

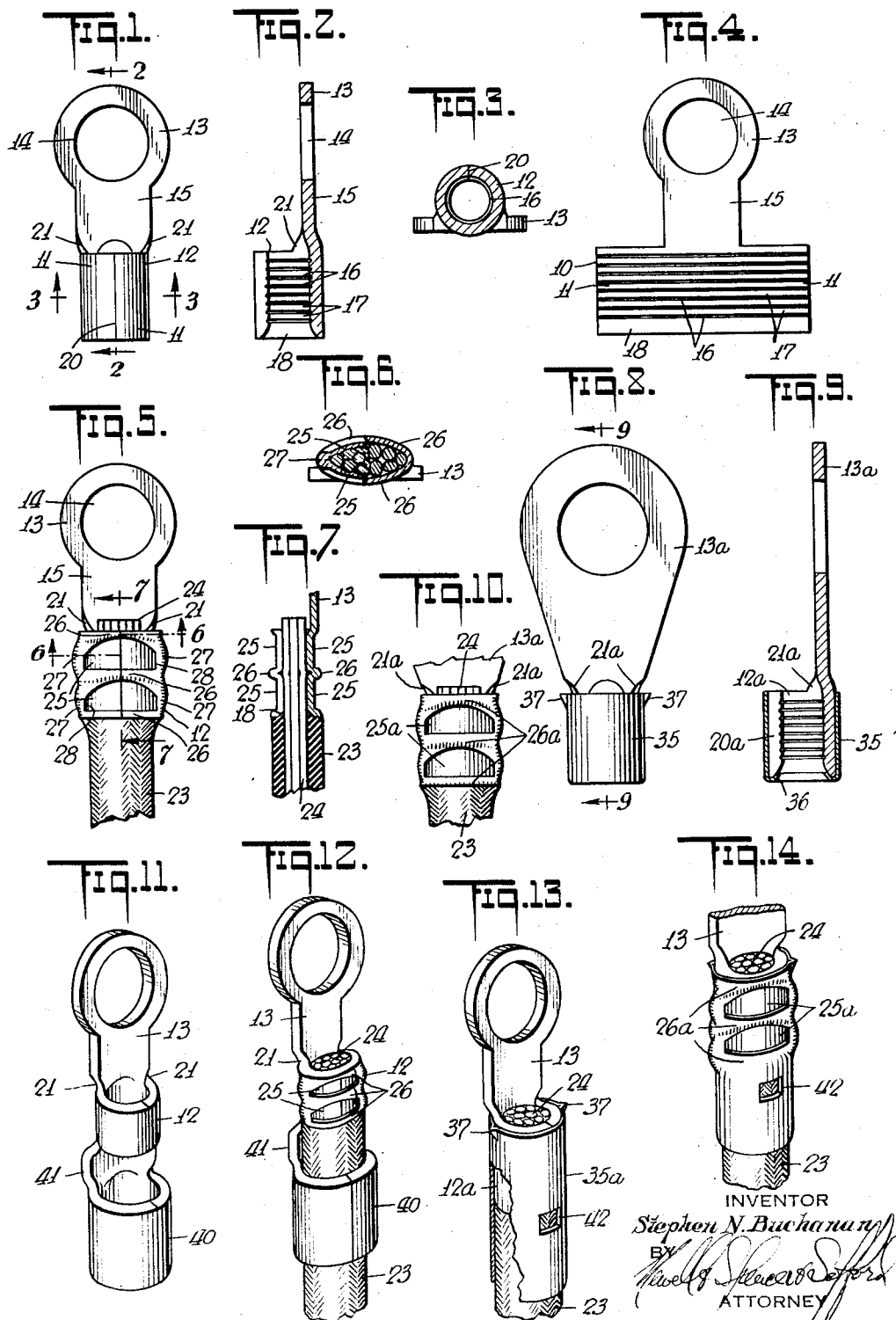
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ELECTRICAL CONNECTOR

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ELECTRICAL CONNECTOR

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The present invention relates to electrical connectors of the type adapted to be connected to electrical conductors for attachment to the binding posts, other connectors, etc., of electrical devices.

In the type of connectors in which a substantially flat contact section extends from one end of a wire holding ferrule, the base of this section where it merges into the ferrule is often structurally weak and subject to undesirable bending or breaking during use.

Also, in a solderless type of connector, whether formed with a seamless ferrule or with a pair of opposed ears folded inwardly to form the wire holding ferrule, it is customary to anchor the wire in the ferrule by flattening a part or all of the ferrule. Any elastic return or subsequent bending of these flattened portions about the fold lines between them will loosen the ferrule grip on the wires and reduce the effectiveness of the electrical connection between the wires and the ferrule. By "solderless" as used herein is meant connectors in which electrical and mechanical connection between the terminal or other electrical element and the wire or other conductor is made primarily by pressure rather than by a fused bond of solder or other foreign metal; it is not intended to exclude the presence of solder in other relations or which may be applied before these parts are assembled or after a solderless connection between them has been formed.

One object of the present invention is to provide a connector which is simple, durable, rugged and economical to manufacture, and which will effectively withstand severe service, and meet the most rigid electrical requirements.

A more specific object is to provide a new and improved connector having a contact base section capable of effectively withstanding bending stresses greater than are incurred in practice.

A further object is to provide a new and improved solderless connector in which the flattened or crimped ferrule is effectively held against bending and in firm gripping electrical contact with the conductor wires.

Various other objects of the invention will be apparent from the following particular description, and from an inspection of the accompanying drawing, in which

Fig. 1 is a top plan view of one form of connector embodying the present invention, and here shown prior to being connected to a conductor.

Fig. 2 is a longitudinal section taken on line 2-2 of Fig. 1.

Fig. 3 is a transverse section taken on line 3-3 of Fig. 1.

Fig. 4 is a plan view of a blank from which the connector of Figs. 1 to 3 is shaped.

Fig. 5 shows the connector of Figs. 1 to 3 after being connected to a conductor in accordance with the present invention.

Fig. 6 is a transverse section taken on line 6-6 of Fig. 5.

Fig. 7 is a longitudinal section taken on line 7-7 of Fig. 5.

Fig. 8 is a top plan view of another form of connector embodying the present invention, and shown prior to attachment to a conductor.

Fig. 9 is a longitudinal section taken on line 9-9 of Fig. 8.

Fig. 10 is a fragmentary top plan view of the connector of Figs. 8 and 9 shown attached to the conductor.

Fig. 11 is a perspective of another form of connector embodying the present invention, and shown prior to attachment to the conductor.

Fig. 12 is a perspective showing the connector of Fig. 11 attached to the conductor.

Fig. 13 is a perspective of still another form of connector embodying the present invention, and shown prior to attachment to the conductor, and

Fig. 14 is a fragmentary perspective of the connector of Fig. 13 shown attached to the conductor.

In the form of the invention shown in Figs. 1 to 4, a terminal lug is preliminarily stamped from sheet-metal such as annealed copper, into a flat blank shown in Fig. 4. This blank has at one end a rectangular section 10, which defines a pair of opposed ears 11, and which is adapted to be rolled into a split cylindrical connector ferrule 12 (Figs. 1-3) for receiving the wires of a conductor. At its other end the blank is formed with a contact section 13 having a stud hole 14 for attachment to the binding post of an electrical device (not shown). The form of this contact section is not essential to the present invention, and is merely shown as representative of any desired electrical device which is to be connected to the wire.

The contact section 13 as shown is provided with a shank 15 which has parallel side edges but which, for the purpose of the present invention, may be of any other suitable shape.

The inner surface of the ferrule section 10 is stamped or otherwise formed with a series of fine parallel grooves 16 extending across its full width, and defining a series of wire gripping ridges 17.

which are substantially wider than said grooves and which have substantially flat crowns in order to afford maximum ferrule area for gripping the wires, and to prevent cutting of the gripped wires. The inner side of the ferrule section at its outer end has a bevel 18 to flare the inner surface of the inlet end of the cylindrical ferrule 12 formed from said section.

The rectangular section 10 of the blank is rolled as shown in Figs. 1 to 3 to form the cylindrical wire receiving ferrule 12, with its line of juncture 20 extending substantially centrally with respect to the sides of the lug.

As a feature of the present invention, the base of the contact section 13 where it merges into the cylindrical ferrule 12 is wide enough to form a pair of corner braces or flanges 21 between the sides of said section and the end of said ferrule, when the blank of Fig. 4 is shaped to form said ferrule. These corner flanges 21 desirably follow the curvature of the cylindrical ferrule 12, and serve thereby to effectively brace the lug against transverse bending across said flanges. Likewise, the cylindrical curvature may extend beyond the rectangular portion 10 into the shank 15 as shown to further increase the resistance of the lug against bending.

I have found that by making the width of the contact section at its base where it merges into the cylindrical ferrule 12 substantially equal to the outside diameter of said ferrule, corner bracket flanges 21 of effective size are formed. Expressed in terms of blank dimensions, such effective flanges 21 may be formed by making the width of the contact section 13 where it connects into the rectangular blank section 10 about one-third the width of said latter section.

It should be noted that the increase in bending resistance of the lug at the base of the contact section 13 is not due merely to an increase in the sectional area of the lug at this region resulting from the increase in the width of said contact base section, but is due mainly to the shape and disposition of this area, and especially to the formation of the reinforcing flanges 21.

The provision of a substantially wide shank for the contact section 13 also serves to increase the current-carrying capacity of the lug with minimum amount of resistance and with avoidance of heating.

The lug shown in Figs. 1 to 3 constitutes an article of manufacture which can be sold, shipped or stored as such. In clamping this lug to an electrical conductor 23 to form the unit shown in Figs. 5-7, the insulation is stripped off the end of the conductor to expose the stranded wires 24. These wires 24 are then slipped into the cylindrical ferrule 12 until the ends of the insulation abut the bevel edge 18. This bevel edge 18 forms a flaring mouth to permit entry of the end of the insulation into the interior of the ferrule as well as to guide the wires of the stranded cable into the ferrule; and it may also with advantage be smoothly rounded so as to eliminate any sharp corners that might cut into the wires or insulation during the ferrule crimping operation to be described.

With the conductor wires 24 inserted into the ferrule 12 as described, the ferrule is flattened or collapsed over said wires to form a solderless connection therewith.

In the collapsed condition the width of the contact section 13 at the region where it connects into the collapsed ferrule is slightly less than the width of the ferrule, but is wide enough so that

the corner flanges 21 extending from the sides of said contact section to the fold sections of said ferrule follow the curvature of said fold sections, and thereby serve to effectively reinforce the lug against transverse bending across said flanges during use.

In the ordinary construction, prior to the present invention if a ferrule were collapsed or bent onto a wire, after the ferrule bending or collapsing pressure had been released, the two ferrule ears would have a tendency to spring back or reopen outwardly slightly along their fold lines, so that the gripping action on the wires would be somewhat relaxed. Also, if the two ferrule ears were not connected together along their line of juncture, they would tend to bend outwardly along their fold lines under stresses encountered during use.

As a feature of the present invention, the ferrule 12 is crimped in such a way as to reduce the possibility of the collapsed ferrule expanding. For that purpose the ferrule 12 is corrugated on each face by a series of narrow flattened areas formed at spaced positions to give alternate fold sections 25 and 26 of different fold angles as shown. The acutely bent crimped sections 25 serve to grip effectively the wires 24 against withdrawal from the ferrule and resist more effectively any expansive return bending at the fold edge, while the less acutely bent sections 26 afford greater structural stability to the flattened side as a whole by reasons of the wider folds longitudinal of the ferrule, and the formation of compressively strong zones bracing the fold edges against expansive bending. These less acutely bent fold sections 26 thus serve effectively to resist the outward bending of the crimped sections 25 about their fold lines.

The crimping operation may be effected by a pair of opposed similar dies (not shown) shaped in accordance with the shape of the ferrule areas 25 to be depressed, and serving to flatten the opposed sections of the cylindrical ferrule 12 and to form said areas. A suitable tool for this purpose is described and claimed in my copending application Serial No. 474,935, filed February 6, 1943, or in the application of U. A. Whitaker, Serial No. 455,039, filed August 17, 1942.

Two or more of the depressed areas 25 on each side of the ferrule are preferably provided spaced from the sides and ends of said ferrule to define the raised fold sections 26 at each end of the ferrule and between the two depressed areas 25, and also ridges 27 along the sides of said ferrule between the raised fold sections 26. As a result of this construction, there is formed along each fold side of the ferrule a continuous border rib, which adds to the rigidity of the ferrule, and which thereby aids in resisting the spreading or expanding of the opposed depressed wire gripping ferrule sections 25 apart.

In the crimping operation, it is desirable to form first one pair of opposed depressed areas 25, and then form the second adjoining pair. In this way any reflex expansive return bending of the first pair of depressed areas as the result of the inherent resiliency of the ferrule metal, will be counteracted by the crimping operation to form the second pair of opposed depressed areas. This second crimping operation results in a deformation of the metal such that the first crimped areas 25 are left under compression in the original fold position they occupied while under bending pressure and thereby imparts to said areas a more effective and corrosion resisting contact.

I have shown by cutting sample terminals across the crimped area that the metal of the ferrule and the metal of the wires within the ferrule are actually coined so that they fit together with no voids left between them. This is illustrated in the left-hand section of Figure 6. Accelerated corrosion tests have shown that with terminals made as described above under suitable crimping pressure an acid or other corrosion liquid does not penetrate into the crimped areas except as it may eat its way by slow corrosion. Thus, the electrical contact is not only equal at its outset but is substantially equally permanent with a well soldered connection. If a high crimping pressure is used there may even be a degree of cold welding between the wires and ferrule, particularly in the case where tinned wire is used or other coating of plastic metal which exhibits a relatively high plastic flow under the crimping pressure.

Another surprising advantage of the construction just described is in its extraordinarily high breaking test. With an ordinary crimped-on terminal the wire tends to be weakened so that it will break at the edge of the terminal with a pull very much below the normal tensile strength of the wire. With a single crimp, I have found that if the crimp is spaced at least $\frac{1}{16}$ of an inch from the end of the ferrule and the crimp made substantially as shown, a pull test of approximately 90% of the normal tensile strength of the wire is attained and this falls off rapidly as the edge of the crimp approaches closer than $\frac{1}{16}$ of an inch to the edge of the ferrule, dropping to 50% or less if the crimp actually overlaps the edge with a sharp edged ferrule. If the crimp 25 which is closest to the lug 13 is made first and the crimp closest to the length of the wire is made last, and particularly if the latter is made under a lesser pressure than the former the pull test can be even further increased, since under these circumstances the latter crimp takes a supporting hold on the wire yieldable to less than the breaking tension, whereas, the crimp closest to the lug 13 holds with an unyielding grip and thereby the tension is apparently distributed between the two or more crimps.

If a single tool is used for making both or all of the crimps simultaneously it is desirable that it should be designed so as to make the deepest crimp at a point more removed from the edge of ferrule which is toward the length of the wire and to make successively shallower crimps as that edge of the wire is approached. This is more particularly described and claimed in a copending application filed by Uncas A. Whitaker, August 17, 1942, Serial No. 455,039.

Advantageously, the line of juncture 20 extends centrally across the crimped areas so that on neither side will the stock of the ferrule have to act with an effective cantilever arm greater than one-half the width of the crimped ferrule.

As a further protection against the reduction in tensile strength by crimping, the edge of the ferrule towards the wire, as illustrated in Figure 2, is rounded or sloped gently at 18, which serves to protect to a substantial extent against the effect described above; so that, even if the crimp is carelessly placed so as to overlap the edge, excessive reduction in the pull test strength would be avoided.

The depressions 25 are preferably substantially elliptical or chordal in shape (i. e., simulating the area between a chord and its arc) except that the points may be cut off by short parallel sides 28,

and are preferably arranged as shown. This results in an actual coining of the metal with production of lateral bulges 27 in which the side areas of the metal are compressed solidly into said bulges 27, while the metal at the sections 26 between the two pairs of opposed depressions 25 and at the ends of the ferrule retains a smooth elliptical cross-section. This construction also serves to afford maximum depressed areas 25 so as to effectively grip the wires 24, and maximum amount of raised areas along the fold sides of the ferrule where it is needed most for rigidity.

The crimped construction shown serves also to undulate the sides of the ferrule along its fold edges so that the different successive sections of each fold edge is not in alignment. This misalignment of the successive section of the fold edges aids in resisting the expansive bending of the wire gripped crimped ferrule section 25.

The corrugations in the opposed facing surfaces of the ferrule formed by the alternate depressed and raised ferrule sections 25 and 26, serve not only to hold the ferrule as described against relaxing outwardly, but also serve to wrinkle the wires 24 in said ferrule. This wrinkling of the wires 24 assists in preventing said wires from being pulled out of the ferrule.

In an alternative form shown in Figs. 8-10 herein, the ferrule is of laminated construction, and before attachment to the conductor 23 comprises the split cylindrical part 12a integral with the terminal lug section 13a, and a thin cylindrical seamless sleeve 35 of suitable metal, such as copper, telescoped over said part with a snug fit as shown in Figs. 8 and 9. This sleeve 35 is substantially co-extensive in length with the ferrule part 13a, and is preferably retained against axial movement on said part by an intumed spun rim 36 at one end of said sleeve embracing the corresponding rim of said part, and by a slight pinching at 37 at its other end.

The contact section 13a is shown shaped with tapering shank sides, and is wide enough at its base to form reinforcing corner flanges 21a for the purpose described with reference to the corner flanges 21 in the construction of Figs. 1-4.

The assembly shown in Figs. 8 and 9 forms a composite unit, which can be sold, shipped and stored as such. The ferrule 12a, 35 can be fitted over the bare conductor wires 24, and crimped thereon with alternate depressed and raised sections 25a and 26a in a manner already described with reference to the construction of Figs. 5-7.

The crimped ferrule part 12a being comparatively thin will be effectively clamped on the wires 24 against expansion. The crimped seamless sleeve 35 will cover the split 20a of the ferrule part 13a and will thereby assist in holding said part against relaxing its grip on the wire, and also will prevent the wires 24 in said part from escaping into or through the split 20a during crimping. Also, this sleeve 35 enhances the neat appearance of the connection.

In Fig. 11 is shown an alternative one-piece construction in which the lug is provided with a second cylindrical split ferrule 40, which is secured to the wire gripping ferrule 12 by an integral connecting piece 41, and which is coaxial with said ferrule 12. This second ferrule 40 is larger in diameter than the wire gripping ferrule 12 so as to snugly receive the insulated part of the conductor 23 (Fig. 12).

In clamping the lug of Fig. 11 to the conductor 23, the lug is slipped over the end of the conductor with the ferrule 40 embracing the insulation, and

the ferrule 12 embracing the bared wires. The two ferrules 12 and 40 are then flattened over the conductor, as shown in Fig. 12.

In Fig. 13 is shown an alternative form of composite lug in which a cylindrical sleeve 35a similar to that shown in Figs. 8-10 extends beyond the ferrule part 12a to embrace a substantial portion of the conductor's insulation. The composite ferrule 12a, 35a is crimped over the bare wires 24 to form the alternate depressed and raised sections 25a and 26a, while the rear projecting section of the sleeve 35a extending over the insulation may be left cylindrical, simply flattened thereon or may be crimped as in the case shown in Fig. 12. A hole or opposite holes 42 in the rear projecting section of the sleeve 35a may be provided to serve as an inspection window.

As more particularly described and claimed in a companion application, the gripping power of such a flattened ferrule on a stranded wire increases with increased thickness of the metal in the ferrule only up to a critical thickness. Any greater thickness, which may be found desirable on the one hand, e. g., to impart a necessary structural strength or electrical conduction will be undesirable on the other hand because of the reduced effectiveness for tightly gripping the wires 24. The thicker ferrule not only is more difficult to crimp tightly onto the wire, but also has greater resilient return after the release of the crimping pressure.

As set forth in said companion application, one way in which this condition can be remedied is by making the ferrule comparatively thick, but reducing its thickness to approximately the critical optimum thickness at the opposite sections where it is to be folded when crimped onto the wire. As will be apparent, the combination shown in Figs. 8-10 and 13-14, is well adapted to use with this invention, both the inner split ferrule 11 and the seamless ferrule 35 being of less than the critical thickness, whereas taken together they may be of thickness greater than the critical thickness.

In all of the alternative embodiments described, the lug will form a strong electrical connection, capable of withstanding severe service and of meeting the most rigid electrical requirements. This desirable result is obtained without the use of solder, and by comparatively simple expedients,

which do not add materially to the cost of manufacture or impair the ease of attachment to the conductor.

As many changes may be made in the above construction, and many apparently different embodiments of this invention may be made without departing from the scope of the invention, it should be understood that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. An electrical connector of the type intended to be crimped onto an electrical conductor and including a terminal contact portion and a rolled ferrule portion integral therewith having a seam formed by two abutting edges where they are brought together into cylindrical shape for receiving the wire of the conductor, and a seamless sleeve telescoped over and embracing said ferrule portion; said contact and ferrule portions being formed of a highly conductive, relatively soft material, and said sleeve being formed of a relatively flexible material resistant to stretching and being relatively thin with respect to the material of said ferrule portion.

2. An electrical connector of the type intended to be crimped onto an electrical conductor and including a terminal contact portion and a rolled ferrule portion integral therewith having a seam formed by two abutting edges where they are brought together into cylindrical shape for receiving the wire of the conductor, and a seamless sleeve telescoped over and embracing said ferrule portion; said contact and ferrule portions being formed of a highly conductive, relatively soft material, and said sleeve being formed of a relatively flexible material resistant to stretching and being relatively thin with respect to the material of said ferrule portion, said sleeve overlapping beyond the end of said ferrule portion remote from said contact portion, whereby said ferrule portion may be positioned over the stripped end of a conductor with said remote end of said ferrule portion abutting the end of the insulation sheath on the conductor and with said sleeve overlapping and embracing the end of said insulation sheath.

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