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[54] **ELECTRICAL CONNECTOR AND METHOD FOR MAKING AN ELECTRICAL CIRCUIT**

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[73] Assignee: **Gardner-Denver Company**, Quincy, Ill.

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[52] **U.S. Cl.** ..... **339/61 M**, 339/107, 339/176 MP

[51] **Int. Cl.** **H05k 1/07**, H01r 13/08

[58] **Field of Search** ..... 339/17 F, 17 L, 17 LM, 339/49 R, 61, 107, 176 M, 176 MF, 176 MP, 208, 210 M, 244 R, 176 P, 176 T, 177, 195, 196

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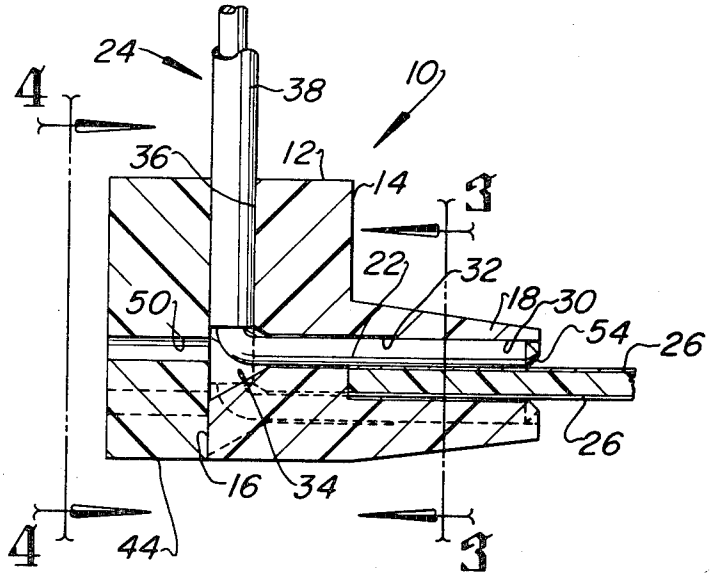
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Assistant Examiner—Lawrence J. Staab
Attorney, Agent, or Firm—M. E. Martin

[57] **ABSTRACT**

An electrical connector comprising a support member in which the ends of one or more flexible conductor wires are removably disposed and supported so that the wire ends form contact elements which may be releasably engaged with another electrical conducting element to form a circuit. The support member may include a removable cover member to facilitate removal and replacement of individual wires. The connector may be formed as a plug and jack assembly as well as an edge connector for connection to a printed circuit board or the like. The connector assemblies may be used in a process whereby individual conductor wires are formed and inserted at one or both ends into the support members or other receptacles to form an electrical circuit.

2 Claims, 15 Drawing Figures



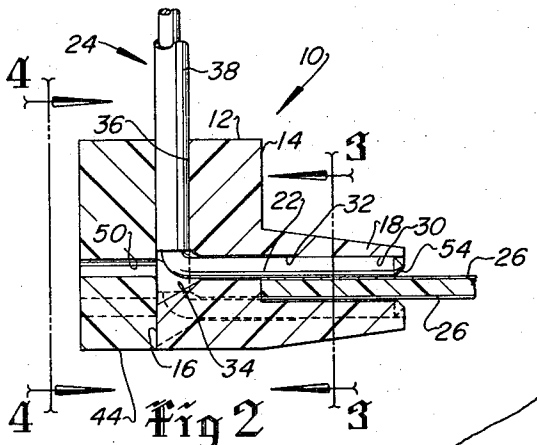


Fig 2

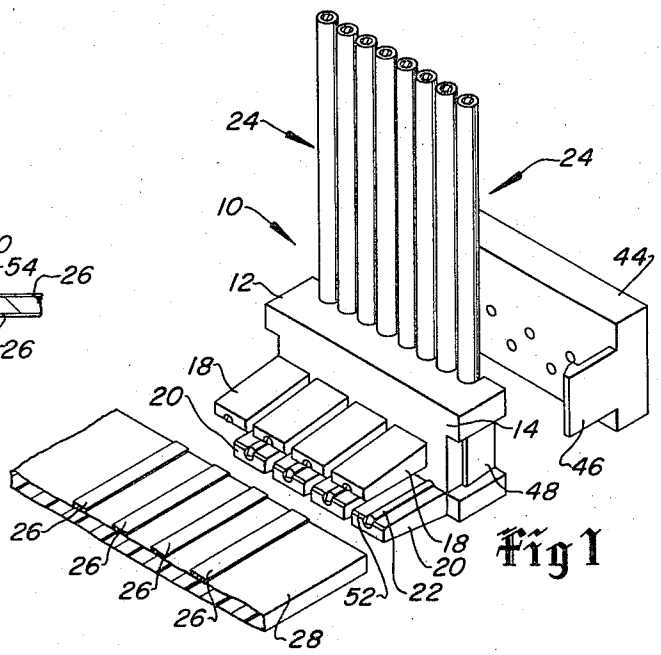


Fig 1

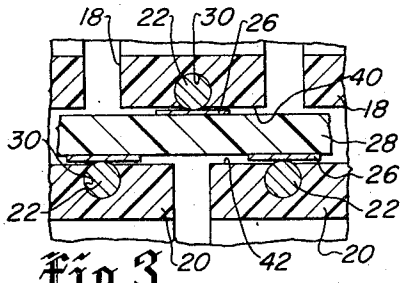


Fig 3

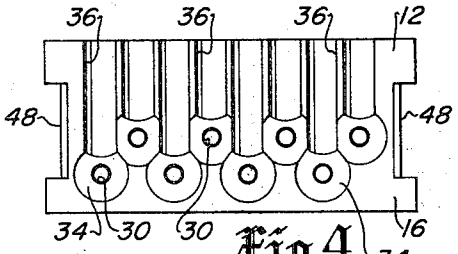


Fig 4

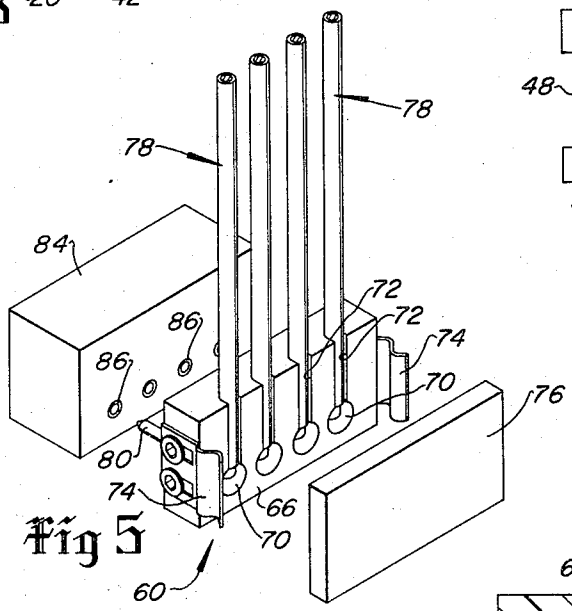


Fig 5

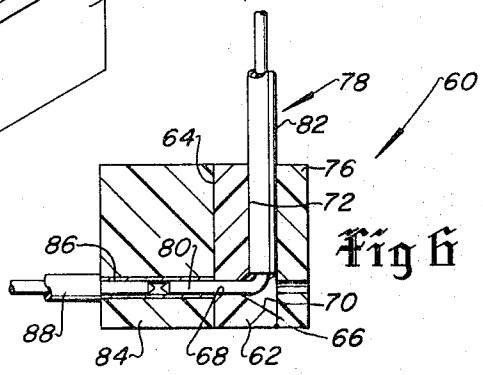


Fig 6

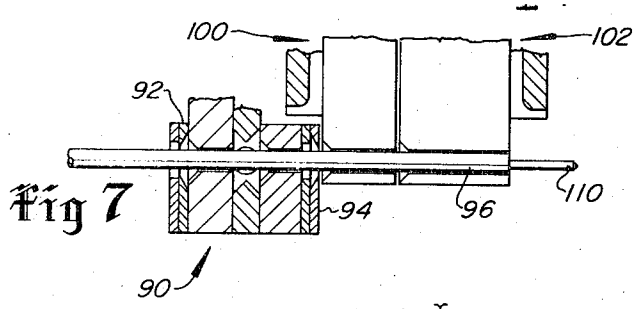


Fig 7

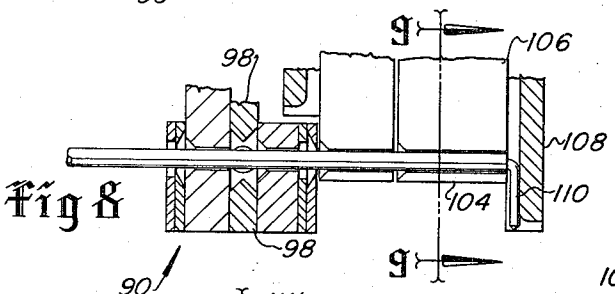


Fig 8

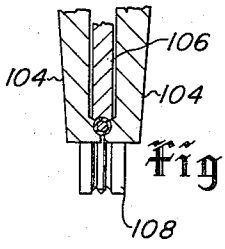


Fig 9

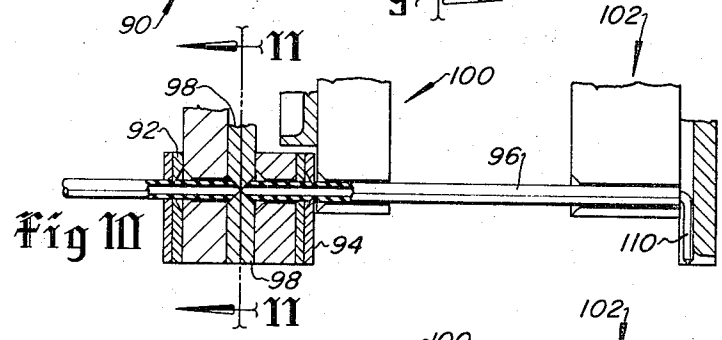


Fig 10

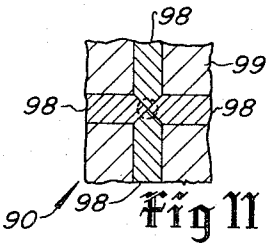


Fig 11

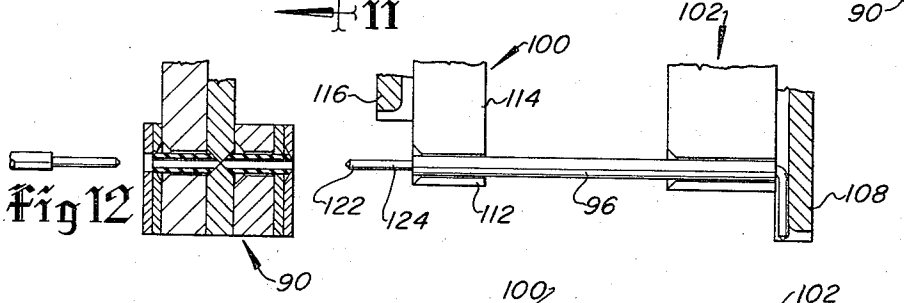


Fig 12

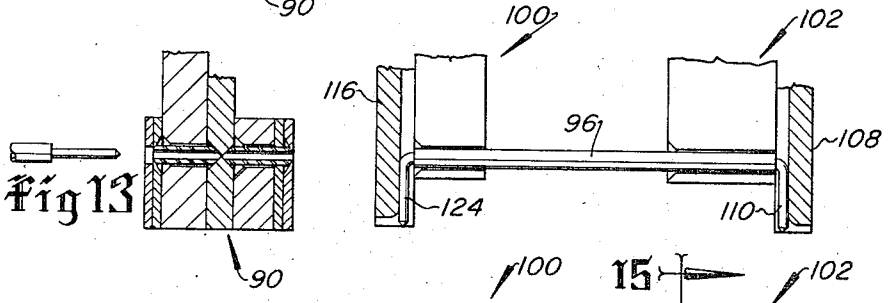


Fig 13

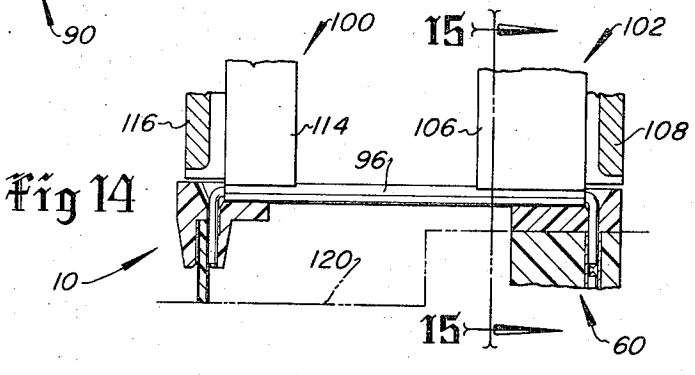


Fig 14

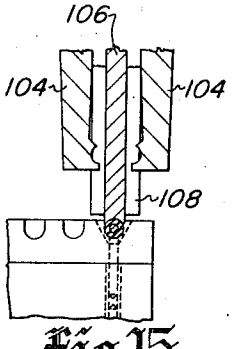


Fig 15

ELECTRICAL CONNECTOR AND METHOD FOR MAKING AN ELECTRICAL CIRCUIT

BACKGROUND OF THE INVENTION

In the art of electrical connectors it is well known to provide devices which are generally characterized by a plug or receptacle structure which supports the conductor wire end portion as well as the electrical contact elements which are attached to the conductor wire proper. In known types of connector devices various types of terminals or contact elements are used which are crimped, soldered, or otherwise joined to the conductor wire itself. In some types of connectors the wire end portion is coined or upset in attempting to form a contact element which has suitable electrical properties and also is mechanically strong enough to withstand coupling and uncoupling with respect to a mating connector device or circuit component.

A longstanding problem with known types of electrical connector devices concerns the inability to form electrical circuit assemblies with wire connecting and circuit making processes readily adaptable to being performed by automatic machines which are reliable and fast enough to be economically feasible. For example, circuit making processes which involve the use of contact elements or terminals which are crimped or soldered to the conductor wire are difficult to automate because of the slow and complex machinery required to form the connection. Moreover, if these forms of connections are built into a connector support block which is part of a separable connector assembly, repair and replacement of individual contact elements in a multiple conductor connector is difficult and often requires replacement of the entire connector assembly. Known types of wire terminations or contact elements which are usable in separable electrical connector devices also usually require special tools or techniques for repair or replacement which makes field maintenance and repair difficult or impossible.

Accordingly, in many electrical circuits it is desirable to provide a connector device which (1) is easily separable from a mating connector or circuit component, (2) has contact elements with suitable electrical properties such as low resistance to current flow, (3) can withstand repeated coupling and uncoupling without mechanical failure of the contact elements, (4) provides for easy manual assembling and automated circuit assembling processes which use fast and uncomplicated machinery even with very dense multiple conductor circuits, (5) provides easy maintenance and field repair of individual terminations in a single or multiple conductor connector without replacement of the entire connector assembly and without the need for special tools or having replacement parts available, and (6) can be easily formed in shapes and configurations to have various numbers of contact elements and be coupled to a variety of circuit components.

SUMMARY OF THE INVENTION

The present invention contemplates an electrical connector which includes the desired features for such devices as noted hereinabove by providing a connector device which uses the terminal end of a conductor wire as the contact element or terminal itself without substantial reshaping of the wire end and without attachment of the wire end to a separately formed terminating device. The present invention provides a connector device comprising a support member or plug for supporting a conductor wire end removably therein in such a way that the wire end forms a contact element or terminal for engaging another contact element on a separable circuit device in electrically conductive relationship. A connector in accordance with the present invention uses conductor wires of sufficient strength and provides adequate support so that repeated quick connect and disconnect operations can be performed.

The present invention also contemplates a method for making an electrical circuit wherein predetermined electrical connections may be made by providing separable connector support members or receptacles into which bare conductor wire ends may be removably inserted. With the circuit making method of the present invention high density electrical circuits may be made automatically and may include separable connector devices which enjoy the desired features for electrical connectors enumerated herein.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an exploded isometric view of an electrical connector device in accordance with the present invention;

FIG. **2** is a transverse section of the connector device of FIG. **1**;

FIG. **3** is a partial section taken along line **3—3** of FIG. **2**;

FIG. **4** is a view from line **4—4** of FIG. **2** with the cover member removed;

FIG. **5** is an exploded isometric view of another embodiment of a connector device in accordance with the present invention;

FIG. **6** is a transverse section view of the connector device of FIG. **5**; and,

FIG. **7** through FIG. **15** illustrates a method of making an electrical circuit in which conductor wire ends are removably connected to a contact element.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. **1** through **4** an electrical connector device in the form of a printed circuit board edge connector is generally designated by the numeral **10.** The connector **10** includes a conductor wire support member **12** which may be molded of a suitable dielectric material such as nylon or other thermoplastic. The support member **12** is characterized by opposed parallel faces **14** and **16,** a row of spaced parallel projections **18** formed integrally projecting from the face **14** and a second row of projections **20** spaced from and parallel to the projections **18.** The projections **18** and **20** comprise means for supporting the terminal end portions **22** of a plurality of conductor wires **24** in such a way that the individual wire end portions form contact elements which may be in electrically conductive but separable engagement with individual conductor means designated by numeral **26** and formed on a circuit board **28.** The circuit board **28** may be generally characterized as a so-called printed circuit card or other suitable conductor supporting member.

The conductor wire support member **12** includes a plurality of elongated holes **30** formed therein. The holes **30** each include a counterbored portion **32,** FIG. **2,** and a conical recess **34** opening to face **16.** As shown in FIG. **4** each recess **34** is intersected by a groove **36** formed in the face **16** which is of sufficient size to ac-

commodate an insulated portion **38** of a conductor wire **24** which is bent perpendicular with respect to the end portion **22** as shown in FIG. **2.** The holes **30** are positioned on the support member **12** such that the portion of the holes extending into the projections **18** and **20** open laterally to a face **40** of each projection **18** and a face **42** of each projection **20** whereby when a conductor wire of suitable diameter is inserted in the hole part of the wire end portion **22** projects beyond the faces. The faces **40** and **42** are substantially parallel and define slot means therebetween for receiving an edge portion of the circuit board **28.** The holes **30** are generally circular in cross section and are formed to permit insertion and removal of a conductor wire end without excessive insertion forces which would result in undesirable bending of the wire. Usually the holes **30** will be larger than the wire diameter by at least one or two thousandths of an inch. The counterbored portion **32** of each hole is provided as relief to facilitate easy insertion of the individual wires in their respective holes. The connector device **10** includes a cover member **44** which may also be formed of a thermoplastic material. The cover member **44** is provided with suitable latch members **46** (one shown in FIG. **1**) which are cooperable with recesses **48** formed in the support member **12** in such a way that a snap connection between the cover member and the support member is formed to properly align the respective members and to retain the wires **24** in the support member as shown in FIG. **2.** The cover member **44** may be easily removed by hand manipulation, without removing the support member **12** from the circuit board **28,** for removal and replacement of individual conductor wires. The cover member **44** may also be provided with openings **50** for insertion of a suitable circuit test probe to engage the respective wire end portions **22.**

As shown in FIG. **3** the conductor wire end portions **22** protrude laterally from the faces **40** and **42** so that separable and electrically conductive engagement is provided of a wire end portion with a contact element formed by conductor means **26** on the board **28.** The projections **18** and **20** are spaced apart such that the connector support member **12,** with the wires inserted therein, is required to be forcibly engaged with the board **28** and the projections undergo slight elastic deflection to provide a clamping action. Beveled edges **52** are provided on the ends of projections **18** and **20** to facilitate insertion of the board edge between the spaced rows of projections. The formation of a plurality of individual projections **18** and **20** provides for assurance that the contact element supported by each projection will be engaged with its respective conductor **26** on the board **28** regardless of any irregularity in the thickness of the board. The wires **24** may be provided with conical or pyramidal shaped pointed ends **54** to facilitate initial engagement of the connector device **10** with the conductor elements on the board **28.** The conductor wire end portions **22** are, however, substantially unaltered and serve as contact elements themselves.

In accordance with the present invention the connector device **10** described above provides for use of a conductor wire end portion as a terminal or contact element. Other than removal of insulation and bending the wire end portion, as shown in FIG. **2,** no other operation is necessary to form a terminal for the connector device **10.** Individual wires may be removed and replaced without removing the support member from the circuit board **28.** Moreover, the connector device **10** may be preassembled with the wires **24** and then connected to the board **28,** or the support member **12** may be first clamped to the board in the proper location and the wires **24** then inserted into the respective holes **30** followed by attachment of the cover member **44.** Accordingly, the connector device **10** provides for an improved circuit assembling technique a preferred form of which is described herein.

Another embodiment of a connector device in accordance with the present invention is shown in FIGS. **5** and **6** and generally designated by the numeral **60.** The connector device **60** includes a conductor support member **62** preferably formed of a dielectric material having opposed parallel faces **64** and **66.** A plurality of spaced apart and parallel holes **68** open to face **64** and include conical recess portions **70** opening to face **66.** Grooves **72** are formed in the support member **62** and intersect the recesses **70.** The support member **62** includes latch means **74** for releasably retaining a cover member **76** in assembly with the support member **62.** The connector device **60** is adapted to removably support flexible conductor wires **78** in such a way that non-insulated end portions **80** of the wires are disposed in the holes **68** and protrude from the face **64** to form contact elements themselves. Insulated portions **82** of the conductor wires **78** are bent substantially perpendicular to the uninsulated end portions and are disposed in the grooves **72.** The connector device **60** comprises a plug type connector which may form a separable electrical connection with a receptacle **84** having plural tubular conductor means **86.** The tubular conductors **86** are dimensioned to receive the wire end portions **80** in electrically conductive engagement therewith. The tubular conductors **86** may be joined to other conductors in a number of well known ways and may also take the form shown in FIGS. **5** and **6** wherein conductor wires **88** are removably inserted in the tubular conductors in the same manner as the wire end portions **80.**

The holes **68** and grooves **72** in the support member **62** together with the cover member **76** provide sufficient support and retention of the conductor wires **78** such that an unsupported part of the wire end portion **80** may be used as the terminal portion of the connector **60** which do not require any other structure to form the contact elements. It is contemplated that solid circular cross section wire of copper and aluminum alloys may be used without encountering problems of bending or insufficient rigidity to permit repeated connect and disconnect operations. Wire diameters as small as 0.032 inches are considered suitable and wires in the range of 0.081 to 0.032 inches diameter are preferred for use with connectors and circuit making processes as disclosed herein. Although circular cross section conductor wires are shown in the drawings it is contemplated that flexible conductors of other cross sectional shapes could be readily accommodated by suitable shaping of the conductor receiving holes in the support members **12** and **62.** The distal ends of the wires in the connector device **60** may also be formed in a conical or pyramidal point to facilitate insertion into the contact elements **86.** This type of shaping of the wire end may be suitably performed using common hand tools such as a knife or manually operated wire cutting and insulation stripping tools. Accordingly, the connector device **60** also uses the conductor wire end portion

in a substantially unaltered form without the need for separate contact elements to form a connector assembly. As with the connector device **10** the connector device **60** provides for removal and replacement of individual wires without complete disassembly from a mating receptacle or other connector portion.

The connector devices **10** and **60** may be advantageously used in an improved circuit making process, a preferred form of which is shown schematically in FIGS. **7** through **15.** The method of making an electrical circuit as disclosed hereinbelow contemplates that automatic positioning apparatus of the general type disclosed in U.S. Pat. Nos. 3,103,735 and 3,185,183 could be utilized with modification to accommodate conductor wire holding and bending devices as disclosed herein. Referring to FIGS. **7** through **15** an electrical circuit formed by interconnecting the connector devices **10** and **60** with a flexible conductor wire could utilize positioning apparatus including a wire cutting and insulation stripping apparatus **90.** The illustrative cutting and insulation stripping apparatus includes pairs of movable insulation cutting blades **92** and **94** which respectively sever the insulation from the trailing end of a length of wire **96** and the leading end of a length of wire yet to be formed in its entirety. Suitable wire feed means, not shown, could provide for feeding the conductor wire **96** through the cutting and stripping apparatus **90.** The wire feeding means would supply wire of an indeterminate length from a source such as a spool or the like, also not shown. The cutting and stripping apparatus **90** includes four pyramid shaped wire cutting and end forming dies **98,** FIG. **11,** supported by a housing **99** and arranged to move radially along perpendicular intersecting axes between open and closed positions as shown by the drawing figures to form pyramid shaped ends on the conductor wire.

A positioning apparatus for making circuit interconnections in accordance with the present invention would also include relatively movable wire holding and bending units designated by numerals **100** and **102.** The unit **102** includes a pair of movable jaws **104** cooperable with a wire pushing finger **106.** A bending device **108** movable in a coordinate manner with unit **102** is also movable relative to the jaws **104** and pushing finger to bend the wire end portion **110** as shown in FIGS. **7** and **8.** The holding and bending unit **100** is similarly provided with jaws **112,** a pushing finger **114** and a bending device **116.**

The method of making a circuit interconnection in accordance with the present invention contemplates that connector devices or wire end receptacles may be predisposed on a structure such as the back side of an automobile instrument panel designated by numeral **120.** Initially, the positioning apparatus would move the wire holding and bending unit **100** into a position in vertical alignment with connector device **10.** The unit **102** and the cutting and insulation stripping apparatus **90** would be positioned adjacent the holding and bending unit **100** so that a conductor wire **96** could be fed into the position shown in FIG. **7.** The leading end portion **110** of wire **96** would be stripped of insulation and suitably pointed as a result of a previous operating cycle of the apparatus **90.** As shown in FIG. **8** the wire end portion **110** would next be bent downwardly and perpendicular with respect to the insulated portion by movement of the bending device **108** to prepare the end portion for insertion into a connector device such as the connector device **60** of FIG. **14** and to hold the wire end in the unit **102** when the unit **102** is moved relative to unit **100** into vertical alignment with connector device **60** as shown in FIG. **10.**

After positioning the wire with respect to the connector devices **10** and **60,** the wire cutting and insulation stripping apparatus **90** is actuated to cut insulation from the trailing end of conductor wire **96** and leading end of the next wire to be formed and to also cut the wire to form the trailing end point **122.** The leading end point of the next wire is also simultaneously formed.

Insulation is removed from the trailing end **124** of conductor wire **96** and the leading end of the next wire to be formed by moving the cutting and stripping apparatus **90** away from unit **100** and withdrawing wire from the cutting and stripping apparatus as shown by the relative positions in FIG. **12.** Suitable actuation of the cutting and stripping apparatus **90** may then be undertaken to remove the stripped pieces of insulation left between the sets of stripping blades **92** and **94.**

After movement of the cutting and stripping apparatus **90** away from unit **100,** the wire bending device **116** is moved downwardly to engage and bend the trailing end **124** of wire **96** to the position shown in FIG. **13.**

The conductor wire **96** is now ready for insertion into the connectors **10** and **60.** As shown by FIGS. **14** and **15** the holding and bending units **100** and **102** are moved vertically downward in a direction substantially perpendicular to the direction in which the wire was fed through the units **100** and **102.** When the bending devices are placed closely adjacent the connectors, FIG. **14,** the sets of jaws **104** and **112** are moved apart and the respective pushing fingers **106** and **114** are actuated by suitable means, not shown, to push the wire end portions directly, without further working, into the respective holes in connectors **60** and **10** as shown. The pushing fingers would normally insert the wires until the insulated portion was disposed in the respective grooves provided therefor on the connectors. Suitable mechanism, not shown, could then be employed to place cover members on the connectors or the operation could be manually performed. Upon completion of the circuit making process for the wire **96** the positioning apparatus would regroup the units **100** and **102** and the cutting and stripping apparatus **90** to the relative positions shown in FIG. **7** and in position over another hole in connector **10** for receiving another wire. A new wire length could then be fed into the units **100** and **102** and another circuit making process commenced.

As may be appreciated from the foregoing description, an improved circuit making process is realized using flexible insulated conductor wire together with connector devices and receptacles which are adapted to support the wire end portions in electrically conductive contact with electrical conductor means which may take various forms.

What is claimed is:

1. An electrical connector device for making separable electrical connections between one or more flexible conductor wires and electrical conducting means characterized by:

a support member including hole means formed therein for receiving one or more flexible electrical conductor wires,

one or more electrical conductor wires disposed in said hole means in such a way that said conductor wires each have an uninsulated end portion the

shape of which is substantially unaltered from the as formed condition supported by said support member for separable and electrically conductive engagement with said conducting means;

said connector device includes groove means intersecting said hole means in said support member for supporting insulated portions of said conductor wires which are bent substantially perpendicular to said end portions;

said support member includes separate projecting portions defining one of a pair of spaced apart faces forming slot means for receiving a connector member including said conducting means, at least one of said separate projecting portions including hole means opening laterally to said one face for receiving and supporting an uninsulated end portion of a conductor wire for electrical conductive engagement with said conducting means; and,

a cover member releasably engageable with said support member for retaining said conductor wires in said hole means so that said end portions of said conductor wires can be inserted in and removed from said support member without substantially altering the shape of said end portions, and said conductor wires together with said support member and said cover member can be separated from said conducting means.

2. The invention set forth in claim **1** wherein: said separate projecting portions are formed to be elastically deflected to provide a clamping action between said connector device and said connector member.

* * * * *