NYLON-JACKETED CONNECTOR

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This invention relates in general to electric terminal connectors of the type which includes an integral tongue portion heretofore made of an assembly of two preformed tubular sleeves in telescopic coaxial relation, in which the outer sleeve constituted a shield of insulating material and the inner sleeve constituted a ducible wire-barrel adapted to be permanently deformed by the application of a squeeze pressure through the outer sleeve to crimp the inner sleeve into a positive electric and mechanical connection with a wire or cable therein.

More specifically, the invention relates to the wire-barrel portion of a terminal connector of the type which must be made very small, one market requirement of such connector being that the tubular assembly forming the connector be about forty-hundredths of an inch in length and twenty-four hundredths of an inch in outside diameter. It is most important that the elements of the assembly be designed so that they can be made cheaply and in large quantities as a factory product.

One difficulty which has been experienced in the use of such connectors, particularly when made in such small sizes, is to prevent flash-overs and tracking. An electric path is apt to form accidentally, leading from the high potential source in the cable conductors attached to the connector, through, or more often around, the exposed ends of the outer insulating sleeve to ground on some object, and this possibility of a flash-over or tracking increases with increase of voltage, frequency and lower air pressure at high altitudes.

Tracking as herein used and sometimes referred to as surface leakage or creeping is the passage of current along a path over the surface of an insulator.

One of the primary objects of this invention is to provide in such connector a longer leakage or tracking path than has heretofore been economically possible, and thus increase the resistance to electric flash-overs without necessity of providing additional resistance material particularly for this purpose.

Broadly, this objective is attained by providing one or more air gaps or pockets located radially between the usual outer insulating sleeve and the current carrying elements of the connector, and placed axially between the exposed ends of the conductors and the exposed ends of the insulting sleeve.

Certain commercial requirements of such devices are that they be capable of use in widely varying temperature conditions, for instance, in electric regions and in refrigerating apparatus where temperatures range minus 40 degrees F., and in fire control circuits and in varnish baking, where the temperature often reaches 400 degrees F.

Another field requirement is that these devices must be capable of withstanding the effects of acids, alkalies and ketones, as well as salt water, aviation fuel, lubricating oils, carbon tetrachloride, hydraulic fluids and like deleterious agencies with which they might come into contact.

In so far as the outer insulating sleeve is concerned, it is required that it be of high tensile and compressive strength; capable of being molded to the required configuration; capable of being made translucent or colored; and having a long life under conditions which tend to destroy its insulating properties. The small all-over size of the connector herein featured necessarily imposes a limitation on the cross section of material of the composite members and this, in turn, complicates the problems indicated by these commercial requirements and which the instant disclosure is designed to meet.

It has been suggested in the prior art to form the inner cable-engaging sleeve of the connector of a soft copper and to form the outer sleeve of rubber or of a thermoplastic material such as vinylidichloride or polybutene. When attempts have been made to form such rubber, vinyl chloride or polybutene insulating sleeves of the reduced cross section of material featured in this disclosure, the premolded sleeves tended to and in time did collapse.

For this reason, in the prior art devices the outer sleeve, irrespective of what material it was formed, was intentionally made to adhere tenaciously to the conductor-engaging copper sleeve and being thus internally reinforced the assembly maintained its intended configuration.

These prior art devices otherwise have not proven satisfactory in actual practice for numerous reasons, including, most seriously, a high production cost. In these known devices, especially where the outer insulating sleeve was thin, the action of the crimping dies thereon had the effect of either cracking open the insulation or of at least thinning and sometimes actually tearing the insulating material at its point of greatest deformation away from its adherence to the underlying wire-gripping sleeve and thus presenting a spot or area of no insulation or of less than the minimum rated insulating effect required of such devices.

In the form of the invention herein specifically selected for illustration there is disclosed a form of electric terminal connector, one end of which comprises an apertured tang or tongue formed integral with a wire-barrel or inner sleeve of the improved connector forming the subject-matter of this disclosure. The thickness of the apertured tongue extension of the inner wire-barrel and the size of wire to be secured therein, as well as other factors not involved here, tend to prescribe the dimensions thereof, both internally and externally.

While it is of advantage to make the wire-barrel element of the connector of soft copper, the electrical conductive requirements necessitate that it be made of somewhat thick cross section of material, and apparently this cannot be avoided despite the desire to make the device small. There is also an advantage in internally reinforcing the outer insulating sleeve and thus permit a reduction thereof in cross section, but it is not required that any such reinforcement possess any conductive capacity and certainly none comparable to the soft copper required of the wire-barrel element.

Accordingly, another object of the invention is to provide a multiple sleeve form of connector whose inner sleeve, while relatively thick as required, is deformable conventionally into cramped engagement with the bare wire or strands of the conductor intruded therein; whose outer sleeve while thin is adequate in its insulating capacity and which provides for a crimping engagement between the insulation of the conductor by an intermediate sleeve which does not necessarily have the conductive capacity of the inner sleeve and which can be interlocked with the inner sleeve when in final position.

This objective is attained broadly by producing a compact, unitary, three-piece assembly of preformed tubular members disposed in telescopic coaxial relation, featuring a thin-walled, rigid, seamless metallic sleeve between the outer insulating sleeve and the inner wire-barrel or
sleeve, operative to tie the crimped inner element to a portion of the conductor insulation; to give the maximum possible structural strength and least addition of material for this purpose to the parts which are to be radially deformed into a crimping engagement with the wire or cable inserted in the assembly.

Among the other objects of the invention is to provide an electric terminal connector of the type above outlined, which will possess the characteristics commercially required of such devices as above indicated, and at the same time to avoid the objections raised against known forms of such connectors.

The disclosure particularly features a construction complete per se as an article of manufacture and in which the outer sleeve of insulating material, while in frictional contact with the intermediate sleeve, is not bonded thereto and thus is free to creep axially along the intermediate sleeve to accommodate itself to its new configuration when crimped without material resistance to an automatic readjustment during the crimping operation, and thus tend to maintain intact the insulating properties for which the sleeve is designed. This requirement that the insulating sleeve have a friction fit on the intermediate sleeve after crimping requires that the bore diameter of the insulating sleeve as molded, be equal to or not materially greater than the external diameter of the Intermediate sleeve.

As specifically required by this disclosure, the internal diameter of the insulating sleeve as molded is preferably less than the external diameter of the intermediate sleeve. This, in turn, calls for a type of thermoplastic material which can be molded to close tolerances, especially in forming the bore of the insulating sleeve, and which has at least a limited plastic memory to shrink onto the intermediate lining and a limited elastic recovery to form the air gaps herein featured. The choice of a thermoplastic material capable of being so molded is restricted by other commercial requirements, such as capacity to make it translucent, to color the same, to provide a narrow plastic range, i.e., 475 degrees to 510 degrees, and it must possess other properties capable of being easily controlled during the molding cycle of the small size articles herein featured.

Making the outer sleeve of a synthetic condensation polymer is amide manufactured under the designation of "nylon," and one form of which is disclosed in the patent to Gordon, No. 2,348,536, granted May 9, 1949, has been most satisfactory. While this material hereinafter referred to generically as "nylon," is not as good an insulator as some other thermoplastics, the better insulating effects when other insulating materials had to be sacrificed somewhat to obtain the highly desirable compensating advantages inherent in using nylon.

On the other hand, it has been found in the instant situation that when a condensation polymeric amide is used for the insulating shield its insulating properties are improved during use; apparently due to an orientation of its crystals incident to the crimping action herein featured.

While it is the intent to make the outer insulating sleeve of such rigidity as will tend to resist collapsing and thus maintain its configuration substantially as molded, the intermediate lining sleeve, of course, does act as an internal reinforcement to the outer sleeve to resist accidental deformation. The disclosure features for the intermediate sleeve the use of a length of annealed commercial brass or bronze, hereinafter referred to generally as copper alloy, the basic stock of which can be purchased in the commercial market as tubing. In one form of the invention where a straight tube was used it was simply cut off from a market size of tubing and used as is without any machining. A cheaper method is to make the sleeve from flat strips of the alloy fed to an eyepot machine. While brass or bronze is not a particularly good electric conductor compared with copper, that property is not required in the instant situation and, on the other hand, making the sleeve of brass or bronze rather than copper contributes to the desire to make the sleeve very thin, to give a high degree of strength to the metal part intended to be permanently deformed to resist subsequent elongation, and to reduce as far as possible the presence of a good conductor in the path of a possible flashback. While rigidity is indicated, it is understood that the sleeve must not be so rigid in its cross section as would offer any material resistance to radial deformation or otherwise defeat the indicated crimping operation, nor so rigid as to resist the desired interlocking incident to the crimping operation of the two inner sleeves of the connector herein featured.

The inner wire-barrel or sleeve is formed of very soft sheet copper which can be rolled into the cylindrical form herein featured and which has a conically flared end which can be easily distended axially, as herein indicated, into the required binding engagement with the rigid intermediate sleeve and to form the funnel-shaped entrance at the free end thereof, as hereinafter described.

The invention also relates to an improved technique in forming an assembly of such a connector with the wire or cable therein to provide the finished assembly.

Various other objects and advantages of the invention will be in part obvious from an inspection of the accompanying drawings and in part will be more fully in the following particular description of one form of connector embodying the invention and of the method of attaching the connector to a cable, and the invention also consists in certain new and novel features of construction and combination of parts hereinafter set forth and claimed.

In the accompanying drawings,

Fig. 1 is an enlarged view partly in section showing a preferred embodiment of the invention deformed into a permanent crimping engagement with an electric cable,introduced into its wire-barrel end and illustrating the assembly of connector and cable in the final form it assumes following a time delay after crimping.

Figs. 2 through 5 are each in a cross-section views through the assembly shown in Fig. 1. Fig. 3 being taken on the line 3-3, to show substantial recession of the outer insulating sleeve from the intermediate metal sleeve, upon completion of a crimping operation as in Fig. 2.

Fig. 4 is taken on the line 4-4 of Fig. 1, showing an intermediate stage of the crimped outer insulating sleeve engaging the intermediate metal sleeve substantially about its entire periphery.

Fig. 5 is taken on the line 5-5 of Fig. 1, showing the outer insulating sleeve as spaced from the crimped free end of the intermediate metal sleeve to form insulating air gaps therewith as indicated at 42 and 43 in Fig. 1.

Fig. 6 is a view in end elevation of the connector per se.

Fig. 7 is a plan view of the connector, considered as an article of manufacture, in its marketed form before being crimped onto the cable and showing an axial section taken on the line 7-7 of Fig. 6.

Fig. 8 is a view in axial section of the component elements of the connector shown in Figs. 6 and 7 assembled in position in the matrix of a die-punch machine and showing a mandrel punch in position about to upset an end of the inner sleeve into engagement with the shoulder of the intermediate sleeve to effect a permanent connection therebetween.

In the several views of the drawings and referring first to the showing of the stock device in Fig. 7, there is disclosed an electric terminal connector 16 provided at one end with an apertured tang or tongue 17, the other end of which comprises an insulating portion 12 formed of three tubular members in coaxial telescopic relation, particularly constituting the subject-matter of this disclosure. The tongue includes a narrow neck portion 13 which forms an integral extension from the inner of the three tubular members forming the connector as hereinafter described.

The outer member 14 of the improved connector is a one-piece, preformed, relatively thin, molded sleeve
formed of nylon, and thus, as above noted, having at least some insulating properties. The end portions 15 and 16 of the sleeve 14 are each of cylindrical form and are of different diameters, with an inclined annular shoulder 17 midway between the sleeve 14, integrally connecting the end portions and facilitating the end portion 16 of larger diameter. The nylon sleeve 14 is dimensioned in its process of being molded so that, when stretched slightly as hereinafter described, the ends of its bore will have diameters exactly equal, respectively, to the outside diameters of an intermediate, rigid lining sleeve 18 of the assembly, and the shoulders 17 will conform more or less exactly to a fit with a corresponding shoulder 19 on the intermediate sleeve 18. As shown in Fig. 1, the smaller end of the nylon sleeve 14 may be provided with an inward-projecting annular flange 20 molded integral therewith and forming a stop for the intermediate and inner sleeves of the connector in those cases where such a stop flange is prescribed.

The nylon sleeve 14 is initially molded to have an internal diameter slightly less than the external diameter of the intermediate rigid lining sleeve 18, and originally the sleeve 14 has an oriented and substantially unstressed characteristics of molded nylon. The part of the nylon sleeve 14 which telescopes the lining sleeve 18 is stretched slightly as it is located in place. This has the effect of initially working the stretched part radially at least to a limited extent so that, when so stretched, it evidences a greater mechanical strength and a greater resistance to an electric break-down than would be the case if it were not so stretched. At this point the outer sleeve evidences some plastic memory and in its tendency to shrink to its molded form it adheres to the intermediate sleeve and to its frictional engagement therewith tends to resist accidental separation therefrom in an axial direction.

The intermediate sleeve 18 has a length in its end 21 of reduced diameter, extending for the length of the corresponding portion 15 of the outer sleeve, and in its end 22 of larger diameter terminates in spaced relation to the wide-open end of the large diameter portion 16 of the outer sleeve to form an overlap area 23 preferably of sufficient axial length to eliminate, or, at least, tend to eliminate the possibility of flash-backs between the inserted cable and any open end and adjacent to the connector. The inner surface of the nylon sleeve 14 and the outer surface of the copper-alloy sleeve 18 are made smooth at their areas of contact forming the joint 24 therebetween so as to offer, in so far as the surfaces are concerned, a minimum of frictional resistance to any relative creeping of these members, and a consequent crimping step.

The inner sleeve 25 of the connector is integral with the neck 13 and tongue 11 and is formed as shown in Fig. 6 by bending winged extensions thereof about a mandrel into a closed tube or sleeve 26 with its free edges meeting to form a closed joint 27.

As shown in Fig. 7, the inner sleeve 25 is a straight cylinder and has initially a press fit in the end 21 of reduced diameter of the intermediate sleeve. The purpose of this press fitting of the parts is to prevent opening of the joint 27 when the connector is crimped onto the cable as hereinafter described. The presence of any such open joint would form a crack into which strands of the wire conductors might extend, with resulting impairment of the desired good mechanical and electric contacts. Maintaining the joint closed defeats any such possibility. Initially, the extension 29 does not contact the intermediate sleeve 18 and the intermediate throat has an angle less than its punch angle as finally formed and shown in Fig. 7. As initially assembled the prestretched nylon sleeve 14 is fast on the intermediate metal sleeve 18 and the sleeve 18 press-fitted on the inner wire-barrel or sleeve 25.

The connector as an article of manufacture is formed in a three-step operation, which steps may take place simultaneously in a die-press operation. First, the intermediate copper-alloy sleeve 18 is gently forced against any incidental frictional resistance, with its smaller end in advance, into the momentarily stretched outer nylon sleeve 14 and until the shoulder 17 and 19 abut as shown in Fig. 8. The stretched insulating sleeve is then permitted to contract into a resilient engagement with the sleeve 18. At this time the insulating sleeve and intermediate sleeve are retained in their positions as so set by reason of the tendency of the nylon sleeve to recover its molded configuration with resulting frictional engagement between it and the sleeve 18, and this is sufficient to resist any accidental relative separation.

The assembly of the insulating sleeve and intermediate sleeve is inserted in the cavity or matrix a of a die-press machine fashioned to receive the same as shown in Fig. 8. The inner sleeve 25 is located snugly within the bore of the sleeve 18 approximately in the position it will assume in the completed structure, with its internal taper free end spaced slightly from the shoulder 19 and opposite end positioned against or almost against a stop wall 6 forming the bottom of the cavity.

The die-press machine includes an upsetting punch or mandrel e movable with a line of thrust into a 45° angle with the axis a—b of the connector. The advance end of the punch is provided with a long cylindrical head d whose diameter is exactly equal to the diameter of the bore 28 of the inner sleeve or of a very slight increase in diameter to force-fit the inner sleeve 25 against the intermediate sleeve, care being exercised not to open the joint 27. The head d is thus designed of sufficiently small diameter so as to avoid any material expansion of either the inner or intermediate sleeve, as the intent here is to leave these tubular members substantially as originally dimensioned and in their press-fit relation. The punch is provided at the inner end of its cylindrical head with a shoulder-forming enlargement e for upsetting the end 29 of the sleeve 25 to form flange 29 in permanent contact with and conforming in contour with the shoulder 19, and thus form the wide-open funnel-forming throat 31 shown in Figs. 1 and 7. In the instant case shoulders 17 and 19 extend at an angle of about 45 degrees with the axis a—b, and the enlargement e likewise extends at an angle of 45 degrees. This means that the extension 29, Fig. 8, has been spread open by the axial advance of the punch from its initial 30 degrees internal flange with 45 degree angle with some incidental thinning of the throat-forming flange 29 at its outer perimeter as shown in Fig. 7. In the use the cable C is first prepared by stripping back its insulation I to expose an end of the conductor wires W forming its core. The stripped-back end of the cable is inserted into the large intake end of the connector until the insulation I abuts against the inclined flange 29' and which forms a stop for limiting the insertion thereof. By the use of suitable crimping tools a squeeze pressure is applied to the diametrically opposite sides of the outer nylon sleeve first in the region of its smaller diameter, along the pressure lines indicated by the long arrows in Fig. 1 and thus along the section line 3—3, to transmit the pressure through the three tubular members, deforming the outer sleeve 14 into an interlocking engagement with the intermediate sleeve 18, deforming the intermediate sleeve into an interlocking engagement with the inner sleeve 25, and deforming the inner sleeve into a permanent crimping engagement with the exposed wires, somewhat following conventional practice in this respect. Then a relatively light squeeze pressure is applied in the plane represented by the short arrows at the right of Fig. 1, thus along the section line 5—5, to transmit pressure through the two tubular members, deforming the outer nylon sleeve into an interlocking engagement with the intermediate sleeve 18 and deforming it into permanent engagement with the cable insulation I. At this time, the right end portion of the nylon sleeve 14 is free to creep towards the right without resistance from the intermediate sleeve 18, which is also free to distend slightly to the right as may be necessary.
Of course, the cross-sectional configuration of the assembled Fig. 1 in the areas crimped will at least initially take the form imposed thereon by the work faces of the crimping dies or tools. In the case herein illustrated the connector is squeezed between power-operated dies. The dies which operate along the line 3—3 have flat faces, while those which operate along the line 5—5 have faces with opposing flat arcs and whose faces on opposite sides of the arcs are slightly spaced apart when the dies are in their position of nearest approach.

Considering the initially dead soft, copper inner sleeve 25, the disclosure features the use of sufficient cross section of material such as may be necessary to carry the voltage at which the device is designed, and this, in turn, calls for the relatively thick-walled wire-barrel or sleeve 25 herein disclosed. While there is some slight axial elongation of the inner sleeve 25, incidental to the crimping operation, any such axial elongation is dimensionally about the same as that of the intermediate sleeve 18, so that there is no noticeable separation of the copper and copper-alloy members. The inner sleeve 25 is not only deformed radially and slightly in an axial direction, but the metal is coined as the result of the crimping, so that in its final form the part projecting beyond the wire-barrel or sleeve 25 is permanently secured to the insulated part of the cable, so that the insulation 1 is tied by the sleeve 18 immovably to the inner sleeve 25 and thus to the bared ends of the wires W. In this way any pull-apart load on the tongue 11 and cable C will be resisted by both of the crimpings in the planes 3—3 and 5—5 and by the non-distensible intermediate sleeve 18.

Reverting to a consideration of what takes place during the first crimping operation, it is noted that the application of pressure on the nylon sleeve tends to elongate both the outer and intermediate sleeves in both axial directions from the point of application of the applied pressure indicated by the long arrow. The elongation of the nylon sleeve 14 will be slightly greater than the elongation of the intermediate sleeve 18. As the adhesion between the nylon sleeve and the intermediate sleeve is simply that of the initial frictional snug fit, and as the crimping force must be sufficient to deform the innermost relatively thick copper sleeve 25, such force is sufficient to overcome any frictional resistance to relative elongation, and the nylon sleeve is free to readjust itself by creeping along the surface of the intermediate sleeve 18 without any noticeable resistance to the deformation of either of the sleeves. Nylon is capable of being stretched up to five hundred per cent of its original length. In this way there is avoided any tearing action of the nylon insulating sleeve, such as would occur if the insulation were bonded to the metal sleeve 16. As the intent here is to provide sufficient cross section of material for handling sleeve 14 under all service conditions to give it the requisite insulating shielding, it is to be noted that in molding the sleeve it be made sufficiently over-size as to its external diameter to compensate for any such thinning as may result from the elongation imposed thereon by the crimping step.

As the result of subjecting the initially cylindrical form of the sleeve 14 to the squeeving effect of the crimping tools, the sleeve 14, in the region of the plane indicated by the section 3—3, changes from a cylinder into an all-over elliptical form in cross section, as shown in Fig. 2.

At the same time the cross section of material at the point of greatest squeeze, tends to thin out so that there is a section of least thickness at 32. Apparently, there is some cold flow of the plastic, so that the rounded ends 33, 34 are of greater section of material than when in their initial molded and slightly distended form.

The inner and intermediate sleeves 25 and 18 take the constricted-waist form with the struts of the connector compressed and incidentally deformed to their wire configuration and retained external to the crimped areas.

The intermediate sleeve 18 is not materially changed in its cross section of material, more or less maintaining its initial thickness, but the soft copper inner sleeve 25 of the connector tends to thin out slightly in the portion 35 subjected to the greatest pressures as may be observed in Figs. 2 and 5, and there is some cold flow of the copper therefrom into the rounded ends 36. As the result of this action both the intermediate and inner sleeves become worked and thus coined, with an increase in strength in the portions so crimped. Of course, the thinnest, outer most portions 32 of the nylon sleeve is squeezed by the crimping tool followed by the intermediate sleeve 18, or, rather, advance inwardly with it and momentarily adhere to the same, as shown in Fig. 2. Thereafter, the deformed nylon sleeve gradually and slowly recedes outwardly from the intermediate sleeve 18. The outermost part of the nylon sleeve becomes greater in its point of greatest inward deformation, so that the space 37 forms a gap of greatest width in the line of the squeeze load, and these gaps, top and bottom, as shown in Fig. 3, gradually reduce in width towards points 38, four being shown in Fig. 3. The rounded ends 33, 34 of the nylon sleeve 14 move outwardly slightly along the major axis of the ellipse away from the rounded ends of the intermediate sleeve 18 to form relatively thin secondary end gaps 39. The gaps 37 and 39 are in communication and connect to form in effect a single clearance and thus an air insulating space between the outer nylon sleeve 14 and the intermediate crimped sleeve 18.

A similar void is established in the region of the squeeze load imposed on the cable insulation 1 in the plane 5—5, Fig. 1. As this portion of the connector is squeezed between the faces of the crimping dies or tools, the squeeze pressure acts through the nylon sleeve and through the sleeve 18 to compress the cable insulation at least slightly. At the same time the sleeve 18 becomes deformed from its initial cylinder into a form resembling in its midportion a flat ellipse provided with side plates opposite sides with side plates bent back upon themselves to form side ribs 40, 41. At this time the nylon sleeve 14 conforms substantially to the wedge contour of the sleeve 18, at least as long as the assembly is under load from crimping apparatus and, in general, the parts take the form shown in Fig. 4. Thereafter the nylon sleeve, in its inherent tendency to revert more or less to its initial molded shape, distends outwardly and separates from the intermediate sleeve 18, and thus forms an upper, internal, air-insulating clearance 42 and a similar lower, internal, air-insulating clearance 43, as best shown in Fig. 5. Apparently there is not always a complete recovery of the nylon sleeve 14 either back to its cylindrical form as molded nor even into its elliptical form resulting from the crimping operation for remnants of the die impressions are often still present after a long period of time as four shallow indentations 44, shown sleeve 14 enlarged.

Considering the finished device as shown in Fig. 1, it is seen that in order for a flash-over or a tracking of electric current to occur it would have to traverse a path from the energized wires W through the inner wire-engaging sleeve 25 and intermediate sleeve 18 to the exterior of the insulating sleeve 14, lapping over the inner crimped cable-receiving portion thereof. Realizing that the intermediate sleeve 18 is not intended to be a particularly good conductor, it is possible that the overlap area 23, covered as it more or less is by the insulation 1,
will tend to prevent flash-backs at the open end of the connector. However, the intermediate sleeve 18 does constitute a conductor and dependence cannot always be placed on the gap 23 to avoid flash-backs from the open end of the insulating sleeve 14 to the adjacent edge of the sleeve 18, especially in the presence of currents of low voltage. Tracking which may occur in the presence of currents of low voltage is more likely to develop and, also, possibility of tracking is more likely to occur after the connector has been in use for a long time and where environmental climatic conditions tend to provide an electric path about the insulating sleeve 14 both externally and interiorly. One such possible path is shown by the dotted dotted lines in Fig. 1 leading from the outer perimeter of the insulating sleeve 14, about its edge encircling the cable insulation 1, and then along the inner wall to the point where the sleeve 18 bends inwardly away from the insulating sleeve 14 at about the plane 4—4.

In effect, the presence of the air spaces 42 and 43 lengthens the overlap 23 by the distance between the end edge of the sleeve 18 and the plane 4—4 and in this way any leakage path is elongated.

The air spaces 37 and 39 are not in the path of any electric members. It is noted from the showing in Fig. 3 that these spaces practically encircle the intermediate sleeve, supplement the insulating effect provided by the outer insulating sleeve; and thus contribute to the provision of a thin insulating sleeve while avoiding electric current penetration therethrough.

These air gaps are each of some material length measured in the direction of any such electric flash-over or tracking and being either filled with air, or more possibly, in the case of the spaces 37, forming vacuum spaces, function as electric insulators, defeating any possibility of flash-over or tracking even in the absence of the flange 20.

While the invention has been illustrated and described with respect to a preferred embodiment thereof, it is to be expressly understood that various changes and modifications may be made therein without departing from the inventive concept underlying the same. Therefore, the invention is not to be limited except so far as is necessitated by the prior art and the scope of the appended claims.

I claim:

1. In the art of crimping an electric connector onto a conductor therein, wherein the connector comprises three members in telescopic relation, the inner member being a sleeve of highly conductive malleable metal fashioned to form mechanical and electrical engagement with a conductor therein, the intermediate member being a sleeve of thin malleable metal and the outer member being a sleeve formed of insulating material having plastic memory and capable of automatically distending outwardly towards its original configuration when free of inwardly deforming forces, and wherein the intermediate sleeve, thereby to form an air space between the outer and intermediate sleeves at the place so deformed while permitting readjustments to take place automatically between the outer and intermediate sleeves.

2. In the art of crimping an electric connector onto a conductor therein, wherein the connector comprises three performed members in telescopic relation, the inner member being a sleeve of highly conductive malleable metal fashioned to form mechanical and electrical engagement with a conductor therein, the intermediate member being a sleeve of thin malleable metal and the outer member being a sleeve formed of insulating material having plastic memory and capable of automatically distending outwardly towards its original configuration when free of inwardly deforming forces, and wherein the outer sleeve adheres to said intermediate sleeve frictionally and is otherwise free to creep thereon, the method which consists in subjecting the connector for a limited length thereof to a crimping squeeze force applied from the outside through all three sleeves, with a force sufficient to bend inwardly both the inner and intermediate sleeves beyond their respective elastic limits and thus permanently deform the inner sleeve into a crimped engagement with conductors therein and thus to deform both the inner and intermediate sleeves into interlocking relation, subjecting the outer sleeve and the intermediate sleeve to a crimping squeeze force applied to the outer sleeve with a force sufficient to bend inwardly the end thereof to a crimping squeeze force applied through the outer sleeve with a force sufficient to bend inwardly the end of the intermediate sleeve beyond its elastic limits, and releasing the connector from all deforming forces acting thereon to permit the outer sleeve in the areas so squeezed to recede outwardly by virtue of its plastic memory from the inwardly deformed portions of the intermediate sleeve, thereby to form an air space between the outer and intermediate sleeves at the two places so deformed.

3. An electric connector including three tubular members in telescopic relation and comprising an inner sleeve of highly conductive metal, an intermediate sleeve of malleable metal secured to the inner sleeve and having a portion thereof deformed inwardly beyond its elastic limit, to cause said deformed portion to assume a permanent inward set, and an outer sleeve molded of an insulating material having plastic memory and capable of returning to its distended relation towards its molded form when released from inwardly directed deforming forces, said outer sleeve in the portion so deformed being spaced radially outwardly from the inwardly deformed portion of said sleeve, to form an air space therebetween, and the balance of the outer sleeve being at all times in frictional engagement with the intermediate sleeve and otherwise free to shift thereon.

4. In a device of the class described, the combination of three tubular members in telescopic relation, the inner member forming a sleeve of malleable, highly conductive metal, the intermediate member forming a sleeve of malleable metal and of less electric conductive capacity than the inner sleeve, said inner and intermediate sleeves being mutually deformed inwardly each beyond its elastic limit to connect the same permanently into a crimped relation, and the outer member constituting a premolded sleeve formed of a plastic insulating material capable of transmitting squeeze forces therethrough without rupturing to effect such mutual deformation of the inner and intermediate sleeves, said outer sleeve being having plastic memory and capable of distending outwardly towards its molded form when free of such squeeze forces, and said intermediate and outer sleeves spaced apart at the portion so cramped to form an air space therebetween by reason of the outer sleeve receding outwardly from the intermediate sleeve by reason of its plastic memory and the side of the outer sleeve forming said air space forming a tracking path.

5. In a device of the class described, an insulated cable having a bare end of its conductor projecting beyond its
insulation, a terminal connector formed of three telescoping tubular members with the conductor bare ends located within the innermost member, an intermediate sleeve of malleable metal having one end portion thereof projecting beyond the innermost member, telescoping the insulation of the cable and having said end portion permanently bent inwardly on the cable insulation, and the outer member being pre-molded approximately to shape and formed of a plastic insulating material having plastic memory and capable of distending outwardly towards its molded form when free of inwardly-directed deforming forces, with the inwardly bent ends of the intermediate sleeve and the outer plastic member spaced apart to form an air space therebetween with the part of the plastic member facing said space forming a tracking path.

6. In a device of the class described, the combination of an outer sleeve of insulating material, a metal tube within the bore of the outer sleeve and in part lining the same, one end of the metal tube being spaced axially inwardly from the adjacent end of said outer sleeve to form the outer sleeve with an overlap area providing initially a relatively short tracking path on the inner surface of the outer sleeve, the end of the inner tube at said overlap area being bent inwardly away from the outer sleeve to form a shoulder therebetween to increase inwardly the length of said short tracking path.

7. In a device of the character described, an insulated cable having a bare end portion of its conductor extending beyond its insulation, a terminal connector formed of three telescoping tubular members as a unit with the bare end portion of said conductor intruded within the innermost member of highly conductive metal, an intermediate member of relatively thin malleable metal having one end portion thereof extending beyond the adjacent free end of said innermost member and telescoping the insulation of said cable, said innermost member comprising a tongue and a barrel portion coextensive therewith with its adjacent free end upset within said intermediate member to secure said members against relative movement, and a pre-molded outer member of flexible insulating material having plastic memory and capable of receding substantially toward its molded form when free of inwardly-directed deforming forces, said innermost member being cramped on the intruded portion of said conductor through said outer member and said extended end portion of said intermediate member being bent inwardly on said cable insulation distally opposite points thereon whereby the extended end portion of said intermediate member is spaced in part from portions of the inner periphery of said outer member to lengthen a tracking path thereon.

8. In an electric terminal connector comprising a plurality of telescopically arranged members, the combination of an inner sleeve of highly conductive metal including an integral tongue portion, an intermediate sleeve of thin ductile metal having a common wall thickness throughout and opposite end portions of differing diameters forming a shoulder therebetween, said inner sleeve having a press-fit on one end portion of said intermediate sleeve with its intruded free end upset against the inner face of said shoulder to secure said sleeves against relative movement, and an outer sleeve of molded insulating material having a force fit on said intermediate sleeve with one end portion thereof extending beyond the free end of said intermediate sleeve, said inner sleeve being adapted to be cramped on a bare end portion of an insulated conductor and the free end portion of said intermediate sleeve deformed inwardly on the insulating sheath of said conductor through said outer sleeve, said outer sleeve having plastic memory and capable of receding substantially to its original form when released from inwardly-directed deforming forces whereby portions of said outer sleeve are spaced from deformed portions of said intermediate sleeve to provide an air space therebetween, the major portion of said outer sleeve remaining at all times in tenacious frictional engagement with said intermediate sleeve but free to yield thereon in response to a crimping operation.

9. In an electric terminal connector comprising a plurality of telescopically arranged members, the combination of an inner sleeve of highly conductive metal including an integral tongue portion coextensive therewith, an intermediate sleeve of thin ductile metal having a common wall thickness throughout and opposite end portions of differing diameters forming an inclined shoulder therebetween, said inner sleeve having a press-fit in the reduced end portion of said intermediate sleeve with its intruded end upset on said shoulder therein to secure said sleeves against relative movement, and an outer sleeve of molded insulating material having a force fit on said intermediate sleeve with one end thereof extending beyond the free end of said intermediate sleeve, said inner sleeve being adapted to be cramped on the bare end portion of an insulated conductor through said outer sleeve, and the free end portion of said intermediate sleeve deformed inwardly on the insulating sheath of said conductor through said outer sleeve, said outer sleeve having plastic memory and capable of substantially receding toward its normal configuration when released from inwardly-directed deforming forces whereby portions of the outer sleeve are spaced from deformed portions of said intermediate sleeve to provide an air space therebetween, the balance of said outer sleeve remaining at all times in tenacious frictional engagement with said intermediate sleeve but free to yield thereon in response to a crimping operation.

10. In an electric terminal connector comprising a plurality of telescopically arranged members, the combination of an inner sleeve of highly conductive metal including a tongue portion coextensive therewith, said inner sleeve having its free end internally tapered to reduce the wall thickness thereof, an intermediate sleeve of thin ductile metal having a common wall thickness throughout and opposite end portions of different external and internal diameters defining an inclined annular shoulder therebetween, said inner sleeve having a press-fit in the smallest end portion of said intermediate sleeve with its tapered free end upset on the inclined shoulder thereof, said intermediate sleeve being adapted to be cramped through said intermediate and outer sleeves on the bare end portion of an insulated conductor wherein intruded therein and the free end portion of said intermediate sleeve deformed inwardly through said outer sleeve into permanent cramped relation with the insulating sheath on said conductor, said outer sleeve having plastic memory and capable of substantially receding toward its normal configuration when released from inwardly-directed deforming forces whereby deformed areas of the outer sleeve are spaced from the deformed portions of said intermediate sleeve to provide an air space therebetween, the balance of the outer sleeve remaining at all times in tenacious engagement with said intermediate sleeve and free to yield therein in response to a crimping operation.

11. In an electric terminal connector comprising a plurality of telescopically arranged members, the combination of an inner sleeve of highly conductive metal including a tongue portion coextensive therewith, said inner sleeve having its free end internally tapered to reduce the wall thickness thereof, an intermediate sleeve of thin ductile metal having a common wall thickness throughout and opposite end portions of different external and internal diameters defining an inclined annular shoulder therebetween, said inner sleeve having a press-fit in the smallest end portion of said intermediate sleeve with its tapered free end upset on the inclined shoulder therein, said intermediate sleeve, an outer sleeve of molded in-
insulating material having plastic memory in tenacious frictional engagement with said intermediate sleeve, one end of said outer sleeve extending beyond the free end of said intermediate sleeve, and an insulated cable having a bare end portion of its conductor intruded into said inner sleeve from the extended free end of said outer sleeve with the adjacent end of the insulating sheath of said cable intruded in the free end of said intermediate sleeve substantially in abutment with the upset end of said inner sleeve, said inner sleeve being crimped on said intruded conductor portion through said outer and intermediate sleeves whereby said intermediate sleeve is crimped on said inner sleeve, and the opposite free end portion of said intermediate sleeve deformed through said outer sleeve to assume a permanent inward set on the intruded end portion of said insulating sheath, said outer sleeve in the portions so deformed being spaced radially outwardly from the inwardly deformed portions of said intermediate sleeve to form an air space therebetween with a portion of said outer sleeve facing said space forming a longer tracking path.

No references cited.