Dec. 23, 1952 M. D. BERGAN 2,622,314

METHOD OF FORMING SPLICED SECTOR CABLES

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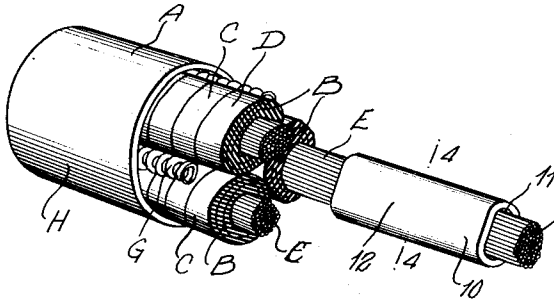


Fig. 1.

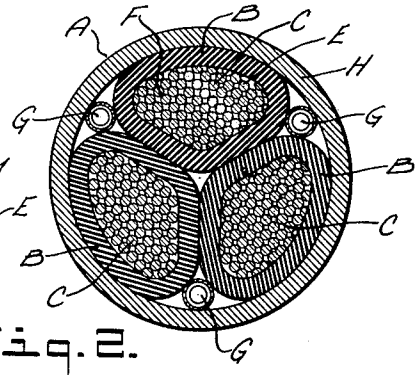


Fig. 2.

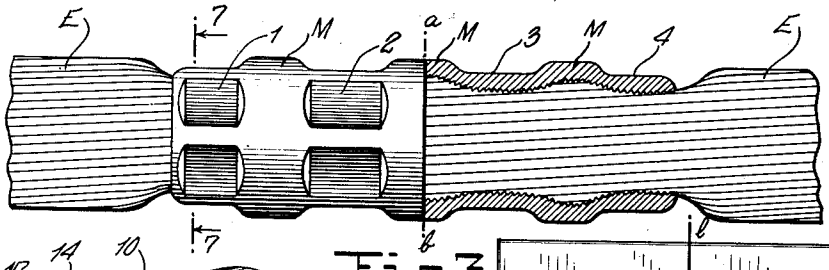


Fig. 3.

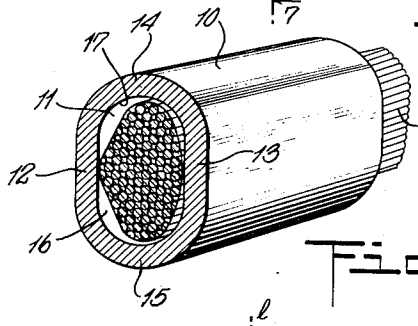


Fig. 4.

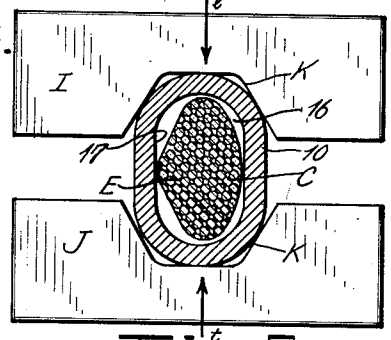


Fig. 5.

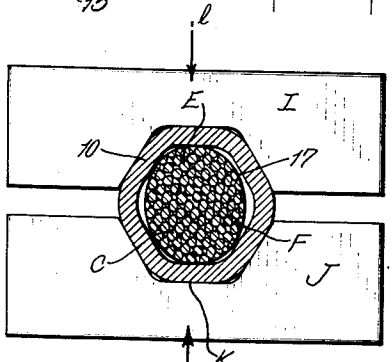


Fig. 6.

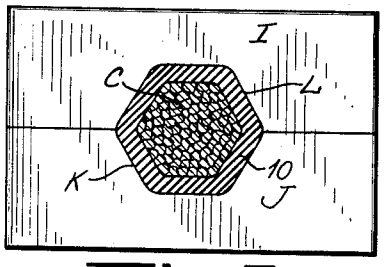


Fig. 7.

INVENTOR.
MARTIN D BERGAN
BY
Warren S. Oeton.
ATTORNEY

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METHOD OF FORMING SPLICED SECTOR CABLES

Martin D. Bergan, Westfield, N. J., assignor to The Thomas & Betts Co., Elizabeth, N. J., a corporation of New Jersey

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1 Claim. (Cl. 29—148)

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The invention relates to the art of coupling together the ends of electric conductors of the type known as sector cables and also relates to the resulting article.

In sector cables the conductors are formed of wire strands spirally twisted together lengthwise to form a core of such wires and which cores are somewhat elliptical in cross section. More specifically defined conductors of sector cables and particularly their stranded wire cores each have their radii rounded into each other and into its arc side. The cores of sector cables are of two forms, one compact and the other not compact. In the compact form the initially round wire strands become polygonal shaped in cross section as a result of efforts to get their core cross section of least dimension and this is done during the manufacture of the cable. In the non-compacted form, the wire strands are all in their initial shape round in cross section with interstices formed between the wires.

In general, the invention relates broadly to the art of connecting sector cables or conductors in end-to-end relation by means of a coupling sleeve into opposite ends of which the bared ends of the conductors are intruded, and the sleeve is then squeezed and otherwise distorted into a crimping engagement with both conductors. Usually such conductors are round in cross section and the coupling sleeves used therewith have a bore of cylindrical form and dimensioned to receive the conductors therein with a more or less snug fit. It has also been known in the art of sector shaped conductors to couple them together by means of a coupling sleeve the bore of which is of a sector shape and dimensioned to receive the sector cables fitted therein with a more or less snug fit and thus without intentional clearance provided therebetween before the sleeve is crimped thereon.

The present invention contemplates an improvement in the technique of coupling together, by the use of a coupling sleeve, the ends of sector-shaped conductors of both the compact and non-compact type and which coupler or splicer sleeve sometimes referred to as a sector cable splicer is utilized to function not only as a connector but also as a former or tool for giving shape to the portions of the conductors crimped thereby.

The primary object of the invention insofar as its method aspects is concerned is to cause a relative shifting of the wire strands of the sector cables in passing from their initial circular or polygonal form into their final hex form under pressure to effect a burnishing action sufficient

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to cause the wire strands to break through the oxide coatings usually formed on both the wires and on the splicing sleeve, and thus to provide a low resistance joint between the conductors and splicing sleeve incidental to the usual crimping operation.

Briefly, this objective is attained by fitting the sector cable into the elliptical bore of a sleeve relatively dimensioned so that there will be initially only the slight and necessary clearance between the cable and sleeve and then subjecting the sleeve to a distortion force under such squeeze pressure as will in succession take up the clearance, will shift the strands of the portions of the conductor in the parts thereof so crimped which contract the cable and sleeve into a smaller all-over section, and will eventually change the initial sector-elliptical form of the assembly into a compacted design of a different cross-sectional design or non-circular geometric form, preferably into a small hex.

Briefly, this objective is attained by practicing the following steps; first, by rotating one after the other the sector cables to be joined, so as to match the ends of the bared conductors as they are brought into alignment; second, by intruding the bared ends so rotatively matched into a splicing sleeve whose bore is elliptical or substantially so and dimensioned in both its major and minor axes to receive the associated sector cable conductor, dimension for dimension, and with a sliding fit, and otherwise, related with very little clearance between them; and finally, to subject each end of the sleeve to at least one crimping operation to deform the sleeve and the portion of the conductor therein to cause both of them to assume a highly compacted form hexagonal in cross section.

The object of the invention relative to its mechanical aspect is to provide a highly efficient mechanical and electrical connection between cables the cores of at least one of which is of sector form.

Various other objects and advantages of the invention will be in part obvious from a consideration of the method features of the disclosure and from an inspection of the accompanying drawings and in part will be more fully set forth in the following particular description of one method of practicing the invention, and the invention also consists in certain new and novel modifications of the preferred method and other features of construction and combination of parts hereinafter set forth and claimed.

In the accompanying drawings:

Fig. 1 is a view in perspective of a three unit, non-compact sector cable of the type whose component sector conductors are intended to be spliced following the invention herein disclosed and which also shows a pair of conductor ends with a splicing sleeve in position thereon prior to being crimped on to the cores intruded therein;

Fig. 2 is a transverse sectional view through any portion of either one of the cables to be spliced;

Fig. 3 is a view of one conductor of each cable coupled in accordance with the features herein disclosed; one half showing the coupling sleeve in elevation and the other half in axial section;

Fig. 4 is a view partly in section taken on the line 4—4 of Fig. 1 and partly in perspective showing the first step of the operation herein featured with the elliptical sleeve loose on one of the sector conductor cores;

Figs. 5 to 7 inclusive are successive views in transverse section of either sector conductor taken at any one of the areas to be crimped such, for instance, as on the line 7—7 of Fig. 3 and showing succeeding steps of the sleeve and core being crimped by the coacting dies of a crimping tool; Fig. 5 showing the relation of sector core and elliptical sleeve at the beginning of a crimping operation; Fig. 6 showing an intermediate stage featuring a fat elliptical form of the shifting core; and Fig. 7 showing the relation of hexagonal core and forming sleeve at the completion of the crimping operation.

In the drawings and referring first to Figs. 1 and 2, for a showing of one of the sector cables to be crimped, there is disclosed a cable A, which is formed of three sector conductors B, arranged in nested relation as shown in Fig. 2. These conductors B are of identical cross sectional configuration so that the detailed description of one will be sufficient for the other two. Each conductor includes a central core C wrapped with an insulation D. The conductor cores C are formed of longitudinally twisted wire strands E and which in the illustrated instance are circular in cross section with interstices F therebetween. Cables of this character usually contain gas tubes G, the whole being enclosed in a lead-sheet jacket H.

It is obvious that in connecting cables in end-to-end relation, the lead sheet of each cable is cut back to expose the ends of its conductors, and the insulation of each cable is cut back to expose its wire strand core. The cables each considered as a whole are relatively rotated so that the conductor ends of one cable will match those of the other in end-to-end alignment. The bared ends of conductor of each cable is then coupled to the corresponding conductor of the other cable by a splicing sleeve particularly constituting the novel feature of the apparatus aspect of this disclosure, so that in the case of the three conductor type of cables herein illustrated, three coupling sleeves will be used. The three sleeves are finally disposed in parallel nested relation in the completed reformed and spliced cabled assembly.

Referring to Figs. 1 and 4 there is disclosed a connector splicing or coupling sleeve 10 which initially is of elliptical form with uniform cross section of material, it being particularly noted that its bore 11 is substantially elliptical or perhaps more accurately described is defined by a pair of parallel straight sides 12 and 13 rounding at opposite ends into each other at top and bottom by means of edges forming arched portions 14 and 15 and which edge portions are circular in cross section. The bore 11 is dimensioned to have an easy sliding but otherwise fairly snug fit on the wire strand conductor C intruded therein. It is a feature of this disclosure that the clearance 16 between the cable core C and the inner wall 17 of the bore 11 be of the least possible aggregate cross sectional area. In other words, the cross sectional area of the bore 11 is only so much greater than the cross section of the core C as will permit the core to be intruded into the bore, taking into consideration that the sleeve is of the so-called elliptical form herein featured and that the core is of the so-called sector form in cross section.

Each pair of conductors are coupled together with one of these sleeves 10 by intruding the bared end of one of the conductors into one end of the sleeve and the bared ends of its companion sector cable conductor is intruded into its opposite end, the ends meeting at or adjacent to the medial plane *a*—*b* as indicated in Fig. 3. Opposite ends of the sleeve are then subjected to the crimping action of a crimping tool as suggested in Figs. 5 to 7. In these figures the crimping tool is of the high pressure portable hydraulically operated type, the tool elements of which include a pair of coacting dies I and J, the opposing work faces of which are defined by a three-sided recess K coacting when the dies are in their final position to form the recess L hex in cross section as shown in Fig. 7 and of less cross sectional area than the aggregate cross sectional area of the cable core and coupling sleeve when in their original uncrimped form as shown in Figs. 4 and 5.

Referring to Fig. 5 for the first step of the crimping operation, it will be noted that the line of thrust *l*—*t* of the dies I and J as indicated by the arrows is along the major axis of both the conductor core C and splicing sleeve 10, and that initially the wire strands E are in whatever position they may happen to be in the balance of the cable as manufactured. As the dies are moved towards each other from the position shown in Fig. 5, to and through the position shown in Fig. 6, the sleeve in the portion so being crimped, of course, tends to assume the configuration of the recesses K in the die faces. During this time the wire strands E tend to rearrange themselves one sliding on the other and tending to assume at least momentarily the fat elliptical form shown in Fig. 6. This distension of the core has the effect of causing the strands E as they slide past one another to break through any oxide coating which may be on the surfaces of the interior strands. At the same time the outer strands are scraping against the bore wall 17 of the coupling sleeve likewise breaking through any oxide coating which may be present both on the bore wall and on the outer surfaces of the wire strands.

At the Fig. 6 stage the strands E are not so compact as they were at the initial Fig. 5 stage, and the interstices F tend to become larger than at other places along the length of the uncrimped core. However, this condition is only momentary but that is sufficient to break down any intervening oxide layers on the strands. It is a feature of this disclosure to limit the possible play of the strands while held in the splicing sleeve.

As the dies approach their fully closed position as shown in Fig. 7, the wire strands become highly compacted even to the extent of losing their

original form circular in cross section and assuming different polygonal forms with the practical elimination of any of their interstices so that the cross section of the cores at the points being crimped tend to approach the aggregate cross sectional area of the strands themselves.

The sleeve **10** at the points crimped likewise become compacted and assume the hexagonal form of constricted and shortened perimeter shown in Fig. 6. As the metal of the sleeve in the portion so crimped is thus worked, the crimped portion becomes slightly harder than the uncrimped portions M between the crimped areas which retains their relative soft character.

In the illustrated form of the invention as disclosed in Fig. 3, four crimps, numbered from left to right as **1**, **2**, **3** and **4**, two at each core end, are suggested, but it is obviously within the scope of the disclosure to use one or more crimps for each conductor.

The coupling sleeve is formed of soft copper particularly in those cases where the wire strands are of copper; however, it is obviously within the scope of the disclosure to utilize any materials usually employed in crimping tubes on to electric conductors.

Attention is particularly called to the fact that the sleeve does not snugly fit the conductor core as is known in all prior similar constructions. It is necessary that some clearance **16** be provided initially between the core and the sleeve, otherwise there would be no possibility of the gradual change in cross section configuration of the cores and their wire strands as they pass from the more or less compacted form shown in Fig. 5 through the relatively less un-compacted form shown in Fig. 7. Thus the disclosure facilitates the possibility of relative shifting of the wire strands one on the other to obtain a clean metal-to-metal contact which gives the effective splicing of the sector conductors to each other as herein featured.

While the crimping into the hexagonal form is preferable it is within the scope of the disclosure otherwise to crimp the elliptical tube onto the sector cable following any known crimp-method. For instance the connector tube may be crimped on to one or both of the sector conductors by means of a die action which will produce six-sided elliptical hexagon or even a true elliptical form without any flat sides. In this application the expression "non-circular geometric form" in cross section refers generically to any non-circular symmetrical closed form outlined by convex curves or angles connected by flat or convex curves and whose cross section may be a hexagon with flat sides and rounded convex angles as shown in Fig. 7, or it may be an elliptical hexagon with curved convex sides, or it may be of a more or less true elliptical form with its endless convex curved outline.

I claim:

In the art of securing a stranded conductor whose cross section initially is of sector form with rounded edges in a coupling sleeve initially having an approximately elliptical cross section whose bore is dimensioned to receive the conductor dimension for dimension with a sliding fit, having parallel straight sides connected at opposite ends by rounded arched portions and wherein the cross sectional area of the bore of the sleeve is only slightly greater than the area in cross section of the conductor to minimize the aggregate area of clearances between the conductor and bore wall when the conductor is in the bore, by means of a die press of the type whose opposing work die faces are defined by three-sided recesses coacting when the faces are closed in contact to form a recess hex in cross section, the method which consists in relatively rotating the conductor and sleeve while free of each other to bring the major and minor axes of the conductor into alignment, respectively, with the major and minor axes of the sleeve, sliding the conductor axially when so rotated into the sleeve, placing the sleeve with the conductor so located therein with the opposing rounded edges of the sleeve located in and substantially fitting in the recesses of the die work faces, causing the work faces of the die press to approach each to effect a uni-directional squeeze action on the sleeve with its contained conductor in the direction of the common major axes of the sleeve and conductor and at a point in the squeeze action prior to the closing of the work faces to reduce the initial dimensions of both the sleeve and conductor as measured along their major axes while momentarily permitting both the sleeve and conductor to expand as measured along their minor axes thereby to cause the conductor to move into the form of a fat ellipse in cross section, more fully filling the bore than initially, with incidental rearrangement of the wire strands which make up the conductor, to cause them to slide one over the other and to cause the conductor to open up and its interstices become larger as the conductor expands in the direction of its minor axis, continuing the squeeze action of the die press to cause a sliding of the strands on each other as the cross sectional area of the conductor contracts and continuing the squeeze action until the die faces contact and thus to deform the sleeve bore and the portion of the conductor therein to cause the same to take a form hexagonal in cross section and to crimp the wall of the sleeve into a clean, direct, metal-to-metal engagement with the conductor with incidental final compressing of the conductor strands in the portion so squeezed.

MARTIN D. BERGAN.

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