May 1, 1962 S. J. FARNELL 3,032,602

ELECTRICAL CONNECTOR

Original Filed Sept. 19, 1957 2 Sheets-Sheet 1

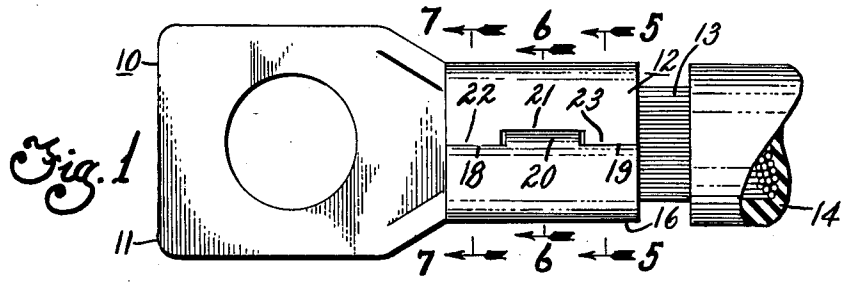


Fig. 1

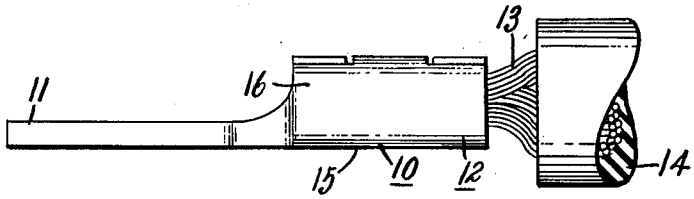


Fig. 2

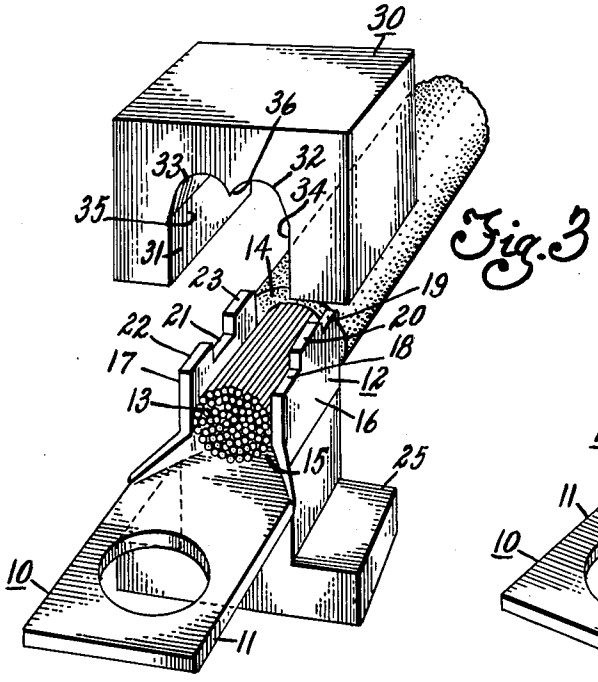


Fig. 3

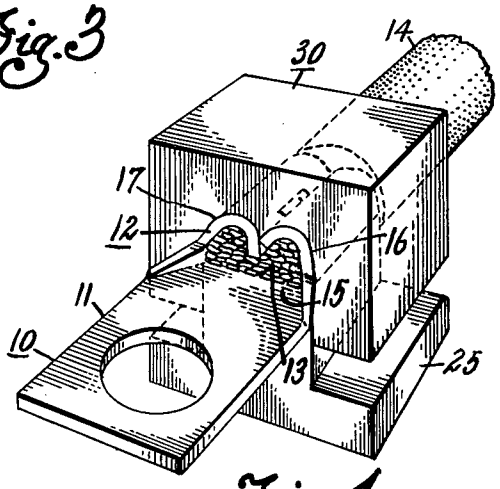


Fig. 4

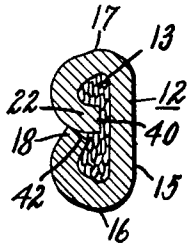


Fig. 7

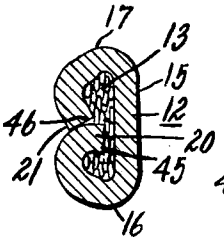


Fig. 6

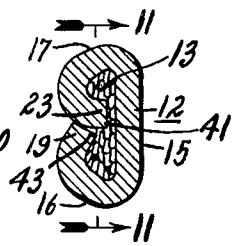


Fig. 5

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ELECTRICAL CONNECTOR

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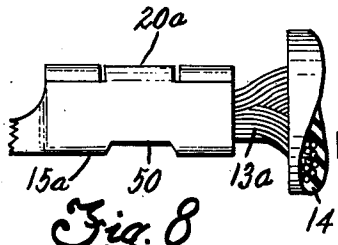


Fig. 8

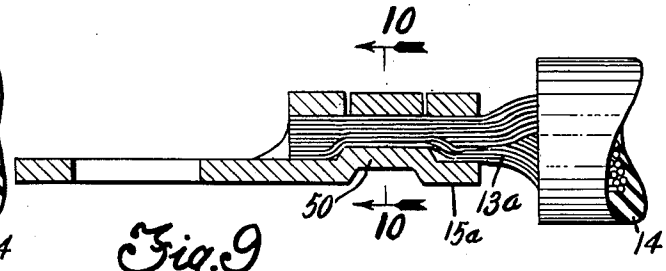


Fig. 9

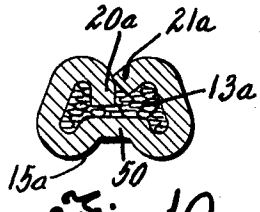


Fig. 10

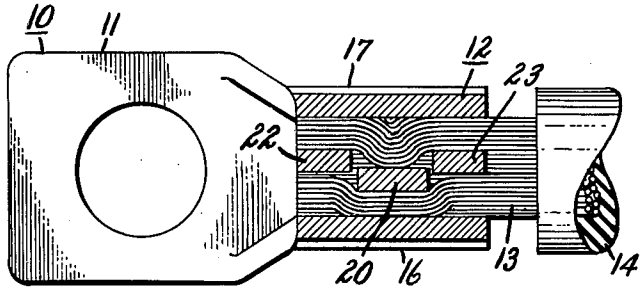


Fig. 11

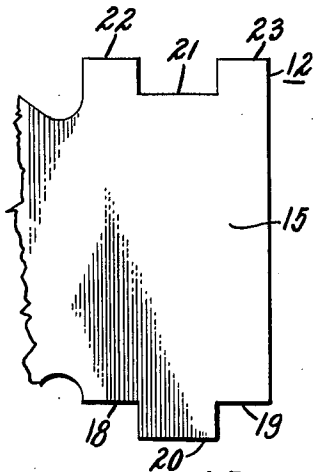


Fig. 12

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ELECTRICAL CONNECTOR

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Continuation of application Ser. No. 684,991, Sept. 19, 1957. This application Dec. 16, 1959, Ser. No. 859,906
3 Claims. (Cl. 174—90)

This invention relates to a terminal or electric connector, and particularly to a terminal having attachment means for applying the terminal to the end of a stranded conductor.

This application is a continuation of application S.N. 684,991 filed September 19, 1957, now abandoned.

An object of the invention is to provide an attachment means for mechanically securing a terminal to a stranded conductor by crimping or clamping a ferrule portion of a terminal onto the stranded wire of a conductor in a manner to provide a high resistance to pull out of the conductor from the terminal and also provide low electrical resistance in the mechanical connection of the terminal to the wire and also enclose the strands of the wire at the mechanical attachment of the terminal to the wire to reduce oxidation of the wire and terminal surfaces within the area of attachment which thereby avoids increase of resistance by aging.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein preferred embodiments of the present invention are clearly shown.

In the drawings:

FIGURE 1 is an elevational view of a terminal having the mechanical attachment feature of this invention.

FIGURE 2 is a side elevational view of the terminal of FIGURE 1.

FIGURE 3 is a perspective elevational view illustrating a terminal in position for attachment to the end of a conductor.

FIGURE 4 is a perspective elevational view showing the completed mechanical attachment of the terminal to a conductor.

FIGURE 5 is a cross-sectional view of the mechanical attachment taken along line 5—5 of FIGURE 1.

FIGURE 6 is a cross-sectional view taken along line 6—6 of FIGURE 1.

FIGURE 7 is a cross-sectional view taken along line 7—7 of FIGURE 1.

FIGURE 8 is a side elevational view of a modified form of the mechanical attachment for attaching the terminal to a conductor.

FIGURE 9 is a cross-sectional view of the terminal attachment of FIGURE 8.

FIGURE 10 is a cross-sectional view taken along line 10—10 of FIGURE 9.

FIGURE 11 is a cross-sectional view taken along line 11—11 of FIGURE 5.

FIGURE 12 is an elevational view of a sheet metal blank from which the terminal of FIGURE 1 is formed.

The terminal illustrated in FIGURE 1 is a spade type terminal that is adapted to be formed from sheet metal, usually of brass or copper. The terminal **10** consists of a terminal end portion **11** adapted for attachment to an electrical appliance. A ferrule portion **12** is provided for mechanical attachment to the stranded conductor **13** that has any conventional insulation covering **14** thereon. Only the stranded wire conductor **13** is disposed within the ferrule **12**.

The ferrule portion **12** which is mechanically crimped or clamped upon the conductor **13** is initially formed as a flat sheet metal blank, as shown in FIGURE 12. After the blank of FIGURE 12 is stamped, the ferrule portion **12** is formed into a U-shaped trough, as shown in FIGURE 3. Thus, the ferrule portion **12**, when formed into the U-shaped trough arrangement shown in FIGURE 3, consists of a bottom wall portion **15** that is generally flat or planar, as more specifically shown in FIGURES 5, 6 and 7. From the bottom wall portion **15**, there rise opposite side wall portions **16** and **17** from the sides of the trough. The side wall portion **16** terminates in the upper edge portions **18** and **19** that are spaced apart by an upwardly extending ear **20** that is integral with the side wall portion **16**.

The side wall portion **17** terminates in an upper edge portion **21** that is spaced between a pair of ears **22** and **23** that extend upwardly relative to the edge portion **21** of the side wall **17**.

As will be seen from FIGURES 3 and 12, the ears **22**, **20** and **23** are arranged alternately on opposite sides of the through-like ferrule portion so that the ears **22** and **23** substantially transversely align with the edge portions **18** and **19** respectively of the wall portion **16** whereas the ear **20** of the wall **16** substantially transversely aligns with the edge portion **21** of the opposite wall **17**.

When a conductor **13**, having the insulation **14** is to be attached to a terminal **10**, the one end of the conductor **13** is stripped of insulation, as shown in FIGURE 3, and the bared end of the conductor **13** is positioned within the ferrule portion **12** of the terminal and supported upon the bottom wall portion **15** thereof. The bottom wall portion **15** of the ferrule is supported upon an anvil or lower die **25**. An upper die **30** has a formed recess **31** therein adapted to slide down over the outer surfaces of the walls **16** and **17** of the ferrule **12**. The recess **31** of the die **30** has a contoured upper surface consisting of the arcuate wall portions **32** and **33** that are formed inwardly from the outer walls **34** and **35** of the recess **31**, the arcuate wall portions **32** and **33** meeting in a sharp edge **36**.

When the upper die **30** is moved downwardly upon the ferrule **12**, the ears **22**, **20** and **23** are curled inwardly along an arcuate path controlled by the arcuate surfaces **32** and **33** of the die **30**. While the ears are the first portion of the ferrule to move through the arcuate path, yet the upper edge of the portions **18**, **19** and **21** of the wall portions **16** and **17** also follow the arcuate path controlled by the walls **32** and **33** of the die until the ferrule is closed and fully crimped or clamped upon the stranded conductor **13**, as shown in FIGURE 4.

As more specifically shown in FIGURES 5 and 7, the ears **22** and **23** of the wall portion **17** curl inwardly until the end surfaces **40** and **41** of the respective ears are pointed toward the inner surface of the bottom wall **15** of the ferrule, these end surfaces **40** and **41** of the respective ears being spaced from the inner surface of the bottom wall **15** and bear against strands of the conductor that are retained between the ears **22** and the wall **15**. Also, the ears **22** and **23**, when curled inwardly from the position shown in FIGURE 3 to that shown in FIGURES 5 and 7, encompass certain of the strands of the conductor and retain the strands between the respective ears and the side walls **17**.

With the ears **22** and **23** being disposed in alternate arrangement relative to the ear **20**, when the edge surfaces **42** and **43** respectively of the edges **18** and **19** of the wall **16** are curled inwardly, these surfaces **42** and **43** engage the outer surfaces of the ears **22** and **23** respectively, as shown in FIGURES 5 and 7, whereby to close the ferrule longitudinally by engagement of the edges **18** and **19** with the outer surfaces of the ears **22** and **23**.

Similarly, when the ear **20** of the wall **16** is curled in-

wardly, as shown in FIGURE 6, the end surface 45 thereof bears upon strands of wire between the ear and the bottom wall of the ferrule. Also, the edge portion 21 has the end surface 46 thereof engaging the outer surface of the ear 20 to close the ferrule longitudinally, as more specifically shown in FIGURE 1. The ears 22, 20 and 23 are thus disposed in substantial longitudinal arrangement, as shown in FIGURE 11 to provide a longitudinally extending portion which bears against strands of the conductor.

When the ears 22, 20 and 23 are curled inwardly simultaneously by downward movement of the die 30, these ears follow a sweeping path, and because of their alternately arranged positions engage the strands of the conductor 13 beyond the longitudinal center line of the conductor at their initial engagement with the conductor and then sweep backwardly toward their respective side walls so that at least some of the strands in the conductor 13 are imparted with a longitudinally extending serpentine bend, as shown in FIGURE 11, which provides a crimp in the wire strands which resists longitudinal pull out of the wire from the ferrule. Also since the ferrule is crimped tightly against the strands of the conductor, there is a cold working of the strands of the conductor which compress or forge the strands into a relatively solid mass within the confines of the ferrule so that the strands as encompassed by the ferrule will be substantially closed against entry of air into the area of mechanical attachment of the ferrule to the conductor and thereby reduce the rate of oxidation of the wire strands which maintains a low electrical resistance factor between the conductor and the terminal over an extended period of time.

In FIGURES 8, 9 and 10, there is illustrated a slightly modified form of ferrule in which the bottom wall portion 15*a* is provided with a raised portion 50 that extends into the interior of the trough of the terminal. This raised portion 50 is substantially transversely aligned with the ear 20*a* and the edge portion 21*a* of the ferrule. Thus, when the ferrule of FIGURE 8 is crimped or clamped upon the conductor 13*a*, the raised portion 50 causes a longitudinally extending serpentine bend or crimp in the conductor 13*a* which provides resistance to pull out of the conductor from the ferrule, this longitudinally extending serpentine bend being normal to that illustrated in FIGURE 11 so that, when the terminal of FIGURES 8, 9 and 10 is used, there will be an added resistance to pull out of the conductor from the terminal.

It is to be understood that the foregoing description is directed to preferred embodiments of the invention and will be forthcoming under ideal conditions. In production activities, however, one or more of the conditions required to obtain optimum results are sometimes not present. Cross sections taken through this type of crimp sometimes show that the ends 42, 43 and 46 of the ears 18, 19 and 21 respectively do not make actual contact with the faces of the opposed ears 22, 23 and 20 as shown in FIGURES 5, 6 and 7. Furthermore, it has sometimes been noted that cross sections of said crimps show the ends 40, 41 and 45 of the ears 22, 23 and 20 respectively in direct contact with the bottom wall of the ferrule 15, rather than spaced therefrom by strands of the wire conductor.

These deviations from optimum conditions are created by several factors. In production activities, it is economically necessary to utilize a single crimping die and a single ferrule for at least two gauge sizes of wire. For this reason, the same ferrule is generally used for a #14 and a #16 gauge wire while another size ferrule and crimping die will be used in connection with a #18 and a #20 gauge wire, etc. This means that the ferrule will either be dimensioned to properly crimp on one wire or the other of the two sizes or the ferrule will be dimensioned as a compromise between the exact dimensions for either of the two sizes. Under these conditions, it

is apparent that the crimp, in certain instances, will not be the optimum crimp for the given wire size.

Similarly, since the wires being crimped are stranded wires, the number of strands have a marked bearing on the form of the crimp. In this connection, as the ears bend over into crimping engagement with the wire, the several strands separate and it has been found that they often do not separate equally. In some instances, a rather large bundle will fall under one ear and relatively few strands will be left for the other ear to engage. This means that the ear engaging the large bundle will not fold to its proper position but that it will become deformed and the wire therebeneath will be deformed heavily while the other ear will have no resistance toward forming due to the fact that insufficient wire is thereunder to present any impediment to crimping. In this instance, therefore, the crimp will not be completely uniform in cross section nor will it be centered with respect to the longitudinal axis of the terminal. The number of strands in the stranded wire also has bearing on the crimp. This varies with the gauge size of the wire and may even be different in a given size of wire, according to the specific gauge of the individual strands used to make up the wire.

Another factor that contributes to deviations in the crimp is directed to the crimping dies per se. As these dies are used, the surfaces thereof begin to wear and there is a tendency for the crimp to become slightly looser as the surfaces of wall portions 32 and 33 of FIGURE 3 begin to wear. In these instances, as soon as wear is apparent, the dies must necessarily be reset and/or reworked slightly in order to bring them back to their original condition.

The die variations from wear and the several other variables noted above will all have effect on the uniformity of the crimp. It is to be understood that these slight deviations from the preferred forms, while affecting the appearance of the crimp, do not affect the electrical or the mechanical efficiency thereof since, in all cases, the wire being attached to the terminal is heavily forged and tightly gripped to provide a satisfactory electrical and mechanical connection.

While the forms of embodiment of the present invention as herein disclosed constitute preferred forms, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. An electrical connection, comprising; a connector including a ferrule having the based end of a stranded conductor disposed longitudinally therein, one portion of the ferrule surrounding the conductor with integral ears extending from opposite sides thereof alternately and curled inwardly to dispose the ends of the alternately arranged ears in a generally longitudinal arrangement with the end surfaces of the ears positioned generally centrally of the ferrule and facing the inner bottom surface of said ferrule, the said sides of said ferrule opposite respectively to the position of the said ears having longitudinally extending straight-edged portions curled inwardly toward the said ears with the end surfaces of the said edge portions facing the outer surfaces of the said ears and contacting said outer surfaces substantially to close thereby the ferrule longitudinally and generally centrally to effect a low resistance electrical connection.

2. An electrical connection, comprising, a connector including a ferrule having the based end of a stranded conductor disposed longitudinally therein, one portion of the ferrule surrounding the conductor with integral ears extending from opposite sides thereof alternately and curled inwardly to disposed the ends of the alternately arranged ears in a generally longitudinal arrangement with the end surfaces of the ears positioned generally centrally of the ferrule and facing the inner bottom surface of said ferrule, said alternate ears alternately transversely displacing strands of said conductor encompassed thereby to effect a longitudinally extending laterally dis-

placed serpentine bend in the so-encompassed strands, the said sides of said ferrule opposite respectively to the position of the said ears having longitudinally extending straight-edge portions curled inwardly toward the said ears with the end surfaces of the said edge portions facing the outer surfaces of the said ears and conducting said outer surfaces substantially to close thereby the ferrule longitudinally and generally centrally to effect a low resistance electrical connection.

3. An electrical connection as defined in claim 1 which includes a raised portion located centrally and extending longitudinally in the bottom surface of the ferrule beneath the said ears against which strands of the conductor are forced by the ears and retained therebetween.

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