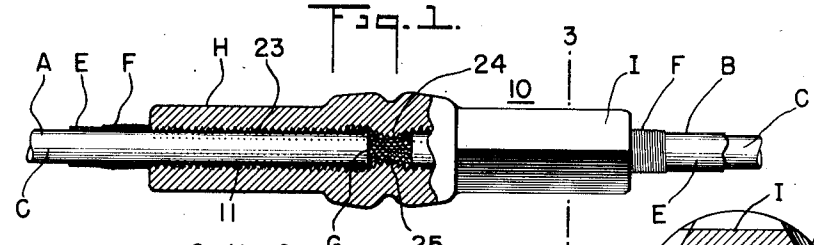
July 22, 1952 M. D. BERGAN 2,604,508

INSULATION PIERCING WIRE CONNECTOR

Filed Nov. 19, 1947

Fig. 1.



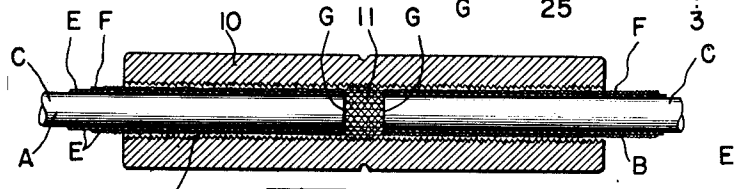


Fig. 2.

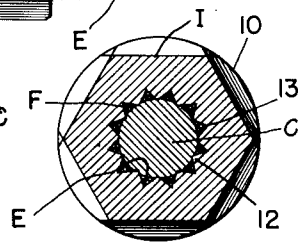


Fig. 3.

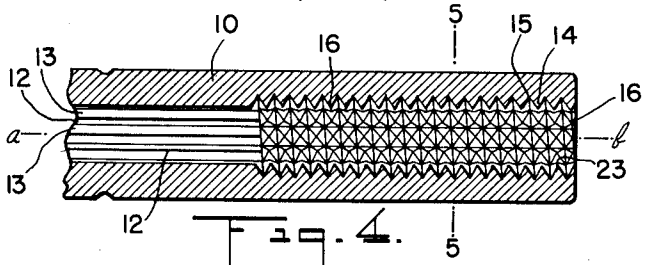


Fig. 4.

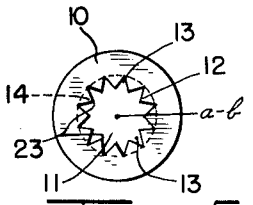


Fig. 5.

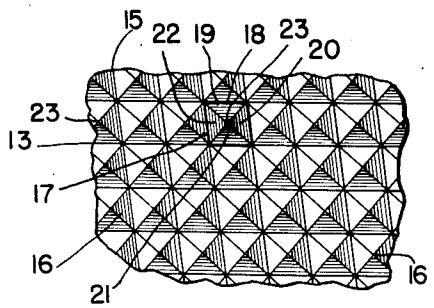


Fig. 6.

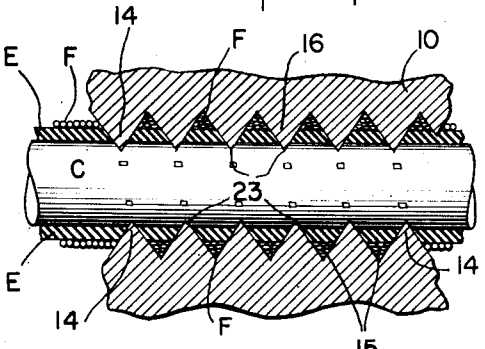


Fig. 7.

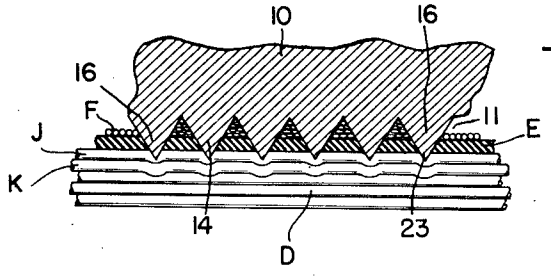


Fig. 8.

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INSULATION PIERCING WIRE CONNECTOR

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Application November 19, 1947, Serial No. 786,901

3 Claims. (Cl. 174—84)

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The invention relates in general to an insulation piercing wire connector and specifically relates to connectors of the tubular type into the bores in which cables are inserted and the connectors distorted into a crimping engagement with the cables.

It is known in the prior art of cable coupling connectors to strip back the insulation on an end of a cable to expose the conductor wires forming the core of the cables, to introduce the stripped back ends of the cable into the bore of a metal sleeve and crimp the sleeve on to the exposed ends of the cables. It has also been suggested to roughen the bore in different ways to enhance the gripping effect of the sleeve on to the cable and its conductors.

In my copending application, Serial No. 618,218, filed September 24, 1945, now Patent No. 2,480,280, granted August 30, 1949 I suggested threading the bore of a connector with a spiral thread constructed to bite into the exposed strands of the conductor forming core of a cable from which the insulation is stripped back. The known form of connectors are dimensioned to engage cables of a size sufficiently large so that the stripping back of the insulation did not present any great difficulty.

There has recently come on the market a form of cable of extremely small diameter known as magnet wire, one form of which includes a core formed of a copper wire inclosed in a coating of varnish, and in some cases a thin tube of enamel, in both cases forming an insulation and which enamel tube or varnish coating is in turn closely wrapped with a layer of cotton or silk thread. It is extremely difficult to strip back the insulation of these small size conductors due, among other things, to the fact that the enamel for instance is tough and resistant to being stripped from the metal core but primarily due to the difficulty of holding these small conductors especially in the field often without the equipment necessary to hold small wire.

The primary object of the invention is to provide an improved technique in making a mechanical and electrical connection between a metallic sleeve and an insulating covering therefor, in such way that the cable insulation is not stripped back and an electric connection over a relatively large area of contact is made as an incident of following the conventional practice of distorting the sleeve into a crimping engagement with the cable inserted into the bore of the sleeve.

Broadly this objective is attained by providing the bore of the sleeve which is to form the connector, or at least that portion of the bore which subsequently becomes involved in the crimping operation, with a plurality of closely related inwardly pointing sharp points arranged in a substantially uniformly distinctive pattern and proportioned to pierce and penetrate the insulation over an extensive area and to intrude more or less into the electric wire or wires forming the core of the cable and at the same time to provide for an extensive area of electric contacting engagement between the sides of the projections and the wire strands which go to make up the wire cores and to do this without necessity of preparing the cable ends to enter the connector.

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More specifically defined the bore of the tubular connector is tapped to provide a spiral V-thread therein and is slotted longitudinally with V-shaped slots, circumferentially spaced to form with the thread a checkerboard pattern of pointed projections, each of four sided pyramidal form with their rectangular bases contacting in edge-to-edge relation.

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 set forth in the following particular description of one form of connector embodying the invention, 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 the several figures are very much exaggerated in size over the parts illustrated in order to show details not easily visible to the eye and in which:

Fig. 1 is a view partly in elevation and partly in axial section of a tubular connector constituting a preferred embodiment of the invention and shown in operative engagement crimped on to a pair of cables;

Fig. 2 is a view in axial section of the connector blank and associated cables of Fig. 1 before being crimped into its final position to form the connector of Fig. 1;

Fig. 3 is a transverse section of the assembly shown in Fig. 1, somewhat enlarged and taken on the line 3—3 of Fig. 1;

Fig. 4 is an axial section of the right end portion of the connector blank shown in Fig. 2 with the extreme right end portion both splined and tapped, and the adjacent left end portion splined but not yet tapped;

Fig. 5 is a transverse sectional view of the connector blank taken on the line 5—5 of Fig. 4;

Fig. 6 is an enlarged view of the bore wall sur-

face shown in the preceeding figures and laid flat to show the checkerboard arrangement of the pyramidal teeth;

Fig. 7 is an enlarged showing of a portion of the disclosure in Fig. 1, illustrating two opposing axial lines of the pyramidal teeth penetrating opposite sides of the insulation and biting into a single wire conductor, and

Fig. 8 is a view similar to the upper portion of Fig. 7 and showing a line of the pyramidal teeth penetrating the insulation and piercing into a conductor of the stranded wire type.

In the drawings and referring first to the complete assembly of connectors and cables in Fig. 1, there is disclosed a tubular connector **10** in its final form in crimped engagement with the cables to be connected thereby. Into opposite ends of the bore **11** there is disposed cables A and B in approximate end-to-end relation and with opposite ends of the connector distorted into a crimping engagement with the intruded ends of both cables to secure them mechanically and electrically to the connector and therethrough to each other.

The wires or cables A and B are each of the magnet wire type and specifically are of the type known as formex insulation magnet wire.

The cables are of identical construction and include in the case of Figs. 1, 2, 3 and 7 a single copper wire C forming the core. In the showing of Fig. 8 the conductor core D is a strand of very fine wires twisted together to form a bundle. The core is inclosed within a layer of insulation extremely thin relative to the core. The insulation illustrated is an enamel baked on to the wire core. It is within the scope of the disclosure to make the insulation of certain types of plastic insulating material containing resins, and a thermosetting varnish containing a formaldehyde derivative is suggested.

The magnet wires as now sold on the market are usually wrapped with an outer layer F of insulating fibrous material such as cotton, silk and sometimes paper.

It is noted that in this case the insulation E and F about the conductor core is not cut back as has been usual in such situations. The cables are simply cut off to provide the squared off ends G and the insulation extends solidly to the ends of the cables in the form manufactured and sold on the market. Referring to the blank tube or sleeve from which the connector **10** is formed it will be understood that initially it is simply an open end cylindrical sleeve provided with a smooth bore extending axially therethrough from end-to-end. This sleeve is formed of any of the malleable metals usually used for crimping on to conductors contained therein and in the instant case the sleeve is formed of soft copper but aluminum would be equally indicated.

The distinctive feature of this disclosure is that the surface defining the wall of the bore is formed of a plurality of sharp pointed projections arranged in closely adjacent relation to form in effect an approximately checkerboard pattern. These projections are formed by slotting the bore wall to provide a series of splines **12** as shown at the left end of Fig. 4, and shown to be V-shaped in cross section and equidistantly spaced apart circumferentially of the bore as shown in Fig. 5, forming V-shaped troughs **13** therebetween. The bore wall so slotted is tapped to provide a spiral thread **14** extending from end-to-end of the sleeve and forming V-shaped troughs **15** between adjacent turns of the thread. The threads and the splines are each of sixty degrees included angle. The troughs between the splines and the troughs between the turns of the thread mutually intersect each other at an angle, as shown in Figs. 4 and 6, of about eighty-five degrees and thus are substantially at right angles to each other. This machining of the wall defining the bore of the sleeve forms the wall into regularly and uniformly spaced apart rows and columns of substantially pyramidal teeth **16**. The base **17** of each tooth as shown by the heavy lines in Fig. 6 outlining one of the teeth marked **18** is substantially square or more accurately is an equilateral parallelogram. The bases of the teeth abut in edge-to-edge relation so that the bore is formed entirely of teeth with no blank spaces therebetween. Each tooth is defined by four sides **19–20–21** and **22**, each side being of triangular form; is symmetrical with its axis which extends radially inwardly and with its apex forming a sharp point **23** directed to the axis *a—b* of the bore. More specifically described, the four sides form two wedges, whose opposing sides are in intersecting planes forming an incluuded angle of about sixty degrees and which four sides form the sharply pointed apex. Differently considered the bore is formed in effect by a large number of sharp points **23** equidistantly spaced apart, opposing sides of the teeth, for instance the opposing sides **19** and **21**, form in effect wedges progressively increasing in their contacting areas with the conductors C and D as the bases **17** are approached.

In the form of the invention shown in Fig. 1, but not in the form shown in Fig. 2, it is suggested that after the bore has been machined as above described the stock sleeve thus formed be indented at its center to provide a pair of center stops **24—25** to limit the insertion of the cables into the opposite ends of the bore **11** as is usual in this art.

In general it will be understood that outwardly of the stops **24—25** in both directions therefrom, the sharp points **23** coact to define a cylinder whose cross section closely approaches the cross section of the cables A and B and sufficiently over-size to permit the cables to be inserted freely into the bore **11** with a sliding fit and without intentional injury to the fibrous wrapping F. The cables are inserted until the stops **24—25** resist any further advance. Opposite ends of the connector **10** are then subjected to the action of any suitable form of crimping tool to form crimps H and I to distort the connector into a binding engagement with both cables and incidentally change each end of the connector from its original circular form into an hexagonal form as shown in Fig. 3.

Considering the action of each tooth **16** with reference to a single wire C it will be appreciated that in moving from the initial position shown in Fig. 2 into the final position shown in Figs. 1, 3 and 7, the pointed apices **23** operate to penetrate first the fibrous covering F and then the insulation E. In passing through the threads forming the covering F its appears that adjacent threads are simply pushed apart without necessarily being cut and are crowded into the troughs **15**. This radial squeezing of the connector is continued until the pointed apices **23** engage in metal-to-metal electric contact with the conductor core C. Of course, any further contractions of the bore **11** will cause the points **23** to bite more or less into the surface of the wire C as shown in Fig. 7. Under the squeeze

force present the sharp points 23 easily break through the outer surface of the insulation E and as soon as each break is made, the two wedges of the associated tooth begin to come into operation and force the insulating material in advance of the inwardly moving teeth outwardly in all directions and into the troughs 13 and 15. As the insulation E is thin and somewhat plastic it can easily accommodate itself into any available space and is undoubtedly compacted and perhaps has lost some of its insulating characteristics, but within the connector insulation is, of course, not desired.

In the case where a stranded form of core wire is used the advance ends of the teeth 16 tends to work themselves into and between the strands which form the outside of the core D as shown in Fig. 8 and in this way the advanced portions of the teeth tend to make electric contact with some of the internal strands and the wedging sides of the teeth tend to make an extensive metal-to-metal contact with the several strands as they become separated by the inwardly advanced teeth. In the showing in Fig. 8, the teeth 16 have penetrated the wrapping forming the outer layer F, have pierced through the enamel insulating coating E, have separated two outside strands, one of which is shown at J and are bearing on an inner strand K in a tendency to buckle it at the points contacted. It is not so much the individual tooth action which is important here, as it is the aggregate coaction of many teeth when considered in their closely grouped relation. It is appreciated that the greatest possible area of contacting surface must be provided between each cable core or conductor and the metal connector and this becomes particularly necessary in the instant device which features small all-over dimensions.

The porcupine, stippled or nutmeg grater effect presented by the gripping points of the bore has the effect of engaging even initially, closely positioned spots over the entire area of the conductor core and these localized spots, of course, each increase in contacting area as more and more of their wedging sides in distinction from the sharp points engage the conductor or conductors as the case may be.

In actual practice and despite the fact that there are remnants of the insulation E and F remaining within the connector, still tests show that the resistance between the connector and conductor is not materially more than would be the case if there was solely a metal-to-metal contact between conductor and connector. Apparently the increase in surface contact provided by the four wedging surfaces 19—22 compensates for any insulating effect presented by the remnants of the insulations.

As so far described it is assumed that the teeth 16 have that degree of hardness which is inherent in the original stock material of which the connector is made with such increase in hardness as may be imposed thereon by the machining incidental to the slotting and threading of the bore as herein featured.

There are situations encountered in this art where the conductor wires are hard or medium hard drawn and thus the teeth herein featured must be of a hardness equal to or greater than that of the wire in those cases where it is desired to have the teeth bite into the conductors as suggested in Fig. 7.

It is accordingly suggested that an even greater degree of hardness may be imposed on the teeth especially when the blank is made of a ferrous metal such as steel. This can be done by electro-plating the outer surface of the tubular blank with a protective coating, say of copper, and then heat treating the toothed bore in a cyanide or carbonizing bath to harden the bore and thus the teeth. This method is more fully disclosed in my application Serial No. 759,241, filed July 5, 1947, entitled "Case-Hardened Cable Connector." In this way there is provided a connector in which the teeth, particularly in the pointed apex thereof, may have any desired degree of hardness while the connector considered as a whole retains its original relatively soft ductile condition and thus may be easily crimped as above described.

I claim:

1. A one-piece connector formed of malleable steel and provided with a preformed bore fashioned to receive a magnet wire of the type which includes a conductor having an enamel insulating jacket baked thereon and to have the connector deformed into a crimping engagement with the conductor in the bore of the magnet wire, at least a portion of the length of the bore wall being formed solely of rugged teeth having sharp pointed, hardened apices equidistantly spaced apart in two directions, considered both longitudinally and circumferentially of the bore, and forming a uniformly stippled area defining a conductor contact surface of cylindrical form, the teeth being each of pyramidal form with substantially square bases arranged in contact in a regular geometric pattern of thread-like spiral columns and straight parallel rows with the columns and rows in intersecting relation and forming a checkerboard design completely covering said portion of the bore and in which each tooth forms the center tooth of a group of five teeth and is reinforced and buttressed at all four sides of its base by the engagement therewith of the four teeth surrounding it, the four sides of each tooth forming two wedges whose opposing sides are in intersecting planes forming an included angle of about sixty degrees and the intersection of which sides form its hard, sharply-pointed apex, the axis of each tooth extending substantially in a radius of said cylindrical contact surface, each side of each tooth forming a V-shaped trough with the adjacent side of the next tooth considered in any direction so that the toothed portion of the bore wall is formed entirely by the inwardly facing sides of the teeth, the aggregate area of said teeth being greater than the area of said toothed portion of the bore wall, and which teeth coact to form said portion of the bore wall as a checkerboard design of inwardly facing teeth and inwardly facing troughs, each of said troughs having maximum depth opposite the apices of the pair of teeth forming the trough adapted to receive that portion of the enamel which is displaced into the same by the associated pair of teeth and said troughs having their least depth where each corner of one tooth base meets the corners of the three adjacent teeth bases.

2. In a device of the class described, the combination of a one-piece tubular connector of ductile metal, a magnet wire including a conductor on which is baked an enamel jacket intruded into an end of the bore of the connector, at least a portion of the bore which contains the magnet wire defined entirely by a set of sharply pointed teeth of pyramidal form with substantially rectangular bases and arranged in a regular geometric pattern of spiral columns and parallel

rows intersecting to form the teeth and each tooth forming a trough between itself and the next adjacent tooth, considered in any direction and each of which troughs is V-shaped in cross section, of maximum depth at its mid-length and decreasing in depth towards its opposite ends, said connector being crimped onto the magnet wire with the sharply-pointed apex ends of the teeth radially penetrating the layer forming the enamel jacket and in electric contact with the conductor at uniformly spaced-apart points on all sides of the conductor, the portion of the enamel between adjacent pairs of teeth, considered in directions at right angles to each other, adhering to the conductor and the portion of the enamel displaced by each tooth being crowded into the space considered radially between the enamel so adhering to the conductor and the bottom of its associated trough.

3. A one-piece sleeve formed of a malleable metal having capacity for electric conductivity and adapted to be deformed into a crimping engagement with the conductor core of an insulated cable inserted in its bore, the wall defining the bore of the sleeve, in at least a part thereof designed to be so deformed, formed completely of a bank of sharply-pointed inwardly extending teeth with their apices defining a closed cylinder,

each tooth being of pyramidal form and said teeth disposed in a continuous, base-contacting, checkerboard relation and forming therebetween troughs V-shaped in cross section on all four sides of each tooth and each of said troughs adapted to receive increments of the cable insulation when the sleeve is crimped onto the cable.

MARTIN D. BERGAN.

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