG. 4, for a typical U-shaped lead 45. Only the U-shaped leads 45 associating with the outer concentric circles 52 are illustrated as extending in an arcuate path in FIG. 4 of the drawings; however, it will be appreciated that all of the electrical leads 45 may have their leg portions 47 similarly arranged. Further, each U-shaped lead 45 associating with a given concentric circle will preferably have its bight 48 arranged at a different radial position than the bight 48 of a U-shaped lead 45 associating with an immediately adjacent concentric circle whereby maximum spacing may be provided between the U-shaped leads 45 comprising the expansion joint 30.

The U-shaped leads 45 are fixed to their associated circular plates 40 after first extending their opposite end portions 46 through associated openings 42 in the supports or plates 40. The outside diameter of each end portion 46 is correlated to the diameter of an associated opening 42 to provide a snug fit between each end portion 46 and its associated plate 40. This snug fit enables the U-shaped leads 45 to be positioned so that the bight 48 of each U-shaped lead 45 is arranged and held at the desired position without requiring special holding fixtures, or the like, prior to fixing the U-shaped leads 45 to the plates 40.

Any suitable technique may be used to fix the end portions 46 of the U-shaped leads 45 in position against each associated plate; however, one technique which has been successfully utilized is to weld each outer end portion 46 of each U-shaped lead 45 to its associated plate 40 as indicated at 62 in FIG. 3.

Reference is now made to FIG. 2 of the drawings for a detailed presentation of the transition members 41 and the manner of attaching members 41 in position. Each transition member 41 of the exemplary expansion joint 30 has a substantially frustoconical configuration and has an inner end portion 64 which corresponds in peripheral outline to its associated electrical conductor 26. Each conductor 26 has a tapered end portion 65 which is arranged, i.e., abutted, against the end portion 64 and suitably fixed thereto. In this example of the invention the conductor 26 is preferably welded to transition member 41 by a weld 66 between tapered end portion 65 of

conductor 26 and inner end portion 64 of the transition member 41.

Each transition member 41 also has a comparatively large diameter outer end portion 67 and the large diameter outer end portion 67 of each transition 41 has an annular planar surface 68 which is placed against an associated plate 40 and welded in position and as indicated at 71 in FIG. 3. The small inside diameter portion 72 of annular planar surface 68 is arranged against its associated plate 40 so that it is positioned outwardly of the outermost of the concentric circles 52 previously described. This arrangement assures that the end portions 46 of the U-shaped electrical leads 45 associating with the openings 42 arranged in the outer concentric circles 52 do not interfere with the placement of annular surface 68 against the outer planar surface of an associated plate 40.

Each transition member 41 also has a central cylindrical projection 73 which corresponds in configuration to the central aperture 55 provided in an associated plate 40. The central projection 73 enables the associated transition member 41 to be installed and centered in position against cylindrical surface 56 of an associated plate 40 to enable welding thereof at a precise position. Each member 41 is of substantially frustoconical configuration, as previously indicated, and has an aperture 74 extending axially therethrough. The projection 73 and annular surface 68 previously described is defined by providing a cutout portion 75 in the large diameter inner end portion 67 of member 41. Further, the terminal end portion of projection 73 extends outwardly of the plane of the annular planar surface 68 as indicated at 76 so as to provide the centering action described above. Thus, it is seen that the expansion joint 30 has identical transition members 41 fastened to plates 40 arranged at its opposite ends and U-shaped leads 45 extending between the plates 40 so that an integral unit of comparatively small outside peripheral outline, i.e. diameter, is provided which is comparatively easy to flex axially yet has optimum structural integrity and current carrying capacity.

The connector 30 also has a cylindrical anticorona discharge shield 80 suitably fastened in position around the circular plates 40. Each of the circular plates 40 has an annular groove 81 provided therein so that it extends radially inwardly toward the center of the plate 40.

The shield 80 has an annular fastening projection 82 adjacent one end which is received within an associated annular groove 81 of one plate 40 so as to fasten the associated end of the shield 80 in position. The annular groove 81 provided in the oppositely arranged plate 40 has an antifriction annular ring such as a Teflon ring 83 and the ring 83 provides wear resistance between the shield 80 and its associated plate 40.

During the expansion and contraction of the electrical conductors 26 there is a tendency for the circular plates 40 to move toward and away from each other. With the cylindrical shield 80 fastened to one of the plates 40 the shield 80 is free to slide across the ring 83 in an unrestrained manner.

In the exemplary embodiment of this invention illustrated in FIGS. 1-4 of the drawings the conductors 26 and expansion joints 30 may be made to any suitable electrically conductive material. Further, the outer protective conduit 21 with its conduit sections 22 and 23 may be made of any suitable protective material either metallic or nonmetallic. In particular, conductors made of EC 1100 or 6201 aluminum alloys have been successfully utilized and wherein the tubular conductors 26 had an outside diameter of 3 inches and an inside diameter of 1½ inches. The shield 80 may also be made of the aluminum alloys such as EC 1100, 6061 or 3003; and, outer protective conduits made of 6063-T4 aluminum alloy have been successfully utilized.

The U-shaped leads 45 may be uninsulated or electrically insulated along their full lengths except at their outer end portions 46 where they are electrically connected to their associated plates 40. Also, any desired number and arrangement of leads 45 may be used between associated plates 40. The exemplary expansion joint 30 illustrates a plurality of 54 U-shaped leads merely by way of example and, as previously in-

dicated, the leads 45 have a combined total conductivity which is equal to or greater than the conductivity of each conductor 26.

It will be appreciated that different materials may be used to make the electrical conductors 26 and electrical leads 45, accordingly a comparison between the leads 45 and conductors 26 has been expressed in this specification in terms of combined total conductivity or current carrying capacity of the leads 45 as compared with the conductivity or current carrying capacity of the conductors 26. Further, each lead 45 may be made of a single wire or of a plurality of wires suitably bunched together.

Another exemplary embodiment of this invention is illustrated in FIGS. 5 and 6 of the drawings wherein the expansion joint illustrated is very similar to the expansion joint 30; therefore, the expansion joint of FIGS. 5 and 6 will be designated generally by the reference numeral 30A and its component parts which are similar to corresponding parts of the expansion joint 30 will be designated by the same numeral as in the expansion joint 30 also followed by the letter designation A and not described again. Only those component parts which are substantially different from corresponding parts of the expansion joint 30 will be designated by a new reference numeral also followed by the letter designation A and described in detail.

The exemplary expansion joint 30A has a pair of identical transition members 90A which serve the same function as the transition members 41 of the expansion joint 30. Each transition member 90A has a small diameter cylindrical inner portion 91A which is arranged in telescoped relation over an associated electrical conductor 26 and suitably welded in position as indicated at 92A. Each transition member 90A also has a large diameter cylindrical portion 93A which is telescoped over the small diameter cylindrical portion 91A as indicated at 94A and fixed thereto in any suitable manner (such as explosive bonding, for example) so as to define a high quality electrical and mechanical connection therebetween. The terminal outer end of the large diameter cylindrical portion 93A may be welded to its associated plate 40A as shown at 71A.

The exemplary expansion joint 30 illustrated in FIGS. 1-4 of the drawings is shown as having its U-shaped leads arranged to extend between a plurality of three concentric circles 50-52 in each plate 40. However, the expansion joint 30A shown in FIGS. 5 and 6 has its U-shaped leads 45A arranged to extend between a plurality of only two concentric circles in each plate 40A and the innermost concentric circle is designated by the reference numeral 50 A, see FIG. 6, while the outermost concentric circle is designated by the reference numeral 52A.

The openings 42A in each plate 40A are of noncircular cross-sectional outline and the cross-sectional outline of each U-shaped lead 45A is also made to correspond to the cross-sectional outline of each opening 42A. In particular, the openings 42A are of substantially elliptical outline while the end portions 46A of each lead 45A are of a corresponding elliptical cross-sectional configuration. However, it is to be understood that the openings 42 and 42A in plates 40 and 40A of expansion joints 30 and 30A respectively may have any desired configuration with the associated U-shaped leads having a corresponding configuration in each instance.

The expansion joint 30A is very similar to the expansion joint 30 and serves an identical purpose of allowing relative movement between a pair of adjoining electrical conductors 26. Each expansion joint 30 and 30A has optimum structural integrity and a plurality of U-shaped leads which in each expansion joint have a combined total conductivity which is equal to or greater than the conductivity of the conductors 26. Further, each expansion joint 30 and 30A occupies a minimum amount of space or volume while enabling comparatively easy axial flexing thereof without tending to buckle the associated electrical conductors in each particular instance.

Although specific configurations have been illustrated for the transition members 41 and 90A of expansion joints 30 and

30A respectively, it will be appreciated that such configurations may be modified to provide easier attachment of chill blocks which may be used during welding of each transition member in position. Also, the particular configuration of a given expansion joint 30 or 30A may be modified to improve the electrical properties thereof so as to minimize corona discharge effects.

The cross-sectional area and configuration of each of the leads 45 and 45A of expansion joints 30 and 30A respectively is preferably determined by test so as to establish the exact force required to axially move the U-shaped leads and assure such force is substantially smaller than the force required to buckle a particular conductor 26. Also, the temper of each U-shaped lead is such as to provide the best fatigue properties.

The exemplary expansion joints 30 and 30A are shown as having their leads positioned and arranged so that the bights of the U-shaped leads have an overall substantially cylindrical peripheral outline and the comparatively larger central portion of each connector also has a cylindrical outer configuration. However, the peripheral outline defined by the bights of the U-shaped leads used to define a given expansion joint as well as the peripheral outline of the central portion of such given expansion joint may have any desired configuration such as elliptical, for example.

It will also be seen that the outer protective conduit 21 for the housed system presented in this specification has comparatively small diameter tubular sections 22 and larger diameter sections 23 suitably fixed together in end-to-end relation. The outside diameter of each section 23 is dimensioned so that it provides adequate radial clearance surrounding its associated expansion joint. However, it is to be understood that the actual overall size of a particular expansion joint and configuration and size of tubular sections 22 may be such that the outer conduit 21 may be comprised solely of end-to-end sections 22 without requiring that the larger sections 23 be utilized.

The electrical power transmission system of this invention with its housed electrical conductors and expansion joints may be used above ground as well as underground and under water.

While present exemplary embodiments of this invention, and methods of practicing the same, have been illustrated and described, it will be recognized that this invention may be otherwise variously embodied and practiced within the scope of the following claims.

We claim:

1. An expansion joint for electrically connecting associated ends of a pair of elongated electrical conductors while allowing relative movement therebetween, said expansion joint comprising, a pair of spaced apart supports each fixed to an associated one of said electrical conductors, a plurality of openings in each support, said openings being arranged inwardly of the peripheral outline of each support and opposite corresponding openings in the other of said supports to define a plurality of cooperating sets of openings in said supports, and a plurality of substantially U-shaped axially flexible electrical leads extending between said supports, each of said leads having opposite end portions extending through an associated set of cooperating openings with each end portion being fixed to its associated support so that with movement of said supports toward and away from each other said leads flex to compensate for said movement, each of said supports having its openings formed therein so that they are arranged in a plurality of concentric closed plane curves and with the bight of each U-shaped lead being arranged to extend toward the outer periphery of each support, said U-shaped leads associating with openings arranged on the innermost of said concentric closed plane curves having a narrow bight and comparatively long end portions and said U-shaped leads associating with openings arranged on the outermost of said concentric closed plane curves having a comparatively wide bight and comparatively short end portions, said U-shaped leads being arranged to provide maximum spacing between immediately

adjacent U-shaped leads, said expansion joint occupying a small volume yet providing a maximum number of easily flexible electrical leads interconnected between said electrical conductors so that the combined current carrying capacity of said leads is not less than the current carrying capacity of each electrical conductor.

2. An expansion joint as set forth in claim 1 in which the openings in each of said supports are formed in a plurality of concentric closed plane curves defined as concentric circles.

3. An expansion joint as set forth in claim 2 in which each of said substantially U-shaped leads has the same overall length.

4. An expansion joint as set forth in claim 2 in which each of said U-shaped leads comprises a bight and a pair of outwardly extending legs, said end portions on each lead extending from opposite ones of said outwardly extending legs and being arranged in a rectilinear path.

5. An expansion joint as set forth in claim 2 in which the outwardly extending legs of each U-shaped lead extend in an arcuate path so as to provide maximum length therefor within a small volume and thereby enable easier flexing of each lead within such small volume.

6. An expansion joint as set forth in claim 2 in which, said electrical conductors are of circular peripheral outline, said supports comprise a pair of substantially identical plates of circular peripheral outline with the circumference of each plate being substantially greater than the circumference of either of said electrical conductors, and further comprising a pair of identical transition members comprising opposite ends of each expansion joint, each transition member having an inner end corresponding in peripheral configuration to its associated electrical conductor and being fixed thereto and an outer end portion of annular cross-sectional area fixed to an associated plate.

7. An expansion joint as set forth in claim 6 in which each transition member is welded to its associated plate and electrical conductor.

8. An expansion joint as set forth in claim 6 in which each of said transition members has a frustoconical configuration.

9. An expansion joint as set forth in claim 8 in which each of said plates has a central aperture extending therethrough and each of said frustoconical transition members has a central projection corresponding in configuration to the central aperture in its associated plate to enable easy centering of each transition member in position on as associated plate.

10. An expansion joint for electrically connecting associated ends of a pair of elongated electrical conductors each having a circular peripheral outline while allowing relative movement therebetween, said expansion joint comprising, a pair of spaced apart substantially identical plates each having a circular peripheral outline with the circumference of each plate being substantially greater than the circumference of either of said electrical conductors, a pair of identical transition members comprising opposite ends of each expansion joint, each transition member having an inner end corresponding in peripheral configuration to its associated electrical conductor and being fixed thereto and an outer end portion of annular cross-sectional area fixed to an associated plate, a plurality of openings in each plate, said openings being arranged inwardly of the peripheral outline of each plate and opposite corresponding openings in the other of said plates to define a plurality of cooperating sets of openings in said plates, and a plurality of substantially U-shaped axially flexible electrical leads extending between said plates, each of said leads having opposite end portions extending through an associated set of cooperating openings with each end portion being fixed to its associated plate so that with movement of said plates toward and away from each other said leads flex to compensate for said movement, each of said transition members having a small diameter cylindrical portion defining said inner end portion and being arranged in telescoped relation over its associated electrical conductor and fixed thereto and having a large diameter cylindrical portion defining its outer end portion.

11. An expansion joint for electrically connecting associated ends of a pair of elongated electrical conductors each having a circular peripheral outline while allowing relative movement therebetween, said expansion joint comprising, a pair of spaced-apart substantially identical plates each having a circular peripheral outline with the circumference of each plate being substantially greater than the circumference of either of said electrical conductors, a pair of identical transition members comprising opposite ends of each expansion joint, each transition member having an inner end corresponding in peripheral configuration to its associated electrical conductor and being fixed thereto and an outer end portion of an annular cross-sectional area fixed to an associated plate, a plurality of openings in each plate, said openings being arranged inwardly of the peripheral outline of each plate and opposite corresponding openings in the other of said plates to define a plurality of cooperating sets of openings in said plates, and a plurality of substantially U-shaped axially flexible electrical leads extending between said plates, each of said leads having opposite end portions extending through an associated set of cooperating openings with each end portion being fixed to its associated plate so that with movement of said plates toward and away from each other said leads flex to compensate for said movement, each of said plates having its openings formed therein in a plurality of concentric circles and the inside diameter of the annular cross-sectional area of the outer end portion of each transition member being arranged outwardly of the outermost of said concentric circles so that upon inserting said U-shaped electrical leads through associated openings in said plates said outer end portions of said transition members are spaced outwardly of said leads to assure each outer end portion of each transition member is fixed to its associated plate without interference from said leads.

12. An expansion joint for electrically connecting associated ends of a pair of elongated electrical conductors each having a circular peripheral outline while allowing relative movement therebetween, said expansion joint comprising, a pair of spaced-apart substantially identical plates each having

a circular peripheral outline with the circumference of each plate being substantially greater than the circumference of either of said electrical conductors, a pair of identical transition members comprising opposite ends of each expansion joint, each transition member having an inner end corresponding in peripheral configuration to its associated electrical conductor and being fixed thereto and an outer end portion of an annular cross-sectional area fixed to an associated plate, a plurality of openings in each plate, said openings being arranged inwardly of the peripheral outline of each plate and opposite corresponding openings in the other of said plates to define a plurality of cooperating sets of openings in said plates, a plurality of substantially U-shaped axially flexible electrical leads extending between said plates, each of said leads having opposite end portions extending through an associated set of cooperating openings with each end portion being fixed to its associated plate so that with movement of said plates toward and away from each other said leads flex to compensate for said movement, each of said circular plates having a substantially cylindrical outer surface and an annular groove therein extending radially inwardly beneath said cylindrical surface, a cylindrical anticorona discharge shield having an annular fastening projection adapted to be received within an annular groove of one of said circular plates to fasten said shield in position and prevent axial movement thereof relative to said one plate, said cylindrical shield extending between said plates and outwardly beyond the other of said plates, and an antifriction annular member carried within the annular groove of the other of said circular plates to minimize wear between said shield and said other plate while allowing free axial sliding movement of said shield relative to said other plate.

13. An expansion joint as set forth in claim 2 in which each U-shaped lead associating with a given concentric circle has its bight arranged in a different radial position than the bight of a U-shaped lead associating with an immediately adjacent concentric circle to thereby assure provision of said maximum spacing.

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