Aug. 27, 1963 E. FLOYD, JR 3,101,766

CRIMPING APPARATUS

Original Filed April 26, 1955

FIG. 1.

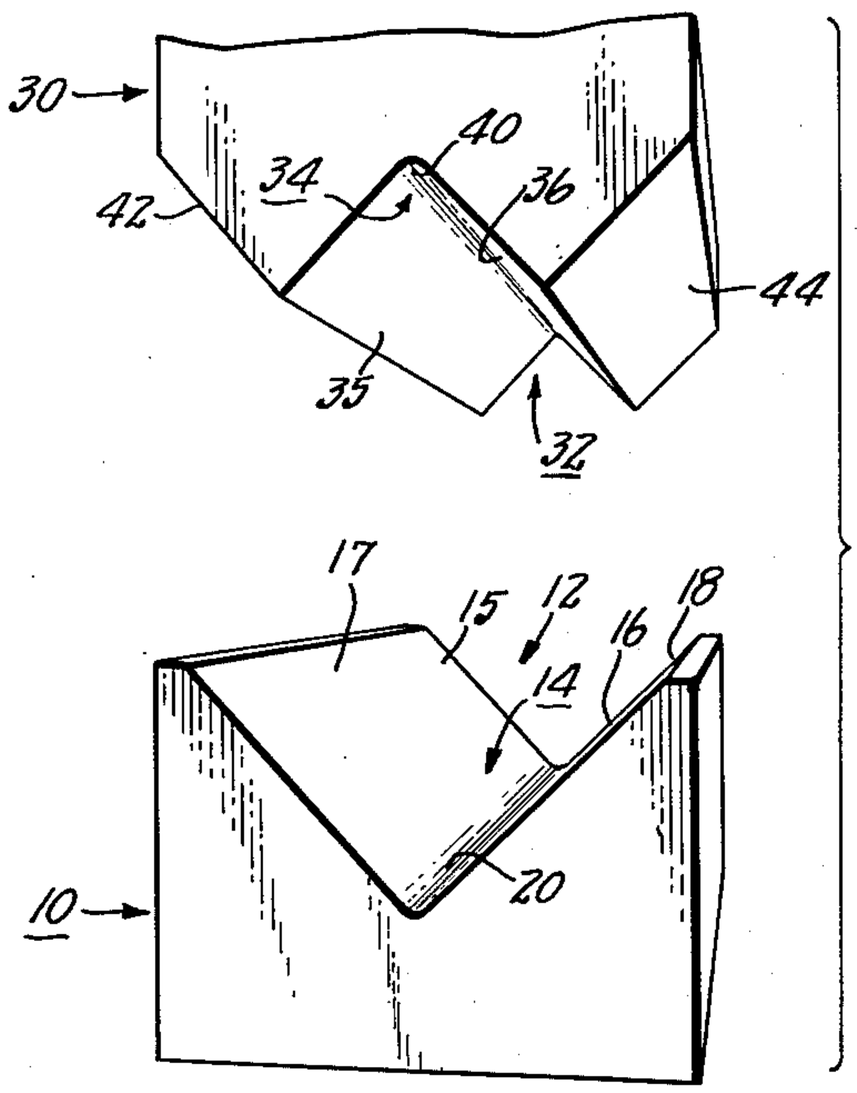


FIG. 2.

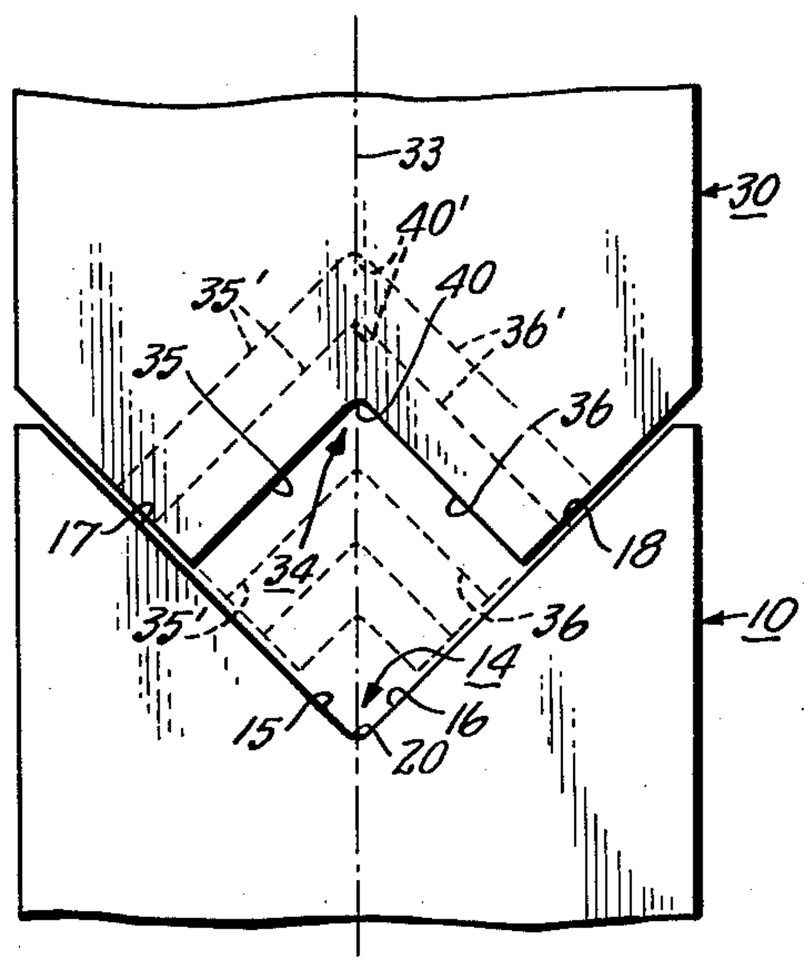


FIG. 3.

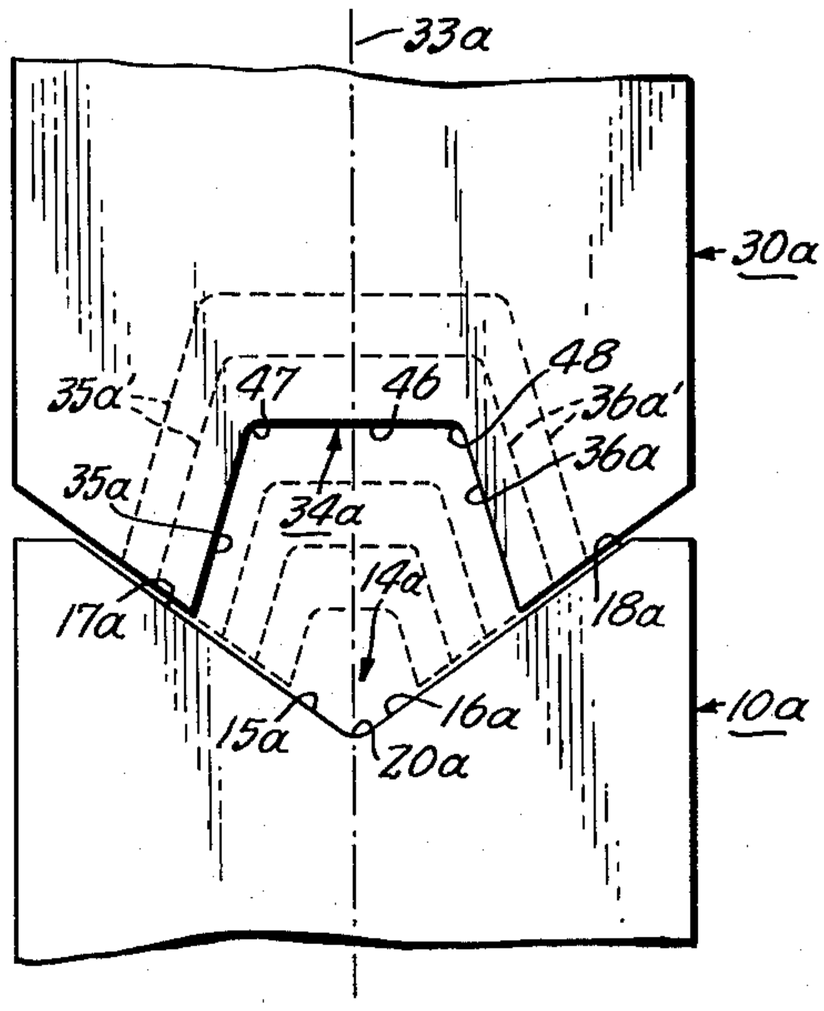


FIG. 4.

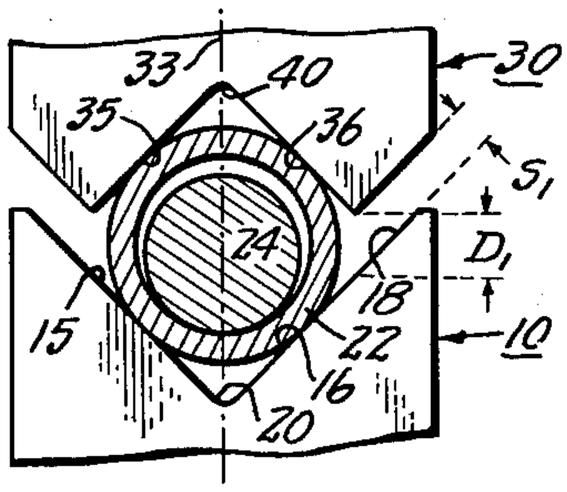
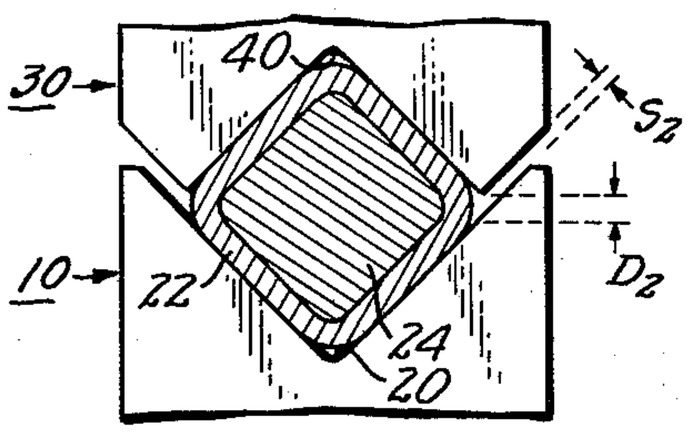


FIG. 5.



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CRIMPING APPARATUS

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2 Claims. (Cl. 153—1)

This application constitutes a continuation of my prior application, Serial No. 504,029, filed April 26, 1955, now abandoned.

The present invention relates to crimping apparatus of a type well-suited for the crimping of connector ferrules onto cores. More particularly, the present invention relates to crimping die apparatus adapted for producing a confined crimping action and for crimping a wide range of sizes of connector ferrules and cores to form strong durable connections.

In crimping connector ferrules and conductors together to form electrical connections, it has heretofore been customary to use either of two types of dies, namely, those producing a "confined" crimping action and those which do not. This confined crimping action occurs when the dies surround the entire perimeter of the work material, at least during the final stages of their closure. Therefore, any work material which is squeezed out of the region between the die faces during the final stages of crimping is prevented from extruding radially outwardly and is forced to flow in an axial direction of the connection.

With an unconfined crimping action, some of the work material is extruded out from between the die faces into the parting spaces between the dies on each side of the connection, i.e., a "flash" portion or rib is formed along opposite sides of the connection.

One of the advantages of confined crimping is that the amount of squeezing and flowing of the work material and the way in which it occurs are precisely controlled, producing optimum conditions of mechanical strength and electrical conductivity in each connection. Moreover, the perimeters of the completed connections from any given dies are always identical and neat in appearance, without any sharp flash portions which may cause voltage stress concentrations.

Usually dies for producing confined crimping are more complicated, and require closely fitting lateral confining parts and sometimes even requiring a number of closely fitting, relatively slidable interleaving plates. Also, dies for confined crimping are usually more difficult to load and unload because of the lateral confining portions which limit the accessibility of the die faces, and which occasionally may cause the work to jam and resist withdrawal.

Among the many advantages of the crimping die apparatus, described herein as embodying the present invention, are those resulting from the fact that a confined crimping action is obtained without the use of any such closely interfitting lateral confining parts. The loading and unloading of the dies is easier, their operation is less critical.

Another advantage of the described embodiments of the present invention is the accommodation of a wide range of sizes of connector ferrules and cores. One of the dies is a universal die having a nest and a pair of die face extension surfaces extending tangentially from opposite side portions of the nest and diverging at an angle in the range from about 60° to about 120°. The second die includes a second nest and a pair of shoulder surfaces on opposite sides of the second nest diverging at the same angle as said extension surfaces. In the closed die position, these shoulder surfaces mate with the extension surfaces producing a confined crimping action.

By changing the second die, a greater or lesser amount of the die face extension surfaces of the first die are used, depending upon the ferrule and core size being crimped, thus readily accommodating a very wide range of sizes of ferrules and electrical conductors.

In accordance with one embodiment of the present invention, these two die nests are generally V-shaped and all of the different sizes of connections produced thereby have a pleasing rhombic outline and are geometrically substantially identical in appearance regardless of their size.

In accordance with another embodiment of the present invention, one of the die nests is generally V-shaped and the others are three-sided, and all of the different sizes of connections produced thereby are pentagonal in outline and geometrically substantially identical throughout the full range of crimp sizes.

The present invention provides the advantageous operating characteristics of confined crimping-type dies, while at the same time avoiding many of the critical requirements of such dies and their closely interfitting lateral confining parts. The present invention also provides the easier loading and unloading characteristics of unconfined crimping dies.

In this specification and in the accompanying drawings are described and shown 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.

The various objects, aspects and advantages of the present invention will be more fully understood from a consideration of the following specification in conjunction with the accompanying drawings, wherein corresponding reference numerals, with appropriate suffixes are used in the various figures to indicate parts and elements performing corresponding functions, and in which:

FIGURE 1 is a perspective view of a pair of die members embodying the present invention;

FIGURE 2 is an enlarged elevational view looking along the axis of the opening defined by the die faces of the die members of FIGURE 1 in closed position;

FIGURE 3 is a similar elevational view of another pair of die members embodying the present invention in modified form shown in closed position; and

FIGURES 4 and 5 are elevational views of the die members of FIGURES 1 and 2, showing, in section, a connector ferrule and an electrically conductive core positioned between the die faces, with the die members positioned at the beginning and at an intermediate stage, respectively, of the crimping operation.

As shown in FIGURES 1 and 2, the first die member, generally indicated at **10**, has a die face, generally indicated at **12**, including an indented working portion formed by a nest portion **14** with a pair of sides **15** and **16** forming a dihedral angle. The die face **12** also includes a pair of extension surfaces **17** and **18** contiguous with the nest **14** and extending tangentially from the opposite sides **15** and **16**, respectively, of the nest portion. As seen in outline in FIGURE 2, the die face extension surfaces **17** and **18** are substantially straight and diverge at an angle lying in the range from about 60° to about 120°. The nest **14** is shown in FIGURE 2 as being generally V-shaped with a rounded vertex **20** between its two sides **15** and **16**.

It is usually desirable to have the sides **15** and **16** planar, with the extension surfaces **17** and **18** also being planar and extending tangentially out from the sides.

The vertex **20** is curvilinear and tangent to the two sides **15** and **16**. In this illustrative embodiment, the sides **15** and **16** are approximately perpendicular to each other.

In operation, the work material, shown illustratively in FIGURES 4 and 5 as including a connector ferrule **22** with an electrical conductor core **24** therein, is rested in the nest **14** with the axis of the ferrule and conductor parallel with the longitudinal axis of the die face **12**. And a second die member, generally indicated at **30**, with the die face **32** opposite the die face **12** is closed toward the die member **10** in a direction **33**, generally transversely to the longitudinal axis of the die faces **12** and **32**.

This die face **32** includes a nest portion **34**, as shown in FIGURE 2, being generally V-shaped and having substantially straight sides **35** and **36** also forming a dihedral angle with a rounded vertex **40** therebetween.

It is usually desirable to have the sides **35** and **36** planar, with the rounded vertex **40** being curvilinear and tangent to them. In this illustrative embodiment, the sides **35** and **36** are also perpendicular to each other and are equal to the effective size of the sides **15** and **16** of the nest **14**, as explained hereinafter.

Adjoining either side of the nest **34** are a pair of shoulders with surfaces **42** and **44**, respectively, sloping back at an angle equal to the angle between the extension surfaces **17** and **18** of the other die face so as to fit flushly thereagainst.

As the die members **10** and **30** move toward each other, the ferrule **22** and core **24** are deformed into a rhombic form, as illustrated in FIGURES 4 and 5. During closure of the dies, the work material extrudes radially outwardly to fill the rounded vertices **20** and **40**.

Also, the work material tends to extrude radially out into the parting space between the die face extension **17** and the shoulder surface **42**, and into the parting space between the die face extension **18** and the shoulder surface **44**. These parting spaces are of equal width. The initial width at the beginning of the crimping action of one of these parting spaces is indicated as S_1 in FIGURE 4.

Advantageously, an effective confining action is obtained preventing the work material from extruding out into these parting spaces and avoiding the formation of any flash portions on the connection. As the ferrule **22** tends to be extruded radially further and further out along the sides **15** and **16**, it continually encounters resistance because it is in continued contact with these sides and with their tangential extensions **17** and **18**, which are acting to wedge the material of the ferrule back into the desired region.

Moreover, the inclination of these surfaces **17** and **18** and the complementary shape of the shoulder surfaces **42** and **44** produces a geometrical advantage with respect to the ratio between the width of the parting space, i.e., S_1, and the die travel distance D_1 remaining before the dies reach their fully closed position. This parting space S_1 is considerably smaller than the die travel D_1 and advantageously continues to be smaller. This geometrical advantage becomes more and more important as the die members approach closely to their fully closed position. As shown in FIGURE 5 with the die members nearly closed, the width of the parting space S_2 is considerably smaller than the remaining die travel distance D_2.

Where the die face extensions **17** and **18** are symmetrically positioned with respect to the direction **33** of die closure, then the ratio between the width of the parting space and the remaining die travel distance is expressed as follows:

$$\frac{S_1}{D_1}=\frac{S_2}{D_2}=\sin\frac{(\theta)}{(2)} \tag{1}$$

where θ is the angle between the die face extensions **17** and **18**. With this angle being in the desired range from about 60° to about 120°, this ratio has a value in the range from about .5 to about .866.

Thus, the material of the ferrule and conductor is effectively confined within the two nests **14** and **34** and is crimped into a rhombic-shaped connection, with the extruded material flowing axially of the connection.

In result, the material of the ferrule is laterally confined by two effects, the wedging action of the sides **15** and **16**, in combination with their tangential extensions **17** and **18**, and the action of the inclined parting spaces producing an effectively more rapid closure of the parting space than the remaining die travel distance. When the dies are fully closed, these shoulder surfaces **42** and **44** bear flushly against the extension surfaces **17** and **18**.

The phantom dotted lines in FIGURE 2 illustrate the way in which the die member **10** is used as a universal die to crimp an extremely wide range of sizes of connections. In order to crimp larger or smaller connections, the upper die **30** is replaced by any one of a set of generally similar dies. These all have V-shaped nests with a pair of straight converging sides **35′** and **36′** of graduated lengths in the different size die faces and with a rounded vertex **40′** of the same size in all of these dies and equal to the vertex **20**.

The relative extent of the nest sides **15** and **16** and the die face extensions **17** and **18** in each case is determined by the size of the die face **32** of the die member **30**. But in each case the sides **15** and **16** are effectively equal to the sides **35** and **36** to form a rugged, durable, rhombic-shaped connection.

As used herein, "rhombic" or similar expression is intended to include any parallelogram form having approximately equal sides and expressly includes a square.

The die members **10*a*** and **30*a*** in FIGURE 3 form a regular equilateral pentagonal crimp. The die face of the die member **10** includes a V-shaped nest portion **14*a*** with a pair of substantially straight sides **15*a*** and **16*a***, and has a pair of extension surfaces **17*a*** and **18*a*** adjoining the nest **14*a*** and extending tangentially from its opposite sides. These extension surfaces are shown diverging at an angle of about 108°. It is usually desirable to have these sides planar, with the rounded vertex **20*a*** being a curvilinear cavity tangent thereto.

The die number **30*a*** has a die face including a general U-shaped nest portion **34*a***. The sides **35*a*** and **36*a*** of the nest cavity are substantially straight, as seen in outline, and diverge at an angle of about 36°. The bottom **46** is flat and perpendicular to the direction of die closure **33*a*** and is joined to the sides **35*a*** and **36*a*** by rounded corners **47** and **48**. The included angles between each of these sides and the bottom is about 108° and desirably these sides and the bottom are planar, with the corners **47** and **48** being curvilinear and tangential thereto.

For crimping a wide range of sizes of connections, the die member **30*a*** is replaced by any one of a set of dies having nests **34*a*** of graduated size, as indicated by the dotted outlines of their die faces. An effective confined crimping action is advantageously obtained similar to that described above, as will be understood from the foregoing description.

From the foregoing, it will be understood that the embodiments of the present invention described above are well suited to provide the advantages set forth, and since many possible embodiments may be made of the various features of this invention, and as the apparatus herein described may be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limting sense, and that in certain instances some of the features of the invention may be used without a corresponding use of other features, or without departing from the scope of the invention.

I claim:

1. A series of dies of different sizes, each die of said series adapted to cooperate with a larger die to form a dieset to make a crimped connection between a metal ferrule and a conductor, wherein the ferrule is entirely supported by the dieset after completion of the crimping operation, each of said dies having crimping faces terminating in a vertex to form a first angle, said crimping faces forming a V in cross section, each die of said series having identical angles, but successively shorter crimping faces forming the sides of the angle, each of said dies of the series adapted to nest within said larger die constituted by a longer crimping face.

2. A series of dies of different sizes, each die of said series adapted to cooperate with a larger die to form a dieset to make a crimped connection between a metal ferrule and a connector, wherein the ferrule is entirely supported by the dieset after completion of the crimping

operation, each of said dies having crimping faces formed by dihedral angles terminating in a vertex to form a first angle, said crimping faces forming a V in cross section, each die of said series having identical angles, but successively shorter crimping faces forming the sides of the angle, each of said dies of the series adapted to nest within said larger die constituted by a longer crimping face, a pair of shoulders in each of said dies in the series, said shoulders comprising rectangular faces, each forming a dihedral angle with one of said working faces, and all of said dihedral angles being equal.

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