March 20, 1956 M. C. LOGAN 2,738,693

HAND TOOL FOR CRIMPING ELECTRICAL CONNECTORS

Filed Nov. 19, 1951

Fig. 1.

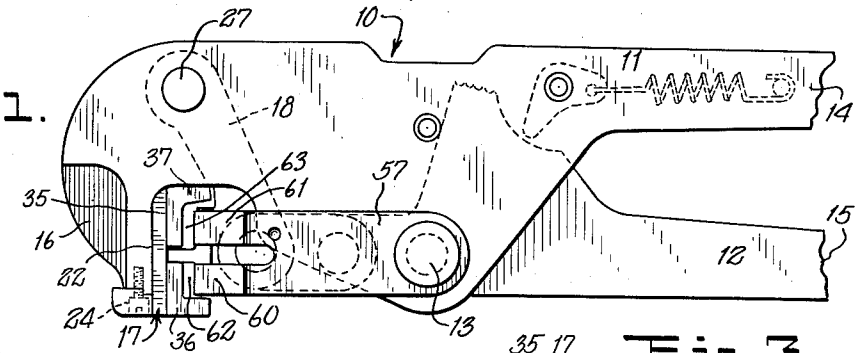


Fig. 2.

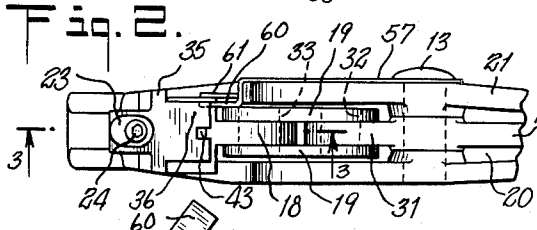


Fig. 3.

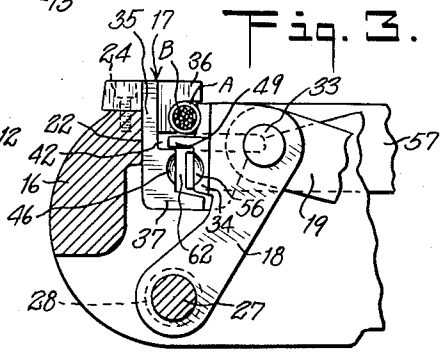


Fig. 4.

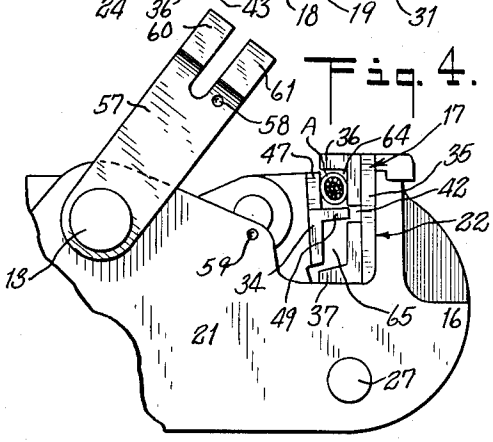


Fig. 6.

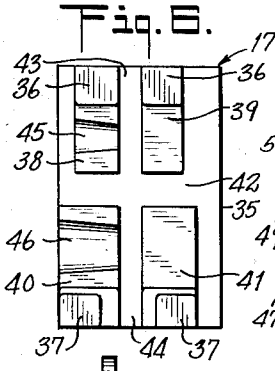


Fig. 7.

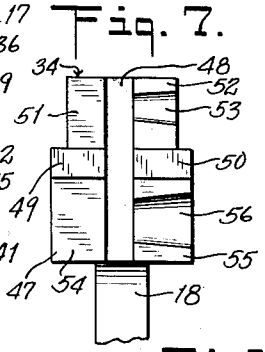


Fig. 5.

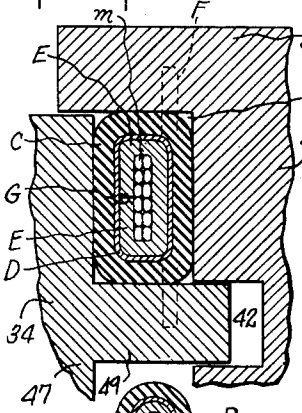
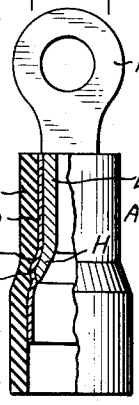


Fig. 9.



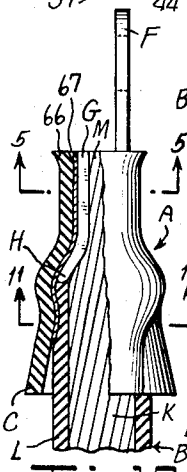


Fig. 8.

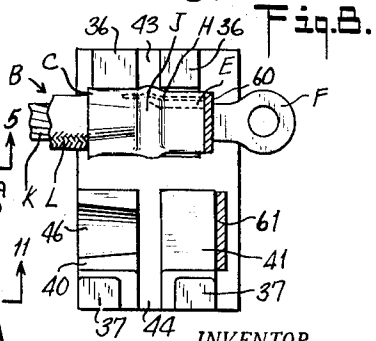


Fig. 11.

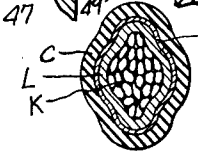


Fig. 10.

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2,738,693

HAND TOOL FOR CRIMPING ELECTRICAL CONNECTORS

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Application November 19, 1951, Serial No. 257,090

8 Claims. (Cl. 81—15)

The invention relates to a method of deforming a tubular electric fitting or connector onto the end of a cable inserted therein; to a crimping tool for practicing the method; and to the resulting finished assembly of connector and cable considered as an article of manufacture.

In so far as the method and the resulting product is concerned, the present disclosure constitutes a development of and a modification of the disclosure in the application of John Nelson Frey, Serial No. 233,662, filed June 26, 1951, and in so far as the tool is concerned, the present disclosure is a development of the similar form of crimping apparatus disclosed in the application of Martin D. Bergan, entitled "Crimping Tool," Serial No. 249,309, filed October 2, 1951, now Patent No. 2,696,747.

A known form of tubular connector as illustrated in Fig. 9 of the accompanying drawings has cylindrical end portions of slightly different external diameters, with the end portions connected by a mid-length portion of somewhat frusto-conical form. The prepared end of an insulated cable is inserted into the connector with the insulation part thereof at the end portion of large diameter and in the smaller end of which connector is located the stripped-back bare wire ends of the cable conductor. The connector in the particular form illustrated is formed of three tubular parts in telescopic relation and comprises an outer molded sleeve of insulating material, an intermediate thin metal lining tube, and an inner sleeve forming a wire-gripping ferrule from one end of which projects an apertured fastening tang.

In such devices it has been a usual practice to crimp, first, one end portion of the connector onto the contained portion of the cable, and then to crimp the other end portion, usually employing crimping dies which form crimps more or less circular and sometimes elliptical in cross section of the fitting. A most serious objection to this practice is that the telescoped parts are not always permanently interlocked, as is evidenced by the possibility of holding the projecting tang with one hand and the outer sleeve with the other hand, and pulling longitudinally, even with a gentle pull, and in which case the inner ferrule sleeve can often be readily pulled out of the outer insulating sleeve. This possibility of easily separating the parts of the connector from each other and separating the connector from the cable is most objectionable in practice.

In the above-identified Frey application it is suggested, in an effort to avoid such separation of the telescoped parts, to flare outwardly the inner end of the inner metal ferrule sleeve, usually by means of a die punch, into a conical binding engagement with the intermediate metal lining tube. This has been quite helpful in locking the flared inner ends of the inner ferrule-forming sleeve to the intermediate lining sleeve while permitting some desirable axial relative movement between the balance of the inner sleeve and intermediate tube. This feature has been retained and somewhat improved in the showing in this application. In the Frey application it was also suggested that the outer insulating sleeve be made from

a synthetic condensation polymeric amide under the designation of "nylon," and molded to its form necessary to fit the lining tube and this also has been retained in this disclosure. It was also suggested that the connector be deformed into a crimping engagement with the cable end therein by crimping first one end of the connector and then the other end as separate steps usually between the dies of a power-operated press.

It is incidentally disclosed, but not claimed, in the Frey application that the faces of the dies which squeeze the small end of the connector onto the bare wire ends are flat, while those die faces which squeeze the large end of the connector onto the insulation of the cable are formed with opposing flat arcs. The present disclosure in its apparatus aspect features a crimping operation by means of which the connector disclosed in the Frey application may be crimped onto the cable at its large and small end portions simultaneously with a single operation of the crimping means herein featured.

The primary object of the invention herein disclosed is to provide a simplified technique for crimping connectors onto cables intruded therein at a plurality of points and in a way best suited for the configuration of the particular area being crimped with a single stroke operation, and to provide apparatus by means of which the improved technique may be practiced and by means of which apparatus the connector may be positively, securely and permanently secured to the cable therein.

While it is usual in this art to crimp the connector onto the cable at two points, one at the place containing the cable insulation and the other at the place containing the bare ends of the cable, it is the latter connection which is of major importance and it is the crimping at the end portion of smaller diameter which is particularly featured in this disclosure.

Broadly considered, the above objective is attained by providing peculiarly contoured work faces to the portion of the dies operating to crimp the connector onto the bare wire ends and which faces will act first to box-in the portion to be crimped and thus to confine all of the material acted upon to a mold cavity more or less rectangular in cross section, while opposing faces of the squeeze dies in their subsequent approach act to crimp the material so confined within the rectangular space. In other words, the disclosure features the cross section of the crimp made at the end of the connector containing the bare wire ends as being of substantially rectangular form and with the bare wire ends compacted within a four-sided pocket in distinction from the usual circular or elliptical form of crimp.

Another object of the invention, particularly considering the two-diameter type of connector above described, is to effect the desired double crimping without interfering with the preformed factory-produced interlock between the flared end of the inner sleeve in its preset binding engagement with the intermediate sleeve. Broadly, this is attained by providing in the work faces of the dies a slot or similar non-engaging area at the point where the flared end of the inner sleeve comes in the crimping operation herein featured.

Again referring to the type of connector disclosed in the Frey application, the ferrule forming inner sleeve is formed by bending winged extensions of the original blank about a cylindrical form of mandrel into a tube with its free edges meeting to form a closed joint located on the side of the ferrule directly opposite the side provided with the tang. It is a practical requirement in this art that the joint must remain closed during the crimping operation, otherwise, as has before happened, some of the wires therein will tend to escape through any open joint which may be present and under such circumstances an unsatisfactory form of crimp is formed.

Accordingly, another object of the invention is to prelocate the joint in the crimping apparatus relative to the loci of squeeze pressure of the dies, so that the deformation of the parts of the ferrule sleeve on opposite sides of the joint shall be of equal degree at every instant of time during the crimping act and in this way the joint is maintained closed at all times.

This objective is attained by utilizing the tang as a projection arranged so that, when fitted into a slot provided therefor in the crimping tool, the tang acts to defeat rotary movement of the connector about its own axis and thus acts to locate the joint in position facing the adjacent flat work face of the adjacent crimping die, so that as the crimping dies approach each other the metal on both sides of the joint are curled inwardly in equal degree.

Incidentally, this prelocating of the connectors exactly positioned one after the other in the crimping tool has the effect of making each finished assembly identical with every other assembly, each with a factory-determined accuracy in the finished product.

Various other objects and advantages of the invention will be in part obvious from a consideration of the method features of the disclosure and from an inspection of the accompanying drawings, and in part will be more fully set forth in the following particular description of one method of practicing the invention, and the invention also consists in certain new and novel modifications of the preferred method and other features of construction and combination of parts hereinafter set forth and claimed.

In the drawings—

Fig. 1 is a view in side elevation of the work end of a crimping tool of the pliers type with the free ends of the handles omitted to save space, constituting a preferred embodiment of the invention, with the jaws and handles closed in their position of nearest approach;

Fig. 2 is a plan view looking down upon the showing in Fig. 1 when the tool has been inverted to present the under side of Fig. 1 facing upwardly;

Fig. 3 is a vertical sectional view in the medial plane of the tool head, taken on the line 3—3 of Fig. 2 and showing a fitting in place and with the parts in the position at the start of the crimping operation;

Fig. 4 is a view in side elevation of the flat side of the tool head, looking down on Fig. 2, with the shiftable die advanced slightly beyond the position shown in Fig. 3 to the position where the dies are about to be interlaced and with the assembly of connector and cable partially crimped, and with the shiftable stop plate elevated into an inoperative out-of-the-way position;

Fig. 5 is an enlarged showing of the upper parts of the dies in Fig. 4, with the shiftable die advanced to its position of nearest approach to the fixed die, showing the crimp fully formed with the crimp in the rectangular form as shown in section on the line 5—5 of Fig. 10;

Fig. 6 is an enlarged elevational view of the work face of the fixed die of the preceding figures;

Fig. 7 is a similar view of the opposing work face of the shiftable die and with the showings of Figs. 6 and 7 in mutually reversed positions;

Fig. 8 is an elevational view of the fixed die work face as shown in Fig. 6 with a small size connector as shown in Fig. 9 located thereon, showing the inner sleeve ferrule portion of the connector in endwise stopped abutment with one of the stop fingers and located thereby properly between the dies and showing the fitting before being crimped onto the cable therein;

Fig. 9 is a view partly in elevation and partly in axial section of a stock connector for the crimping of which the present disclosure is particularly, but not solely, designed;

Fig. 10 is a similar view of the assembly of the finished article with the connector of Fig. 9 crimped onto the cable as herein disclosed and forming the finished article; and

Fig. 11 is a transverse sectional view taken on the line 11—11 of Fig. 10 and showing a somewhat elliptical form of crimp in cross section at the large insulated end of the cable.

In the drawings there is shown a crimping tool 10 of the pliers type used in the illustrated case to crimp a stock connector A as shown in Fig. 9 onto a cable B shown in Figs. 8 and 10.

The connector A comprises three members in telescopic relation as shown in Fig. 9 and includes an outer sleeve C of insulating material, partially lined with a thin metal tube D, and an inner sleeve E forming a wire-engaging ferrule from one end of which projects an apertured tang F. The inner ferrule or sleeve E is of cylindrical form with a closed joint G along the side opposite that side from which extends the tang. The ferrule E is provided at its inner end with an outwardly flared end H which intrudes into an annular recess I formed in a bead J in the intermediate tube and which bead projects into the outer insulation sleeve C and interlocks therewith. The cable B as shown in Fig. 10 includes a core K of twisted, small wire conductors with its jacketing insulation L stripped back at one end to form bare end wire conductors M.

In the drawing there is shown a crimping tool 10 of the pliers type used in the illustrated case to crimp the connector A onto the end of cable B inserted into the bore of the connector.

The tool includes a long main body, frame or relatively stationary member 11 and a long lever 12 pivotally connected thereto at pivot pin 13 and with the member and lever provided, respectively, with extensions forming a lower handle 14 when considered upside down from the showing in Fig. 1, and an upper handle 15 normally disposed in parallel relation as shown in Fig. 1. Member 11 and lever 12 are made of tool steel castings and are of relatively great depth in their flatwise dimension in order to absorb strains from the several pivots. An upturned solid end 16 of member 11 forms a seat for receiving a replaceable die element 17 forming the relatively fixed jaw of a squeeze clamp. A rockable link 18 pivoted to the member 11 forms the coacting die and the relatively shiftable jaw of the clamp. The shiftable jaw 18 is connected to lever 12 by a pair of short connecting links 19 forming therewith a toggle connection for shifting the die element 18 to and from the die element 17.

The portion of the frame member 11 between the end 16 and its handle 14 is slotted as shown in Fig. 2 and provides a pair of spaced-apart parallel cheek plates 20 and 21 integrally connected at their ends and between which plates the rockable jaw 18 and toggle-forming parts are for the most part contained.

The upturned end 16 is provided on its inner side with an upstanding, flat face 22 against which abuts the die element 17 and the end is provided in its upper face with an apertured eye 23 which receives a screw 24 threaded into the portion 16 to secure the die in place.

Link 18 forming the shiftable jaw is of triangular form with its lower end reduced in width and formed with a disk-like boss 28, rockably mounted on a pin 27 whose ends are fitted in the cheek plates 20 and 21 with a driven fit. Unscrewing the screw 24 out of the eye 23 permits the removal and replacement of the fixed die 17.

The lever 12 is a lever of the first class and is fulcrumed intermediate its ends to provide a long arm which forms the upper handle 15 and a very short arm 31 which projects from the pin 13 towards the shiftable jaw and forms the power element of the toggle connection. The links 19 are in pairs on opposite sides of the arm 31 as shown in Fig. 2, and at one end are pivoted thereto by dowel pin 32 which forms the knee of an equal length arm toggle. The opposite or forward ends of the links 19 are

on opposite sides of the upper, wide end of the shiftable jaw **18** and are pivoted thereto by a pivot pin **33**. The parts so far described are more fully disclosed and claimed in the above-identified United States Patent No. 2,696,747.

The particular novelty in this disclosure over the similar form of tool disclosed in United States Patent No. 2,696,747 relates particularly, first, to the work faces of the die **17** and the coacting die part forming the work face of the head **34** of the shiftable jaw **18**, and, second, to the feature which resists opening of the joint in the ferrule sleeve of the connector.

Referring, first, to the details of the die **17** as shown in Fig. 6 and which may be called the female die, it includes a base plate **35** from the top and bottom of which extend parallel pairs of flanges **36** and **37** adapted to lap, respectively, the top and bottom of the head **34** of the jaw **18** when in interfitting relation. The work face of the die **17** is formed of four projections substantially of the same depth, two relatively narrow upper projections **38** and **39**, respectively, integral with the upper flanges **36**, and two relatively wider, lower projections **40** and **41** integral, respectively, with the lower flanges **37**, and in each case forming the projections L-shaped in side elevation as shown in Figs. 1 and 3. The upper and lower projections are spaced apart to form therebetween a recess **42** extending transversely from edge to edge of the die. The upper projections are spaced apart transversely to form an upper, vertically extending slot **43**, and the lower projections are similarly spaced apart to form a lower slot **44**. The slots **43** and **44** are in alignment and intersect the recess **42** at its mid-length and at right angles thereto. The advance or work-engaging faces of the projections **39** and **41** are each flat except that their edges are rounded when necessary to avoid presenting sharp edges to the parts of the connector engaged thereby. The advance or work-engaging faces of the projections **38** and **40** are provided, respectively, with shallow grooves **45** and **46**, each defining an arc of a circle in all vertical cross sections thereof and each of a little less than one-half frusto-conical form with their inner ends of least cross section, respectively, at the upper slot **43** and lower slot **44**.

The male forming die head **34** at the top of the jaw **18** as shown in Fig. 7 includes a base plate **47** provided centrally of its width with a long, narrow, upstanding slot **48** designed to register in opposition with the pair of aligned slots **43** and **44** of the die **17**. A transversely spaced-apart pair of short ribs **49** and **50** project in parallel relation from the base plate **47** on opposite sides of the slot **48** and are dimensioned to intrude into the opposite ends of the recess **42** to form an interlacing relation between the dies as they approach and reach their position of nearest approach during the crimping operation, as hereinafter described.

The portion of the base plate above the short ribs forms a pair of projections **51** and **52** disposed to face, respectively, the projections **39** and **38** and thus form an upper pair of work-engaging pressure clamps. The projection **52** is provided with a groove **53** of semi-conical form corresponding in configuration with the opposing groove **45** and coacting therewith to form an upper work-containing pocket when the jaws are in their position of nearest approach. The portion of the base plate below the ribs forms a pair of projections **54** and **55** disposed to face, respectively, the projections **41** and **40** and thus form a lower pair of work-engaging pressure clamps. The projection **55** is provided with a groove **56** of semi-conical form, corresponding in configuration with and coacting with the groove **46** to form a lower work-containing pocket. The grooves which form the pair **46** and **56** are longer and deeper, respectively, than the grooves which form the pair **45** and **53**.

A stop plate **57** formed of thin spring steel has one end mounted on the outer side of cheek plate **21**, that is, on the side of the dies which contain the pair of upper grooves **45**, **53**, and the pair of lower grooves **46**, **56**. The stop plate is pivoted to one end of the pin **13** which permits the stop plate to be swung into an inoperative position as shown in Fig. 4 or into its operative position as shown in Figs. 1, 2 and 8 and in which operative position it may be snap-locked against accidental movement by means of an indenture button **58** fitting in a socket **59** formed in the cheek plate **21**. The outer free end of the stop plate is bifurcated and the bifurcations bend inwardly to form two stop fingers **60** and **61** disposed when in operative position to face, respectively, the short work space formed between the projections on the upper ends of the jaws and the lower work space formed between the projections on the lower ends of the jaws. The upper finger **60** is bent inwardly slightly greater than is the lower finger **61** in order, in each case, that each finger lie close to its associated die projections as is shown in Fig. 8 in connection with the work space formed between the grooves **45—53**. The free ends of the stop fingers each terminate short of the work face of the die **17** by a distance sufficient to form narrow slots **62** and **63** of a width just sufficient to permit the tang F to pass therethrough and thus to hold the connector in relation to the dies fixed against rotation about its own axis.

In operation it will be understood that the two work-containing spaces or pockets on opposite sides, that is, above and below the pair of ribs **49—50**, are designed to receive connectors of different sizes and, in the case of the tool illustrated, the upper pocket is designed to receive connectors for Nos. 22–14 wires and the lower pocket to receive Nos. 12–10 wires. As the operation is the same for either pocket the action will be specifically described for the upper pocket in connection with a small size connector.

Assuming that the squeeze jaws are wide open, even more fully open than is shown in Fig. 3, and with the stop plate in place, a cable B with its conductor ends M exposed is inserted into the connector until the cable insulation L abuts the inner sleeve as shown in Fig. 10, and the assembly so formed is passed from left to right in the showing in Fig. 8 through the upper pocket **64** until the advanced end of the outer sleeve abuts the stop finger **60**. The parts are so dimensioned that the flared end H at the mid-length portion of the connector comes opposite the upper slot **43** so that in the subsequent squeezing of the opposite end portions of the connector the portion of the connector containing the flared end is not deformed but remains in its initial pre-fixed condition as shown in Fig. 9.

As the connector is advanced axially thereof into this position abutting the finger **60** the tang F is passed through the narrow slot **62** and this has the effect of rotatively locating the joint G exactly in position facing the flat projection **39** at its mid-length. As the shiftable jaw **18** is advanced by the action of the toggle the head **34** advances from the position shown in Fig. 3 towards the intermediate position shown in Fig. 4 and during which advance the small end of the connector is squeezed between the flat-faced projections **39** and **51**. At the same time the large end of the connector is squeezed between the grooves **45** and **53** of the projections **38** and **39** and in this way the large and small ends of the connector are at least partially deformed into their crimping engagement with the contained cable. The ribs **49** and **50** are dimensioned in their projecting length so that they begin to enter the recess **42** at the same time the base plate **47** enters the space between the flanges **36**, **37** to form the boxed-in upper mold pocket or cavity **64** and the lower mold pocket or cavity **65** as shown in Fig. 4. This closing-in of the pockets before the final squeezing step, particularly in the case of that end of the pocket which is to cause the connector to clamp the bare wire ends is important because enclosing this small end prevents any of the material forming the outer sleeve from escaping from the pocket in which it is now contained. It is noted

that at this time the cross section of each of the pockets is quadrilateral at the end shown in Fig. 4 and at their opposite ends the pockets are each outlined by arcs tending to form a circle in all cross sections thereof.

As the toggle action further advances the shiftable jaw the part of the connector within the end of the pocket shown in Fig. 4 gradually tends to assume more definitely a rectangular configuration, and when the jaws are in their position of nearest approach the cross section of the connector at its small end portion tend to assume the somewhat rectangular form with opposing sides parallel and with rounded corners as shown in Fig. 5.

It is noted from the showing in Fig. 5 that as the connector is squeezed between the projections **39** and **51** the loci of the squeeze forces are balanced on the opposite sides of the joint G with the result that the sides of the inner sleeve forming the joint move inwardly together simultaneously and one side is at no time in advance of the other, and in this way the joint G is maintained closed at all times and no loose conductor ends can escape through the joint.

The crimping of the small end of the connector has the effect of causing the adjacent end to bell out slightly as shown at **66** of Fig. 10 to form an annular gap **67** between the outer sleeve and the lining tube.

While this rectangular form of crimp is being formed at the small end of the connector its large end takes the form somewhat elliptical in cross section imposed thereon by reason of squeezing the large end between the squeeze faces of the dies provided by the part-conical form of the grooves **45** and **53**. When the jaws have reached the point of nearest relative approach the crimped portion of the outer sleeve C and the intermediate lining tube D will be somewhat elliptical in cross section as shown in Fig. 11, and which form of crimp has been found to be highly satisfactory to bind the connector to the unstripped end of the cable insulation L.

It is understood that in the case of a large connector in the lower pocket a similar crimping will be had with the smaller end crimped between the flat opposing work faces of the projections **41** and **54** to form a crimp somewhat rectangular in cross section as shown in Fig. 5 and with the opposing concaved work faces **46** and **56** of the projections **40** and **55** forming a crimp somewhat elliptical in cross section as shown in Fig. 11.

I claim:

1. A crimping device for crimping a tubular fitting onto wire conductors therein, including a pair of coacting squeeze dies each including a base plate and with the base plates disposed substantially in parallel relation and one fitting in the other when in their position of nearest approach, one of the base plates provided with a rib projecting towards the other base plate and the other base plate provided with a recess for receiving the rib in an interlacing relation, each base plate provided with a slot registering with the corresponding slot in the other base plate, and said slots extending at right angles, respectively, with the rib and recess, and each slot forming on opposite sides thereof a projection with the two projections of one die being opposed to the corresponding two projections of the other die to squeeze simultaneously with one operation of the device the fitting therebetween at two spaced-apart places in the length of the fitting while leaving the part thereof lying therebetween and facing the slots substantially free of any squeezing deformation.

2. The device defined in claim 1 wherein the work faces of the opposing projections on one side of the registering slots are flat and substantially parallel to each other when the dies are in their position of nearest approach and the work faces of the opposing projections on the other side of the registering slots are each provided with grooves which register to form a pocket defining opposite sides of a circle in all cross sections thereof when the dies are in their position of nearest approach.

3. A crimping device for crimping a tubular fitting whose opposite ends are of different diameters onto wire conductors therein, including a pair of coacting squeeze dies, each including a base plate, one of the base plates provided with a flange at one end thereof, and said base plate provided with a recess spaced from and parallel to the flange, the other base plate provided with a rib for intrusion in the recess in interlacing relation therewith, the first-named base plate together with its associated flange and the other base plate with its associated rib forming between them a pocket extending transversely of the dies and open at opposite ends for receiving therein the tubular fitting, the die parts forming one end of the pocket having flat opposing faces and coacting when the dies are in their position of nearest approach to form this end of the pocket substantially rectangular in cross section and fashioned to receive the end of the fitting having its smaller diameter, and the parts of the base plates defining opposite sides of the pocket at the other end thereof provided with registering grooves for receiving the end of the fitting having its larger diameter.

4. The device defined in claim 3 wherein the registering grooves which define the associated end of the pocket are circular in all cross sections of the same when the dies are in their position of nearest approach.

5. A crimping tool for deforming the tubular part of fittings into a crimping engagement with a cable therein, said tool including a pair of jaws pivotally connected, each jaw provided with a die of a coacting pair of dies, one of the dies provided with a recess and the other die provided with a rib disposed when the dies are in their position of nearest approach and approaching said position to form an interlacing relation between the dies, one of the dies provided at top and bottom with a flange projecting toward the other die and between which flanges the other die fits to form a boxed structure, and said dies coacting to provide a pocket on one side of the interlacing recess and rib, a stop plate having one end pivotally connected to one of the jaws and its other end forming a resilient stop finger extending across the end of the pocket and adapted to limit the axial advance in one direction through the pocket of the tubular part of the fitting, said finger terminating short of the other die to form a narrow slot-like clearance therewith for receiving a tang extending from the tubular part of the fitting and for restraining the tang from rotary movement about the axis of the fitting.

6. The tool defined in claim 5 and wherein the stop plate is pivotally connected and has two positions, one an operative position lapping the pocket and the other an inoperative position swinging clear of the pocket, and a detent for securing the plate against accidental movement away from its operative position.

7. A device for crimping tubular fittings of different sizes onto conductors therein, said device including a pair of coacting dies movable toward each other in their operative stroke, each die provided with a base plate, one of the base plates provided mid-length with a rib projecting therefrom towards the other base plate and the other base plate provided mid-length with a recess for receiving the rib in an interlacing relation, one of the dies provided at its top and bottom with flanges between which the other base plate fits, hereby providing, when the dies are approaching and in their position of nearest approach, a pocket designed to receive a fitting therein, each base plate provided with a slot with the slot in one registering with the slot in the other base plate and extending at right angles to the length of the rib and recess forming the interlock, the slot in each base plate dividing the work face into two block-like projections whose surfaces which face their companion surfaces of the other die form pressure faces between which the fitting is squeezed, said two opposing pressure faces provided with grooves of semi-conical form in plan and increasing in

width and in depth from the inner end at the slot towards its outer end.

8. The device defined in claim 7 in which the two block-like projections are of substantially the same width considered transversely, that is, lengthwise of the rib and recess forming the interlace.

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