United States Patent [19]

Ammon

[11] **3,868,162**

[45] **Feb. 25, 1975**

[54] **ELECTRICAL CONNECTOR**

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[73] Assignee: **Elfab Corporation,** Dallas, Tex.

[22] Filed: **Sept. 4, 1973**

[21] Appl. No.: **393,787**

[52] **U.S. Cl.** ... **339/17 M,** 317/101 D, 339/176 MP, 339/184 M

[51] **Int. Cl.** **H05k 1/07,** H01r 13/64

[58] **Field of Search** ..... 339/17, 18, 75, 66, 65, 339/176, 184, 186, 217, 219, 220, 221; 317/101 D, 101 DH

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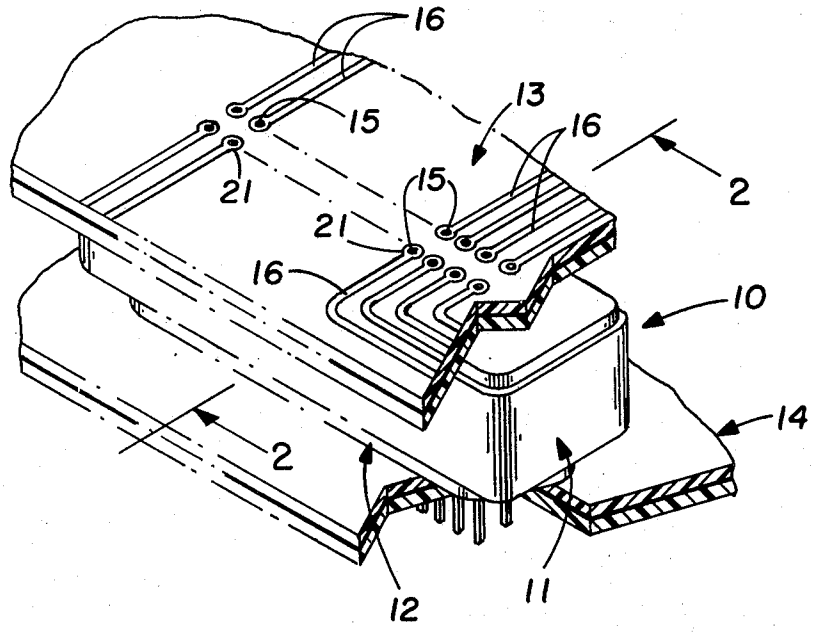
Primary Examiner—Roy D. Frazier
Assistant Examiner—Terrell P. Lewis
Attorney, Agent, or Firm—Clegg, Cantrell & Crisman

[57] **ABSTRACT**

An electrical connector comprising interengageable receptacle and plug members each including a plurality of contact elements which complete a series of electrical circuits through the connector when the members are interengaged. The plug and receptacle members are each formed by press fitting contacts into plated-through holes in an insulative substrate and then covering the protruding contacts with a lay-over insulative housing. The press fitted neck portion of each contact is reinforced by a longitudinally extending stiffening rib to permit the use of a contact material of relatively uniform thickness.

13 Claims, 15 Drawing Figures



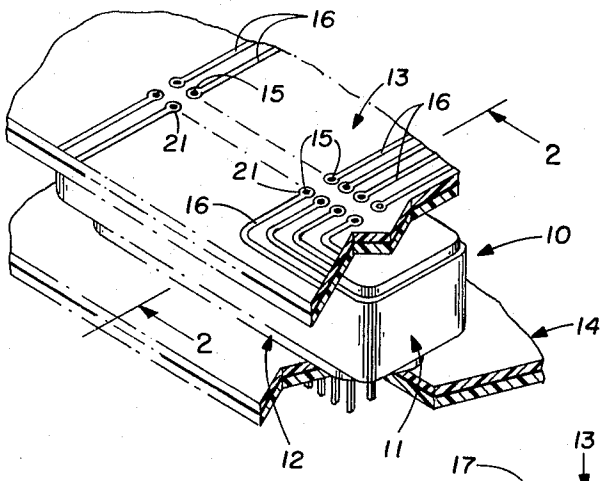


FIG. 1

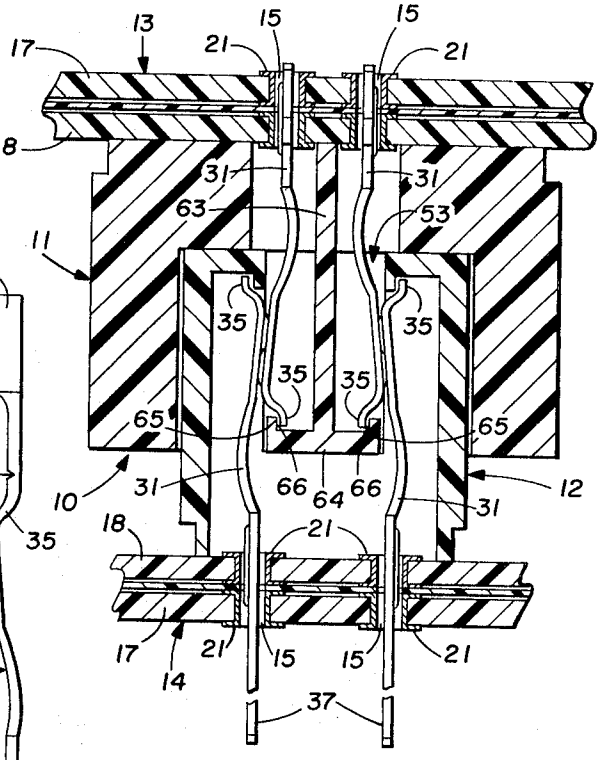


FIG. 2

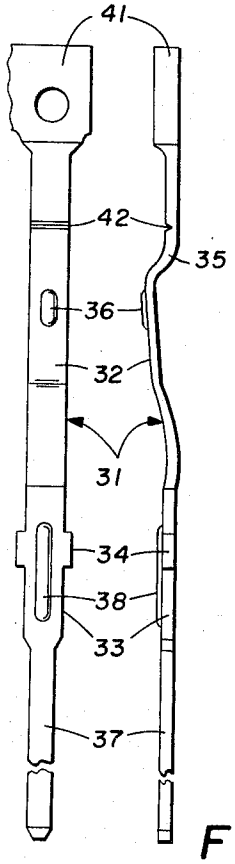


FIG. 4b

FIG. 4a

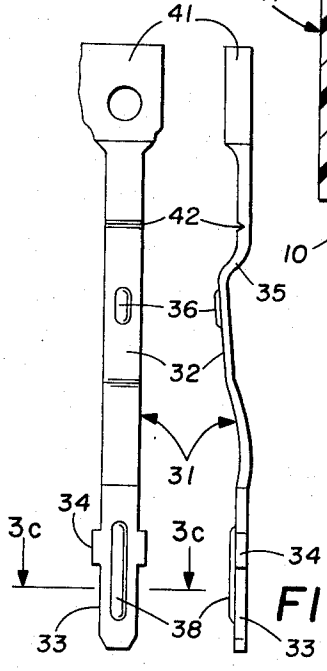


FIG. 3a

FIG. 3b

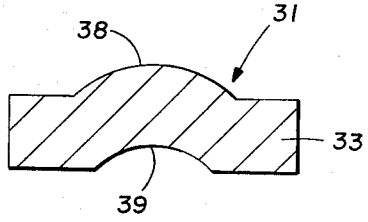


FIG. 3c

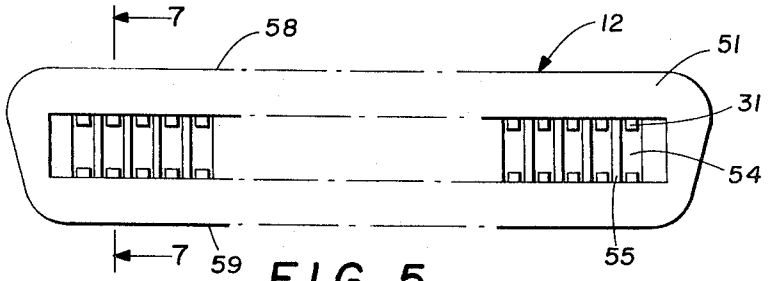


FIG. 5

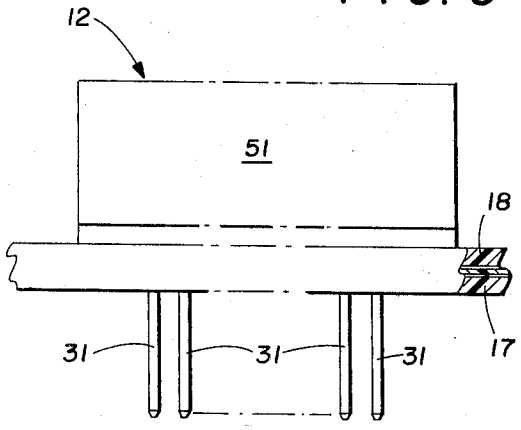


FIG. 6

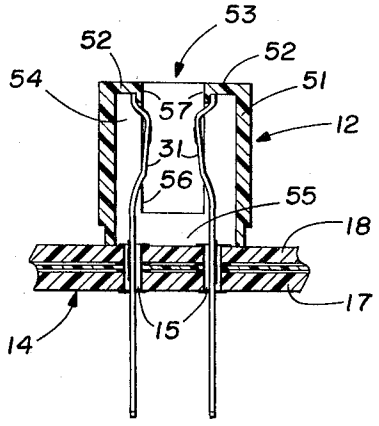


FIG. 7

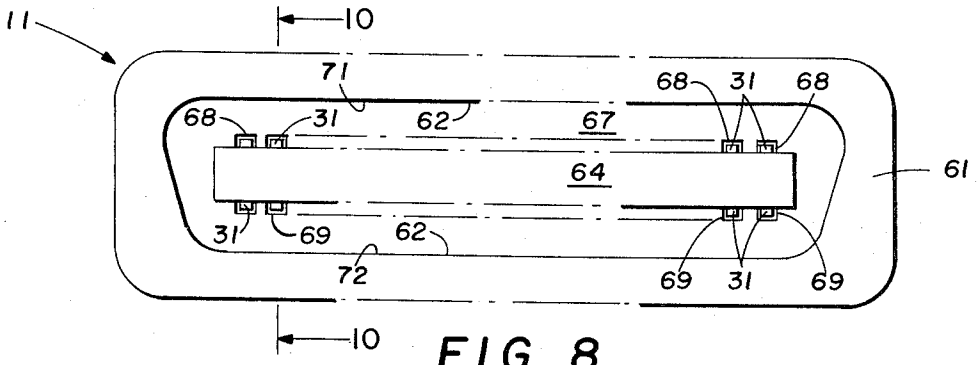


FIG. 8

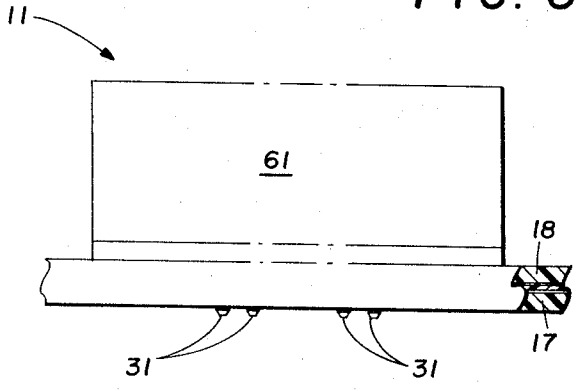


FIG. 9

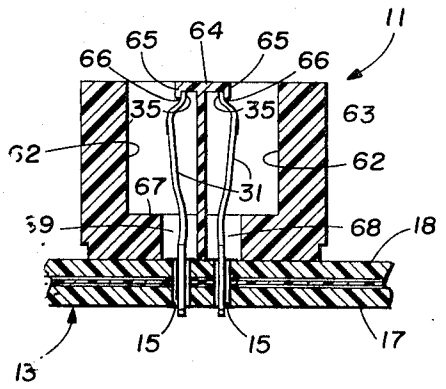


FIG. 10

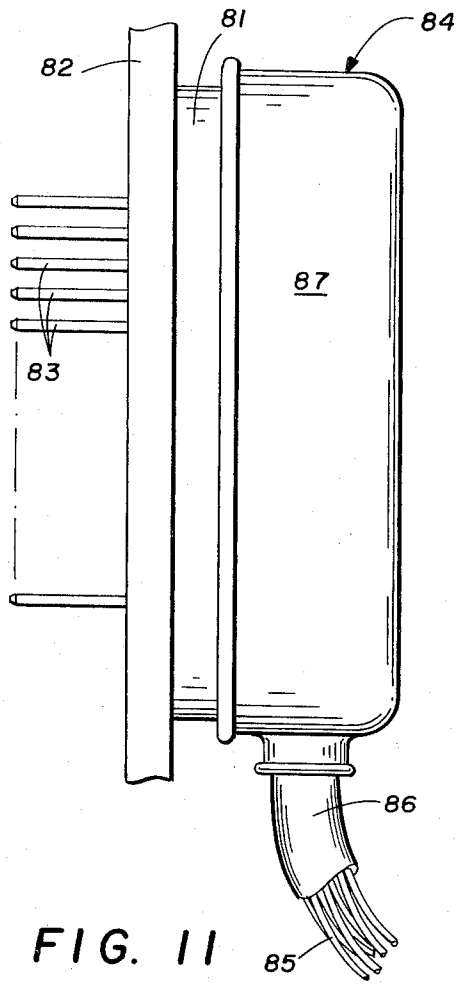


FIG. 11

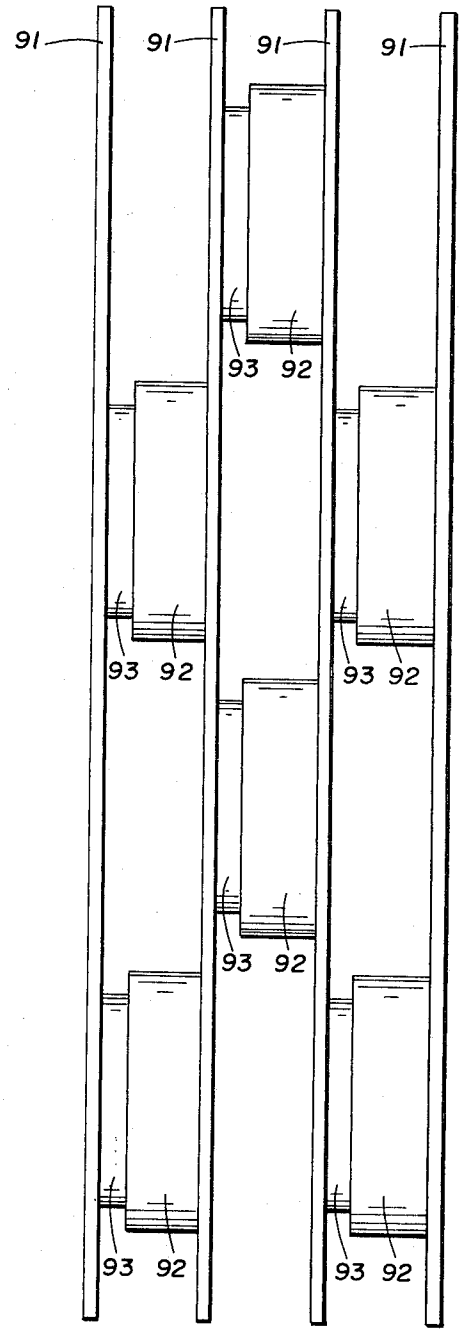


FIG. 12

ELECTRICAL CONNECTOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to an electrical connector and, more particularly, to an electrical connector including substrate mounted plug and receptacle members which are engagable to complete a plurality of electrical circuits through the connector.

2. History of the Prior Act

One type of connector used in interconnecting backpanels for printed circuit cards is that shown and claimed in U.S. Pat. No. 3,671,917 to J. P. Ammon et al, assigned to the assignee of the present invention. Such connectors include rows of contact terminals press fitted into receiving apertures in a substrate, generally known as a motherboard, and then covered by a layover insulative housing. The connector housings include a top opening for receiving the edge of a printed circuit card to be terminated, generally known as a daughter board.

Substrate mounted, card edge connectors, such as that disclosed in the Ammon et al patent, possess many advantages. For example, rows of contacts may be simultaneously press fitted into plated through receiving holes in the substrate for interconnection with printed wiring on the motherboard. This technique of manufacture, as taught in U.S. Pat. No. 3,676,926, produces rapid connector assembly and may also be used to produce a multi-layer motherboard in accordance with the teachings of U.S. Pat. No. 3,660,726. Further, substrate mounted card edge connectors, such as that disclosed in the Ammon et al patent employ a layover insulator which also contributes to speed of assembly and ease of repairability and preloading.

For certain applications, such as where it is inconvenient or impossible to terminate one set of circuit paths along a card edge, the motherboard mounted edge connector is not practicable. In these situations it would be desirable to use mating plug and receptacle members which, unfortunately, possess a number of disadvantages. Generally, in prior art plug and receptacle connectors each contact in both the plug member and the receptacle member must be individually assembled into a housing and then individually wired to a circuit path. This consumes a great deal of assembly time and leads to a more expensive product.

The connector of the present invention combines the function of a plug and receptacle connector with the advantages of a substrate mounted, card edge type connector.

SUMMARY OF THE INVENTION

The invention relates to an electrical connector member having contact terminals inserted into a substrate and covered by a layover insulative housing. More particularly, the invention involves an electrical connector including interengagable plug and receptacle members comprising a pair of planar mounting substrates having a plurality of contact terminals mounted in each. A pair of interengagable, insulative plug and receptacle housings each comprise an outer shell having side walls open at the bottom to permit the shells to fit down over and substantially enclose the contact terminals and top openings adapted for interengagement with one another. The plug housing is laid over the contact terminals mounted in one substrate while the receptacle housing is laid over the contact terminals mounted in the other substrate. The contact terminals in one substrate are electrically coupled to the contact terminals in the other substrate when the plug and receptacle members are interengaged.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and for further objects and advantages thereof, reference may now be had to the following description taken in conjunction with the accompanying drawing, in which:

FIG. **1** is a perspective view of the interconnected plug and receptacle of the electrical connector of the present invention;

FIG. **2** is a vertical cross-section view taken about lines **2—2** of FIG. **1**;

FIG. **3A** is a front view of one embodiment of a strip supported contact terminal used in the invention;

FIG. **3B** is a side view of the contact of FIG. **3A**;

FIG. **3C** is a cross-section view taken about the lines **3***c*—**3***c* of FIG. **3A**;

FIG. **4A** is a front view of another embodiment of a strip supported contact terminal used in the invention;

FIG. **4B** is a side view of the contact shown in FIG. **4A**;

FIG. **5** is a top view of the receptacle member of the of the connector of the present invention;

FIG. **6** is a front view of the receptacle member shown in FIG. **5**;

FIG. **7** is a vertical cross-section view taken about the lines **7—7** of FIG. **5**;

FIG. **8** is a top view of the plug member of the connector of the present invention;

FIG. **9** is a front view of the plug member shown in FIG. **8**;

FIG. **10** is a vertical cross-section view taken about the lines **10—10** of FIG. **8**;

FIG. **11** is a side view of a receptacle member constructed in accordance with the invention in interengagement with a cable connector plug member; and

FIG. **12** is a side view of a plurality of motherboards interconnected by the connector of the present invention.

DETAILED DESCRIPTION

Referring to FIG. **1**, there is shown a plug and receptacle electrical connector **10**, constructed in accordance with the invention. The connector **10** is shown interengaged with the plug member **11** overlying and partially enclosing the receptacle member **12**. The plug member **11** is attached to and includes a first substrate **13** while the receptacle member is fixed to a second parallel substrate **14**. Both of the substrates **13** and **14** preferably comprise either single or plural layer conventional printed circuit boards, having a plurality of rows of holes **15** formed therein. A function of the connector **10** is to complete a plurality of circuit paths **16** located on the first substrate **13**, through the connector **10** to a plurality of circuit paths (not shown) located on the second substrate **14**.

Referring now to FIG. **2**, there is shown a cross-section view of the connector **10** illustrating the manner in which the plug member **11** and the receptacle member **12** are mechanically interfitted within one another and electrically interengaged. Each of the substrates **13** and **14** may comprise, in one embodiment,

a pair of conventional printed circuit boards **17** & **18**. The boards **17** and **18** are preferably formed of an insulative material such as a glass filled epoxy resin (known as G-10 Printed Circuit board material) and may be either single or double sided, i.e., each board may have conductive pathways **16** (FIG. **1**) formed on either one or both surfaces. Enlarged pads **21** are formed on the surfaces of the boards **17** and **18** surrounding each one of the holes **15**. The inside surface of each of the holes **15** is preferably plated with an inner layer of a conductive material such as copper, and an outer layer of tin-lead material so that the upper and lower pads **21** surrounding each hole **15** are joined by a continuous metal layer forming the walls of a conventional plated-through hole.

The adjacent boards **17** and **18** are separated by a thin layer of insulative material **22**, such as "MYLAR" polyester film available from E. I. duPont de Nemours & Co. Each of the sheets **22** is drilled with holes to correspond with those in the board so that the plated-through holes in the pads **21** lie in axial alignment but are electrically isolated from one another by the insulative sheets **22**.

When the boards **17** and **18**, of both the substrates **13** and **14**, are arranged with the plated-through holes **15** in axial alignment, conductive metal contact terminals **31** are press fitted into the holes **15** to be held tight and motionless. If desired, the tin-lead material in the hole may be heated and reflowed following the press fitting operation. The contacts **31** are preferably assembled into the boards **17** and **18** in accordance with the techniques of U.S. Pat. No. 3,676,926 to form multi-layer boards in accordance with U.S. Pat. No. 3,660,726, both of which are assigned to the assignee of the present invention.

Referring to FIGS. **3A** and **3B** there are shown, respectively, front and side views of a strip mounted contact terminal **31**. The terminals are preferably stamped from a single long thin strip of metal, such as phosphor-bronze, and then finished by plating with a layer of nickel and an outer layer of gold, or some other acceptable contact plating. The contact terminals are joined to a common support strip **41** by a beveled reduced section **42**.

Each of the contact terminals **31** comprises a connector portion **32** and a neck section **33** separated by a shoulder portion **34**. The neck section **33** is of such a width and thickness that when a contact **31** is press fitted into a contact receiving hole **15**, there is a tight frictional engagement between the neck **33** and the malleable inner walls of the hole **15** so that the contact is held rigid and motionless. The connector portion **32** of the contact terminal **31** is curved into a bowed configuration and is terminated at its upper end by a flange portion **35**. A small detent **36** is impressed into the face of the connector portion **32** to provide a "snap action" engagement with other contact terminals. The contact terminal of FIGS. **4A** and **4B** is identical to that of FIGS. **3A** and **3B** except that the former also includes a shank portion **37** to permit additional wiring connections by such techniques as wire wrapping.

As can be seen from reference to FIGS. **3A** and **3B**, the thickness of the contact **31** is uniform and relatively thin throughout its entire length. To insure that the uniformly thin contact **31** flexes above the surface of the substrate, a central, axially extending ridge **38** is formed from a point just above the shoulder portion **34** to a point just above the bottom of the neck section **33**. The ridge **38** is formed generally along the region of the contact to be press fitted into a receiving hole. As best shown in FIG. **3C**, the ridge **38** is formed by stamping a groove **39** into the opposite face to plastically deform the metal. The central ridge **38** provides stiffness and rigidity to the present contact to ensure that flexure thereof occurs above the surface of the mounting substrate.

FIGS. **5–7** show, respectively, top, side and end cross-sectional views of a receptacle member **12** constructed in accordance with the invention. Referring first to FIG. **7**, there is shown a corss-sectional view of the receptacle member **12** illustrating a pair of contact terminals **31** press fitted into the receiving holes **15** and substantially enclosed by an insulative housing **51**. The housing **51** is preferably formed of a moldable insulative material such as nylon, plastic or a polycarbonate material and includes an outer shell which is open at the bottom to allow the shell to fit down over and receive the contact terminals **31**. The upper portion of the housing is partially closed by two U-shaped edge sections **52** defining a top opening **53** for receiving a plug member to engage the contact terminals **31**. The housing **51** is preferably divided into a plurality of internal chambers **54** by transversely extending wall sections **55**, each of which includes a central slot **56** for receiving a portion of a plug member. Each of the chambers **54** receives an opposed pair of contact terminals **31** when the insulative housing **51** is laid over the terminal ends. An overhanging lip **57** is formed on the innermost portion of each of the U-shaped sections **52** to support the flange portions **35** and preload the contacts **31**.

As may be seen from the top view in FIG. **5**, the receptacle member **12** is polarity keyed by making one side wall **58** of the insulator **51** somewhat longer than the other side wall **59**. When the receptacle member **12** is used with a plug member similarly keyed, it is impossible to reverse the polarity of the mating contacts because the members will only fit together in one orientation.

FIGS. **8–10** show, respectively, top, side and end cross-sectional views of a plug member **11** constructed in accordance with the invention. Referring to FIG. **10**, there is shown a cross-section of the plug member **11**, illustrating a pair of contact terminals **31** press fitted into receiving holes **15** in the substrate **13** and covered by an insulative housing **61**. The plug housing **61**, like the receptacle housing **51**, is preferably formed of a moldable insulative material and includes an outer shell which is open at the bottom to allow the shell to fit down over and receive the contact terminals **31**. The plug housing **61** comprises a pair of spaced, parallel, upwardly extending side walls **62** and an upwardly extending central rib **63**, parallel to and spaced between the walls **62**. The central rib **63** includes a transverse strip **64** extending along the top and forming a U-shaped edge **65** along each side of the strip **64**. The inner portion of each of the U-shaped edges **65** is terminated by an overhanging lip section **66** which contacts and supports the flanged portion **35** of each contact terminal **31**.

The inside bottom portion of the plug housing **61** is formed by a floor **67** which is perforated by a plurality of spaced slots, each of which is divided into two adjacent chambers **68** and **69** by the central rib **63**. Each of

the chambers **68** and **69** receives one contact terminal **31** of an opposed contact pair when the insulative plug housing **61** is laid over the terminal ends.

As can be seen from the top view in FIG. **8**, the plug member **11** is polarity keyed by making one side wall **71** of the insulator **61** somewhat longer than the other sidewall **72.** When the plug member **11** is used with a receptacle member similarly keyed, it is impossible to reverse the polarity of the mating contacts because the members will only fit together in one orientation. For example, the receptacle member **12** (of FIG. **5**) would only interengage the plug member **11** (of FIG. **8**) with wall **58** adjacent wall **71** and wall **59** adjacent wall **72.**

Referring again to FIGS. **5, 6,** and **7,** the receptacle member **12** is assembled by separating the required number of contact terminals **31** (FIGS. 3A & B or 4A & B) from a strip and inserting the shanks thereof into receiving holes **15** in the substrate **14.** The contact terminals **31** are then press fitted into the holes to form two rows. The receiving holes **15** into which the opposed contact terminal pairs are inserted are spaced from one another so that the bowed sections of the contactor positions **32** of opposed terminal pairs are separated from one another a distance slightly less than that between the mating plug member contacts to be inserted. The insulative housing **51** is then laid over the upper ends of the contact terminals to receive opposed pairs of contacts up into the chambers **54.** When the housing **51** is initially placed over the contact terminals **31,** it comes to rest with the ends of thh overhanging lip portions **57** in contact with the ends of the flange portions **35,** as can be visualized from FIG. **7.** The insulative housing **51** is placed in final position by caming the contact terminals **31** apart and pressing the housing downwardly, as taught in U.S. Pat. No. 3,671,917. In the finally assembled receptacle member **12,** the flanges **35** rest against the inside edges of the overhanging lip portions **57** and exert a preselected loading force against them.

Similarly, the plug member **11,** of FIGS. **8, 9** and **10** is assembled by separating a selected number of contact terminals **31** from a strip and inserting the shanks thereof into receiving holes **15** in the substrate **13.** The contacts **31** are then press fitted into the holes to form two rows of opposed contact pairs. The insulative housing **61** is then laid over the upper ends of the contact terminals to receive opposed pairs of contacts up into the chambers **68** and **69.** The housing **61** is placed in final position by caming the opposed rows of terminals toward one another and pressing the housing downwardly. In the finally assembled plug member **11,** the flanges **35** rest against the inside edges of the overhanging lip portions **66** and exert a preselected loading force against them.

When the plug and receptacle members **11** and **12,** respectively, are interengaged, as shown in FIG. **2,** the central rib **63** extends down into the top opening **53** while the body of the receptacle member **12** is received within the parallel walls **62** of the plug member **11.** As the plug member **11** is being inserted into the receptacle member **12,** the contactor portions **32** of the respective terminals **31** engage one another. The spacing of contacts is such that, during interengagement, both plug and receptacle contacts are moved from their rest positions, i.e., abuting the respective lip portions, and slid along the surface of one another until the opposed detents **36** have "interlocked" each other, as shown in FIG. **2.** This ensures a positive electrical connection between the contacts of the plug member **11** and the contacts of the receptacle member **12.**

In other embodiments of the invention it will be understood that cable connectors can be made by press fitting contacts into a substrate, laying an insulative housing over the contactor positions, severing the contact supporting section of the substrate from the remainder, attaching cable wires to the tails of the contacts and covering the cable wires and attachments with a cable hood.

It should be noted that either the plug member **11** or the receptacle member **12** can be used with a mating cable connector. Referring to FIG. **11,** there is shown a receptacle member **81** mounted to a substrate **82** and having a plurality of outwardly extending contact tails **83.** For example, the substrate **82** may comprise part of an interconnecting backpanel for electronic components (not shown). The receptacle member **81** is interengaged to a cable connector plug **84** which terminates a plurality of wires **85** bound into a cable **86.** The cable connector **84** may be of a type similar to the "Blue Ribbon" cable connector manufactured by the Amphenol Corporation. The wire/plug interconnections are covered by a cable hood **87.** Thus, it can be seen how electrical circuits on a backpanel can be interconnected with circuits in a cable by means of the connector of the present invention.

Referring to FIG. **12,** it can be seen how the plug and receptacle members of the connector of the present invention may be used to directly interconnect and "stack" a plurality of circuit panels. Each panel **91** may comprise either single or multi-layer interconnecting backpanels and may have both plug members **92** and receptacle members **93,** mounted thereto. By interengaging the mating plug and receptacle members **92** and **93,** the electrical circuits on the panels **91** are easily interconnected.

Having described the invention in connection with certain specific embodiments thereof, it is to be understood that further modifications may now suggest themselves to those skilled in the art and it is intended to cover such modifications as fall within the scale of the appended claims.

What is claimed is:

1. An electrical connector including interengagable receptacle and plug members, comprising:

first and second substrates having aligned contact receiving hole arrays therein, each of said hole arrays lying along a linear path;

a plurality of contacts press fitted into the holes in each of said substrates, said contacts each including a contactor portion resilient in a direction transverse to said linear paths lying along said hole arrays;

an insulative receptacle housing placed down over to substantially enclose the press fitted contacts on the first substrate, said receptacle housing having bottom openings of sufficient size to receive the contactor portions of said contacts and a top opening to receive a plug member, said receptacle housing having substantially planar inner wall surfaces extending parallel to said linear paths lying along said hole arrays and spaced from any engagement with the rear portions of said receptacle contacts; and

an insulative plug housing placed down over to substantially enclose the press fitted contacts on the second substrate, said plug housing having bottom openings of sufficient size to receive the contactor portions of said contacts, and a top opening surrounding a central rib, said central rib having substantially planar inner wall surfaces extending parallel to said linear paths lying along said hole arrays and spaced from any engagement with the rear portions of said plug contacts, said plug and receptacle members being interengagable by inserting the central rib of said plug into the top opening of said receptacle to receive the receptacle housing into the top opening of said plug housing and bring the respective plug and receptacle contacts into generally parallel, facing electrical engagement along a line parallel to said linear hole arrays and spaced from the inner wall surfaces of both said plug and said receptacle housings with the forces of engagement between contacts being in a direction perpendicular to said line of engagement.

2. An electrical connector including interengagable receptacle and plug members so set forth in claim **1** wherein:

the contacts are press fitted into the first substrate in two parallel rows along said linear paths with the contactor portions of adjacent receptacle contacts in different rows, forming contact pairs, facing toward one another and spaced from the inner wall surfaces of said receptacle housing;

the contacts are press fitted into the second substrate in two parallel rows along said linear paths with the contactor portions of adjacent plug contacts in different rows forming contact pairs, facing away from one another and being separated by the central rib of said plug housing and spaced from the inner wall surfaces of said central rib; and

the contactor portions of said plug and receptacle contacts electrically connect one another when said plug and receptacle members are interengaged along a line parallel to said linear paths with forces of engagement being perpendicular to said paths.

3. An electrical connector including interengagable receptacle and plug members as set forth in claim **2** wherein:

each of said receptacle contacts are preloaded to exert a force toward the adjacent contacts in said pairs; and

each of said plug contacts are preloaded to exert a force away from the adjacent contacts in said pairs.

4. An electrical connector including interengagable receptacle and plug members as set forth in claim **3** wherein:

said contacts each include a flange portion at the upper end thereof;

said receptacle housing includes a pair of lip portions parallel to said linear paths lying along said hole arrays and spaced from one another on opposite sides of the top opening, said contact flanges engaging said lip portions to preload said receptacle contacts with forces acting in a direction perpendicular to said linear paths; and

said plug housing including a pair of lip portions extending on opposite sides of said central rib to engage the contact flanges and preload said plug contacts with forces acting in a direction perpendicular to said linear paths.

5. An electrical connector including interengagable receptacle and plug members as set forth in claim **1** wherein:

said contacts each include a central, axially extending stiffening ridge formed in the contact region press fitted into the holes in the substrates.

6. An electrical connector including interengagable receptacle and plug members as set forth in claim **5** wherein:

said contacts are of generally uniform thinness and each also include a groove formed in the opposite surface thereof from said ridge.

7. An electrical connector including interengagable receptacle and plug members comprising:

a pair of planar mounting substrates;

a plurality of contact terminals mounted in each of said substrates in contact arrays wherein said contacts mounted in each substrate lie along linear paths;

a pair of interengagable, insulative plug and receptacle housings each comprising an outer shell having side walls open at the bottom to permit said shells to fit down over and substantially enclose said contact terminals above said substrates and top openings adapted for interengagement with one another the inner surfaces of said outer shells being substantially planar and extending parallel to said linear paths spaced from said contacts, said plug housing being fitted down over contact terminals mounted in one substrate and said receptacle housing being fitted down over contact terminals mounted in the other substrate, contact terminals in one substrate being electrically coupled to aligned contact terminals in the other substrate along a line of engagement parallel to said linear paths by forces perpendicular to said linear paths when the plug and receptacle members are interengaged.

8. An electrical connector including interengagable receptacle and plug members as set forth in claim **7** wherein:

each of said contact terminals includes a flange portion at one end thereof, a neck section at the opposite end thereof mounted in said substrate and a contactor portion in between; and

said outer shells including lip portions adjacent the top openings which engage the flange portions of said contact terminals to flex each of said contacts above the point of engagement of said contacts in said substrate and uniformly preload said contacts with forces acting in a direction perpendicular to said linear paths.

9. An electrical connector including interengagable receptacle and plug members as set forth in claim **8** wherein:

each of said contact terminals are of generally uniform thinness and also include a central, axially extending stiffening rib formed in one surface thereof in the region of the neck section to ensure said contact terminals flex above the surfaces of said subtrates.

10. An electrical connector including interengagable receptacle and plug members as set forth in claim **7** wherein:

said contact terminals are mounted in said substrates in opposed contact pairs; and

said insulative housings each include wall surfaces spaced from said contacts and extending perpendicular to said linear paths to separate adjacent ones of said contact pairs.

11. An electrical connector member adapted for interengagement with a cable connector, comprising:

a planar substrate having aligned contact receiving holes therein;

a plurality of contacts press fitted into the holes in said substrate, said contacts each being resilient in a direction transverse to said aligned holes; and

an insulative housing having bottom openings of sufficient size to receive said contacts and a top opening to receive a cable connector, said housing being placed down over said press fitted contacts to substantially enclose said contacts and to receive a cable connector in the top opening with the contacts of said cable connector in conductive engagement with the contacts of said connector member;

a cable including a plurality of wires, each attached respectively to one of said press fitted contacts on the opposite side of said substrate from said insulative housing; and

a cable hood attached to said substrate and enclosing said wires and their respective points of attachment.

12. A plurality of stacked, interconnected printed circuit substrate arrays comprising:

a plurality of insulative substrates arranged in parallel planes and spaced from one another a preselected distance;

a plurality of longitudinally spaced contact receiving hole arrays in each of said substrates, each of said holes being plated and in electrical connection with circuitry on said substrate, said hole arrays lying along linear paths of predetermined length, each path being opposite to a path on a parallel adjacent substrate;

a plurality of contacts press fitted into the holes in each of said substrates, said contacts each including a contactor portion resilient in a direction transverse to said linear paths lying along said hole arrays, the contacts on one substrate extending toward an adjacent substrate;

an insulative receptacle housing placed down over to substantially enclose the press fitted contacts on a first one of said plurality of substrates and extending toward said spaced parallel adjacent substrate, said receptacle housing having bottom openings of sufficient size to receive the contactor portions of said contacts and a top opening to receive an interconnecting plug member, said receptacle housing having substantially planar inner wall surfaces extending parallel to said linear paths lying along said hole arrays and spaced from any engagement with the rear portions of said receptacle contacts;

an insulative plug housing placed down over to substantially enclose the press fitted contacts on a second one of said plurality of substrates and extending toward said spaced, parallel adjacent substrate and in alignment with said receptacle housing, said plug housing having bottom openings of sufficient size to receive the contactor portions of said contacts, and a top opening surrounding a central rib, said central rib having substantially planar inner wall surfaces extending parallel to said linear paths lying along said hole arrays and spaced from any engagement with the rear portions of said plug contacts, said plug and receptacle members being interengagable by inserting the central rib of said plug into the top opening of said receptacle to receive the receptacle housing into the top opening of said plug housing and electrically connect circuitry on said adjacent substrates by bringing the respective plug and receptacle contacts into generally parallel, facing electrical engagement along a line parallel to said linear hole arrays and spaced from the inner wall surfaces of both said plug and said receptacle housings with the forces of engagement between contacts being in a direction perpendicular to said line of engagement.

13. A plurality of stacked, interconnected printed circuit substrates as set forth in claim **12,** wherein:

said substrate arrays comprise at least three substrates;

each substrate includes a housing enclosed array of contacts projecting toward the surface of a parallel adjacent substrate; and

each housing and contact array is interconnected with a mating housing on the adjacent substrate to electrically couple each of the substrates in said stack.

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