United States Patent [19]

Haitmanek

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[45] **May 21, 1974**

[54] **ELECTRICAL CONNECTOR**

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[21] Appl. No.: **309,514**

[52] **U.S. Cl.** ..... **339/97 C,** 339/276 T, 174/84 C

[51] **Int. Cl.** **H01r 11/20,** H01r 11/08

[58] **Field of Search** ..... 24/16 R, 16 PB, 20 W, 22, 24/23 W; 339/95-99, 223, 276; 174/84 C, 94 R

[56] **References Cited**

UNITED STATES PATENTS

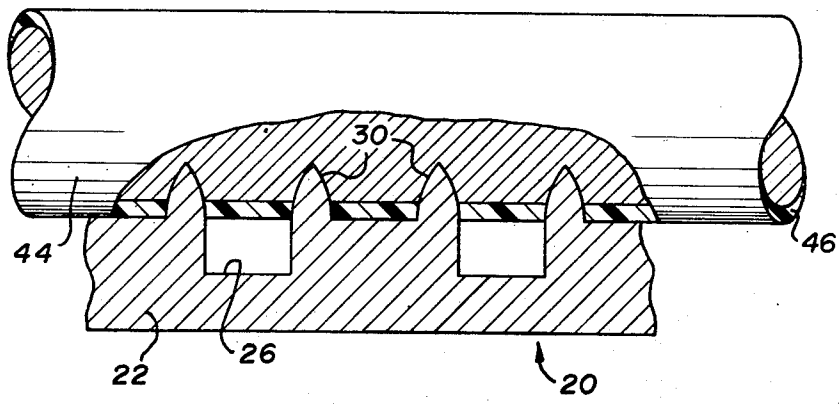
3,728,665	4/1973	Frey	339/276 T X
3,261,063	7/1966	Rutty	24/23 W
3,636,592	1/1972	Beach	24/23 W
3,736,627	6/1973	Sosinski	339/98 X
3,355,698	11/1967	Keller	339/276 R X
3,735,331	5/1973	O'Donnell et al.	339/97 C

Primary Examiner—Bobby R. Gay
Assistant Examiner—Lawrence J. Staab
Attorney, Agent, or Firm—David Teschner; Jesse Woldman

[57] **ABSTRACT**

An electrical connector having an internal tooth structure and a selectively grooved conductor engaging inner surface therebetween providing reduced thickness web portions responsive to the expansion and contraction of an enclosed conductor to prevent relative movement at the interface between the conductor and the connector thereby maintaining secure mechanical and electrical contact therebetween under even extreme conditions of temperature cycling.

12 Claims, 10 Drawing Figures



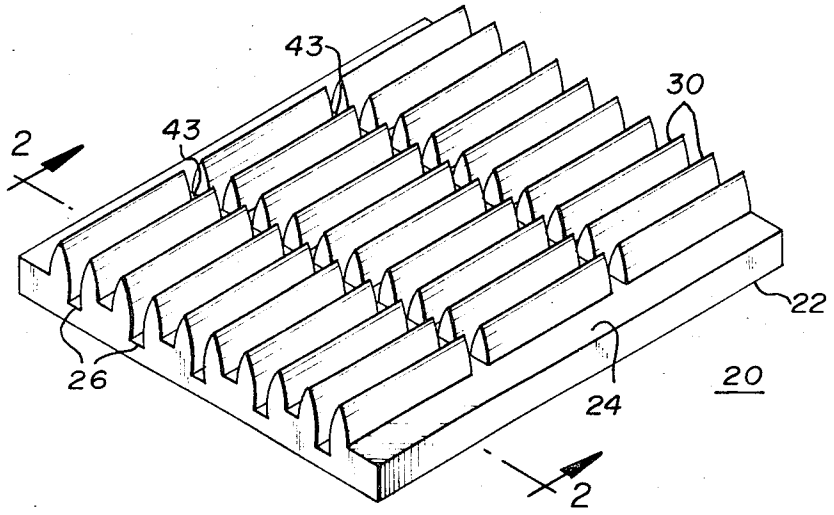


FIG. 1

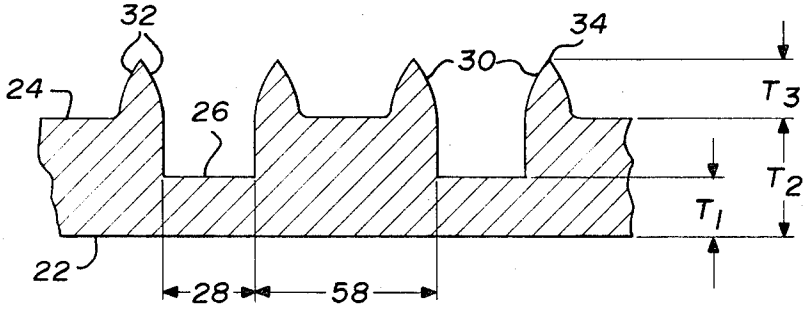


FIG. 2

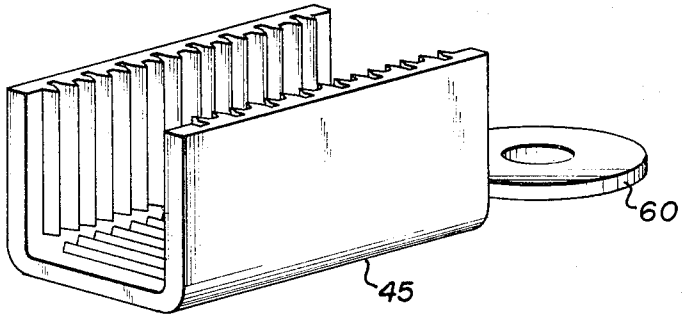


FIG. 3

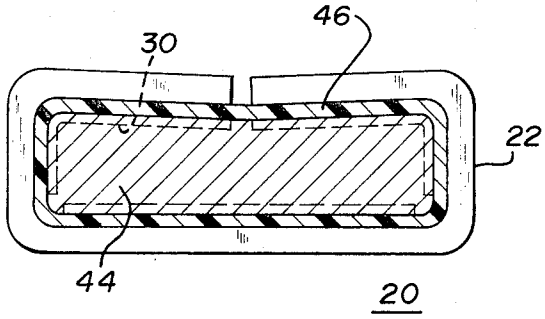


FIG. 4

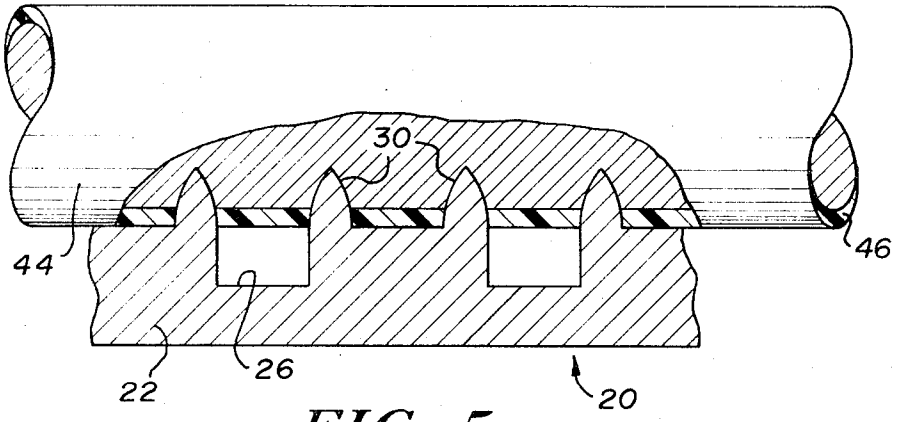


FIG. 5

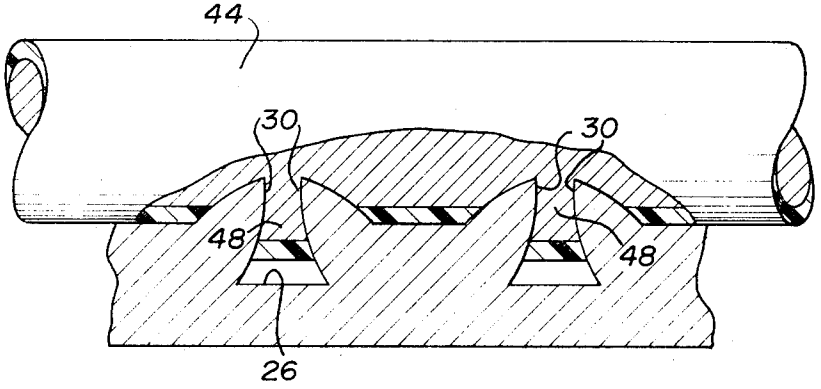


FIG. 6

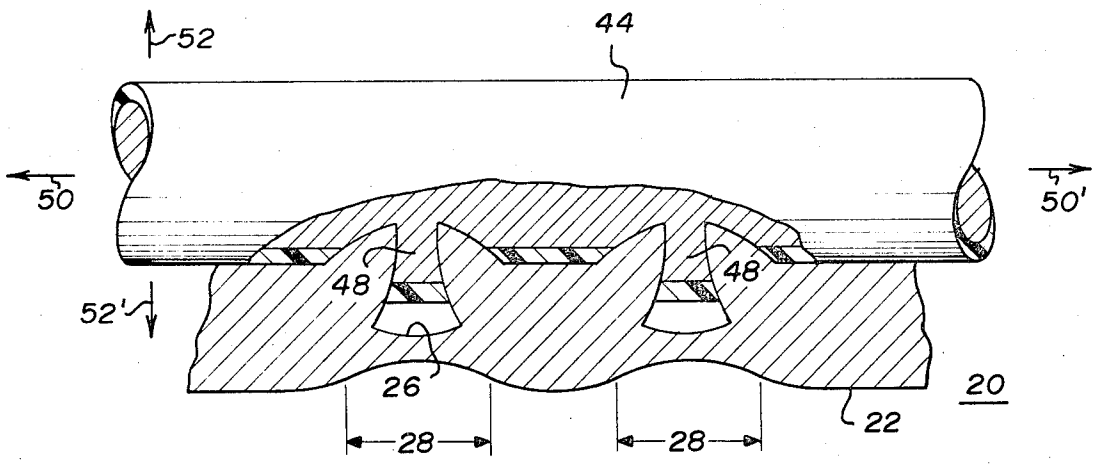


FIG. 7

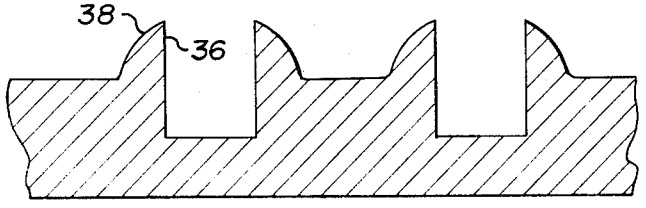


FIG. 8

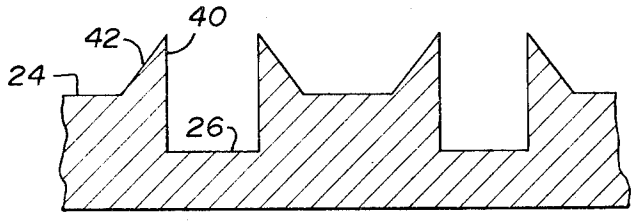


FIG. 9

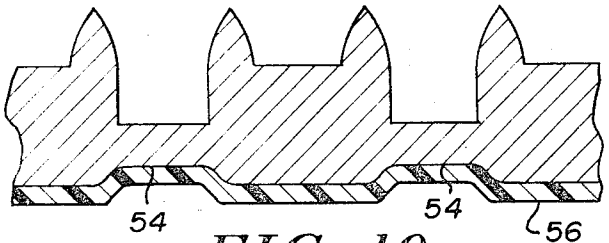


FIG. 10

ELECTRICAL CONNECTOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention is directed to the field of connecting devices and principally to an improved electrical connector.

2. Description of the Prior Art

In the field of electrical connecting devices having generally elongate ridge-like tooth forms as exemplified, for example, in U.S. Pat. No. 3,293,355 issued Dec. 20, 1966 to Gropp et al., U.S. Pat. No. 3,355,698 issued Nov. 28, 1967 to Keller, and U.S. Pat. No. 3,436,946 issued Apr. 8, 1969 to Gropp et al., the device was generally fabricated of copper or copper alloy material designed principally for attachment to copper conductors having a similar co-efficient of expansion. In the event the connection was subjected to extremes of temperature cycling both the connector and the conductor encased therewithin would expand or contract in like manner thereby generally avoiding relative motion or displacement therebetween which motion would tend to disrupt or destroy the integrity of the connection. Such devices were, however, found to be generally unsatisfactory for use, for example, with a conductor having a coefficient of expansion sufficiently different from that of the connector as to cause relative motion between the connector and the conductor upon temperature cycling of the connection as, for example, where a copper or copper alloy connector was employed with an aluminum conductor, thereby destroying the established interface contact with a consequent deterioration of the connection. Attempts to solve this problem by providing, for example, an aluminum connector for use with aluminum conductor were generally unsatisfactory since such a connector not only lacked the requisite resiliency and deformability necessary for such applications, but was also more expensive to manufacture and was additionally limited in use to applications involving only aluminum conductors. It should also be noted that because of the higher resistivity of aluminum material as compared with copper or copper alloy material, a connector formed from the former must, of course, be commensurately larger and generally more expensive, than a comparable copper or copper alloy connector having the same electrical rating.

SUMMARY OF THE INVENTION

The invention overcomes the limitations and difficulties noted above with respect to prior art devices by providing an electrical connector suitable for use with a conductor having either a similar or substantially different coefficient of expansion, thus providing a means for establishing a more secure, reliable, and economical electrical connection between, for example, a copper or copper alloy connector and an aluminum conductor than was possible with such prior art devices. The device comprises a series of generally parallel protruding elongate teeth extending generally transversely across the inner surface of a crimpably deformable base member. Intermediate each selective pair of teeth is a selectively proportioned grooved portion defining a region of predetermined thickness somewhat less than the major thickness of the base member, thereby providing expandable web-like portions spaced one from another by ungrooved regions having a thickness

essentially equal to the base member major thickness, the grooved portions being readily responsive to the expansion and contraction of a conductor about which the base member is crimped. The established interface contact is thereby securely maintained upon the thermal cycling of the connection, thus insuring a superior electrical and mechanical connection therebetween. The elongate teeth extending on either side of the grooved portions terminate in a relatively sharp edge adapted to pierce the outer surface of the conductor or the insulation disposed thereabout and penetrate the interior of the conductor, each pair of said teeth being disposed in such manner as to convergingly deform somewhat upon penetration of the conductor to engage the conductor interior in hook-like fashion to increase the engagement therebetween. The grooved portions of the connector also serve to provide a pocket adapted to accommodate a portion of the conductor extruded thereinto during the crimping operation and subsequent expansion of the conductor. The teeth may be provided with either arcuate or generally planar sides or a combination thereof to control the direction of deflection and to insure adequate conductor penetration and separation of the insulation disposed about an insulated conductor. It is therefore an object of this invention to provide an improved electrical connector.

It is another object of this invention to provide an electrical connection between a connector and a conductor having different coefficients of linear expansion.

It is a further object of this invention to provide a means for preserving the integrity of an electrical connection established between elements having different coefficients of linear expansion and exposed to large thermal excursions.

It is a further object of this invention to provide a reliable connection between a copper or copper alloy connector and an aluminum conductor.

It is still another object of this invention to provide a longitudinally expansive electrical connector.

It is still a further object of this invention to provide an electrical connector having selectively spaced expandable regions responsive to the forces exerted thereon by an expanding and contracting conductor engaged therewithin.

Other objects and features of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawings which disclose by way of example the principle of the invention and the best mode contemplated for carrying it out.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a perspective view of an electrical connector constructed in accordance with the concepts of the invention.

FIG. 2 is a fragmentary elevational view, in section, of the device of FIG. 1 taken along the lines 2—2.

FIG. 3 is a perspective view of the device of FIG. 1 pre-formed into a generally U-shaped ferrule and having an attaching means coupled thereto.

FIG. 4 is a front elevational view, partly in section, of the device of FIG. 1 crimped about an insulated conductor.

FIG. 5 is a fragmentary side elevational view, in section, of a portion of the device of FIG. 1 in a first stage of engagement with an insulated conductor.

FIG. 6 is a fragmentary side elevational view, partly in section, of the device of FIG. 1 in a further stage of engagement with an insulated conductor.

FIG. 7 is a fragmentary side elevational view, in section, of the assembly of FIG. 6 after engagement showing the manner of expansion thereof upon thermal cycling of the connection.

FIG. 8 is a fragmentary side elevational view, in section, of a portion of a further embodiment of a connector constructed in accordance with the concepts of the invention.

FIGS. 9 and 10 are fragmentary side elevational views, in section, of a portion of further embodiments of an electrical connector constructed in accordance with the concepts of the invention.

Similar elements are given similar reference characters in each of the respective drawings.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Turning now to FIGS. 1 and 2 there is shown an electrical connector 20 constructed in accordance with the concepts of the invention. Connector 20 comprises a base member 22 having an inner surface 24 within which are formed a series of selectively spaced grooved portions 26 which, as shown in FIG. 1, extend essentially transversely across substantially the entire inner surface 24 of base member 22. Each of the grooved portions 26 extend preferably the same depth below the inner surface 24 of base member 22, the particular depth of the grooved portions 26 being controlled or regulated to provide a predetermined thickness thereat designated as T_1 in FIG. 2, which, as will be described in more detail hereafter, functions as an expandable web-like region. The ungrooved portions of the base member 22 intermediate the grooved portions 26, and having a thickness designated in FIG. 2 as T_2, provide relatively rigid regions therebetween. The expandable web-like regions defined by the grooved portions 26 are shown in FIG. 2 as encompassing a length 28 bounded by the ungrooved portions of the base member 22. Protruding outwardly from the inner surface 24 of base member 22 are a series of preferably parallel transversely extending teeth 30 arranged in pairs extending substantially along the entire length of the grooved portions 26 and bordering the opposing sides thereof. Each tooth 30, as illustrated in FIGS. 1 and 2 comprise generally arcuate exterior surfaces 32 convergingly disposed to define a relatively sharp edge 34 which, as will be explained in more detail hereafter, provides both insulation and oxide piercing means.

As illustrated, one of the surfaces 32 of each tooth 30 is arranged generally coplanar with the adjacent sidewall of an associated grooved portion 26, the opposing surface of each tooth 30 terminating at the inner surface 24 of base member 22. With this arrangement, each of the teeth 30 tend to buckle or deflect towards one another above an associated grooved portion 26 as they are forcibly urged into engagement with a conductor, the result of this tooth deflection being described in more detail hereafter. Other tooth contours which may be similarly employed are shown, by way of example, in FIGS. 8 and 9. As illustrated in FIG. 8 one surface of each tooth is generally planar as at 36, and the other surface is arcuate as at 38. The embodiment illustrated in FIG. 9 includes a tooth form having generally converging planar surfaces 40 and 42, surface 40 communicating with the sidewall of an associated grooved portion 26 to form an extending plane thereat similar to the arrangement shown in FIG. 8, while the opposing surface 42 is disposed at a generally oblique angle with respect to a plane normal to the plane of the inner surface 24 of base member 22 to form a saw-tooth type configuration. Although the teeth may extend uninterruptedly across substantially the entire inner surface 24 of base member 22 a series of longitudinally extending slots or channels 43 as shown in FIG. 1 may be provided to permit the base member 22 to be more readily pre-formed or folded therealong to provide, for example, a generally U-shaped base member 45, as shown in FIG. 3. The height of teeth 30 above the inner surface 24 of base member 22 indicated in FIG. 2 as T_3 is selected to provide predetermined penetration into the conductive portion of either an insulated or non-insulated conductor. For example, where the connector 20 is employed for preselective piercing of a non-insulated conductor or the bared portion of an insulated conductor, the tooth height T_3 may accordingly, be less than that designed for use with an insulated conductor where, in the latter case, the teeth 30 are required to pierce through the outer insulative covering and then through to a similar depth within the conductive portion of the conductor. As will be explained in more detail hereafter, the grooved portions 26 also function to provide expansion pockets for accepting a portion of the conductor as the base member 22 is crimped thereto and during expansion of the conductor.

Turning now to FIGS. 4, 5 and 6, there is shown, in detail, the various stages in the assembly of connector 20 to a conductor such as 44. In FIG. 4, for example, there is shown, in cross-section, the base member 22 crimped about the insulated conductor 44, the teeth 30 of the base member 22 having been suitably proportioned to pierce through the insulated covering 46 of the conductor 44 and penetrate the conductive portion thereof to a predetermined depth, which may be in the order of from 5 to 50 percent of the diameter of the conductor. During the first stage of the crimping operation, which is more clearly illustrated in FIG. 5, the teeth 30 are caused to pierce through the insulative covering 46 and penetrate the conductive portion of the conductor 44 substantially as shown, the teeth 30 being substantially undeflected during this stage of the procedure. However, as an increased crimping force is applied to the assembly, the teeth 30, as illustrated in FIG. 6, are caused to deflect under the increased crimping pressure and fold inwardly towards one another over the grooved portion 26 therebetween. A portion 48 of the conductor 44 intermediate each pair of inwardly extending teeth 30 is thereby substantially extruded into the channel formed by the grooved portions 26 and lockingly entrapped therein. The conductive portion of the conductor 44 is thus engaged by a substantial portion of that surface of the tooth 30 opposite the side adjacent to the grooved portion 26 and also by the other surface of the tooth 30 communicating with the grooved portion 26, together with the sides of the grooved portion 26 adjacent thereto. It is thus seen that a substantially greater area of contact is provided between the teeth 30 and the conductive portion of the conductor 44 than that provided solely by the tooth surfaces themselves. Where the conductor 44 and the connector 20 are formed from materials having

a similar coefficient of expansion, the connection illustrated in FIG. 6 will provide a superior electrical and mechanical connection between such members under even relatively severe thermal excursions because of their generally similar rates of expansion and contraction in response to temperature variations. Because of its unique configuration, the connector **20** may be employed with equal efficacy where its coefficient of expansion is substantially different than that of the conductor to which it is to be attached. For example, the conductor **44** may be formed from aluminum or similar material, and the connector **20** formed from copper or copper alloy material, the difference in the coefficient of expansion between the two materials being in the order of approximately 1.5 to 1, aluminum having approximately a 50 percent greater coefficient of expansion than copper. Thus, upon the temperature cycling of such a connection, the aluminum conductor will tend to expand or contract both radially and longitudinally within the connector to a greater extent than the copper connector. Referring to FIG. **7**, the conductor **44** will tend to expand longitudinally as indicated by arrows **50**, and **50'** and radially outwardly generally as indicated by arrows **52**, and **52'**. Since the expansion of the conductor **44** is greater than the expansion of the connector **20**, a longitudinally directed force will be applied to the connector **20** tending to elongate the connector longitudinally in response to the expansion of the conductor **44**. The web-like expandable regions indicated generally at **28**, having a thickness somewhat less than the major thickness of the connector base member **22**, will tend to stretch and thin out, as illustrated, within its elastic limit in response to the forces generated by the expanding conductor **44**, thereby maintaining intimate engagement between the conductor **44** and the base member **22**, despite their different rates of expansion. The radial expansion of the conductor **44** is accommodated, to a large measure, by reason of the chambers formed by the grooved portions **26** wherein the extruded portions **48** of conductor **44** are permitted to expand freely therewithin, thereby substantially reducing those forces tending to radially enlarge the connector and disturb the configuration of the original connection. Upon the cooling of the assembly, the elements thereof will contract in a similar manner to their original state, thereby providing an unimpaired connection therebetween. The interity of the joint may thus be preserved despite repeated cyclings of the assembly, thereby providing a secure, reliable, and permanent electrical and mechanical connection between dissimilar metals. The outer surface of the base member **22** may be recessed as at **54** in FIG. **10**, the recesses **54** extending in generally opposed parallel relationship to the grooved portions **26** formed in the inner surface of the base member to provide the desired thickness thereat. This arrangement may also be found useful where it is desired, for example, to provide an insulative coating such as **56** about the outer surface of the base member **22**, the recesses **54** thereby providing means for retaining the insulative covering **56** in position thereabout. The embodiment illustrated in FIG. **10** may also be found particularly useful where it is desired to reduce the depth of the grooved portion **26** below the inner surface **24** of the base member **22** while providing a predetermined web portion thickness T_1. The length of the expandable web portion regions **28** (FIG. **2**) relative to the length of the ungrooved portions of the base member **22** intermediate each pair of grooved portions **26** may be readily chosen to provide a greater or lesser degree of expansion, as necessary or desirable. For example, where it is desired to provide a relatively high degree of expansion, the length of the expandable web portion region **28** may be at least equal to or greater than the length of the ungrooved portion region indicated generally in FIG. **2** at **58.** Conversely, where less expansion is desired, the length of the expandable web portion region **28** may be proportioned to be somewhat less than the length of the ungrooved portion region **58.** The connector **20** may be coupled to a further member such as, for example, a terminal board or further connector by means of a tongue portion coupled to the base member **22,** such as indicated for example at **60** in FIG. **3.** Although the particular coupling means illustrated therein is shown as an apertured tongue member, a forked tongue, tab, or tab receiving receptacle may alternatively be employed to effect a similar result.

It will of course be appreciated that although other configurations may be employed, it has been preferable to contour the bottom surface of the grooved portion **26** to define a generally planar surface substantially parallel to the inner surface **24** thereof to provide a generally constant thickness T_1 within the expandable web portion region **28.**

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An electrical connector comprising: a base member formed from electrically conducting ductile metallic material and having an inner surface, an outer surface, and a first thickness defined by the spacing between said inner surface and said outer surface; a series of generally elongate selectively spaced grooved portions arranged in a predetermined pattern within said base member inner surface, the bottom of said grooved portions extending below said base member inner surface a predetermined depth and the sidewalls of said grooved portions extending upwardly normal to the plane of said inner surface, the spacing between the bottom of said grooved portions and said base member outer surface defining a second thickness thereat, said second thickness being less than said first thickness; a series of selectively deformable teeth extending outwardly from said base member inner surface a predetermined distance, said teeth being arranged in pairs, each tooth of said pair extending along substantially the length of and adjacent to an associated one of the pair of opposing sidewalls of an associated one of said grooved portions, said teeth having convex exterior surfaces defining the sides thereof, said exterior surfaces converging to a sharp edge defining the top of said teeth, the exterior convex surface of each of said teeth adjacent a corresponding grooved portion communicating smoothly with an adjacent sidewall of said grooved portion to provide a continuous surface thereat; the regions of said base member defined by said second thickness providing expandable web portions intermediate said base member first thickness regions, said base member thereby being longitudinally responsive to the expansion and contraction of a conductor disposed therewithin upon the selective closure of said base member about such conductor so as to form a mechanical and electrical coupling therebetween.

2. An electrical connector as defined in claim 1 wherein said teeth extend generally transversely across said base member inner surface generally normal to the longitudinal axis of said base member.

3. An electrical connector as defined in claim 1 wherein the height of said teeth above said base member inner surface is at least equal to the depth of the bottom of said grooved portions below said base member inner surface.

4. An electrical connector as defined in claim 3 wherein said teeth are all of equal height and have symmetrical convex exterior surfaces defining the sides thereof.

5. An electrical connector as defined in claim 1 wherein said teeth are all of equal height and have symmetrical convex exterior surfaces defining the sides thereof.

6. An electrical connector as defined in claim 1 wherein the spacing between adjacent pairs of said teeth is greater than the spacing between the opposing teeth of a pair of said teeth.

7. An electrical connector as defined in claim 1 wherein said teeth are distributed generally evenly over said base member inner surface.

8. An electrical connector as defined in claim 1 wherein said teeth are arranged in longitudinally extending rows.

9. An electrical connector as defined in claim 1 further comprising means for coupling said base member to a further member.

10. An electrical connector as defined in claim 1 wherein the bottom surface of each of said grooved portions is planarly disposed generally parallel to the plane of said base member inner surface.

11. An electrical connector as defined in claim 1 wherein said base member outer surface has a series of generally elongate recesses disposed therein, said recesses each extending in generally parallel opposed relationship with respect to a corresponding one of said base member inner surface grooved portions.

12. An electrical connector as defined in claim 11 wherein each of said teeth have symmetrical convex exterior surfaces defining said sides thereof.

* * * * *