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2,617,845

TERMINAL WITH INSULATION PIERCING FERRULE

Filed Oct. 16, 1947

Fig. 1.

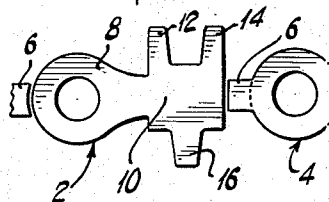


Fig. 2.

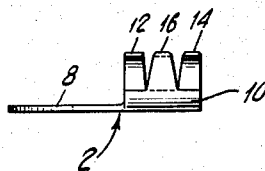


Fig. 4.

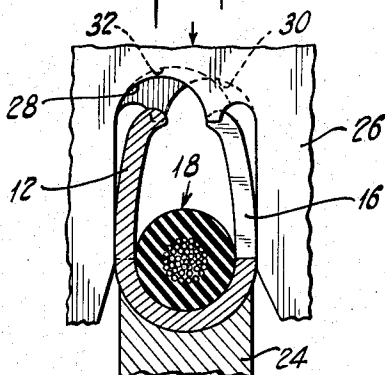


Fig. 3.

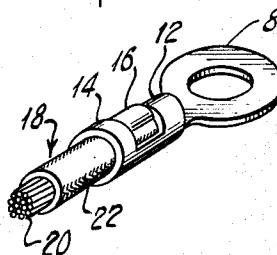


Fig. 5.

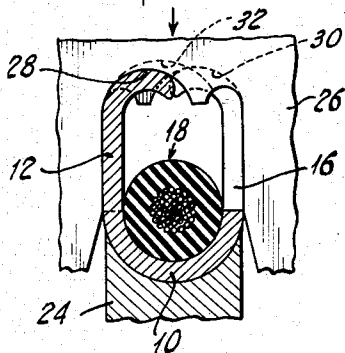


Fig. 6.

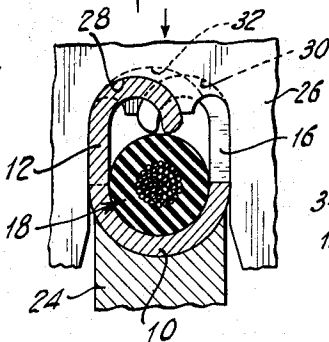


Fig. 7.

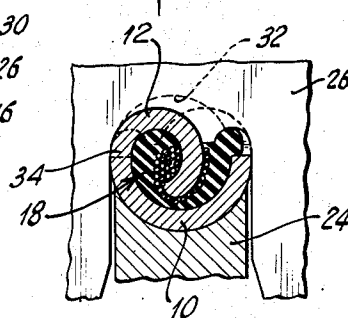
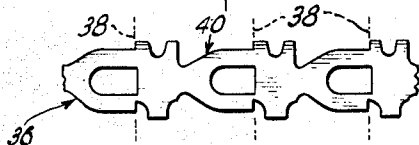


Fig. 8.



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TERMINAL WITH INSULATION PIERCING
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Application October 16, 1947, Serial No. 780,117

1 Claim. (Cl. 173-269)

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This invention relates to electrical connectors and connections and to the method of making the same. More particularly the invention relates to connectors which are crimped onto cables or wires and to the resulting electrical connection with a wire or a plurality of wires or other electrical connectors, and the method of making such electrical connection.

An object of this invention is to provide electrical connectors and connections which avoid the difficulties of the prior art. A further object is to provide electrical terminals which are inexpensive to manufacture and to apply, and which are dependable and efficient in use. Another object is to connect insulated wires by connectors of the type which pierce the insulation to make a permanent and permanently low resistance connection with the central conductor, and at the same time grip the wire with a high mechanical strength.

In the past iron which is used broadly to include steel has been considered unsuitable for electrical connectors except for low grade circuits where wide variations in the contact resistance are unimportant; and in fact, the Underwriters' Laboratories, Inc. has had a ruling against the approval of iron connectors. The conductivity of iron is low as compared with copper; it is subject to corrosion or rusting and the rusted surfaces give very poor conductivity so that the contact resistance increases appreciably. In the field of crimped (i. e., pressure-formed connectors) steel has been particularly avoided because its physical properties have been considered unsuitable for making absolutely tight pressure connections with copper wire by simple compression between the dies which are moved together, and also unsuitable for maintaining such pressure contact after release from the dies. Steel has been considered too hard to form itself to the copper wire so as to give a connection so tight as to maintain good electrical contact with long life and so as to keep corrosion away from the contact areas. It has been generally believed that only copper and brass could be so effectively crimped without such spring-back as would impair the electrical contact.

In the copending application of James C. Macy, Serial No. 679,630, filed June 27, 1946, now Patent 2,557,126, issued June 9, 1951, there is disclosed a terminal structure and a mode of attaching the same to an insulated or uninsulated cable or wire. That terminal structure is ideally suited for attachment to the un-

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stripped end of an insulated cable. The terminals of the same general character as those disclosed in that Macy application are highly advantageous for use with the present invention, and will therefore be used as the illustrative embodiment in the following description. In accordance with the present invention these terminals are constructed of iron, such as soft low-carbon steel. The steel of these terminals, however, is given a low contact resistance and extraordinary high stability of resistance by first coating the steel with a metal wet by mercury, especially a metal such as copper which is readily wet, but not amalgamated, and then applying a coating of mercury and over it a metal such as tin, which does readily amalgamate with an excess of mercury. This coating is advantageously applied in accordance with the methods disclosed in the application of Annis G. Asaff, Serial No. 551,141, filed August 25, 1944, now abandoned. The mercury and tin may be applied separately or they may be applied together in the form of an amalgam. In any event there is mercury present in the coating in excess of that which will combine with the tin so that the free mercury creeps along any uncoated metal surfaces in which the terminal comes in contact.

The thin amalgam layer being plastic readily forms itself to the uninsulated surface configuration of the wire. If there is spring-back tending to open crevices between the wire and the connector, the mercury soft plastic amalgam remains in them merely drawing in from larger masses which have been extruded during crimping.

The present invention is not limited to terminals of the type disclosed in that Macy application, but on the contrary the present invention contemplates constructing many different types of electrical terminals of sheet steel. The invention has particular advantage with the insulation piercing connectors shown and the connections made therewith, but it is applicable also to other types of crimped connectors and connections, for example as shown in U. S. Patent Nos. 2,379,567 and 2,359,083.

The particular surface treatment of the steel as referred to above has outstanding advantages, including the fact that it insures good electrical contacts; and also it prevents corrosion even upon surfaces which are not initially covered.

Prior to this invention connectors have been made in the form of strips each comprising a succession of blanks or terminals, partially

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formed, such as terminals which are completely formed except for the cutting apart and applying to the wire. One such strip is shown in Patent No. 2,396,913. These strips are fed to a terminal-applying tool or press which cuts each terminal free and applies it to the end of a wire.

In this specification and the accompanying drawing, 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 drawing:

Figure 1 is a top plan view of one complete terminal blank which constitutes one embodiment of the invention, together with the end of the strip from which this terminal has been cut;

Figure 2 is a side elevation of the terminal blank of Figure 1 after it has been formed into a terminal;

Figure 3 is a perspective view of the terminal of Figure 2 after being crimped to the end of an insulated wire;

Figures 4 to 7, inclusive, are sectional views which illustrate the crimping operations whereby the terminal of Figure 2 is crimped to an insulated wire; and,

Figure 8 is a plan view of a strip of terminal blanks constituting another embodiment of the invention.

Referring particularly to Figure 1 of the drawing, there is shown a terminal blank 2 which has just been cut from the continuous strip indicated at 4. At each end of blank 2 there is an intervening piece 6 which facilitates the cutting of the terminal blank from the strip without moving the blank from the plane of the strip. At the left piece 6 is shown cut free and this constitutes waste material, and at the right piece 6 is shown connected to the end of the strip. Blank 2 has a connecting portion 8, a ferrule portion 10, and three ears 12, 14 and 16.

Referring now to Figure 2 wherein the terminal blank is shown formed into a terminal, the ferrule portion 10 is substantially semi-cylindrical and the ears project upwardly from the longitudinal edges of this semi-cylindrical portion and have their free upper ends turned somewhat inwardly toward each other. The terminal in this form may be attached by crimping to an unstripped end of a wire such as wire 18 of Figure 3 which has a core 20 of multi-stranded wire and insulation 22.

The attachment of the terminal to the wire is by a crimping operation best understood by referring to Figures 4 to 7. Thus, in Figure 4, the terminal of Figure 2 having the end of a wire 18 therein is positioned on a die or anvil 28 which has associated with it a curling die 26. As the dies move together, as illustrated in Figures 4 to 7, ear 12 shown at the left rides in a spiral or cylindrical forming face having a surface 28 extending to the right and thence downwardly; and ear 16 rides in a similarly shaped face 30 extending to the left and thence downwardly; ear 14 (which does not show in Figure 4, but which is positioned directly behind ear 12) rides in a face 32 (shown in broken lines) which ex-

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tends to the right and thence downwardly. Die 26 moves downwardly relative to die 24 to the position shown in Figure 7, so that the ears are crimped in accordance with the showing of Figures 5, 6 and 7.

Thus, as pointed out more fully in the above-mentioned Macy application, ears 12 and 16 pierce the insulation and the stranded core so that they grasp the central portion of the core very tightly. As shown in Figure 7, ear 12 has its curled end embedded in or curled around the stranded core and the ear is formed into substantially a spiral. At the left, the base of the ear and adjacent section of the ferrule portion 10 form a C-clamp 15 which is somewhat thickened by the crimping operation, and which provides a rigid clamp holding the ear in its clamping position. Ear 16 is similarly curled from the other side of the ferrule portion 10 (see Figure 3). Surface 32 is so shaped that ear 14 is curled around the outside of insulation 22 so that it forms with ferrule portion 10 a substantially cylindrical portion clamping the outside of the wire. Therefore, the terminal is clamped rigidly to the wire and good electrical contacts are provided by ears 12 and 16.

In Figure 8 there is shown another embodiment of the invention, a terminal strip, generally indicated at 26, is cut as indicated at 38 by broken lines, into terminal blanks 40. These terminal blanks are formed into terminals similar to terminal 2 of Figures 1 to 7 and are attached to wires in a similar manner.

As pointed out above, the terminals of the illustrative embodiment are formed of soft steel which is plated with copper and coated with mercury and tin in accordance with the disclosure of the Asaff application, but prior to the coating the strips are blanked out to the configurations shown respectively in Figures 1 and 8. Thus all of the exposed surfaces of the strip are coated.

The steel terminals of the present invention are superior in many respects and for many uses to similar terminals made of copper or brass. For example, for terminals which must pierce insulation, the terminals of this invention are much superior to those made of copper or brass.

An annealed, soft, low-carbon steel is advantageously used in the practice of this invention. The high strength and high modulus of elasticity of such steel as compared with copper, for example, permits the use of thin and narrow piercing prongs or ears on the terminal with ends sharp enough to easily pierce the insulation and make good contact with the wire core. The desirable characteristics referred to above avoid the tendency of the ears to crimple or "squat down" before effectively piercing the wire. The relatively low yield point and low limit of elasticity of such annealed soft steel make it possible to crimp the connectors with the proper deformation and to assure when once crimped that the terminal will maintain the tightly crimped condition even under relatively severe stress.

For certain types of terminals I have obtained very satisfactory results with "steel strapping" which is a steel of the character referred to above. Specifically, steel having the designation of SAE 1010 is ideal for certain uses. However, the high degree of uniformity which is obtainable in steel or iron makes it possible to obtain a steel or iron which is ideally suited for each particular type of terminal. In this regard, the terms steel

and iron are used in the broader sense with it

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being understood that the term steel includes iron which is substantially free of carbon.

With terminals such as those shown in the drawing, it is important that the metal be sufficiently soft in the ferrule portion of the terminal to permit it to be compressed in the final stage of crimping, but yet the metal must be stiff enough to transmit the compressive forces without buckling. Furthermore, the metal at the side of the crimped ferrule is thickened during the crimping operation, thus limiting the "spring-back" so that the crimped terminal will maintain, as closely as possible, the extreme crimped condition which it reaches during the maximum extent of the crimping operation. In addition to this the ferrule must be thickened so as to give greater rigidity to each C-clamp section, which is the C-shaped section of the terminal including the side and bottom of the ferrule portion and the ear which exerts the main gripping force. The thickening and curling of the metal also involves work-hardening so that the crimped ferrule has increased rigidity.

Steel has the further advantage over copper that it will not slowly yield to a maintained force, but on the contrary holds the compressive force; whereas, copper cold flows slowly under like forces before they reach an equilibrium condition, and during this cold flow the compressive force may be relieved to some extent so that the crimp is somewhat loosened.

The steel from which the connectors of the type shown in the drawing are made, must have compressive strength sufficient to overcome its resistance to bending on the radius of the curling die faces 28, 30 and 32 which is approximately one-third of the width of the ferrule, plus its resistance to sliding in the die. However, this compressive strength must be low enough to obtain plastic flow by compression in the walls of the ferrule portion during the final closing together of the crimping dies; in this way the ferrule portion and the wire are deformed simultaneously. This gives considerable latitude for any particular application because the relative amounts of deformation of the ferrule portion and the wire need not be maintained within close limits. That is, with a terminal of soft steel on a relatively hard wire, there may be more deformation in the sides and ears of the crimped

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terminal than in the wire, whereas with a harder steel or softer wire there may be relatively much less deformation in the terminal; but yet the results obtained with each of these terminals are extremely satisfactory for use under specific conditions.

While the present invention is disclosed in connection with insulation-piercing terminals it is to be understood that some of the advantages of the invention can be realized with other and different types of connectors.

From the foregoing it will be seen that an electrical connector made in accordance with the present invention is well adapted to attain the ends and objects hereinbefore set forth and to be economically manufactured since the whole combination is suited to common production methods and is susceptible to a wide latitude of variations as may be desirable in adapting the invention to different applications.

I claim:

An electrical connector of the insulation piercing type comprising a base of soft steel, a plating of copper over said steel and a mercury-tin amalgam on said copper.

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