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.

4 Claims, 15 Drawing Figures
ELECTRICAL CONNECTOR AND METHOD FOR MAKING AN ELECTRICAL CIRCUIT

This is a division of application Ser. No. 340,781, filed Mar. 13, 1973 now U.S. Pat. No. 3,855,567.

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 sub-

stantial 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 removable 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 numerical 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 accommodate 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 thereinfor 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 conductor 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 re-inserted 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 a latch means 74 for releasably retaining a cover member 76 in assembly with the connector 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 reconnect 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 sub-
stantially unaltered form without the need for separate contact elements to form a connector assembly. As with the connector device 60 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 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 portion 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.

We claim: 1. An improved method of making electrical connections with insulated flexible conductor wire between at least two connector devices which are adapted to receive, respectively, opposite uninsulated end portions of a flexible conductor wire, comprising the steps of: preparing one end portion of an indeterminate length of conductor wire by cutting and stripping a predetermined length of insulation therefrom; providing first and second wire holding means for holding opposite end portions of a conductor wire and feeding an end portion of said conductor wire into and through said second holding means and
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7 into said first holding means; bending said one end portion substantially perpen-
dicular with respect to the insulated portion to se-
cure said one end portion in said first holding
means; moving said first holding means into a position adja-
cent one of the connector devices after bending said one end portion and thereby pulling said con-
derator wire through said second holding means; then,
cutting the conductor wire to length by severing the
wire on the side of said second holding means from
which said conductor wire was fed and stripping a
predetermined length of insulation from the other
end portion of said conductor wire; bending said other end portion substantially perpen-
dicular with respect to the insulated portion; and
then,
inserting said end portions of said conductor wire di-
rectly in said connector devices without further
working said end portions.
2. The improved method set forth in claim 1 together
with the step comprising:
forming a pointed end on said conductor wire on
each end portion.
3. An improved method of making electrical connec-
tions with insulated flexible conductor wire between at
least two connector devices which are adapted to re-
ceive, respectively, opposite uninsulated end portions
of a flexible conductor wire, comprising the steps of:
preparing one end portion of an indeterminate length
of conductor wire by cutting and stripping a prede-
termined length of insulation therefrom;

8 providing first and second wire holding means for
holding opposite end portions of a conductor wire
and feeding an end portion of said conductor wire
into and through said second holding means and
into said first holding means with said second hold-
ing means disposed adjacent one of said connector
devices; bending said one end portion substantially perpen-
dicular with respect to the insulated portion to se-
cure said one end portion in said first holding
means; moving said first holding means into a position adja-
cent the other connector device after bending said
one end portion and thereby pulling said conductor
wire through said second holding means; then,
cutting the conductor wire to length by severing the
wire on the side of said second holding means from
which said conductor wire was fed and stripping a
predetermined length of insulation from the other
end portion of said conductor wire; bending said other end portion substantially perpen-
dicular with respect to the insulated portion; and
then,
inserting said end portions of said conductor wire di-
rectly in said connector devices without further
working said end portions.
4. The improved method set forth in claim 3 together
with the step comprising:
bending said other end portion to secure said other
end portion in said second holding means.