Sept. 26, 1944. V. E. CARLSON 2,359,084

CRIMPING DIE FOR ELECTRICAL CONNECTORS

Filed June 11, 1943

Fig. 1.

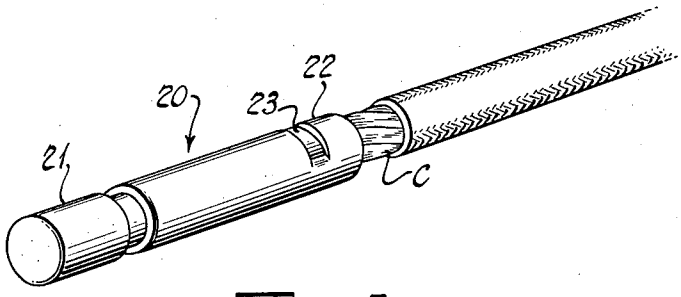


Fig. 2.

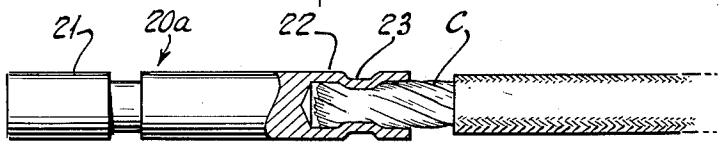


Fig. 3.

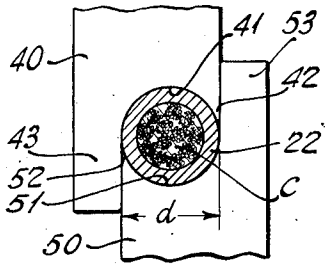


Fig. 4.

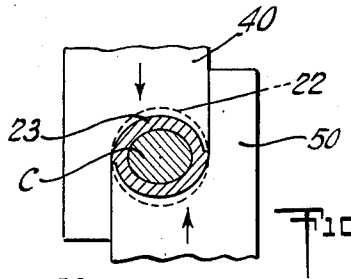


Fig. 5.

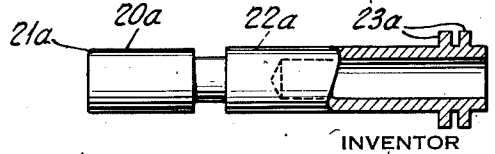
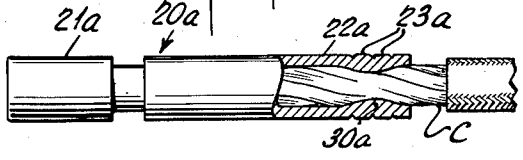


Fig. 6.



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2,359,084

CRIMPING DIE FOR ELECTRICAL CONNECTORS

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Application June 11, 1943, Serial No. 490,416

8 Claims. (Cl. 140—113)

This invention relates to terminal devices and fittings for wire and cable and to apparatus for applying such devices and fittings to wire and cable. More particularly, the invention relates to apparatus for effecting a practicable crimped connection in a pin-type of electrical connector.

Heretofore, various pin-type electrical connectors have been available in the prior art. They have found applications wherever conductors had to be connected into complicated circuits rapidly and in cramped quarters, such as in radios, airplanes, automobiles, marine craft and the like. The copending application of Vernon E. Carlson, Serial No. 465,547, filed November 14, 1942, illustrates an improved example of the type of plug or receptacle in which a pin-type terminal of the sort contemplated by the present invention may be used. In the past, most of the pin-type terminals have been attached to electrical conductors by soldering. In some instances, they have been attached by a crimping operation, but because of the fact that the pins had to pass through closely fitting holes in the receptacles, most of the crimping operations known to the prior art were not well suited to installations of this type due to flattening and consequent lateral extension of the crimped ferrules during the operation to an extent such that they would not pass easily through the closely fitting openings of the receptacles. Thus, either the pins were difficult to insert into the receptacles or else they had to be made long enough so that the crimped portions thereof extended beyond the outer surfaces of the receptacles. In many instances these receptacles are used where space considerations will not permit the use of long pins.

It is an object of the present invention to provide connecting means whereby an electrical connector may be secured to a conductor and yet be received in a fitted receptacle in an improved manner. A further object is the provision of means for crimping an electrical connector onto an electrical conductor, whereby the connector is not spread by the flattening of the crimping operation, and whereby the over-all cross-sectional dimensions of the crimped areas of the connector are no greater than adjoining uncrimped portions thereof. Another object is the provision of means for crimping an electrical connector onto an electrical conductor, whereby the cross section of the connector at the crimp is reduced in one direction while it is held substantially constant in any other direction. Other objects will be in part pointed out as the description proceeds and will in part become apparent therefrom.

The copending application of Vernon E. Carlson, Serial No. 455,033, filed August 17, 1942, discloses means for crimping a ferrule, e. g., onto an electrical connector, wherein the ferrule is afforded lateral support to prevent it from buckling outwardly while the metal in the sides thereof is compressed, and the top and bottom are likewise supported by smooth, concave surfaces by which the ferrule is (in the preferred embodiment) more or less flattened and therefore somewhat compressed between its sides.

An important feature of said prior application is the substantial avoidance of inturned folds in the ferrule by use of dies having generally concave supporting surfaces which are free from inwardly directed projections or convex areas at any point where substantial inward buckling of the ferrule could result. The dies shown in the preferred example of said prior application are provided with narrow convex areas, or shelves, adjacent the lateral faces of the dies, but because these areas were kept close to the lateral faces (relative to the thickness of the ferrule) they can not result in inward folding of the ferrule such as would relieve (by buckling) the circumferential compressive stresses; but, on the contrary, they serve to facilitate engagement of the ferrule by the dies so as to concentrate compressive stresses in the lateral portions of the ferrule. Although for many cases this action is very advantageous, in other cases it is desirable to leave the crimped area more nearly circular or elliptical and/or to distribute beyond, and inwardly of, the lateral edges the circumferential compression resulting from crimping.

According to one feature of the present invention, therefore, each crimping die is made smooth, and semicircular or elliptical in cross section, with a relatively sharp ferrule engaging projection close to a diameter extending between the dies, the projection on one die being at one end of said diameter and the projection on the other die being at the other end thereof; and each of said projections being adapted to engage the material of the ferrule in the direction of its crimping movement. Thus the combined effect of these ferrule-engaging projections on the closing of the die is to tend to rotate the ferrule in the die, a tendency which is resisted only by the frictional engagement of the ferrule on the smooth, curved surfaces of the die. The result of these stresses is a compression and thickening of the material of the ferrule distributed around

the circumference of the ferrule. As in said prior application, it is important that each ferrule-engaging projection, or shelf, should be so close to the lateral supporting face of the die, that no inward buckling can be caused thereby to relieve the compressive stresses; and advantageously this projection or shelf is as narrow as practicable.

In this specification and the accompanying drawing, I have shown and described preferred embodiments of my invention and 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 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 accompanying drawing, in which exemplary embodiments for achieving the above objectives are set forth and in which similar reference characters refer to corresponding parts throughout:

Figure 1 is a perspective view of a pin-type electrical connector crimped onto an electrical conductor in accordance with the invention;

Figure 2 is an elevational view, partly in section, of the connector and conductor illustrated in Figure 1;

Figure 3 is an elevational view, partly in section, of a pair of dies embodying the invention and in position to crimp an electrical connector onto an electrical conductor;

Figure 4 is a view similar to that of Figure 3 but showing the dies after they have been closed to crimp the connector onto the conductor;

Figure 5 is an elevational view, partly in section, of a modified type of electrical connector adapted to be used in practicing the invention; and

Figure 6 is a view similar to that of Figure 5, but showing the connector crimped onto a conductor.

Figure 1 illustrates an electrical connector, generally indicated by **20**, having a terminal contact portion **21**, a ferrule portion **22**, and fastened, as by crimp **23**, onto an electrical conductor C. Figure 2 illustrates the manner in which the cross section of connector **20** is reduced in forming crimp **23**.

Referring to Figure 3, an upper crimping die **40** and a lower crimping die **50** are shown in operative engagement with the ferrule portion **22** of an electrical connector and with the electrical connector fitted over the end of an electrical conductor C. Die **40** is provided with a generally semicylindrically shaped die surface **41** which terminates on its right-hand side, as viewed in Figure 3, in a plane above the center of its radius of curvature with a narrow flat shelf **42**. On its left-hand side die **40** extends downwardly, as at **43**, to form an extended die surface which merges tangentially with the semicylindrically shaped surface. Lower crimping die **50** is similar to die **40** in that it correspondingly is provided with a generally semicylindrically shaped portion **51**, a narrow flat shelf **52** which terminates in a plane below the center of the radius of curvature of the semicylindrically shaped surface, and an extension **53** which forms an extended die surface projecting upwardly from and merging tangentially with the generally semicylindrically shaped die surface. The outer diameter of ferrule **22** is indicated by *d*, and, as will be observed in Figure 3, the axis of the cylindrical ferrule coincides with the axes of curvature of the generally semicylindrically shaped die surfaces.

The shelves **42** and **52** result from a cut-off from each curved surface of about 30° from the point at which it would, if extended, have intersected the surface of the extension **53** or **43** of the opposite die. This cut-off serves several important purposes: In the first place, it provides a sharp projection to engage the ferrule with a rotational stress, as described above. In the second place, it avoids extrusion of material of the ferrule into any clearance space between the dies as the dies close. If the cut-back is not too great, moreover, the narrow projection on the die ending with the shelf will be capable of sufficient flexing to close such clearance space when sufficient pressure has accumulated to extrude the ferrule material over the projection; but at the same time, by virtue of the cut-back, the projection may have enough strength and stiffness to avoid binding against the opposite die with such pressure as to prevent full closing or to injure the opposite die. I have found it advantageous to cut back about 15°–30° of the curvature from the point where it would intersect (or merge with) the surface of the opposite die; although it may be as much as 50° or more. In the third place, the cut-back permits a closing of the dies toward one another beyond the position in which the axes of their radii of curvature are coincidental. This can also be achieved by using a curvature of diameter greater than the width of the opening between the dies, but it is advantageous to have the curvature of the die fit approximately the initial curvature of the ferrule, as shown in Figure 3, so that the crimping is substantially entirely by circumferential compression rather than by flattening.

Figure 4 illustrates the manner in which the cross section of ferrule **22** is reduced to present a substantially elliptical configuration forming crimp **23** and conforming to the surfaces of dies **40** and **50** in their closed relationship. It will be noted that extensions **43** and **53** have provided lateral support to the ferrule to prevent it from spreading, so that its longer dimension is still equal to *d*, whereas its shorter dimension is somewhat less than *d* as a result of having been compressed by the closing together of the dies. Because the shelves **42** and **52** have moved down almost to a diameter between the dies, the spaces beyond their edges no longer extend beyond the desired maximum diameter, but instead crimped depressions are formed on each side of the ferrule separated by less than a diameter.

Figure 5 illustrates an electrical connector **20***a* wherein ferrule portion **22***a* is provided with more or less elliptical ridges, or fins, **23***a* which extend radially somewhat above and below the outer surfaces of terminal contact portion **21***a*. Figure 6 represents the manner in which fins **23***a* may be compressed by dies of the type illustrated in Figures 3 and 4, and in accordance with the invention, to effect a holding means or crimp having dimensions which conform to the dimensions of terminal contact portion **21***a* so that they no longer would form an obstruction to the insertion of the connector into a plug or receptacle.

From the foregoing examples it will be apparent that the invention lends itself to the forming of a crimp in a substantially cylindrically shaped ferrule, wherein the crimp is of reduced cross section, or alternatively, to the form-

ing of a crimp having a cross section the same as the rest of the electrical connector where, before the crimping operation, the portions to be crimped were of greater dimensions than the over-all dimensions of the contact portion of the electrical connector.

As various embodiments may be made of the above invention and as changes might be made in the embodiments above set forth, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawing is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In apparatus of the class described and adapted to crimp the ferrule of an electrical connector onto an electrical conductor, a pair of dies arranged to close upon one another; each of said dies having a semicylindrically shaped die surface of substantially the same diameter as the diameter of the ferrule to be crimped and being extended on one side to form a die surface projecting tangentially from the semicylindrically shaped die surface, and each of said semicylindrically shaped die surfaces terminating on its other side in a sharp edge spaced from the tangential surface of the opposing die by a narrow shelf facing said opposing die and representing a cut-back of said semicylindrically shaped die surface of about 15° to 30°, whereby said pair of dies may be closed together upon the ferrule to crimp the ferrule onto a conductor with the extended die surfaces providing lateral support to the ferrule to keep it from spreading during the crimping operation and with the shelves providing sufficient clearance between the dies to permit them to be closed upon one another to within less than the diameter of the ferrule being crimped.

2. In apparatus of the class described and adapted to crimp the ferrule of an electrical connector onto the end of an electrical conductor, a pair of dies each having a surface comprising a plane portion blending into an arcuately shaped surface of revolution and terminating in a relatively narrow shelf which forms with the arcuately shaped surface a dihedral angle and which represents a cut-back of the arcuately shaped surface from the point at which it would, if extended, meet said plane portion of the other die of about 15° to 50°.

3. A pair of dies, each having an extended straight portion at one side of its central die surface and a cooperating portion at its other side adapted to fit against and slide on the straight portion of the other die and each having a smooth, concave intermediate recess the surface of which merges at one side smoothly into the surface of said straight portion and at its opposite side terminates with a narrow shelf forming therewith a dihedral angle, said narrow shelf being at a lower level, measured in a direction parallel to the straight portion of the die and toward the bottom of the recess, than the opposite end of said surface where it merges into the surface of said straight portion.

4. A pair of dies each having a straight portion at one side of its die recess and a cooperating surface at its other side adapted to fit against and slide on the straight portion of the other die, and a smooth, concave recess the surface of which at one side merges smoothly into the surface of said straight portion and at its opposite side terminates at a narrow shelf by which it is spaced from the straight portion of the other die.

5. A tool for crimping ferrules and the like onto wire or the like which comprises a pair of dies each having an extended straight portion at one side of its die recess and a cooperating surface at the other side adapted to fit against and slide on the straight portion of the other die, and each die having a smooth, concave recess the surface of which merges at one side smoothly into the surface of the straight portion and at its opposite side terminates in a narrow shelf forming a dihedral angle at a lower level, measured in direction parallel to the straight portions of the dies and toward the bottom of said recess, than the opposite end of said surface where it merges into the surface of the straight portion of the die, and means for moving said dies toward one another under high pressure along a direction parallel to the straight portions of the dies to a position in which the shelves of the dies are approximately at opposite sides of a line through the center of the die cavity.

6. A pair of dies each having a straight portion at one side of its die recess and a cooperating surface at the other side thereof adapted to fit against and slide on the straight portion of the other die, and a smooth concave recess the surface of which merges on one side smoothly into the surface of said straight portion and at its opposite side has a sharp projection adapted to engage the material of a ferrule, whereby, when said dies are closed onto a ferrule, the ferrule is engaged at opposite sides by said projections and a circumferential stress is imposed thereon.

7. A pair of dies each having a straight portion at one side of its die recess and a cooperating surface at the other side thereof adapted to fit against and slide on the straight portion of the other die, and a smooth concave recess the surface of which merges on one side smoothly into the surface of said straight portion and at its opposite side terminates at a narrow shelf by which it is spaced from the straight portion of the other die, said shelf being of width such that the material at the adjacent end of the die forming said shelf can resiliently flex to an extent substantially equal to its clearance from the straight portion of the other die when subjected to a pressure slightly less than that required to extrude a portion of a ferrule across said shelf.

8. In apparatus of the class described and adapted to crimp the ferrule of a pin-type electrical connector onto an electrical conductor, a pair of substantially semi-cylindrically shaped dies adapted to close together upon the ferrule; one side of each die being extended with a plane surface beyond the center of curvature of the semicylindrically shaped portion and the other side of each die terminating short of the center of curvature of the semicylindrically shaped portion, whereby the dies may be made to approach one another with the extended side of each die overlapping the other die and with the short side of each die allowing sufficient clearance for the dies to approach one another with a maximum separation therebetween of less than twice the radius of curvature of the semicylindrically shaped die portions.

VERNON E. CARLSON.