July 16, 1957 J. C. MACY 2,799,841

ELECTRICAL CONNECTOR AND METHOD OF ITS MANUFACTURE AND USE

Filed June 16, 1951 2 Sheets-Sheet 1

Fig. 1.

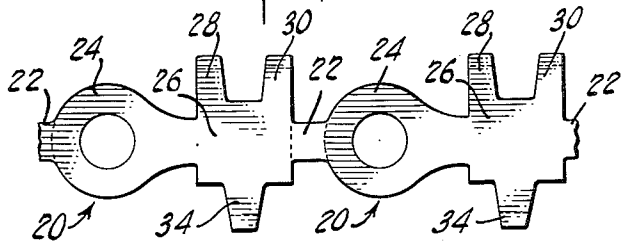


Fig. 2.

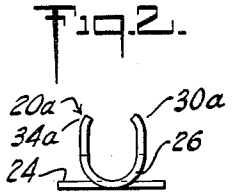


Fig. 3.

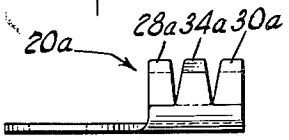


Fig. 4.

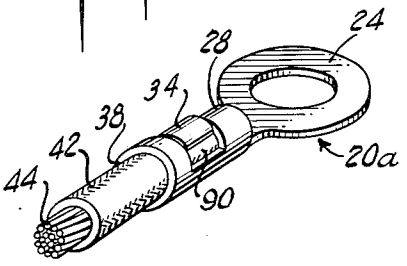


Fig. 5.

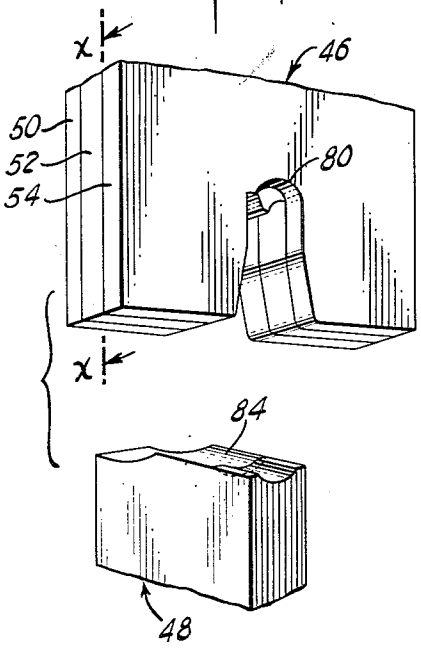
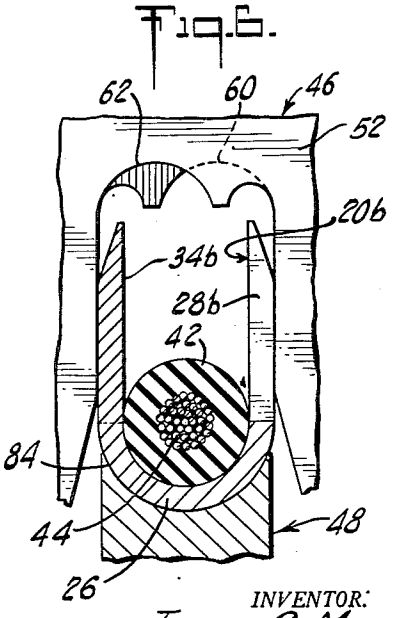


Fig. 6.



INVENTOR:
JAMES C. MACY.

BY
Curtis, Morris & Safford.
ATTORNEYS.

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ELECTRICAL CONNECTOR AND METHOD OF ITS MANUFACTURE AND USE

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Fig. 7.

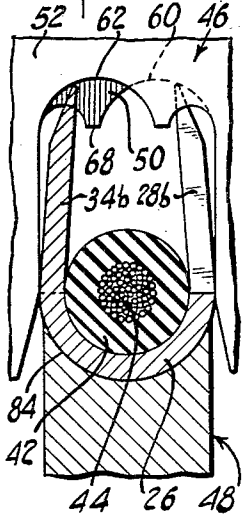


Fig. 8.

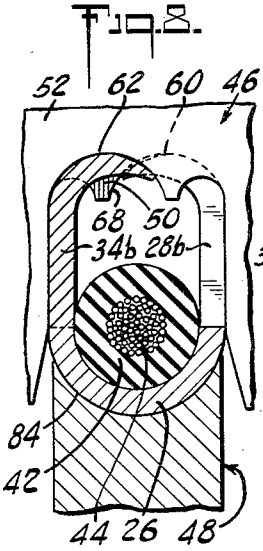


Fig. 9.

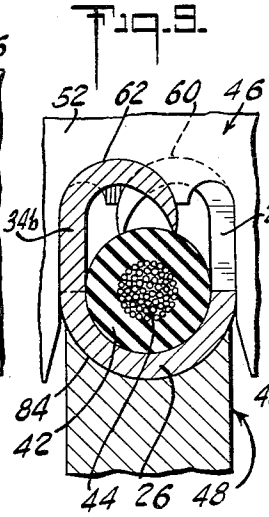


Fig. 10.

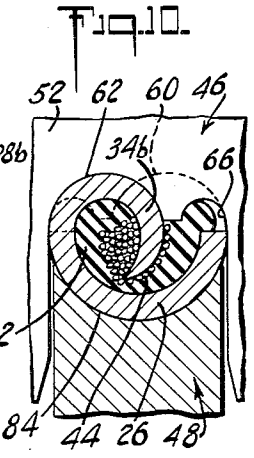


Fig. 11.

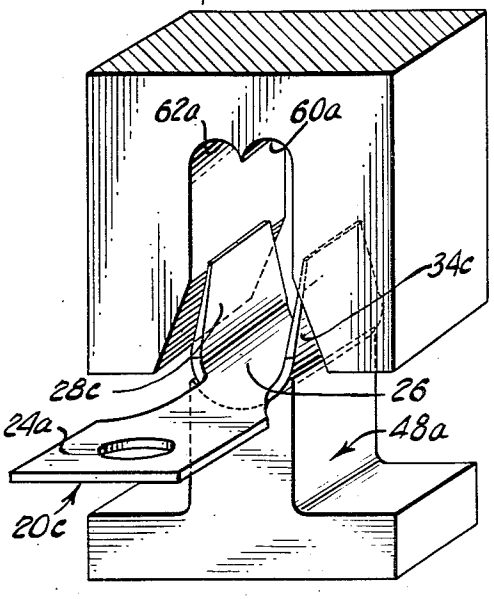


Fig. 12.

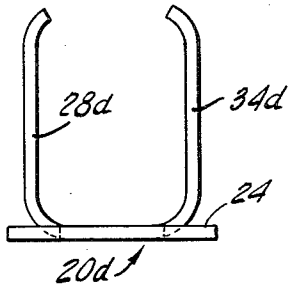
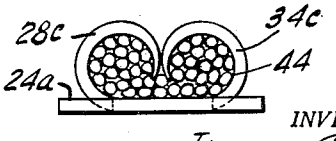


Fig. 13.



INVENTOR.
JAMES C. MACY.

BY
Curtis, Morris & Safford.
ATTORNEYS.

United States Patent Office

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Patented July 16, 1957

2,799,841

ELECTRICAL CONNECTOR AND METHOD OF ITS MANUFACTURE AND USE

James C. Macy, Westfield, N. J., assignor to AMP Incorporated

Application June 16, 1951, Serial No. 231,984

10 Claims. (Cl. 339—276)

This invention relates to electrical connectors; and more particularly to the type which are pressure-crimped onto electrical conductors; and in one aspect to such connectors formed and especially adapted for use in automatic machines; and in another aspect to such connectors which, when applied to insulated wires, can pierce the insulation in such a fashion that the wire conductor is contacted by connector portions which pierce the conductor insulation sheath. This application is a continuation-in-part of my copending application Serial No. 679,630, filed June 27, 1946, now U. S. Patent 2,557,126, and of my copending application Serial No. 717,842, filed December 23, 1946, now U. S. Patent 2,600,012. Reference is made to these applications for further disclosure of related connectors and connections as well as methods and means of their manufacture and use.

The art of applying terminal and other connectors to electrical conductors by crimping or pressure-forming them onto wires has become of quite general and quite successful use. Connections thus applied are compact, electrically and mechanically more secure and, in most applications, the completed connections are less costly than the prior connections in which the wire conductors were merely wrapped and/or soldered. Many applications of pressure-formed connectors, however, demand high tensile strength and security under conditions of vibration and flexure, high electrical conductivity and stability, resistance to corrosion, compactness, and at the same time, economy in the manufacture of the connectors and in their application to conducting wires. The subject invention has been most important in the development of connectors which meet these requiremens, these connectors being thereby well adapted to application to wires by high-speed semi-automatic machines, even at rates measured in thousands of completed connections per hour.

The development and use of connectors which are adapted for application directly onto insulated wires by pressure-forming, without previously stripping the insulation from the wire, has been retarded by many unforeseen difficulties, many of which arose out of the physical characteristics of insulated wires. Prior to my inventions, such connectors often times made only poor or intermittent contact with the actual conductor, and they were thus suitable only for use in high voltage and low current applications, wherein low current capacity avoided serious voltage loss or heating by the contact resistance. It is, accordingly, an object of the present invention to provide compact insulation-piercing connectors which can consistently produce connections of high and stable current capacity.

The present invention is thus mainly directed to two general objectives: the development of such improved insulation piercing connectors, and the development of low cost, compact, sturdy and efficient, electrical connectors which are well adapted for high speed application to wires by manual or automatic machinery, with or without the piercing of insulation on the wires.

In my prior applications I have described and claimed inventions according to which the wire is laid in or above an open trough of a connector from which ears project inwardly, and these ears then curled and driven into or against the wire as it lies in said trough. These ears were disclosed as upstanding from the sides of a central base portion of the connector wire-engaging portion; the ears and base portion thus forming the wire-receiving ferrule-forming trough open at the top and ends. As the wire need be merely located in this space, rather than within a cylindrical ferrule, automatic assembly of the wire and a connector is greatly facilitated, as will be more fully brought out.

The present invention is an improvement on this, with the general objects of improving the structure of electrical connectors of the types described so that ear portions of such connectors will consistently and accurately follow sharply curved paths of travel determined by curved die surfaces during crimping, and so that said connectors may thereby be applied to wires at great speed in connector-applying machines. A more particular object is to prevent accidental collapse or inward buckling of the ears in the curling dies. A further object is to improve the ear portions of such connectors so that the ends of the ears will closely scrape the die surfaces in order to gather any stray strands of wire when applied to a bare stranded wire. Another object is to so improve such connectors as to give large areas of contact and thereby produce connections of relatively high current capacity, particularly in the case of insulation-piercing service; more particularly, it is an object of this invention to provide for effective use of generally trapezoidal or rectangular ear portions, that is, ears having a generally straight tip the edge of which is transverse to the axis of the ear and preferably approximately parallel to the longitudinal axis of the connector at the base of the ear, to permit their making contact of substantial length with the conductor and thus provide the desired large contact area. Another object, in the case of insulation-piercing connections, is to facilitate and assure the piercing of the insulation by the ears and the driving of the ears into intimate contact with the conducting core. Yet another object is to provide economical connections of high current-carrying capacity and of great strength, electrical stability, and compactness. A further object is to develop connectors of the type described which, by their adaptation to their use in sharply curved die surfaces, reduce the wear and tear and maintenance costs of such dies.

These objects, as well as other objects which will be apparent from the following specification and claims, are met by forming the free ends of the ears to certain shapes and, in some aspects, by certain methods of forming. Each shape has characteristic advantages. The ear ends, according to this invention, are structured so that one surface of the ear, near the end, is turned toward the geometric surface generally defining the other surface of the ear; the outer surface is turned inward, such as by tapering the thickness of the ear from its outer surface or by curling the end of the ear inward, or the ear is otherwise tapered in thickness.

In this specification and the accompanying drawings, I have shown and described a preferred embodiment of my invention and suggested various modifications thereof; but it is to be understood that these are not intended to be exhaustive nor limiting of the invention, but on the contrary are given for purposes of illustration in order that others skilled in the art may fully understand the invention and the principles thereof and the manner of applying it in practical use so that they may modify and adapt it in various forms, each as may be best suited to the conditions of a particular use.

In the drawings:

Figure 1 is a top plan view (enlarged) of a connected strip of terminal blanks;

Figure 2 is an end view of the blank with the ferrule portion pre-formed into a suitable trough;

Figure 3 is a side view of the blank with said pre-formed ferrule portion;

Figure 4 is a perspective view of the completed terminal applied to an insulated conductor;

Figure 5 is a perspective view of a set of dies for applying a terminal to a conductor;

Figure 6 is a front cross-sectional view taken on a plan *x—x* immediately behind the first plate **54** of the upper die shown in Figure 5, through a connector and insulated conductor; the die set being in the initial stage of the installation onto the conductor;

Figures 7, 8 and 9 are views similar to Figure 6, but showing successively later stages of the die operation;

Figure 10 is a view similar to Figure 6, showing the final stage of the die operation;

Figure 11 is a perspective view of a second form of connector embodying this invention, shown in position between a pair of dies adapted to crimp it onto a wire;

Figure 12 is an end view of a third embodiment of this invention; and

Figure 13 is a cross-sectional view of a crimped connector of the type shown in Figure 11.

Figure 1 shows a series of connected terminal blanks **20** attached head to tail in the flat form in which they leave the blanking dies. Generally, such a strip of blanks is stamped from sheet metal stock and completely formed as a continuous strip of connectors, prior to their being severed one from another by cutting or punching out of the connecting link **22**, or more advantageously this link may be omitted and the connectors severed by a shearing operation as described and claimed in my copending application Serial No. 231,983, filed June 16, 1951, herewith, now U. S. Patent 2,730,718. In automatic-machine application, this severance is generally accomplished during the crimping cycle of the machine. Illustratively, one of the blanks **20***a* is shown in Figures 2 and 3 after a "U-ing" or bending operation thereon, whereupon it forms a connector which can be applied directly to an insulated wire.

This connector **20***a* (Figures 2 and 3) has rather elongated ear portions **28***a*, **30***a* and **34***a* upstanding from a base portion **26**, shown in this embodiment as a rounded channel although it may be flat or of other channel forms. This channel in turn is shown integrally connected to a secondary connector portion, shown representatively as ring-tongue **24**. As shown in Figure 4, the ear portions **28***a* and **34***a* are curled sharply inward and driven into contact with a wire conductor **44** enclosed in its insulation sheath **42**. In the particular connection shown for purposes of illustration, the ear **30***a* is wrapped around, rather than driven into, the insulated wire.

The means of completing such an insulation-piercing connection comprise crimping or curling dies such as are shown in Figures 5 and 6, including a crimping die **46** and a lower die or anvil **48**. Briefly, a connector **20***b* similar to that shown in Figures 2 and 3 is oriented between such dies with its ear portions extending upwardly toward or into the upper die **46** and its channel base portion **26** resting on or projecting above the lower die surface **84**. An insulated wire is then placed on or above the base portion **26** or the connector **20***b* (Figure 6), after which the dies are brought together with sufficient force to properly crimp the connector onto the wire (Figures 7 through 10). This may be done in plier-like hand tools, but is preferably done in a power-driven press wherein the connectors are automatically fed in strip form to the dies and severed from their strip during the crimping cycle of the machine. An automatic machine of a suitable type is shown and claimed in the patent of Vernon E. Carlson, No. 2,396,913.

The upper crimping die assembly **46** (Figures 5 and 6) may conveniently be made of three die plates **50**, **52** and **54**, secured together in any suitable manner, such as by rivets. These die structures are also described and claimed in my copending application Serial No. 10,021, filed February 21, 1948. The crimping process is also described in that application as well as in my above-mentioned copending application Serial No. 679,630.

As shown in Figures 6 through 10, as the two dies **46** and **48** are moved together, ear **34***b* enters the channel in die plate **52**. At the same time ears **28***b* and **30***b* enter similar channels in plates **50** and **54** and the ears respectively engage the concave die faces **62**, **60** and **80**, being curled thereby inwardly toward one another. Initially the ears may not curl over from their outer ends but instead may continue substantially straight, the opposing ears being bent or cantilevered from an area closer to the base portion **26**, as is shown in Figure 7. Further closing causes these ears **28***b*, **30***b* and **34***b* to collapse outwardly to conform with the die surfaces **60**, **62** (Figure 8) and **80**. The subject invention, embodied in this example with the ends of its ears **28***b*, **30***b* and **34***b* sharpened, or swaged to a tapered thickness, hastens and insures conformity of the ears to the die surfaces during the first driving of the ears over the curling die, thereby gaining several advantages, as will be more fully explained below.

Further closing of the dies gives the effect shown in Figure 9, with each of the ears **28***b* and **34***b* piercing the insulation sheath **42** at an angle so nearly normal to the surface of the insulation as to assure the piercing and avoid deflecting the ends of the ears. The ear **30***b* is caused, by the particular die surface **80** shown for illustration (Figure 5), to strike the insulation at a deflecting angle so that ear **30***b* wraps tightly around the conductor without piercing the insulation. The final closing of the dies drives each piercing ear through and into good contacting relationship with the stranded wire core **44** as is shown in Figure 10, the materials of the terminal and wire are substantially confined within the die so that the final compression can cause coining, i. e., plastic flow, of the metal tending to give it permanent conformity with the die faces and resulting in a substantially inelastic compacting and pressing together of the wire conductor **44** and ears **28***b* and **34***b*.

Where the wire conductor has but a single strand the ears do not substantially pierce the conductor, but can be wrapped thereabout from opposite sides so as to clamp it firmly with a shear stress between the edges of staggered ears an/or individually to grip the wires by the tightness of their curls. By using the proper curvature on the die faces, having regard to the material and the bevel of taper of the end portions of the ears, these ends may be made to scrape the periphery of the conductor as they curl around it, and thus to give a clean surface on the pressure contact area. By tapering the thickness of the end of the ear, according to this invention, from one side or the other, this action can be controlled so as to tighten or open the curl from the condition left by traverse across the die face.

The radii of curvature of the several die surfaces and the angle and location of bevelled edges on the ears may be chosen so that any or all of the ears may have the described gripping and/or clamping characteristics, as desired. Thus, with either a stranded or solid wire, the alternate connector ears on opposite sides of the ferrule portion may be made to press the wire respectively to the right and to the left, giving it an undulatory effect which further increases the pull-out strength of the connection, as well as the shear stress previously referred to which improves and maintains the electrical contact.

The particular point at which the ear penetrates the wire is not critical, although there is advantage in the

point as shown. If the point is moved closer to the base of the ear, the end of the ear should enter at a slope such that it moves slightly away from its base before it curls back toward it; the end of the ear may advantageously be sharp on its outer edge and bevelled on its inner edge to bend it back somewhat before it meets the central conductor core so that its inherent resiliency will tend to press it against the conductor and assure contacting engagement. If the point of piercing is moved further from the base of the ear one will ordinarily use a correspondingly longer ear, and advantageously it will be curled beyond 180° of arc to the desired angle of penetration or the inner edge sharpened and the outer edge relieved where it comes into contact with the wire, or both, so that it is at a suitable angle for puncture, advantageously a narrow angle to the radius of the wire.

I have found that ear portions such as those of the connector described can be made consistently to take the sharply curved shape of a die surface substantially throughout their length if their ends are swedged or otherwise tapered in thickness. By tapering the ears in thickness, the advantage is secured that they tend to bend first near the end; and once the end is properly bent, the resulting stresses assure that the rest of the ear will then bend progressively outward against the die, thus giving a smooth curl without danger of unsupported buckling. Also, I have found that the ear may be tapered in plan as well as in thickness, but it should be of a trapezoidal shape rather than pointed so as to assure sufficient area of contact when the ear is pushed against the wire. The taper, whether in thickness or in width or both, should leave the end of the ear sufficiently strong to retain substantially the curvature of the curling die while it pierces the insulation on the wire. As is illustrated in Figure 7, the first yielding may be a bending and buckling of the ear near its base. By tapering the thickness of the ear, the bending seen in Figure 8, wherein the ear **34** has buckled outwardly against the die surface **62**, occurs more readily. This, as already pointed out, proceeds substantially from the tip downward. The bending in the upper part of the ear imposes an outwardly directed reaction stress on the part below and thus precludes the possibility of the ear buckling inward.

Pointed ear portions, having a generally triangular shape, have been used before for piercing the insulation on a conductor. However, the electrical contact made by such pointed ears tended to be of low current capacity because of the extremely small area of contact made by a pointed ear abutted against a wire. Besides yielding a more uniformly satisfactory product by assuring consistently accurate curling by the dies, I find that the tapering in thickness of the ear portions enables the wider ear more easily to pierce the insulation with a chisel-like entrance and to give an elongated contact with the conductor, and thus a high current-carrying capacity, which avoids excessive resistance heating at the contact under relatively high current conditions. This chisel-like entrance also assures a minimum of stretching and tearing of the insulation, which is usually a tough material quite resistant to being cut or pierced, and thus it permits the ear portion to be more easily driven into the wire, without opening a wide gap in the insulation, and then to scrape tightly around the conductor, or to be driven into and among the strands of a stranded core as is shown in Figures 7 through 10.

Another advantage of my invention, mentioned previously, is that by tapering the ear from one side more than the other it may be caused to be deflected to one side or the other within the wire; for instance, tapering only the outside surface of the ear tip, leaving a sharp inner edge as shown in Figure 6, will cause the ear to be curled a bit more sharply by the camming effect or crowding of the insulation under the bevelled face when the ear is driven through it. In short, the directing of the ears into good contact with the central conductor of an insulated wire is thus given an additional means of control.

Where the central conductor of an insulated wire is made of a group of strands of wire, and entrance into the bundle of strands by the ear portion is desired, the tapering or sharpening of the ear tip, e. g., by swedging the edge of the blank before it is rolled up, allows them more readily to part the strands and penetrate the bundle to give contact with many strands against the faces of the ear when the final compression of the connection is affected. In addition, the dies may be skewed so as to enable them to present the ears with their leading edges parallel to the lay of the spiral strands and hence to enter easily between strands without cutting them.

A second embodiment of this invention, which also embodies inventions more fully disclosed and claimed in my copending application Serial No. 717,842, filed December 23, 1946, is shown in Figure 11, wherein the ferrule portion is comprised of two lateral ear portions **28***c* and **34***c* disposed on opposite sides of a base portion **26***a*, forming a U-shaped trough. This assembly is crimped onto a conductor by die means **46***a* and **48***a* similar to those previously described; however, the ears **28***c* and **34***c* of this embodiment are curled by an upper die **46***a* which presents laterally adjacent curling surfaces, advantageously a pair of parallel cylindriform troughs **60***a* and **62***a*, which are generally of radii of curvature approximately one-quarter of the width of the base. During crimping such ears **28***c* and **34***c* curl toward one another from their tips, by the present invention, and then are driven down together into the wire strands, and, due to the curl given them by the die surfaces, tend to diverge outwardly toward their bases as the compression is completed—this may occur to a marked extent if the ears are longer than those generally used, or if the ends of ears are pre-curled as in Figure 12, and is more pronounced in connections where the wire strands lay parallel to the entering ear edge, as the ears then tend to continue in their curled path until the assembly is compacted together. Figure 13 illustrates the making of such a connection. The wire strands may then be finally compacted into three groups; a bundle in the grip of each of the two curled ears and a third group wedged beneath their divergent ends, thus increasing the number of strands in direct contact with the connector and their total area of contact. In actual practice the wire will ordinarily not be as neatly divided, but in any case, the broad area of contact, compactness, and great sturdiness produced by the invention result in an excellent connection; and this connector has therefore proven very successful, particularly in automatic machine application to such wires.

As will be obvious to those skilled in the art, the secondary connector (**24**, **24***a*) is not essential to the invention. The channel formed by the base portion **26** and ear portions **28***c* and **34***c* may be used alone or with different contact or connector portions. When used alone these provide low cost and yet very effective means for permanently providing an external contact on an insulated wire or for joining two or more conducting elements together, e. g., joining a stranded wire and metallic ribbons which serve as capacitor leads.

A most advantageous result of embodying the subject invention in connectors, particularly of this second type, has been found to occur in their most general application; to bare stranded wires. Tapering the thickness of the ears **28***c* and **34***c*, as shown in Figure 11, thus assuring their close conformity to the die surfaces **60***a* and **62***a* and giving them a chisel-like shape, enables such ears to cleanly scrape the die surfaces to gather in any stray strands of wire. The strands of such wires, therefore, generally need not even be manually "dressed," that is, straightened and pressed or twisted together into a neat bundle, prior to the application of a connector thereto. By this same action, according to the invention, the wire need not be threaded into the terminal, but merely placed

in the recess of the female die or over the open channel of the connector. By avoiding the manual threading of the wire into the terminal, this permits higher speed operation of the machine, an advantage which is extremely important in regard to the cost.

Although the tapering of the ears can be done by removing metal, e. g., machining or grinding, advantages accrue from the process of swedging, i. e., pressing, rolling or hammering, in forming the tips of the ears to the tapered thickness, as this may be done in the die sets which blank and form the connectors. The resulting work-hardening may be retained to strengthen the ear tips if the stock or blanks are not annealed after swedging the ears. Thus even though the ears are quite thin they are hard enough to be driven into an insulated wire and against the conductor.

The manner of tapering the thickness can be varied to meet the needs of different applications. Generally only the ends of the ears need be sharpened permitting the general strength of the connector to be maintained. Swedging the ears on their outer surface only has been found to facilitate the use of a male curling die and, in any case, to facilitate the curling of the ears in toward the center of the wire after penetration, whereas swedging only the inner face, which is the inner or interior surface of the U or trough on which the wire rests during the crimping operation, has been found to better adapt them for scraping and gathering stray strands of a bare stranded wire. A combination of these two is also advantageous.

Where early conformity to the upper die is the important consideration, or where the curling troughs **60***a* and **62***a* are provided on the male die **48***a* instead of the female die **46***a* as shown, the exterior tips of the ear may be given the inward slope by pre-curling them in the blanking dies. This is shown in Figure 12. Where the die surfaces are reversed as mentioned above, this pre-curling prevents the ends from catching on the edges of the male die. Having the outer faces of the ears turned in at their ends, whether by bending the ears as in Figure 12 or by swedging them from their outer surface, facilitates the action of the curling dies. As can be readily inferred from the previous discussion, ears which are pre-curled may also advantageously be swedged or otherwise sharpened.

The terminals may be blanked from a variety of materials; I have found that the physical properties of half-hard brass, 70–30 commercial or cartridge brass, are suitable for this purpose. Quarter-hard electrical copper can be used if desired and even fully annealed pure copper can be used. Soft sheet steel can be used successfully in many applications, as more fully disclosed and claimed in the copending application of Franklin L. Pierce, Serial No. 780,117, filed October 16, 1947. Although this invention has been described above as applied in single connectors, its use in continuous strips of connectors which are individually severed from the strip at the time of application to a wire is particularly advantageous. The connectors in the strip may be in a state of semi-completion, e. g., merely as blanks with the projecting ears to be formed in the applying machine, in the same or a previous state from the crimping and severing operations, by means of appropriate dies.

The dimensions of the ear portions are not critical, but in order to acquire large areas of contact and the resulting high conductivity, the tip margins of the ears must be of substantial width (i. e., the dimension along the edge of the ear which is remote from and parallel to the base portion of the connector) in order for them to be of sufficient strength and current carrying capacity. This width is advantageously greater than one-half the width of such ears at their junction with the base of the ferrule, as is shown in the accompanying drawings. The length of the ears from their tips to the base portion is determined by the curvature and point of entry which they are to follow in the crimping and the thickness or absence of insulation to be pierced, and, the shape of the base portion, i. e., whether it is flat, angular, or curved in cross-section.

In the case of insulation-piercing service, the ears should be long enough to travel along the die surfaces until turned back upon themselves, advantageously approximately 180°, before striking the insulation; and then to have enough remaining length in the ears to push the end, after piercing the insulation, fully into engagement with the central conductor. As can be seen from the accompanying drawings, the length of the ear portions of the various embodiments is approximately equal to, or greater than, the distance across the trough of the connector measured at a height above the bottom approximately half the distance between the ears.

Since the trough may be either rounded or flat-bottomed, this distance may be taken at a height above the base where this height is one-half the said distance, thus avoiding any ambiguity as what can be considered the distance across the trough.

I claim:

1. An electrical connector comprised of a trough-like ferrule base portion, provided with ear means extending from a side edge of said base portion, said ear means having outer and inner faces which substantially follow plane surfaces in at least part of their length, the surface of one of said faces at the end portion of said ear means being turned toward the plane including the surface of the other face, the end edge of said end portion extending at least one-half the base width of said ear means and generally parallel to the longitudinal axis of said ferrule base portion, the metal forming said ear means being all on the ferrule trough side of any plane surface followed by the outer face of said ear means.

2. An electrical connector as defined in claim 1 wherein the ear means is reduced in thickness toward its free end.

3. An electrical connector as defined in claim 1 wherein the outer face of the ear means, at least near its free end, is turned inwardly.

4. An electrical connector as defined in claim 1 wherein the ear means is tapered in thickness and of relatively greater hardness near its free end.

5. An electrical connector as defined in claim 1 wherein the free end of the ear means is pre-curled inwardly.

6. An electrical connector comprised of a trough-like base portion, provided with ear means extending from a side of said base portion, said ear means having a length at least equal to the distance across said trough measured at a height above the bottom of said base portion where said height is approximately one-half said distance, said ear means having a minimum width at its free end, said width being greater than one half the maximum width of said ear means, the outer face of said ear means adjacent its free end being sloped inwardly.

7. An electrical connector comprised of a trough-like ferrule portion, said ferrule portion having a base portion and a plurality of integral ears extending upward from the sides of said base portion, said ears having a length approximately equal to or greater than the distance across the trough measured at a height above the bottom of said base portion where the ears are spaced twice said height, said ears having generally straight tip edges at least approximately parallel to the longitudinal axis of said base portion, said tip edges having a longitudinal extent of at least half the longitudinal extent of said ear measured at said height, whereby the ears have, at most, only a gentle taper in width, and said ears having outer and inner side faces which substantially follow plane surfaces in at least the free end portions of their length, the plane of one of said faces of each ear converging toward the plane including the end portion of the other face of that ear.

8. A sheet metal electrical connector comprising a trough-like ferrule base portion, ear means integrally ex-

tending from said base portion, said ear means being lateral extensions relative to the longitudinal axis of said base portion and adapted to be curled about bending axes parallel to said base portion axis to supplement said base portion in forming a ferrule, at least the free end portions of the inner and outer faces of said ear means being planar surfaces substantially parallel to said bending axes, the plane of one of said faces in the end portion thereof converging toward the plane including the other face and toward the longitudinal end edge of said other face.

9. The method of attaching to wire or the like connectors including ferrule portions which comprises stamping from malleable sheet metal a connector having a base and an integral ear extending from at least one side of said base, pre-bending the end of said ear inwardly, pushing said ear respectively across the concave surface of a curling die whereby to curl said ear to a radius shorter than one-half the lateral width of said ferrule and to guide said ear endwise onto a line of abutment against said wire, driving said end into the wire and compressing the rest of the ferrule, with plastic flow of its metal, into tight engagement with said wire.

10. The method of attaching to a wire or the like connectors which comprises stamping from malleable sheet metal connectors including ferrule portions each having a base and at least one integral ear portion extending from at least one side of said base portion, reducing the thickness of the free end of said ear, pushing said ear respectively across the concave surface of a curling die whereby to curl said ear inwardly and to guide said ear onto a line of abutment against said wire, driving said end into the wire and compressing the ferrule, with plastic flow of its metal, into tight engagement with the wire.

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