

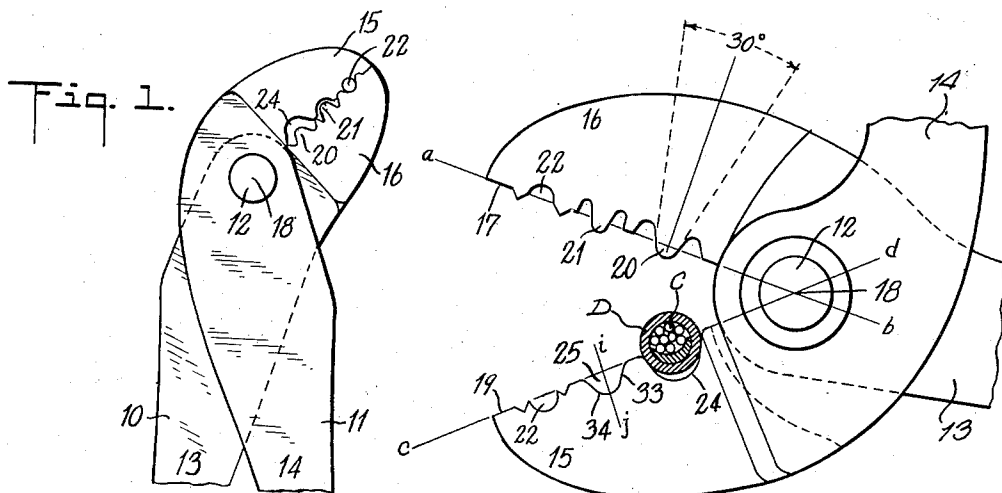
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**2,583,625**

# METHOD OF AND TOOL FOR CRIMPING TUBES

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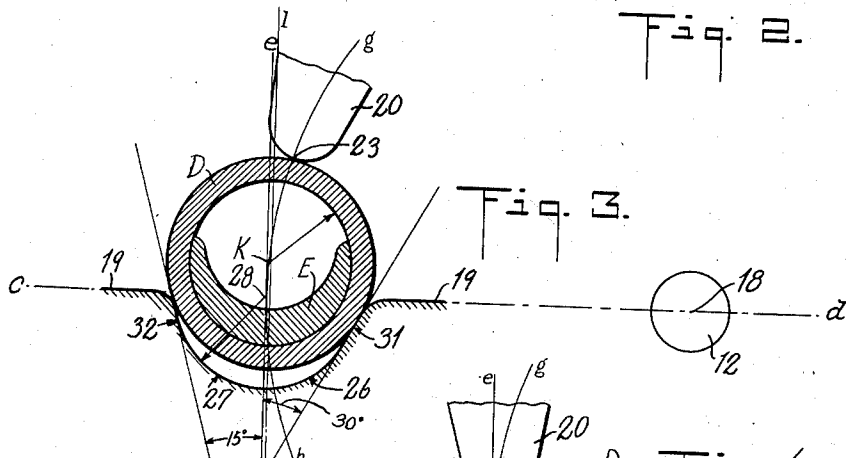


Fig. 3.

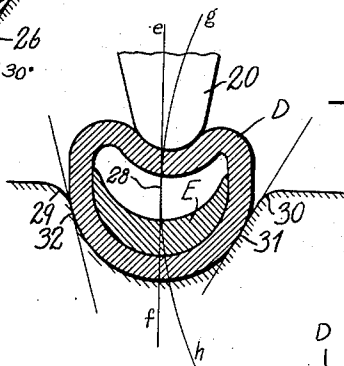


Fig. 4.

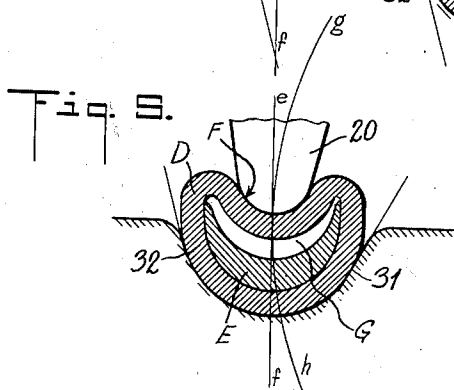


Fig. 8.

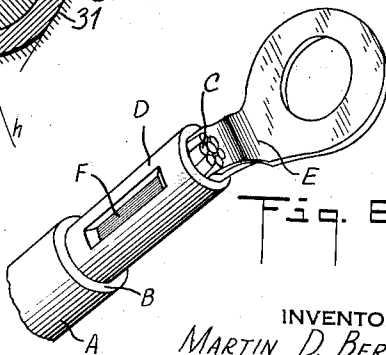


Fig. 8.

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## UNITED STATES PATENT OFFICE

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METHOD OF AND TOOL FOR CRIMPING  
TUBES

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The invention relates in general to a new technique in indenting, crimping, or otherwise locally deforming cylindrical metallic tubes; and the invention specifically relates to a new method for so crimping electric terminals, tips, connectors, or similar tubular members on to a cable, wire or other electric connector. The invention also relates to a tool of the pliers type or rather to the nest forming element of such a tool for use in practicing the method and also to the resulting product.

It is a common practice at present in the electric art to provide electric terminals, connectors, tips and the like, hereinafter referred to generally as stock pieces, and formed either of a single tube, or of two parts, that is, a tube into one end of which a preformed tongue or tang is inserted at the factory. When it is desired to form a cable end equipped with a terminal formed from such stock pieces, it is the usual practice to strip back the insulation of the cable so as to expose an end of its conductor; to insert the exposed end of the conductor into one of such stock terminals, and then by crimping or indenting one side of its tube to deform a limited length of the same into a binding engagement with the intruded end of the conductor, or in the case of the two-part device into a binding engagement with both the tang and the conductor.

This crimping is done usually by means of a hand tool resembling a pair of pliers. These tools are characterized in that the work face of one of its jaws sometimes hereinafter referred to as a female element is provided with a recess or nest, dimensioned for receiving the tube to be crimped and a projection or indenter extends from the other jaw sometimes hereinafter referred to as the male element, for indenting or crimping the tube when so held in its nest.

In crimping these terminals on to their cable ends when performed with the usual form of crimping tools, it has been found in practice that the resulting terminal tended to lose its desired true cylindrical form, on the side thereof opposite the crimp; tended to bulge out of the nest towards the side thereof opposite the fulcrum of the jaws of the tool and formed on the side thereof opposite the crimp a thin flash or ridge.

This tends of course to give an unfinished ribbed appearance to the otherwise smooth surface desired on the uncrimped face of the terminal.

Further the material forming such bulge, flash or ridge was simply wasted material, not economical in any case and particularly objectionable in a situation where, because of the sometimes very

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small size of the terminal and the necessity to fit in a limited space, any material not needed to perform a useful function took up room, was apt to scratch or mar the surface of adjacent articles and otherwise was most objectionable.

Accordingly an object of the invention is to provide an improved technic in performing such crimping and analogous tube deforming operations; which will eliminate the formation of such flashes, bulges and the like and on the contrary will provide a neat, smooth continuous appearance to the entire area of the terminal involved in any such crimping operation and which will utilize all of the material appropriated therefore in the designing of the same to provide the necessary structural strength.

Another object of the invention particularly relating to the finished structure is to provide a cable terminal which will be more efficient than known similar terminals in that a more positive and permanently locked grip is obtained on the entire portion of the conductor engaged by the crimp and in which the distorting strains on the tube are more evenly distributed than has been possible heretofore.

Broadly this object is obtained by arranging the opposing sides of the nest, recess or holding socket in the die or jaw of the crimping tool as a wedging seat for receiving the tube and disposing the tube relative to the direction of travel of the indenter, while traveling as usual on an arc, so that there will be obtained an on-center indenting of the tube and a crowding of the seated portion of the tube inwardly towards and finally into a deforming engagement with the bottom of the nest.

More definitely defined the invention relating to the tool features a form of seat in which its opposing and inwardly directing side or inclined at different angular inclinations to a center line bisecting the nest, and locating the seat side with the smaller angle on that side of the nest which is remote from the fulcrum or axis of rotation of the jaws, and with the seat side of greater angularity on the side nearest the fulcrum of the jaws.

Various other objects and advantages of the invention will be 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, tools and resulting cable terminal hereinafter set forth and claimed.

In the drawings:

Fig. 1 is a view in side elevation of the head end of a goose-neck crimping tool with the handle ends omitted, with the jaws in their fully closed position; and illustrating a preferred embodiment of the tool aspect of the invention.

Fig. 2 is an enlarged view of the jaws of Fig. 1 in wide open position and showing a stock terminal of the two-part type and containing a stranded conductor forming a unit inserted in the largest nest, that is, the nest nearest the fulcrum of the jaws;

Figs. 3 to 5 inclusive are enlarged explanatory views in cross section on a plane midlength of the indent of the finished article shown in Fig. 6, of the left or largest indenter and associated nest of the preceding figures; with the cable forming strands of the conductor omitted for clearance, and illustrating in order three successive steps of the method aspect of the invention; Fig. 3 showing the indenter about to engage the tube in offset relation to its associated nest; Fig. 4 showing an intermediate step with the tube twisted clockwise slightly as it is driven into the nest by the further advance of the indenter, and Fig. 5 showing the final step of the crimping operation; and

Fig. 6 is a view in perspective of a cable end equipped with a finished terminal produced by following the method herein featured and illustrating the resulting article aspect of this disclosure.

The final product resulting from practicing the method, and herein selected for specific discussion, is a cable end equipped with a terminal of the open eye type as shown in Fig. 6. There is disclosed an end of a cable A, the insulation B of which has been stripped back to expose its stranded conductor C and which stripped back conductor end is intruded into a cylindrical tube or sleeve D. Into this sleeve is also intruded the curved tang or tongue E of the terminal. Also following somewhat known practices the sleeve has been crimped, depressed or deformed on one side to form an indent or stake mark F of elongated form for securing the sleeve with its tang permanently to the intruded portion of the conductor. A cross section of the finished device at any point along the length of the indent or stake mark F and spaced from the opposite ends, will have the form shown in Fig. 5.

It is intended that the tube D and the tang or tongue E be made of an oxygen free copper of high conductivity and that the completed stock be hot-tinned.

Referring to the plier-like hand tool shown in Fig. 1, there is disclosed a tool of the usual goose-neck form. The tool comprises two parts 10 and 11 pivotally connected by a fulcrum pivot pin 12 and provided with long lever handles 13 and 14. The relatively short angled lever ends forming continuations of the handles constitute a nest jaw or female element 15 and an indenter jaw or male element 16.

The indenter jaw is provided with a work face 17 designated by the line *a-b* passing through the axis of rotation 18 provided by the fulcrum pivot 12, and the indenter jaw is provided with a coating work face 19 designated by the line *c-d* also passing through the axis of rotation 18.

The indenter work face 17 is provided with a plurality of projectors spaced along its length and forming indenter 20 nearest the fulcrum for

use with large size tubes, and another indenter 21 midlength of the work face 17 for use with a smaller size of tube. There is also shown part of an installing hole 22 but this does not per se constitute any part of the present disclosure. The invention herein, in so far as the tool is concerned, will be described with reference to the large size indenter 20, and associated nest, but in general the description will be equally applicable to the smaller indenter 21 and its associated smaller nest, except for obvious differences in dimensions. The several indentors have a length perpendicular to the sheet of the drawing, that is, equal to the width of the indenter jaw, sufficient to provide the length desired of the indent F shown in Fig. 6. Each indenter is U-shaped in cross section with its sides inclined at about thirty degrees with each other and rounding to form a nose 23 semi-circular in cross section. The nests are of the same length as the indentors and in general the jaws 15-16 constitute flat plates formed of forged steel and are of equal thickness of material.

The work face 19 of the nest jaw 15 is provided with two spaced apart U-shaped recesses or nests; a large inner nest 24 cooperating with the indenter 20, and a small nest 25 cooperating with the indenter 21. There is also shown an outer recess forming part of the installing hole 22.

Referring first to the large nest 24, and for convenience referring to the enlarged showings of the same in Figs. 3-5, it is noted that the bottom 26 thereof defines a portion of a cylinder, almost a semi-cylinder, uniform in all cross sections thereof and which cross sections define an arc 27 of a circle whose center is at the axis and which center in turn is at least approximately in the plane of the nest work face 19.

The arc 27 may be considered as substantially bisected by a nest center line *e-f* perpendicular to the plane of the work face 19, indicated by the line *c-d* in Fig. 3 and passing through the center 28. The opposing sides of the nest as they merge into the face 19 are sharply rounded, that is, have a small radius as they round into the work face 19 to form the corners or edges 29-30 best shown in Fig. 4.

The particular feature of novelty in this tool is that between the rounded corners 29-30 and the strictly cylindrical bottom portion of the nest, indicated by the arc 27, the sides are straight or rather flat for at least a short distance. These flat sides, ignoring the rounded corners, form the throat of the recess or nest 24. The straight side 31 forming the side of the nest throat nearest the fulcrum, forms an angle of thirty degrees with the nest center line *e-f* and the other straight side 32 forms an angle of fifteen degrees with the nest center line *e-f* as indicated by the light inclined lines in Figs. 3-5.

The most advanced point of the rounded nose 23 of the indenter 20 moves in a circular arc *g-h* whose center is at the axis of rotation 18 of the fulcrum pivot pin 12, and which arc passes as indicated through the nest 24 adjacent the center of its bottom defined by the arc 27. Differently expressed the center line *e-f* forms a tangent to the arc *g-h* at the center 28 of the arc 27.

The smaller nest 25 is of a contour similar to that of the nest 24 thus described, except that in this case the sides are more widely spread apart, the side 33 nearest the fulcrum forming an angle of thirty-five degrees and the other side 34 forming an angle of twenty-five degrees with its cen-

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ter line  $i-j$  corresponding to the center line  $e-f$  of the recess 24 in Fig. 3.

In operation and referring to Fig. 3 it will be seen that the stock tube of the size intended to fit the nest 24, is of larger external diameter than the width of the throat of the nest and is of slightly larger diameter than that of the arc 27 forming the bottom of the nest. By reason of the greater size of the tube, and the difference in angularity of the inwardly directed straight sides 31 and 32, the center of the outer circumference of the tube D is off-set slightly from the nest center line  $e-f$  and is located initially at K in the center line  $l-m$  which is parallel to and thus offset slightly towards the fulcrum from the nest center line  $e-f$ .

The most advanced point of the indenter nose 23 initially engages the circumference of the tube offset from both the center lines  $e-f$  and  $l-m$  on the side thereof towards the fulcrum point 18 as shown in Fig. 3. The kinetic force thus acting along the arc  $g-h$  downwardly on the tube and substantially along the line  $e-f$  as viewed in Fig. 3, is of course resisted by two reacting static forces acting with upwardly directed components on the tube, one at the straight thirty degree side 31, and the other at the straight fifteen degree side 32. It thus follows that the reactionary pressures at 31 and 32, are acting at each instant of time during the crimping of the tube, along two lines, one perpendicular to the surface 31 and the other perpendicular to the surface 32 and one thus forming an angle with the arc  $g-h$  different from the angle formed between the arc  $g-h$  and the other reactionary pressure line. The indenter then has a tendency to push the tube considered as a rigid body towards the left as it is lowered from the showing in Fig. 3 towards the position shown in Fig. 4.

However, the tube meets the wall or side 32 which is steeper with reference to the center line  $e-f$  than the side 31 from which it is receding, with the result that the lower right side of the tube is forced snugly downwardly into the nest and about the left side 32 as a shifting fulcrum. The right side of the tube finds it easier to move down the flat high angled side 31, which more nearly approaches a horizontal, than does the left side, in any tendency thereof to move up the steeper and thus more nearly vertical side 32. As a result there is a slight rotary movement of the tube clockwise about its own axis as it is forced down into the nest. The center of the tube originally at K in Fig. 3 moves laterally from the center line  $l-m$  towards the center line  $e-f$  until the original center of the tube has shifted both laterally and inwardly of the nest to the center point 28 of the arc 27.

Let it be recalled that the cylindrical bottom of the nest defined by the arc 27 is of slightly smaller diameter than the external diameter of the stock tube as shown in Fig. 3. This means then that when the lower portion of the tube is forced firmly on to its final curved seat provided by the bottom of the nest, the lower portion of the tube as shown in Figs. 4 and 5 has been deformed by the smaller diametered nest, and at least to a slight extent, the side of the finished tube opposite to the indent F as shown in Fig. 6, has been grooved or recessed in those portions which were forced into engagement with the U-shaped wall defining the portion of the nest 20 below the rounded corners 29-30.

Of course, the indenter deforms the upper por-

tion of the tube as shown in Figs. 4 and 5 so that very little of the tube has escaped some degree of deformation both under compression and under tension, at least in the area which includes the length dimensions of the indentation shown at F in Fig. 6.

By practicing the method herein disclosed it is possible to crimp tube after tube quickly and accurately without the formation of ridges or other undesired deformation in the cross section of the material. In this case any tendency of the tube to shift laterally, in the direction away from the fulcrum is resisted by the stop provided by the relatively steep side 32. The action of the tube is primarily a downward rotative action as it squeezes into the nest. As the indenter approaches the limit of its movement as shown in Figs. 4 and 5 the pressure imposed thereby is directed perpendicularly along the nest axis  $e-f$ , so that the resulting finally completed article as shown in Fig. 6 is symmetrical relative to this axis, and the pressure on the conductor strands is substantially equalized. The indent F in all cross sections thereof is of a wide spreading U-shaped form projecting far into the bore of the tube and rounding therefrom into the opposite and somewhat upstanding parallel sides of the tube. The portion of the tube opposite the indent, that is, the bottom side of the tube of Fig. 6 and which has been forced into the nest arc 27 of reduced diameter, will be substantially semi-cylindrical but in an almost unperceptible way will be of slightly less diameter than the end portions of the tube which of course retain their original diameters externally of the area subjected to the crimping operation herein featured. This means that the underside of the tube D will show a slight depression having the length of the indent F, that is the thickness of the jaw and the arc length of the arc 27, or at least that portion of the arc which engages the tube but will be free of any ridges, bulges or like showings such as are found in prior art devices.

The result of the peculiar crimping operation herein featured is that the lower portion of the resulting terminal and in the area opposite the indent F is semi-cylindrical as above noted and having been compressed or jammed into the nest is distorted under compression. The opposite side, that is within the length of the indent F is in the form of a wide spreading U in cross section and having been depressed by the indenter is somewhat elongated and deformed under tension. Under these circumstances the two sides in the portions projecting beyond the nest 24 as shown in Fig. 5 merge gradually from the region, the material of which is thus under compression, into the region the material of which is thus under tension.

It is understood, of course, that the material forming the ends of the tube D, that is the portions exteriorly of the indent F are not affected by the operations herein featured and retain the physical characteristics which identified the stock tube as it came from the factory.

With reference to the tang or tongue E it will be understood that in those cases where the tang and tube are assembled as part of the operation herein featured for securing the cable conductors to the terminal, the tang will initially have a fairly snug but freely sliding fit in the tube in order to permit an easy intrusion of the tang into the tube. Then by reason of the crimping operation herein features the reducing of cross section of the part of the tube within the nest

will cause the nested portion of the tube, first to shrink on to the convex curved outer side of the tang to take up any clearance therebetween, and then in its continued shrinking to deform the tang to conform to that of the tube, with a slight reducing of width between the horns of the crescent like tang and a slight raising of the same along the sides of the tube as shown in cross section in Fig. 5.

It is understood that the strands forming the conductor C in the length thereof engaged by the indent F are brought more nearly into parallel relation than initially arranged in the cable are reduced in over-all cross sectional area and are thinned out into the crescent space G shown in Fig. 5.

In this way more of the strands which originally were interior strands are brought into contact with the curved surfaces convex surface of the indent F and the concaved surface provided by the tang E of Fig. 5, or by the adjacent convex surface of the tube D in those cases where a separate tang is not used.

In any event a more positive grip and a better mechanical and electrical connection is provided between the conductor and terminal than has been possible heretofore.

#### I claim:

1. A crimping tool comprising two jaws, a pivot connecting the jaws, one jaw provided with a work face having an indenter projecting therefrom and the other jaw provided with a work surface having a recess therein and toward which the indenter approaches intrusion when the jaws approach each other, said work face and work surface intersecting at the axis of the pivot, the bottom of the recess forming in cross section an arc substantially the arc of a circle and approximately symmetrical with respect to a line perpendicular to the plane of said work surface, the sides of the recess adjacent its throat being each substantially straight for at least a portion thereof and said straight sides being inclined towards each other and towards said perpendicular line, the angle made by the straight portion on the side nearest the pivot forming a greater angle with said perpendicular line than does the straight portion on the side remote from the pivot and the arc of movement of the most advanced part of the indenter being tangent to

said perpendicular line adjacent the plane of said work surface.

2. The tool defined in claim 1 wherein the sides of the recess between the straight portions and the work surface form sharply rounded corners at the throat of the recess.

3. The tool defined in claim 1 wherein the angle formed between the perpendicular line and the straight portion on the side nearest the pivot is about thirty degrees and the angle formed between the perpendicular and the straight portion on the side of the recess remote from the pivot is about fifteen degrees.

4. In the art of deforming a limited length of a cylindrical tube in the act of crimping it onto a conductor inserted in its bore, the method which consists in initially fitting the tube between the inclined side walls of a recess formed in a work face of a support and wherein the bottom of the recess is the arc of a circle whose diameter is slightly less than the diameter of the tube and whose center is at the work face, said sides being flat, forming different angles with the work face and rounding sharply with the work face, applying a crimping force to the tube opposite its supported side, causing said force to operate along an arc whose center is at the work face and on the side of the recess nearest the side wall of lesser inclination to the work face, and continuing to apply said force until the supported part of the tube is squeezed into a conforming fit with the bottom of the recess, and thereafter continuing to apply the force until the side of the tube engaged by the force becomes depressed into its bore.

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#### REFERENCES CITED

The following references are of record in the file of this patent:

#### UNITED STATES PATENTS

| Number    | Name               | Date          |
|-----------|--------------------|---------------|
| 1,793,293 | Varney et al. .... | Feb. 17, 1931 |
| 1,834,436 | Straley .....      | Dec. 1, 1931  |
| 1,836,497 | Phelps et al. .... | Dec. 15, 1931 |
| 2,109,837 | Davis .....        | Mar. 1, 1938  |
| 2,275,163 | Thomas .....       | Mar. 3, 1942  |
| 2,288,348 | Funk .....         | June 30, 1942 |
| 2,382,292 | Carlson .....      | Aug. 14, 1945 |