Oct. 6, 1970 A. M. ZAK 3,533,055

ELECTRICAL CONNECTOR AND METHOD AND APPARATUS FOR MAKING SAME

Filed March 14, 1968 4 Sheets-Sheet 1

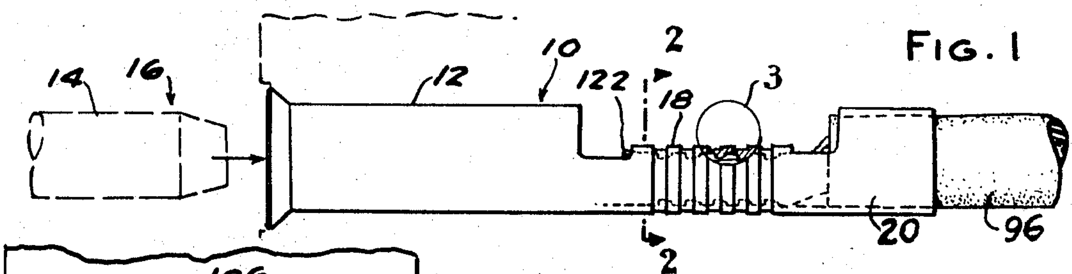

FIG. 1

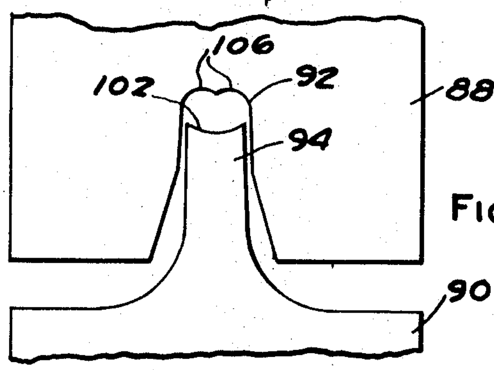

FIG. 7

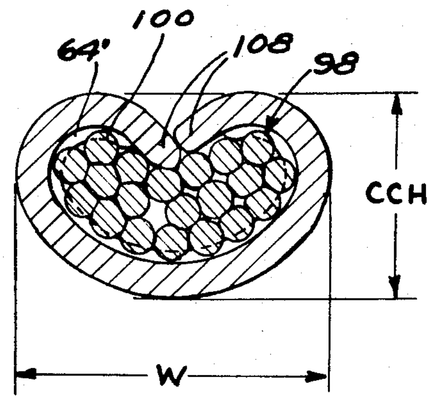

FIG. 2

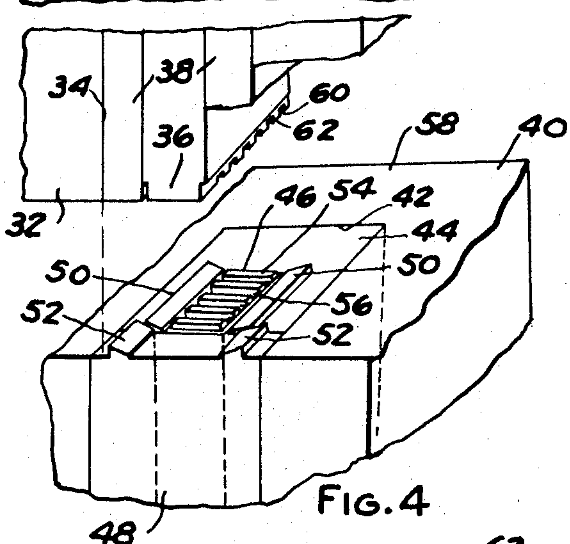

FIG. 4

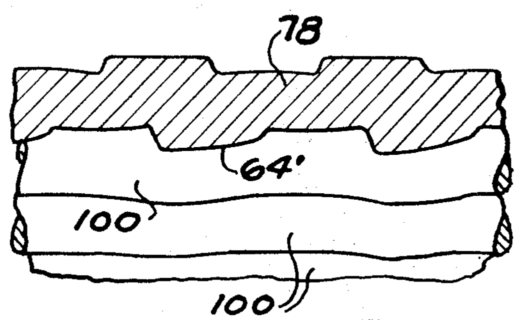

FIG. 3

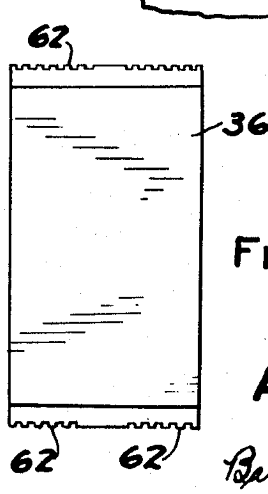

FIG. 5

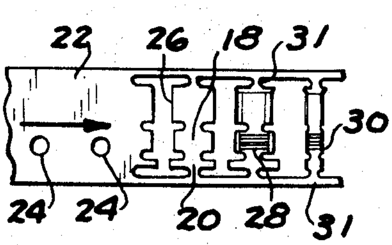

FIG. 6

INVENTOR.
ALFRED M. ZAK

BY

Barnes, Kisselle, Raisch & Choate

ATTORNEYS

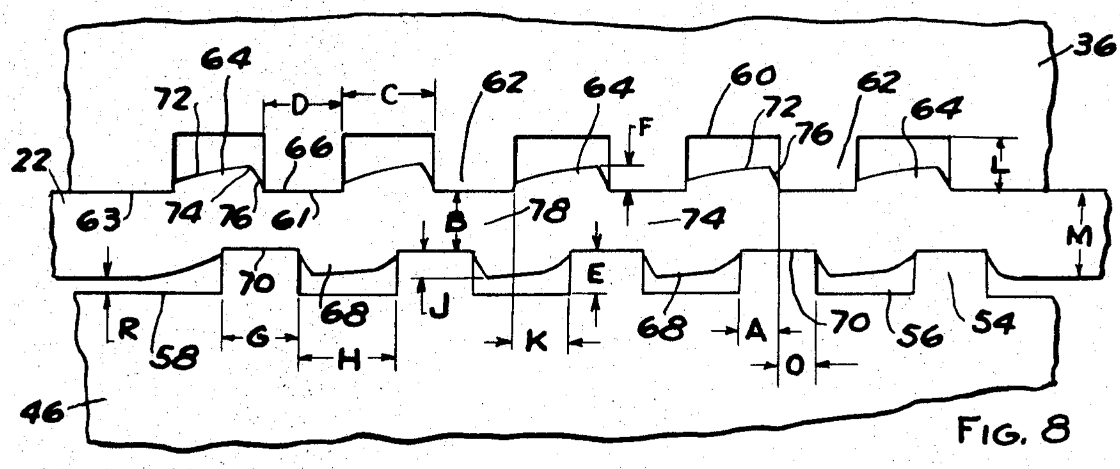

FIG. 8

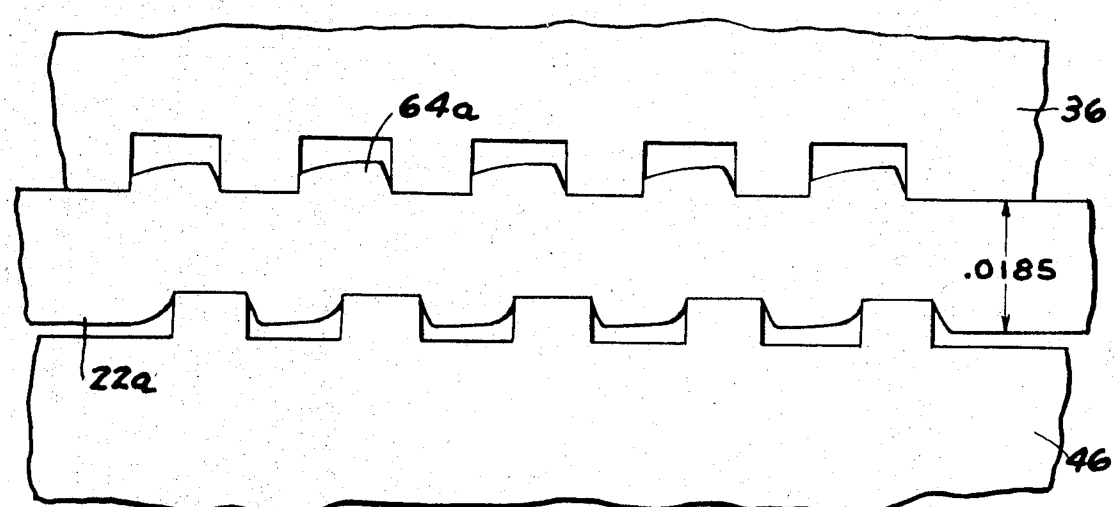

FIG. 9

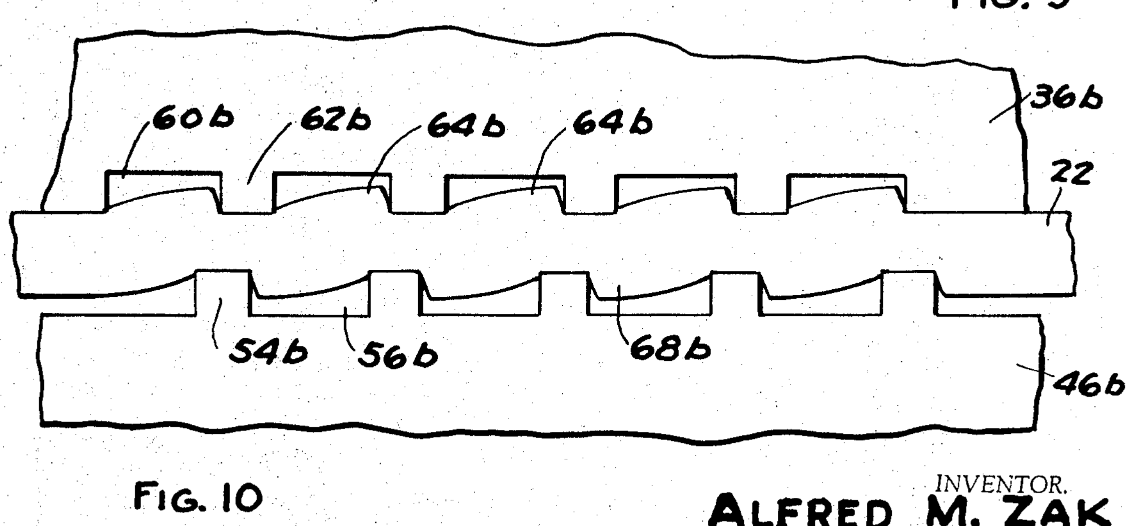

FIG. 10

INVENTOR.
ALFRED M. ZAK
BY
Barnes, Kisselle, Raisch & Choate
ATTORNEYS

ELECTRICAL CONNECTOR AND METHOD AND APPARATUS FOR MAKING SAME

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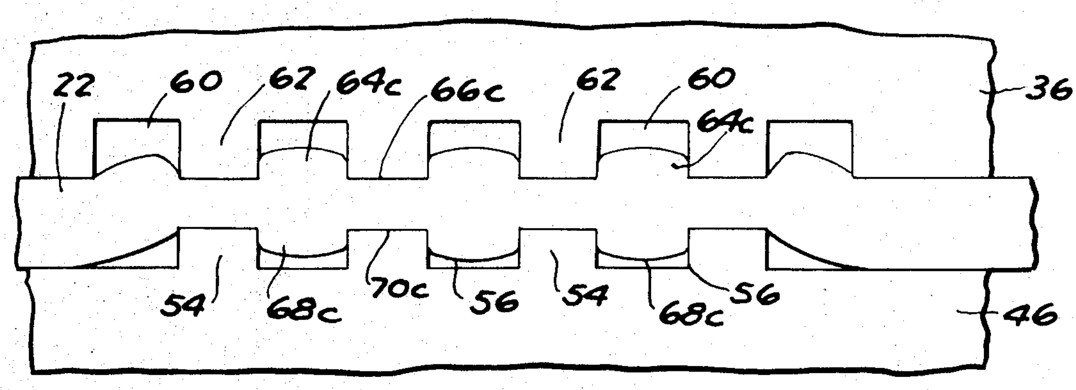

FIG. 11

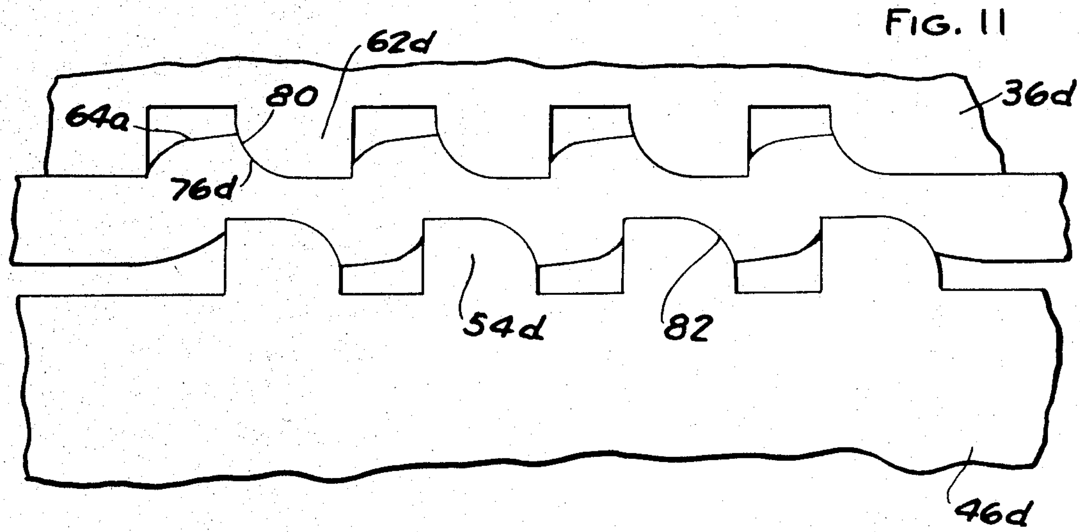

FIG. 12

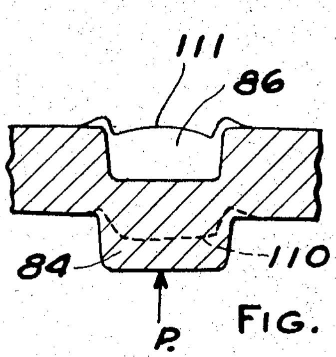

FIG. 18

INVENTOR.
ALFRED M. ZAK
BY
Barnes, Kisselle, Raisch & Choate
ATTORNEYS

ELECTRICAL CONNECTOR AND METHOD AND APPARATUS FOR MAKING SAME

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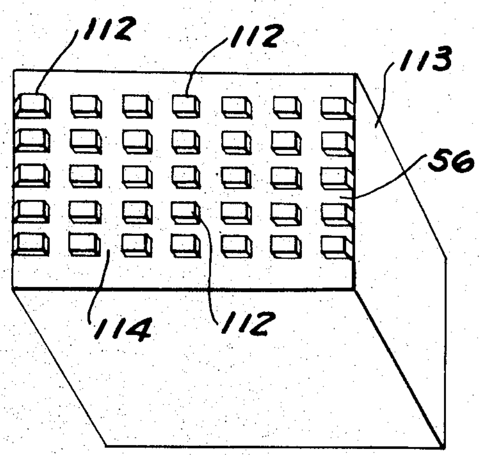

FIG. 13

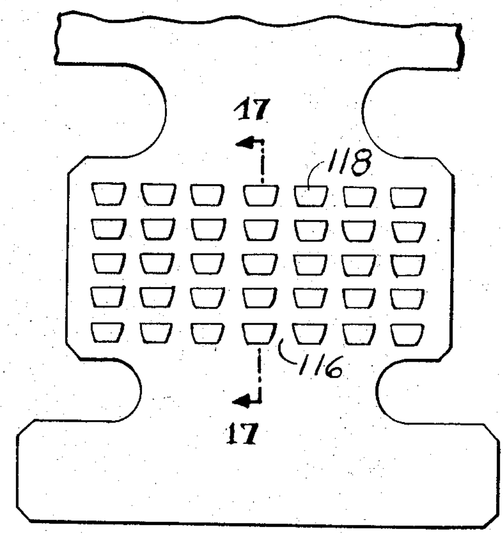

FIG. 14

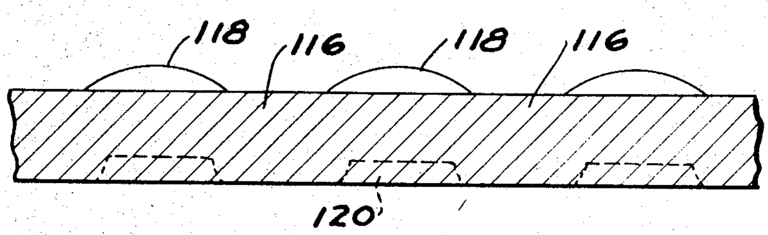

FIG. 15

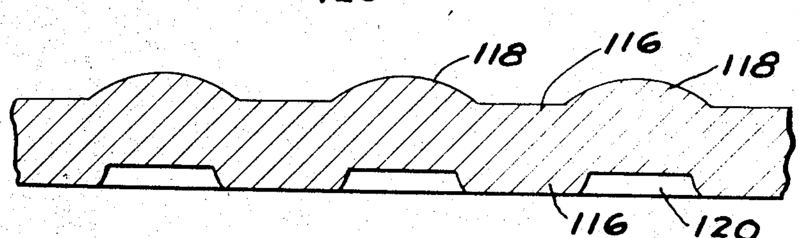

FIG. 16

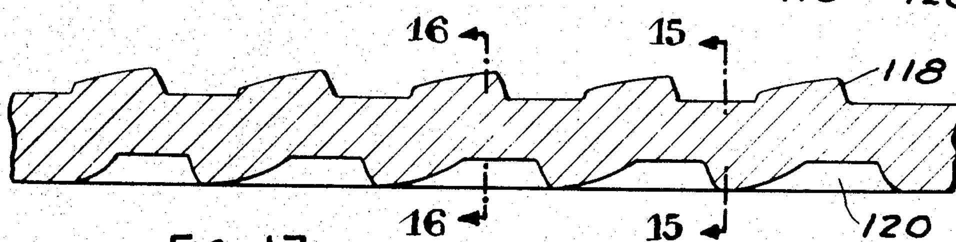

FIG. 17

INVENTOR.
ALFRED M. ZAK
BY
Barnes, Kisselle, Raisch & Choate
ATTORNEYS

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3,533,055
ELECTRICAL CONNECTOR AND METHOD AND APPARATUS FOR MAKING SAME

Alfred M. Zak, 6110 Casmere Ave.,
Detroit, Mich. 48212
Filed Mar. 14, 1968, Ser. No. 713,041
Int. Cl. H01r 5/08, 11/08
U.S. Cl. 339—276 12 Claims

ABSTRACT OF THE DISCLOSURE

A method and apparatus for forming wire grip serrations on an electrical connector wherein a series of spaced ribs or serrations are formed on the inside or wire gripping face of the connector and spaced grooves are formed on the outer side of the connector. The teeth and grooves are formed by a punch and die arrangement wherein the punch is formed with a series of spaced grooves and the die is formed with a series of spaced projections for displacing metal into the grooves on the punch and thereby form the ribs. The spaces between the grooves on the punch preferably overlap the projections on the die so that when the punch and die are closed the metal of the strip from which the connector is formed is displaced both vertically and laterally.

This invention relates to electrical connectors and more specifically to the wire grip portions of electrical connectors.

Wire connectors, or terminals as they are sometimes called, are usually formed at one end with a ferrule portion in which the bared end of a wire is crimped. The wire grip portions are conventionally formed with a series of transversely-extending serrations which, when the wire grip portion is crimped around the bared end of a wire (particularly a multistrand wire), are intended to embed in the wire and thus retain the connector on the end of the wire. In some instances these serrations are formed by bending the wire grip portion of the connector into zig-zag shape. In other instances the serrations are formed by the manner generally illustrated in U.S. Pat. No. 3,112,150 wherein a series of ribs are formed on the outer surface of the wire grip portion by a punching operation so that the inner or wire-gripping surface is defined by a series of spaced grooves aligned with the ribs.

The prior art methods of forming the wire grip portion of an electrical connector have several disadvantages. The tooling employed for forming the wire grip portion is costly to fabricate and costly to maintain. The prior art tooling is subjected to wear which adversely affects the forming operations and which requires very precise alignment. The wire grip portions of prior art electrical connectors require relatively great crimping pressures to hold the wire and even the relatively high crimping pressures employed do not result in the high pull strengths required or desired by many industrial users.

It is an object of this invention to increase the wire holding strength of a wire connector without increasing the size of the connector.

A further object of the invention is to increase the wire holding strength of a wire connector without increasing the crimping pressures.

Another object of the invention is to reduce the cost of tooling employed in forming the wire gripping portion of a wire connector and to reduce the maintenance cost of such tools.

Still another object of the invention is to facilitate forming of the wire gripping portion of a wire connector in a conventional multi-station progressive die assembly.

Other objects and features of the present invention will

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become apparent from the following description and drawings in which:

FIG. 1 is a fragmentary elevational view, partly in section, of a wire having an electrical connector formed in accordance with this invention secured to the end thereof.

FIG. 2 is a sectional view along the line **2—2** in FIG. 1.

FIG. 3 is an enlarged view of a portion of the wire grip portion of the connector illustrated in FIG. 1.

FIG. 4 is a fragmentary perspective view of a punch and die arrangement according to the present invention for forming the wire grip portion of the connector.

FIG. 5 is an elevational view of the punch illustrated in FIG. 4.

FIG. 6 is a fragmentary plan view of a strip of sheet metal stock from which the connector is formed and showing in a condensed manner progressive stages of formation.

FIG. 7 is an end view of a punch and die arrangement employed for crimping the connector on the bared end of a wire.

FIGS. 8, 9, 10, 11 and 12 are views illustrating different punch and die arrangements according to the present invention which may be utilized for forming the wire grip portion of the connector and also illustrating the cross sectional configuration of the wire grip portion resulting from the use of such punches and dies.

FIG. 13 is a perspective view of a modified form of die section according to the present invention.

FIG. 14 is a fragmentary plan view of the wire grip portion of an electrical connector formed by utilization of a die section such as shown in FIG. 13.

FIG. 15 is a sectional view along the line **15—15** in FIG. 14.

FIG. 16 is a sectional view along the line **16—16** in FIG. 14.

FIG. 17 is a sectional view along the line **17—17** in FIG. 14.

FIG. 18 is a fragmentary sectional view showing a wire grip serration on an electrical connector of conventional construction.

In FIG. 1 a female electrical connector, generally designated **10**, is formed at one end with a cylindrical barrel portion **12** for receiving the cylindrical barrel portion **14** of a male connector **16**. Connector **10** is formed at its other end with a wire grip portion **18** and an insulation grip portion **20**. Such connectors are usually formed in a progressive die assembly from a strip of resilient sheet metal such as brass. A strip of such metal, designated **22**, is shown in FIG. 6. As the strip **22** is fed through the successive stations of the progressive die assembly in the direction of the arrow in FIG. 6, it is initially formed with a series of indexing pin holes **24**. The connector is then blanked from the strip to the configuration shown at **26** after which the serrations **28** are formed in the wire grip portion at a successive station. At a further station the wire grip portion **18** and the insulation grip portion **20** are bent into U-shape as indicated at **30** to receive the end of a wire. The connectors remain attached to the continuous edges of strip **22** by lugs **31** so that they may be wound into a coil (not illustrated) from which they are severed when the connectors are eventually crimped on the bared ends of wires.

In the showing in FIG. 6 only those operations relating to the wire grip portion **18** and the insulating grip portion **20** are illustrated. As a consequence, in actual practice there are one or more stations in the die assembly between the blanking station and the station that forms the serrations **28** and one or more stations between the serration forming station and the station in which the wire grip and insulating grip portions are formed into U-shape.

A portion of the station of a progressive die assembly at which the serrations **28** are formed is generally illustrated in FIG. 4. The vertically reciprocating punch assembly comprises a punch retainer **32** in which a rectangular cavity **34** is ground for receiving a punch member **36** with an insert side plate **38** at each side thereof. The stationary die assembly at the wire grip forming station comprises a die retainer **40** in which a rectangularly-shaped cavity **42** is ground for receiving a composite die comprising a die block **44** which is slotted to receive a die member **46**. Cavity **42** also receives a die block **48** for initially forming the insulating grip portion **20** of the connector. Adjacent each side of cavity **42** die block **44** is fashioned with inclined abutments **50** for coining the opposite lateral free edges of wire grip portion **18**. Die block **48** is fashioned with similar abutments **52** for coining the opposite free lateral edges of the insulating grip portion **20**.

Die member **46** is in the form of a blade fashioned with a series of spaced, rectangularly-shaped teeth **54** separated by a series of rectangularly-shaped grooves **56** ground into the upper end of the blade. Teeth **54** protrude upwardly above the top flat reference face **58** of the die; or, stated differently, teeth **54** protrude upwardly above "die level." Punch member **36** has a series of rectangularly-shaped grooves **60** ground into the lower end thereof which are separated by rectangularly-shaped teeth **62**. The lower end faces **61** of teeth **62** are flush with the lower flat reference face **63** (FIG. 8) of the punch. When the various punch and die components are assembled as shown in FIG. 4, teeth **54** form a series of spaced projections which protrude above the die level **58** and grooves **60** form a series of spaced cavities in the flat reference surface **63** of the punch assembly.

In view of the manner in which the serrations are formed on the wire grip portion of the connector in accordance with the present invention, punch member **36** which, as illustrated in FIG. 4, is also in the form of a rectangularly-shaped blade may be made substantially wider than die blade **46** and may be formed with a series of teeth **62** at each of the four corners thereof (FIG. 5) for a purpose explained more fully hereinafter.

Referring now to FIG. 8, there is illustrated a preferred configuration and relative disposition of punch and die blades in accordance with the present invention. As illustrated in FIG. 8, on the punch member **36** the width of each tooth **62**, designated D, is approximately the same or slightly less than the width, designated C, of each groove **60**. Likewise, in the die blade **46** the width, designated G, of each tooth **54** is generally equal to or slightly less than the width, designated H, of each groove **56**. Preferably each tooth **62** on punch member **36** overlaps approximately one-half of each tooth **54** on die blade **46**. In other words, in the arrangement shown in FIG. 8 the dimension A equals the dimension O. The sheet metal strip **22** is illustrated as having a thickness M.

When the punch and die are closed on the strip **22** portions of the metal strip are squeezed between the overlapping portions of the teeth **62** on the punch and the teeth **54** on the die. The squeezed metal flows laterally as well as vertically into grooves **60** on the punch member **36** and grooves **56** on the die member **46** so that the serrations on the upper or wire engaging surface of the connector are defined by a series of upwardly projecting ribs **64** separated by grooves **66**. On the lower or outer face of the connector the serrations **28** are defined by a series of grooves **70** separated by ribs **68**.

When the punch and die arrangement illustrated in FIG. 8 is employed as shown, the top faces **72** of ribs **64** slope inwardly toward the plane of the metal in the direction to the left which is the wire end of the connector; that is, the right hand end of the connector as viewed in FIG. 1. These inwardly sloping surfaces terminate at their upper end in a crest **74**. The trailing side faces of ribs **64** are angled downwardly or inwardly as at **76** at a relatively steep angle. As shown in FIG. 8, ribs **68** on the lower or outer face of the terminal have a configuration generally the reverse of ribs **64**.

In FIG. 8 the final thickness of the wire grip portion between ribs **64** is designated B; the height of ribs **64** is designated F; and the depth of grooves **70** is designated J. While theoretically the punch **36** can be driven downwardly to an extent such that the punch and die are closed completely on the metal strip, in practice, due to the resistance of the metal and its resilience, a clearance R will result between the lower face of the strip **22** and the top reference surface **58** of die member **46**.

Since the dimension A represents the portion of each tooth **54** of the die which is not overlapped by a tooth **62** on the punch, it follows that if the dimension A is increased then the dimension K is decreased and the slope of the top face **72** of ribs **64** will be less. As will be explained more fully hereinafter, it is preferred to have an appreciable slope on the top face **72** of each rib **64** and a substantial mass of metal in each rib **64**. Optimum results have been obtained when dimension A is equal to approximately one-half of the width of the groove **60** in punch member **36**; that is, approximately one-half of the dimension C as shown in FIG. 8, and the dimension A equals dimension O. Also in the preferred arrangement the width of teeth **62** and **54** are substantially equal to the width of grooves **60** and **56**; that is, dimensions C, D, G and H are substantially equal.

The height of the ribs **64** are in part determined by the dimension B. Preferably the ribs should have a height approximately one-third of the wire diameter in the case of a multi-strand wire. If the height of the ribs **64** is too great the ribs may impose too great a stress on the wire strands when the connector is crimped on a wire. Likewise, if the rib height is too great, the thickness of the connecting portions **78**, that is the dimension B, will be decreased to a point of impairing the strength of the wire grip portion. The depth of grooves **60**, that is dimension L, should never be more than necessary to clear the tops of the ribs formed by displacement of metal into grooves **60**. An excessive L dimension will merely weaken the teeth **62**. Likewise, an excessive E dimension will merely weaken the teeth **54** on the die. The depth of the grooves on the outer or lower face of the connector, that is the dimension J, will in the arrangement illustrated in FIG. 8 correspond generally to the height of the ribs **64** on the top or inner face of the connector. The dimension J is not critical.

It must be appreciated that the parts are illustrated in FIG. 8 on a highly enlarged scale. For example, assuming the metal strip **22** has a thickness of about .0125" in the arrangement shown in FIG. 8, the height of ribs **64** (that is the dimension F) is only about .0036" while the width of these ribs (dimension C) is only about .013".

The arrangement illustrated in FIG. 9 is similar to that shown in FIG. 8 except the sheet metal strip ***22a*** is substantially thicker than strip **22** and the height of the ribs ***64a*** are slightly greater than the height of ribs **64**. In other respects the arrangement illustrated in FIG. 9 is substantially the same as that shown in FIG. 8. The configuration, dimensions and relative positions of punch member **36** and die blade **46** are the same as shown in FIG. 8.

In FIG. 10 punch member ***36b*** is formed with a series of grooves ***60b*** separated by teeth ***62b***. Likewise, the die blade ***46b*** is formed with teeth ***54b*** and grooves ***56b*** between the teeth. However, as distinguished from the punch and die member illustrated in FIGS. 8 and 9, in the arrangement shown in FIG. 10 grooves ***60b*** and ***56b*** are wider than grooves **60** and **56**, respectively, and teeth ***62b*** and ***54b*** are narrower than teeth **62** and **54**, respectively. In this arrangement ribs ***64b*** are wider than ribs **64**. However the top faces ***72b*** of ribs ***64b*** are inclined at a slightly lesser angle than top faces **72** of ribs **64**. Since grooves **60*b*** and **56*b*** are wider than grooves **60** and **56**, they are easier to grind but teeth **62*b*** and **54*b*** are weaker than teeth **62** and **54**.

In FIG. 11 punch member **36** and die blade **46** are the same as those illustrated in FIGS. 8 and 9 but are illustrated with teeth **62** vertically aligned with teeth **54** and grooves **60** vertically aligned with grooves **56**. When the punch and die are arranged in this fashion the ribs **64*c*** and **68*c*** are of generally the same configuration and vertically aligned. Likewise, grooves **66*c*** are vertically aligned with grooves **70*c***.

While it is preferred that the metal working faces on the ends of teeth **62** and **54** are flat, nevertheless these surfaces can be formed with a rounded contour if desired. For example, in FIG. 12 teeth **62*d*** on punch member **36** are fashioned with a rounded corner **80** and the teeth **54*d*** on die member **46*d*** are likewise formed with a rounded corner **82** reversely positioned with respect to the rounded corner **80** of the opposed projection **62*d***. In view of these rounded corners on the punch and die members the ribs **64*d*** are correspondingly contoured at their leading faces **76*d***.

In the arrangements illustrated in FIGS. 8 through 12 the teeth on the punch overlap at least a portion of the teeth on the die. This punch and die arrangement is preferred so that in the finished wire grip portion **18** there is assurance that each rib **64** will be backed up at least in part on the outer side of the connector by a portion of a rib **68**. In this respect the wire grip serration of this invention differs from the prior art type such as illustrated in FIG. 18 wherein the punch and die arrangement is such that each rib **84** on one side of the wire grip portion is vertically aligned with a groove **86** on the opposite side of the wire grip portion.

The connector is adapted to be crimped around the end of a wire by means of the crimping tool assembly illustrated in FIG. 7 which includes a punch member **88** and a die member **90**. This crimping tool assembly is of conventional design wherein the punch member **88** is fashioned with a crimping cavity **92** and the die member **90** is fashioned with an anvil **94**. When securing the connector to the end of a wire, the bared end of the wire is inserted in the wire grip portion **18** with the adjacent insulation **96** within the insulation grip portion **20**. In the arrangement illustrated the wire, generally designated **98**, is of the multi-strand type, each strand being designated **100**. The wire is inserted in the connector and the wire grip portion is placed on the seat **102** of anvil **94**. In this connection it will be observed that when the wire grip portion is formed as described the outer or bottom face of the wire grip portion is defined by the lower face **104** (FIG. 8) of the metal strip and the lowermost portions of ribs **68** which are generally coplanar therewith. There are no protrusions on the lower or outer face of the wire grip portion. The outer face of the wire grip portion is defined essentially by a series of regularly-spaced grooves in the outer face of the sheet metal.

The inner face of a wire grip portion is defined by a plurality of inwardly projecting ribs **64**. When the crimping punch **88** is brought downwardly on the wire connector with the end of the wire inserted therein, the free edges of the wire grip portion **18** are turned radially inwardly and downwardly by the curved surfaces **106** of recess **92** so that in the crimped condition these edges, designated **108**, assume the position illustrated in FIG. 2. The closed crimped height, designated CCH in FIG. 2, will vary with the gauge of the wire but, in any event, must be such that a considerable pressure is exerted on the strands of wire within the wire grip portion. While this CCH dimension might vary considerably for wires in the range of 14 through 20 gauge, the width of the crimped wire gripping portion of the terminal; that is, the dimension W in FIG. 2, may remain nearly constant.

The amount of pull that can be exerted on the connector while still retaining it on the end of the wire depends upon the gripping action or friction between the wire gripping portion **18** and the wire. In the case of a multi-strand wire it is important that both the exterior and the interior strands **100** be subjected to considerable pressure when the connector is crimped on the end of the wire. If the interior wires are not subjected to considerable pressure there will be little frictional resistance between the surfaces of the adjacent interior wires and consequently the assembly will not be capable of withstanding tension to the desired degree because only the outer strands will be absorbing most of the load.

The wire gripping portion on a connector formed in accordance with the present invention has very marked advantages over conventionally formed wire gripping serrations in relation to the ability to subject the interior strands of the wire to considerable pressure. In a conventionally formed wire gripping serration as shown in FIG. 18, the rib **84** is formed on the exterior face of the connector and on the inner face of the connector there is located a groove **86** directly opposite rib **84**. When a connector of this type is crimped around the bared end of a wire in a conventional crimping tool assembly such as shown in FIG. 7, instead of the wire embedding into the groove there is a tendency for the groove **86** to nearly "wipe out." More specifically, when the rib **84** is subjected to a crimping pressure, designated by the arrow P in FIG. 18, the rib is displaced inwardly to a large extent so that its outer surface assumes the position designated **110** and the bottom of the groove **86** is displaced inwardly to the position designated **111**. With this arrangement while the outer strands of the wire are embedded slightly into grooves **86**, the inner strands of the wire are not subjected to any substantial pressure.

With the wire grip portion **18** of the connector formed in accordance with the present invention a much stronger connection between the connector and the wire is obtained. It will be observed that the ribs **64** define inward projections on the inner wire gripping surface of the connector. Thus, the wire strands **100** are subjected to crimping pressure much sooner when the crimping punch **88** descends. Furthermore, it will be observed that each rib **64** is backed up on the outer side of the connector by a relatively substantial mass of metal forming the opposed rib **68**. This differs from conventional wire grip serrations where there is a groove directly opposite each rib. When the wire grip portion of the present invention is crimped around a wire, the crimping pressures are transmitted more directly to the interior wire strands and sooner in relatiton to the stroke of crimping punch **88**. As a consequence, as shown in FIG. 3, even the wire strands **100** which are located adjacent the center of the wire are subjected to considerable pressure and are distorted so that they are in firm frictional engagement with the adjacent wires.

When the connector of this invention is crimped on a wire the ribs **64** and **68** are flattened and reoriented to some extent as shown at **64′** and **68′** in FIG. 3; but, in any event, ribs **64′** become embedded firmly within the outer wire strands **100** and produce localized distortions of substantially all the wire strands. It will also be appreciated that since the portions **78** of the metal strip interconnecting the adjacent ribs **64** are of reduced thickness (dimension B in FIG. 8), the ribs **64** are readily reoriented when subjected to the crimping pressure. This also results in a better gripping acttion between ribs **64** and the strands of wire as shown in FIG. 3.

Pull tests conducted for the purpose of comparing the pull strength of the wire grip serrations of the present invention and wire grip serrations of the conventional type illustrated in FIG. 18 conclusively show that a much stronger connection is obtained with the wire grip of the present invention with less crimping pressures. For example, with the wire grip serrations of the type illustrated in FIG. 18 a pull test of 37 lbs. was obtained on 16 gauge stranded wire where the closed crimped height (CCH) was .066" and a pull test of 56 lbs. was obtained on the same wire with a closed crimped height of .060". When a connector having a wire grip portion formed in accordance with the present invention (specifically of the type shown in FIG. 8) was crimped on a 16 gauge stranded wire, a pull test of 70 lbs. was obtained with a closed crimped height of .066" and a pull test of 72 lbs. was obtained with a closed crimped height of .060". As a matter of interest, the 16 gauge wire employed itself had a tensile strength of 75 lbs. Thus, with the wire grip serrations of the present invention the connector was capable of withstanding a pull test nearly equal to the tensile strength of the wire itself. Tests have also shown that, while the millivoltage drop resulting from a wire grip serration of the type herein disclosed is slightly greater than that obtained with a conventional wire grip serration, the increase is of such small magnitude as to be insignificant.

As mentioned previously, based on numerous tests, the configuration of the wire grip portion shown in FIG. 8 is preferred. The wire grip section shown in FIG. 10 gives equally good results for 16, 18 and 20 gauge wires but a slightly lesser pull strength for 14 gauge wire. The wire grip sections shown in FIGS. 11 and 12 also produce high pull strengths but have a tendency to cause a substantial increase in the width of the strip (length of the connector) which may give rise to problems in feeding the strip through successive stations.

FIG. 13 illustrates a blade type die insert **113** generally similar to that illustrated at **46** in FIG. 4 except that the teeth **54** are not formed as continuous ribs across the width of the blade but rather as a series of small teeth **112** spaced apart transversely by cross grooves **114**. These individual teeth **112** are formed simply by grinding grooves **114** perpendicular to grooves **56** in the end face of blade **113**. A die insert of the type illustrated in FIG. 13 will produce a wire grip portion having more undisturbed metal as compared with a wire grip portion where the ribs extend continuously across substantially the full width of the wire grip portion. The metal of the connector registering with grooves **114** is undisturbed when the punch and die are closed upon one another. This is the section of metal designated **116** in FIGS. 14 and 15. Each rib of the wire grip serration is defined by a series of spaced humps **118** extending in rows across the wire grip portion **18** rather than a rib extending continuously across the wire grip portion. In this arrangement a cavity **120** partially underlies each rib hump **118**. These spaced cavities are formed by teeth **112**. However, when viewed in section lengthwise of the connector, the rib formation produced by the die section illustrated in FIG. 13 does not differ substantially from the cross section shown in FIG. 8. This is evidenced by a comparison of FIG. 17 with FIG. 8. The cross channels or cross grooves **114** may be formed if desired on the punch member or on both the punch and die members. In either case since less metal in the strip is deformed, the pull strength of the connector will be somewhat less than that obtainable where the ribs extend continuously across the wire grip portion and where the closed crimped height remains the same. However even with the type of die section shown in FIG. 13 the pull strength is substantially increased over that obtainable with the conventional wire grip serration shown in FIG. 18 and can be increased by decreasing the closed crimped height.

The die arrangement illustrated in FIG. 13 permits the formation of deeper ribs and thinner connecting portions between the ribs. The deeper ribs result in deeper penetration into the wire for the same crimp height and therefore adapts the connector for use with heavier gauge wire.

The tooling required for forming a wire grip serration according to the present invention can be produced economically. The punch member **36** can be formed as a blade wherein the grooves **60** are ground directly across the edge of the blade rather than being formed as a cavity. It is true that grinding a tooth in this fashion produces a tooth structure which is somewhat weaker than where the cavity between adjacent teeth is formed by a hobbing operation. However in the metal displacing operation according to the present invention the teeth in the punch and die are not subjected to excessive lateral pressures. Thus, forming these teeth by a grinding operation is not objectionable. For example, referring to FIG. 8, in the present arrangement when the punch and die are closed upon the strip of metal, the metal flows freely in a lateral as well as a vertical direction and the teeth of the punch and die members are not subjected to any substantial lateral pressure. The metal flows freely into the grooves between the successive teeth. The ribs are formed substantially freely in the grooves of the punch and die and there is no tendency for the workpiece to seize on the tools. Therefore, there is no excessive side thrust which would have a tendency to break the teeth. As a result the punch and die members of the apparatus described are not subjected to nearly as much wear as in conventional tooling for forming wire grip serrations of the type illustrated in FIG. 18. For this reason the punch and die members can be formed as blades with teeth ground therein.

It will also be observed that with the arrangement illustrated and described herein there need not be perfect alignment between the punch and die sections as is the case with tooling used for forming the conventional wire grip serrations. For example, the rib formation shown in FIG. 8 is not appreciably altered if the punch is shifted slightly relative to the die. With the present invention, since punch member **36** is formed as a blade and arranged in retainer **32** with insert plates **38** at each side thereof, teeth **62** can be ground at all four corners of the blade as shown in FIG. 5. As the teeth wear, the blade can simply be re-oriented to present all four corners successively to the metal strip. Furthermore, even with substantial wear on the teeth of the punch and die the formation of the desired rib configuration is not substantially impaired.

Another advantage from the tooling standpoint of forming the wire gripping rib on the inside of the wire grip portion rather than on the outside resides in the fact that when the rib is formed on the outside each successive station in the progressive die assembly must have clearance ground into the lower die section in order to accommodate the outwardly or downwardly projecting rib. The grinding of such clearances in die sections not only weakens them but also creates numerous problems in connection with sharpening the dies. As mentioned previously, the provision of an interior serration or rib also results in a greater pressure being tansmitted to the interior wire strands at a lesser crimping height to create a better holding power with less strain on the crimping tooling. Thus, the provision of the interior rib also results in economy from the standpoint of maintaining the tools for crimping the connector on the wires. Economies in relation to the cost of crimping tooling are also achieved by reason of the fact that tests have shown that the same crimping tooling and the same connectors are suitable for use with 14, 16, 18 and 20 gauge wires by merely adjusting the crimp height.

In forming the wire grip serrations in accordance with the present invention metal is caused to flow freely to provide the rib formation. The metal adjacent each rib is not subjected to the severe stresses which result from the formation of a wire grip serration of the type illustrated in FIG. 18. Thus with the present invention there is less tendency for the metal to fracture. The wire grip serrations can thus be spaced closer together to provide more serrations per unit length of connector. The serrations can be extended across substantially the full width of the wire grip portion **18** so that when it is crimped around a wire the inwardly projecting ribs extend almost completely around the periphery of the group of strands forming the wire.

A further advantage of the wire grip according to the present invention is that the free end of the bared wire need not extend outwardly beyond the inner end of the wire grip portion in order to result in a high pull strength. In FIG. 1 it will be noted that the ends of wire strands **100** extend outwardly beyond the wire grip portion at **122** and that these wire ends as a group are radially expanded relative to the crimped portion of the wire. In an electrical connector having a conventional wire grip portion the pull strength is lower if the ends of the wire strands terminate within the wire grip portion rather than beyond it. In a conventional electrical connector the resistance offered by the expanded ends of the wire is relied upon to a degree to achieve the desired pull strength. With the wire grip portion of the connector formed as disclosed herein the pull strength is substantially unaffected by the fact that the wire ends do not extend outwardly beyond the wire grip portion.

I claim:

1. An electrical connector comprising a sheet metal body having a wire retaining end provided with a wire grip portion of generally U-shape, said wire grip portion being adapted to receive the bared end of a wire and to be crimped thereon by turning the ends of the U inwardly and pressing them toward the bight portion of the U, said wire grip portion having an inner wire engaging face and an outer face, a series of transversely extending ribs on each of said faces, said ribs being spaced apart lengthwise of the wire grip portion with the spaces therebetween defining grooves, the grooves on one of said faces at least partially overlapping the grooves on the other face in a direction lengthwise of the wire grip portion and the ribs on one face at least partially overlapping the ribs on the other face in a direction lengthwise of the wire grip portion, the grooves and ribs on each face being staggered and asymmetrical relative to the ribs and grooves, respectively, on the opposite face in a direction lengthwise of the wire grip portion, the metal sections between the overlapping portions of the grooves forming a connection between laterally adjacent ribs which is thinner than said sheet metal.

2. An electrical connector as called for in claim **1** wherein the ribs on one of said faces protrude from said face with the bottoms of the grooves therebetween being substantially flush with said one face, the ribs on the other face having their outermost surfaces substantially flush wtih said other face with the bottoms of the grooves therebetween being depressed into said other face.

3. An electrical connector as called for in claim **1** wherein the ribs on said wire engaging face project inwardly from said wire engaging face and the bottoms of the grooves between the last-mentioned ribs are substantially flush with said inner wire engaging face, the outer end faces of the ribs on the outer face of the wire grip portion being substantially flush with said outer face and the bottoms of the grooves in the outer face being offset inwardly of said outer face.

4. An electrical connector comprising a sheet metal body having a wire retaining end provided with a wire grip portion of generally U-shape, said wire grip portion being adapted to receive the bared end of a wire and to be crimped thereon by turning the ends of the U inwardly and pressing them toward the bight portion of the U, said wire grip portion having inner and outer faces, a series of transversely extending ribs on each of said faces, said ribs being spaced apart lengthwise of the wire grip portion with the spaces therebetween defining grooves, the grooves on one of said faces at least partially overlapping the grooves on the other face in a direction lengthwise of the wire grip portion and each rib on one face overlying approximately half of the juxtaposed rib on the opposite face in a direction lengthwise of the wire grip portion, the metal sections between the overlapping portions of the grooves forming a connection between laterally adjacent ribs which is thinner than said sheet metal.

5. An electrical connector as called for in claim **4** wherein each groove on said opposite face overlies approximately one-half of the juxtaposed groove on said one face.

6. An electrical connector comprising a sheet metal body having a wire retaining end provided with a wire grip portion of generally U-shape, said wire grip portion being adapted to receive the bared end of a wire and to be crimped thereon by turning the ends of the U inwardly and pressing them toward the bight portion of the U, said wire grip portion having inner and outer faces, a series of transversely extending ribs on each of said faces, said ribs being spaced apart lengthwise of the wire grip portion with the spaces therebetween defining grooves, the grooves on one of said faces at least partially overlapping the grooves on the other face in a direction lengthwise of the wire grip portion and the ribs on one face at least partially overlapping the ribs on the other face in a direction lengthwise of the wire grip portion, the metal sections between the overlapping portions of the grooves forming a connection between laterally adjacent ribs which is thinner than said sheet metal, the transversely extending ribs on one of said faces being interrupted along their length by depressed sections which define grooves extending lengthwise of the wire grip portion.

7. An electrical connector comprising a sheet metal ferrule crimped around the bared end of a wire, said ferrule having a series of spaced inwardly protruding ribs on the inner side thereof which extend around the inner periphery of the ferrule and are separated by grooves, the outer surface of the ferrule having a plurality of spaced grooves therein which extend around the outer periphery of the ferrule and are spaced apart to form a plurality of ribs therebetween, the outer faces of the last-mentioned ribs being substantially flush with the outer surface of the sheet metal formig the ferrule and the radially inner faces of the first-mentioned ribs being spaced radially inwardly of the inner surface of the sheet metal forming the ferrule, each of said outer ribs overlapping approximately half of the opposed inner rib and being axially offset from the adjacent groove on the inner surface of the ferrule.

8. An electrical conductor comprising a sheet metal ferrule having a wire retaining end provided with a wire grip portion of generally U-shape; said wire grip portion having an inner wire engaging surface; said wire engaging surface having a radially distorted portion surrounded by a generally smooth portion; said distorted portion being defined by a series of ribs spaced apart lengthwise of the wire grip portion; said ribs protruding inwardly from said wire engaging suface and extending around the inner periphery of said wire grip portion; said ribs being separated by grooves; the outer surface of the wire grip portion having a plurality of spaced grooves recessed therein which extend around the outer periphery of the wire grip portion and are spaced apart lengthwise thereof to form a plurality of ribs therebetween; the outer faces of the last-mentioned ribs being substantially flush with the outer surface of the sheet metal forming the wire grip portion and the bottoms of the first-mentioned grooves being substantially flush with said smooth, undistorted portion of said inner wire engaging surface; the grooves on one of said surfaces at least partially overlapping the grooves on the other surface in a direction lengthwise of the wire grip portion and the ribs on one surface at least partially overlapping the ribs on the other surface in a direction lengthwise of the wire grip portion; the grooves and ribs on each surface being staggered and asymmetrical relative to the ribs and grooves, respectively, on the opposite surface in a direction lengthwise of the wire grip portion; the metal sections between the overlapping portions of the grooves forming a connection between laterally adjacent ribs which is thinner than said sheet metal.

9. An electrical connector as called for in claim **8** wherein the outer peripheral portions of said wire are curved radially inwardly at the axial portions thereof adjacent said inner ribs.

10. An electrical connector as called for in claim **8** wherein said wire is of the multi-strand type, the peripherally outer strands being curved radially inwardly at the portions thereof adjacent said inner ribs and the interior strands having a curved configuration to conform generally to the axial configuration of the radially outer strands.

11. An electrical connector comprising a sheet metal body having a wire retaining end provided with a wire grip portion of generally U-shape; said wire grip portion having an inner wire engaging surface and an outer surface; said wire engaging surface having a radially distorted portion surrounded by a generally smooth undistorted portion; said distorted portion being defined by a series of ribs spaced apart lengthwise of the wire grip portion; said ribs protruding inwardly from said inner wire engaging surface and extending around the inner periphery of said wire grip portion; said ribs being separated by grooves; the outer surface of the wire grip portion having a plurality of spaced grooves recessed therein which extend around the outer periphery of the wire grip portion and are spaced apart lengthwise thereof to form a plurality of ribs therebetween; the outer faces of the last-mentioned ribs being substantially flush with the outer surface of the sheet metal forming the wire grip portion and the bottoms of the first-mentioned grooves being substantially flush with said smooth, undistorted portion of said inner wire engaging surface.

12. An electrical connector as called for in claim **11** wherein the volume of the metal forming said ribs corresponds to the volume of the grooves in the outer surface of the wire grip portion.

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RICHARD E. MOORE, Primary Examiner

J. H. McGLYNN, Assistant Examiner

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