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Karl et al.

[11] **3,826,861**

[45] **July 30, 1974**

[54] **TERMINAL CONNECTORS FOR INSULATED CONDUCTORS**

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[73] Assignee: **Utilux Pty., Limited**

[22] Filed: **July 3, 1972**

[21] Appl. No.: **268,807**

Related U.S. Application Data

[63] Continuation of Ser. No. 7,064, Jan. 30, 1970, abandoned.

[30] **Foreign Application Priority Data**

Feb. 5, 1969 Australia 50006/69

[52] **U.S. Cl.** ..... **174/84 C,** 29/628, 29/630 F, 174/90, 339/98, 339/276 R

[51] **Int. Cl.** **H02g 15/08**

[58] **Field of Search** ..... 174/84 C, 90, 94 R; 339/97 R, 97 C, 223 R, 276 R, 276 T, 98; 29/630 F, 628

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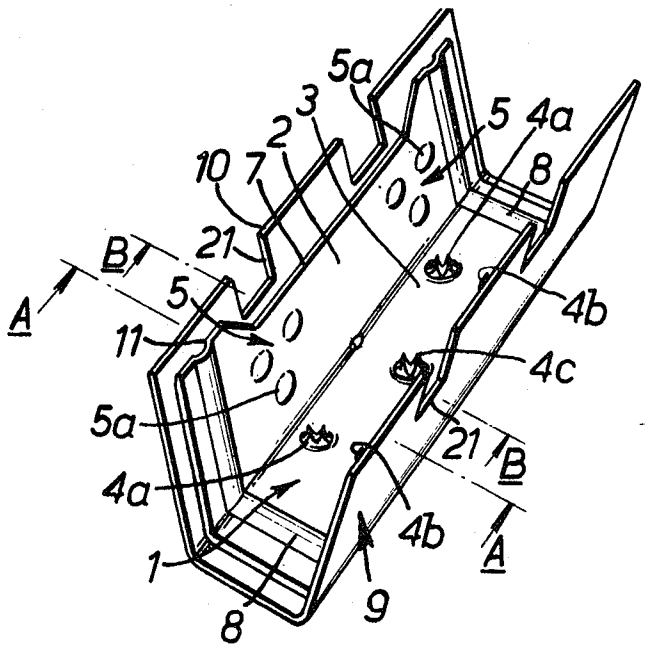
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[57] **ABSTRACT**

An electrical terminal connector for crimping onto an insulated electrical conductor, comprising a trough-shaped ferrule, an insulation piercing element, such as a group of spikes, projecting from the side walls of the ferrule, and conductor engaging means, such as dimples, projecting into the space and located in co-operating juxtaposition with respect to the element, the side walls during crimping being rolled inwardly so that the conductor engaging means engages the conductor and the element pierces the insulation to make electrical contact with the conductive core of the conductor.

3 Claims, 9 Drawing Figures



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SHEET 1 OF 3

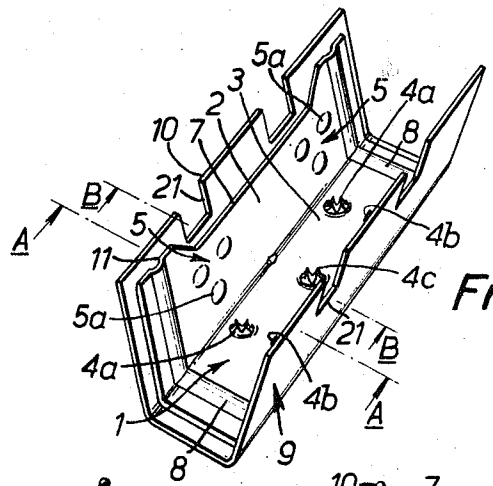


FIG. 1.

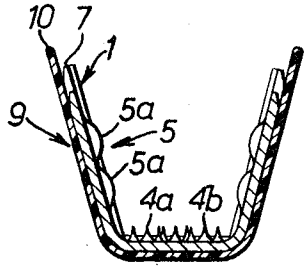


FIG. 2.

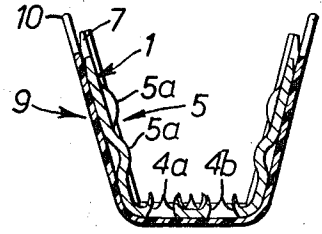


FIG. 3.

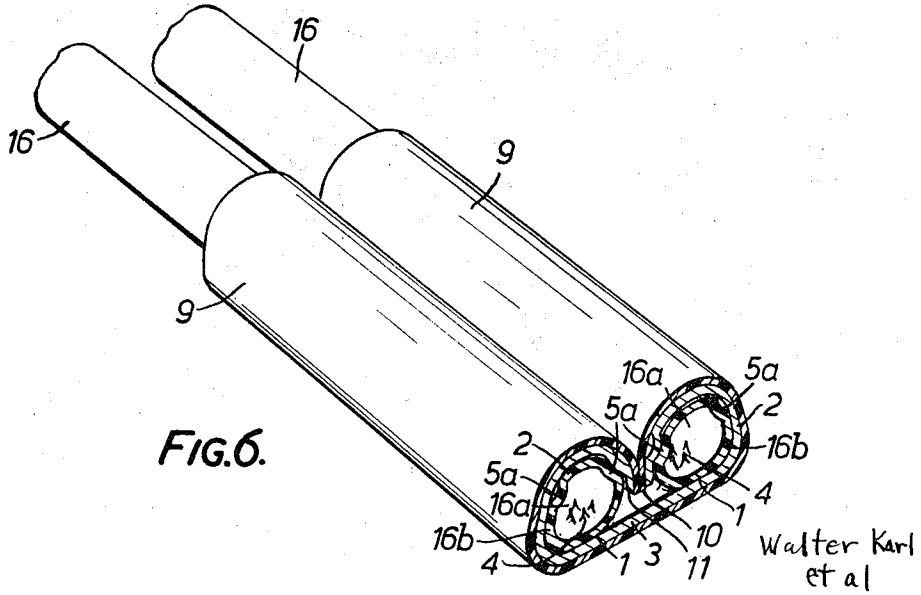


FIG. 6.

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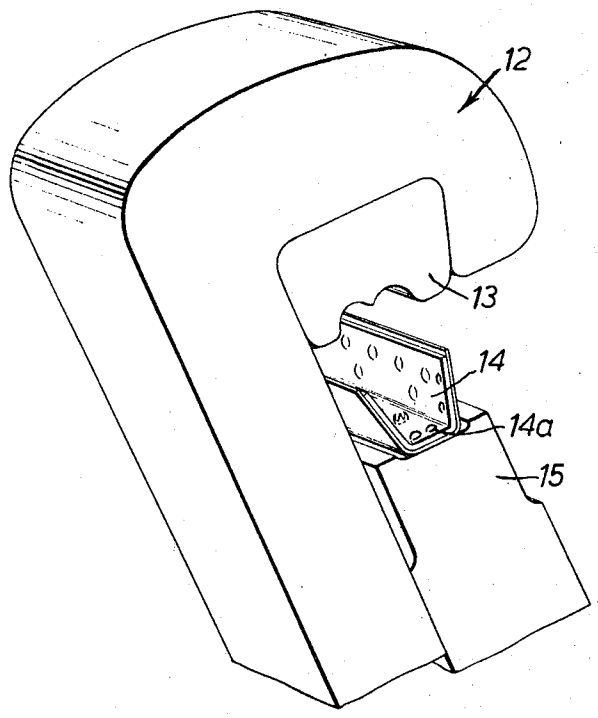


FIG. 4.

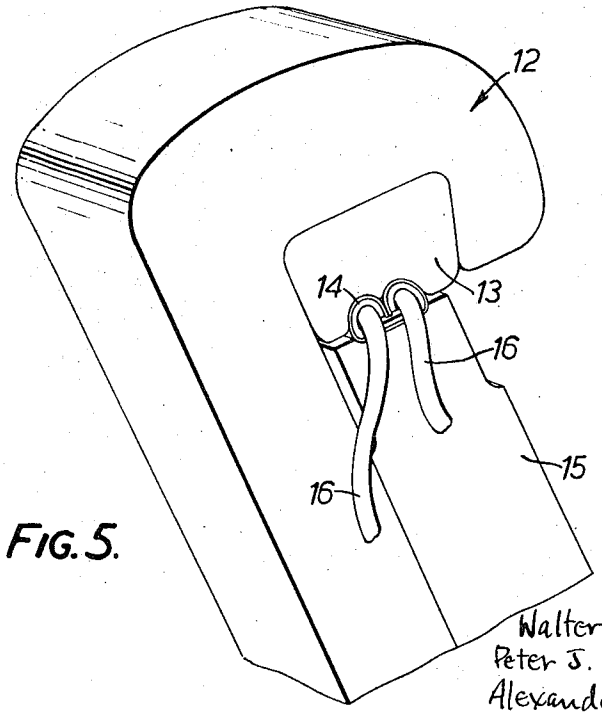


FIG. 5.

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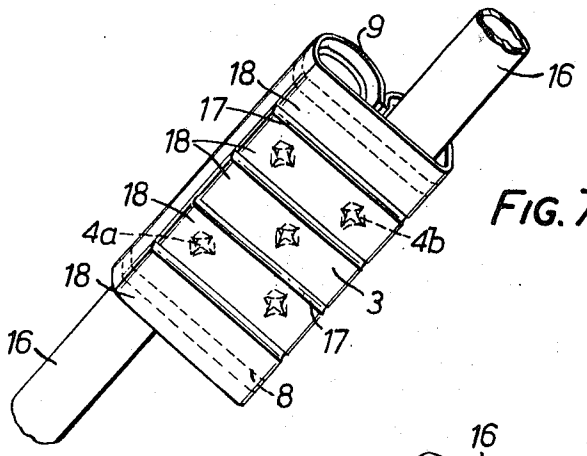


FIG. 7.

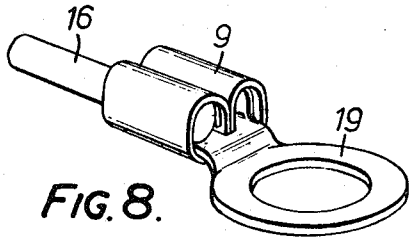


FIG. 8.

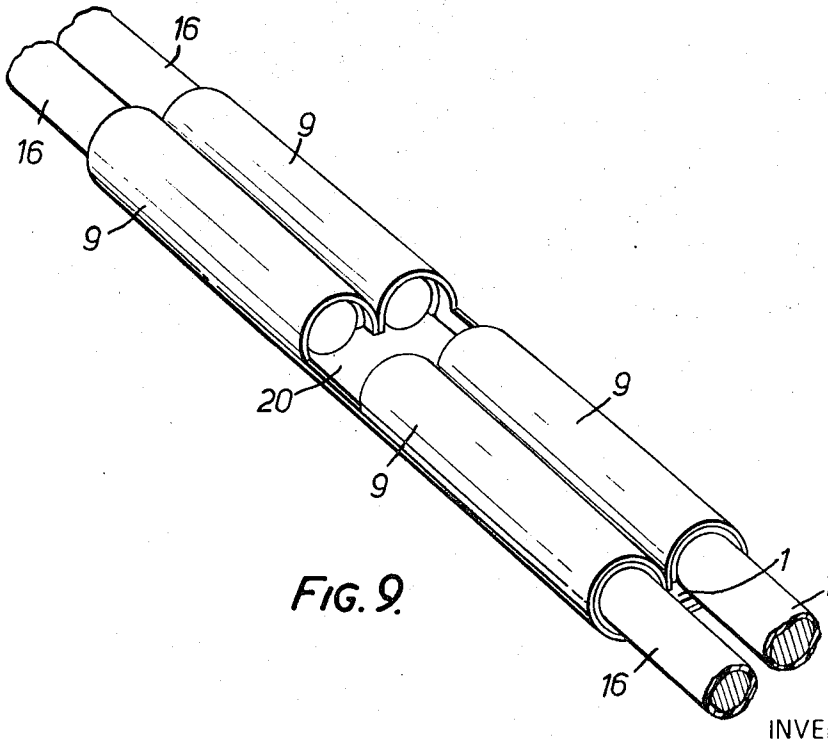


FIG. 9.

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TERMINAL CONNECTORS FOR INSULATED CONDUCTORS

This application is a continuation application of the prior U.S. application Ser. No. 7,064 filed Jan. 30, 1970, now abandoned.

This invention relates to electrical terminal connectors of the type formed from metal sheet and intended to be attached to an electrical conductor by the process well-known as crimping. The term "terminal connector" is used to embrace devices which terminate a conductor and also those which serve to connect conductors electrically to each other.

Conductors used in the electrical industry often consist of a conductive core provided with an outer sheath or skin of plastic, paper or other suitable insulated covering. Other types of conductor consist of a conductive core provided with a coating or film of enamel, polyvinyl acetal or other tough, elastic, insulating film. In addition, electrical conductors intended to consist merely of a conductive core are often dirty or have an oxide or sulphide film which effectively increases the electrical contact resistance or may be severe enough to insulate the conductor. For example, with aluminium conductors a hard adherent surface film of aluminium oxide forms rapidly after the bare metal is exposed to air. Before good electrical contact can be made the aluminium oxide, which has a high electrical resistance, must be removed or broken down and the conductor then protected against reoxidation. If the aluminium oxide film is not removed or broken down, contact resistance will be of a high value and result in a poor electrical connection.

It is to be understood that the term "insulation" as used in this specification and the appended claims is to be construed to include paper, plastic or other suitable insulating sheathing, also an insulating coating of enamel, polyvinyl acetate or other tough, elastic insulating film, and in addition other surface films such as oil or dirt, oxides, or sulphides.

In the past, a common procedure has been to strip or abrasively clean insulated electrical conductors individually before attempting to make an electrical connection. This procedure is time consuming and expensive and, for certain hard and resilient insulating films such as aluminium oxide, is impractical when relatively fine wire is involved.

Furthermore, it has been a problem to join and make electrical contact between conductors even after stripping or abrasion cleaning. Copper wires may be soldered or welded in applications such as the connection of field windings of electrical motors but this is time consuming and expensive. In many circumstances the electrical joint or connection must be re-insulated after soldering making this form of connection more time consuming and more expensive.

In other applications such as joining copper telephone wires, the paper insulation is stripped back, the bared copper conductors twisted together and then the electrical joint or connection re-insulated. Alternatively, if plastic insulated wire is used some economy can be achieved by not stripping the plastic from the wire but applying heat while twisting the plastic insulated wires together, the plastic becoming soft and flowing while hot, allowing the wires to make electrical contact. On cooling, the plastic solidifies and insulates the twisted connection. This method is commonly known as a "hot-twist" connection. With both a hot-twist connection and a bared and twisted copper connection, noise due to faulty or dirty contact as well as electrical and thermal noise is generated in the connection and is heard as "noise" and "static" in a telephone receiver. Whilst the level of noise due to mechanical, electrical and thermal effects may be acceptable for telephone conversations, it is not satisfactory when telephone lines are used to transmit computer data which is becoming increasingly common.

For economy, aluminium is sometimes substituted for copper as the conductive core in electrical conductors. Aluminium to aluminium, or aluminium to copper connections cannot be twisted together because of the hard adherent insulating surface film of aluminium oxide.

Although aluminium may be soldered by special preparation and methods, this is time consuming and expensive. Welding is more satisfactory but is more time consuming and expensive. When soldering or welding is adopted, the wires must be stripped of insulation and then re-insulated after the connection has been made.

The primary object of the present invention is to provide a terminal connector capable of being crimped to an insulated electrical conductor without first removing the conductor insulation.

A further object is to provide a terminal connector such that a given connector may be applied to conductors in a wide range of different conductive core diameters and different insulation materials.

Another object is to provide a terminal connector capable of improved mechanised and electrically conductive engagement between the connector and a conductor.

Another object is to provide a terminal connector which is simpler and less expensive to manufacture than connectors proposed hitherto.

In accordance with the invention as seen from one aspect there is provided an electrical terminal connector intended to receive and be crimped to one or more insulated electrical conductors, comprising a generally trough-shaped ferrule-forming member of sheet metal having a base part and two side wall parts, at least one insulation piercing contact element in respect of each conductor to be received formed in one of said parts and projecting into the space between said side wall parts, and conductor engaging means in respect of each contact element protruding from another of said parts into said space and located in co-operating juxtaposition with respect to the related contact element; whereby each side wall part can be rolled inwardly towards the base and crimped about a conductor so that each said conductor engaging means engages the conductor and the co-operating contact element pierces the conductor insulation to make electrical contact with the conductive core of the conductor.

A terminal connector in accordance with the present invention may be used for copper to copper, aluminium to copper and aluminium to aluminium connections, in such applications as the joining of telephone wires, the connections of field windings of motors and other similar applications involving the joining or connection of small insulated wires. Noise generated in a connection incorporating the invention due to mechanical electrical and thermal effects, is less than that generated in a connection made by the twisting, soldering or welding

methods. Because the terminal connector is insulation-piercing and may furthermore be manufactured as a pre-insulated terminal connector, insulation stripping is not necessary and no re-insulation is required on completing the connection. A connector according to the invention may be applied to conductors faster than soldering or welding a connection. Thus, because of rapid application and avoidance of any stripping or re-insulating operations and because only one size of connector need be involved within a wide range of different conductive core diameters, a terminal connector in accordance with the present invention is economical to manufacture and to apply.

The invention makes it possible to crimp into interlocking engagement and good electrical conductive engagement in one size of terminal connector a range of insulated wires with a conductive core diameter of, for example, 0.012 inch to 0.035 inch with varying diameters of insulation and differing insulation materials. Hitherto the wire range or different diameters of conductive cores which could be satisfactorily terminated by a given crimp-type connector has been restricted. For example, to terminate a range of conductive core diameters smaller than 0.015 inch and larger than 0.025 inch diameter up to three or more connectors of different dimensions may be required.

Embodiments of the invention will hereinafter be described, by way of example only, with reference to the accompanying drawings in which:

FIG. 1 is a perspective view of a terminal connector in accordance with the invention;

FIGS. 2 and 3 are cross-sections of the terminal connector shown in FIG. 1 on the lines A—A and B—B respectively;

FIGS. 4 and 5 are perspective partial views of a crimping tool in the open and closed condition respectively;

FIG. 6 is a perspective view of the terminal connector of FIG. 1 crimped to a pair of conductors and showing a cross-section taken on a line corresponding to line A—A of FIG. 1;

FIG. 7 is an underside perspective view of the terminal connector of FIG. 1 crimped to a pair of conductors; and

FIGS. 8 and 9 are each a perspective view of an alternative embodiment of the invention.

Referring generally to the drawings, the terminal connector of FIG. 1 comprises a metal ferrule-forming member 1 located in a surrounding insulation member 9 of insulating material. In one application, the unstripped ends of a pair of insulated conductors are arranged in the member 1 and, as shown in FIGS. 4 and 5, the connector is crimped in a crimping tool to produce a finished connection as shown in FIG. 6 in which the conductive cores of both conductors are in electrical contact with the metal member 1. Other arrangements of conductors are possible. Also, the connector of FIG. 1 may serve as the conductor-receiving ferrule of a terminal as shown in FIG. 8.

Reverting to FIG. 1, together with FIGS. 2 and 3, the metal member 1 is generally trough-shaped with slightly diverging side walls 2 extending upwardly from a base 3. Pairs of insulation-piercing contact elements 4*a* and 4*b* are formed in the base by bursting the base metal so as to leave groups of upstanding spikes of metal, each group of spikes constituting a contact element. A further group of spikes is similarly formed centrally in the base to constitute a locating element 4*c*.

Conductor engaging means 5 are formed in the side walls 2, one such means being aligned for co-operation with each one of the contact elements 4*a* and 4*b*. As shown each conductor engaging means 5 consists of a group of three dimples 5*a* located with respect to each other so as to be at the corners of an inverted triangle, the dimples protruding into the trough of the member 1.

Adjacent each end of the member 1 there is perferably, and as shown, provided conductor support means in the form of a rib 8 extending transversely across the base 3 and continuing up each side wall, the ribs protruding into the trough of the member 1.

Along the upper edge 11 of each side wall 2 a portion of the metal is cut away to leave a clearance recess 7 lying between the ribs 8 but extending at least as far as the extent of the conductor engaging means 5 and the contact elements 4.

The insulation outer cover member 9 is a sheet of suitable plastics material formed to fit closely to the member 1 and fixed to the member 1 with adhesive. Preferably, and as shown, the overall dimensions of the insulating member 9 are somewhat greater than those of the member 1 so that the insulation member extends beyond the ends and the upper edges of the member 1. Also, the upper edges 10 of the side walls of member 9 are formed with recesses 21, each recess being aligned with one of the contact elements 4.

The terminal connector of FIG. 1 may be crimped to a pair of conductors using a crimping tool 12, as shown in FIGS. 4 and 5, the tool comprising an appropriately contoured anvil 13 and a ram 15. The connector, referenced 14, is located as indicated on the ram and the ends of a pair of insulated conductors 16 arranged longitudinally on the base of the connector so that one conductor overlies one pair of contact elements (e.g. 4*a* in FIG. 1) and the other conductor overlies the one pair of contact elements (e.g. 4*b* in FIG. 1). When the crimping tool is operated each side wall of the connector is rolled over the adjacent conductor and the edges of the side walls move to lie against each other facing towards the connector base. The central locating element 4*c* assists in retaining the conductors in their correct positions during crimping.

Referring also to FIG. 6, as the crimping operation progresses each conductor is engaged by the corresponding conductor engaging means 5 and held captive between the dimples 5*a*. The crimping pressure forces each conductor onto the underlying contact elements so that the elements pierce the insulation 16*b* and make good electrical contact with the conductive core 16*a* of the conductor. The dimples 5*a* serve to localise the crimping pressure over the contact elements and also press into the insulation 16*b* to assist in retaining the conductors firmly in the connector.

The crimping operation also causes the ribs 8 (FIG. 1) to grip the conductors, the ribs pressing into the insulation. Thus, each conductor is supported at its extreme end and also at the point just after the conductor enters the connector so that the effect of stressing or flexing of the conductor relative to the connector is not transmitted to the region of the contact elements 4*a*, 4*b*.

The recesses 7 in the edges of the ferrule-forming member 1 ensure that the edges do not foul the contact

elements 4*a*, 4*b* or interfere with the contact-making process. Furthermore, the recesses avoid possible damage to conductors having small-diameter conductive cores, e.g. 0.012 inch diameter, which may be difficult to maintain straight during the crimping operation, particularly in the region midway along the connector. The depth of the recesses **7**, that is from the edge **11** of the member **1** to the bottom of the recess, is preferably approximately equal to the diameter of the smallest conductive core to which the particular connector is intended to be crimped. During the development of the present invention it was noted that if a recess such as recess **7** was not provided then when crimping conductors having cores of 0.012 inch diameter up to 50 percent of such cores were severed whereas provision of the recess avoided any failures.

It will be noted from FIG. **6** that, after crimping, the connector is enveloped by the insulation member **9** resulting in a fully insulated connection, the edges **10** of the member **9** being held captive between the edges **11** of the ferrule-forming member **1.** Thus if heat should be applied to the connection, reliance is not placed on the adhesive to maintain the insulating member in position around the ferrule-forming member **1.** The recesses **21** in the edges of the insulation member ensure that said edges do not interfere with the contact-making process, particularly when small diameter conductors are involved. On the other hand, when the same connector is being applied to a large diameter conductor, the edges of the insulation member will still be held captive by the edges **11** of the ferrule-forming member even though the recesses **21** extend between said edges **11.**

It will be apparent that the terminal connector of FIG. **1** can alternatively be applied to a pair of conductors so that the conductors enter the connector from opposite ends, as seen in FIG. **7,** which figure also shows a preferred formation of the underside of the connector during the crimping operation. This formation consists of transverse ridges **17** created by providing corresponding grooves in the pressure face of the ram **15** of the crimping tool **12** (FIG. **5**), so that the crimping pressure is concentrated in the areas **18** lying either side of the ridges, said areas including the contact elements such as **4***a* and also the ribs **8.** Thus, the areas **18** are crimped at high pressure whilst the ridges **17** are crimped at a lower pressure. This causes corresponding deformation of the conductors **16** thereby increasing the longitudinal pull necessary on the conductors to pull them from the crimped connector. If desired the ridges **17** can be preformed in the base of the connector during manufacture.

The embodiment of the invention as so far described is susceptible to modification. For example, the insulation piercing contact elements may be interchanged with the corresponding conductor engaging means so that the former are located in the side walls and the latter are located in the base. Also, the number of contact elements **4***a*, **4***b* may be varied and in some applications one contact element will be sufficient for each conductor. With some larger diameter conductors, the recesses **7** may be replaced by smaller recesses aligned one with each contact element (similarly to the location of recesses **21** in the insulating member **9**). Alternatively the recesses may be dispensed with altogether where large diameter conductors are involved. Likewise the recesses **21** in member **9** may be varied.

Regarding the conductor support means these may take a form different from the ribs **8**; for example a series of dimples as indicated at **14***a* in FIG. **4.** Preferably, six dimples are provided, two in the base of the ferrule-forming member and two in each side wall the spacing being such that, after crimping, each conductor is engaged by three dimples. This form of conductor support means permits the side walls to be more readily rolled over during the crimping operation. Referring to the conductor engaging means **5,** the groups of dimples **5***a* may each be replaced by a parallel pair of spaced ridges extending in the longitudinal direction of the connector and, after crimping, presenting a similar sectional appearance to that shown in FIG. **6** in respect of the dimples **5***a*.

Another embodiment of the invention is shown in FIG. **8** in which a connector as previously described is constituted as part of a unitary terminal structure including a termination portion **19** intended to be locked under a screw. As shown there may be only one conductor crimped to such a terminal connector. Obviously, the termination portion can take any desired form depending on the particular application.

A further embodiment is shown in FIG. **9** in which two of the terminal connectors of FIG. **1** are joined end-to-end by an integral bridging piece **20** to form a connector for connecting together three or (as shown) four conductors.

Terminal connectors in accordance with the invention may be manufactured in chain form, joined either end-to-end or side-to-side. Adjacent connectors can be joined by an integral metal link, as when the connectors are stamped from a continuous strip of metal or individual connectors can be linked by being attached by adhesive to a continuous strip of insulating plastics material which, in relation to each connector, constitutes the insulation member **9.**

It is to be understood that the invention is not limited to pre-insulated terminal connectors, in that the insulation member **9** may be dispensed with if the intended application is such that an uninsulated connection is acceptable.

The unique performance of a terminal connector in accordance with the invention is demonstrated by the following test results using one size of terminal connector for connecting two conductors from the following: paper insulated copper wire, paper insulated aluminium wire and 70°C plastic-insulated copper wire. The test was to place the completed crimped connections in an oven at a high temperature for 45 minutes then to transfer the connections immediately to a refrigerated chamber at a low temperature for 45 minutes, this being repeated 25 times.

Wire Combination and Detail	TEST—25 cycles 45 mins alternately at each temperature	Average Initial Resistance Milliohms	Average Final Resistance Milliohms	Average Change in Resistance Milliohms
Copper 0.012" to 0.012" diameter, paper insulated	+70°C to −25°C	5	7	2

-Continued

Wire Combination and Detail	TEST—25 cycles 45 mins alternately at each temperature	Average Initial Resistance Milliohms	Average Final Resistance Milliohms	Average Change in Resistance Milliohms
Copper 0.012" to 0.035" diameter, paper insulated	+70°C to −25°C	4	6	2
Copper 0.035" to 0.035" diameter, paper insulated	+100°C to −0°C	1	2	1
Copper 0.016" to 0.016" diameter, plastic insulated	+70°C to −25°C	4	4	±0
Copper 0.016" to 0.035" diameter, plastic insulated	+70°C to −25°C	3	3	±0
Copper 0.035" to 0.035" diameter, plastic insulated	+70°C to −25°C	1¼	1¼	±0
Aluminum 0.020" to 0.020" diameter, paper insulated	+70°C to −25°C	4	6	2
Aluminum 0.025" to 0.025" diameter, paper insulated	+70°C to −25°C	3	4	1
Aluminum 0.020" to copper 0.016" diameter, paper insulated	+70°C to −25°C	4	6	2

We claim:

1. An electrical terminal connector for electrically and mechanically connecting a pair of parallel insulated electrical conductors, comprising

a. a deformable generally trough-shaped electrically conductive ferrule (**1**) including generally planar horizontal base (**3**) and vertical side wall (**2**) portions,

1. one of said base and side wall portions containing intermediate its ends a pair of laterally-spaced inwardly directed insulation piercing means (*4a*, *4b*) for piercing the insulation of said conductors, respectively, when said conductors are arranged longitudinally in said ferrule, thereby to establish electrical connection between said ferrule and the conductive cores of said conductors;

2. the other of said base and side wall portions containing intermediate its ends a pair of inwardly directed conductor engaging means each consisting of a group of inwardly directed protrusions (**5**) arranged laterally of and directly opposite said piercing means for engaging the outer surfaces of said conductors, respectively, the protrusions of each group being so arranged that the associated conductor is held captive therebetween, said piercing means being arranged solely on said one of said base and side wall portions and said conductor engaging means being arranged solely on the other of said base and side wall portions;

3. each of said side wall portions containing at its upper edge (**11**) a clearance recess (**7**) that defines a pair of upper edge portions arranged at opposite ends of said side wall portion, respectively;

4. said side wall portions having such a height as to permit them to be progressively crimped inwardly together upon the upper surfaces of said conductors and downwardly between said conductors, thereby to cause said conductor engaging means to hold the respective conductors captive and to force said conductors into piercing engagement with said insulation piercing means; and

b. a trough-shaped cover of insulating material (**9**) arranged about the external surface of said ferrule, said cover having base and side wall portions contiguous with the corresponding portions of said ferrule, respectively, the side wall portions of said insulating layer having a greater height than the side wall portions of said ferrule, thereby to permit the cover side walls, when said ferrule is crimped upon said conductors, to extend around the upper surfaces of the ferrule side walls with the free extermities (**10**) of said cover extending downwardly between said conductors and being held captive solely by the cooperation between the corresponding downwardly extending portions of the ferrule side walls, whereby said protrusions serve to localize the crimping pressure over the piercing means and also press into the conductor insulation to assist in retaining the conductors firmly in the connector.

2. Apparatus as defined in claim **1,** wherein said ferrule further includes internal conductor-engaging ribs (**8**) arranged on opposite sides of said clearance recesses, respectively, each of said ribs extending continuously transversely across said ferrule base portion and completely transversely across said ferrule side wall portions to the free edges (**11**) thereof.

3. Apparatus as defined in claim **2,** wherein each of said insulation piercing means comprises a group of metal spikes that surround an opening contained in the base portion and project upwardly between the ferrule side wall portions.

* * * * *