United States Patent [19]

Witte et al.

[11] **3,885,850**

[45] **May 27, 1975**

[54] **CONTROLLED RETENTION FORCE CONNECTOR WITH DETENT**

[75] Inventors: **Roy Witte,** Rolling Meadows; **Edward Kirby,** Morton Grove; **George Mack,** Roselle, all of Ill.

[73] Assignee: **TRW Inc.,** Cleveland, Ohio

[22] Filed: **Mar. 5, 1973**

[21] Appl. No.: **338,332**

[52] **U.S. Cl.**..... **339/91 R;** 339/184 R; 339/196 R; 339/253 R

[51] **Int. Cl.**..... **H01r 13/54**

[58] **Field of Search**..... 339/74, 75, 91, 176, 184, 339/186, 191, 192, 195, 196, 253

[56] **References Cited**

UNITED STATES PATENTS

1,157,026	10/1915	Meschenmoser	339/184 R
1,376,068	4/1921	Benjamin	339/176 S
2,002,558	5/1935	Von Holtz	339/74 R
2,093,677	9/1937	Hickman et al.	339/176 S
2,704,831	3/1955	Smith	339/91 R
2,997,687	8/1961	Walter	339/91 R
3,004,235	10/1961	Cohen	339/186 M
3,316,521	4/1967	Fletcher, Jr.; et al.	339/186 M

FOREIGN PATENTS OR APPLICATIONS

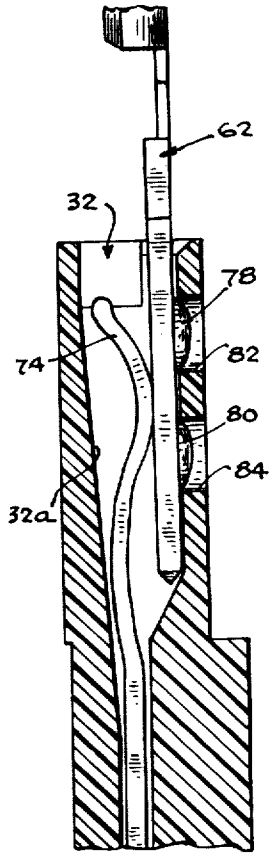
1,029,090	5/1966	United Kingdom	339/184 M
1,202,348	8/1970	United Kingdom	339/184 M

Primary Examiner—Joseph H. McGlynn
Attorney, Agent, or Firm—Lawrence S. Cohen

[57] **ABSTRACT**

A connector assembly with male and female elements in assembly to define electrical contact between predetermined circuits the female element having one element of a detent securing means thereon in the insulating body thereof with the contact elements of the male element having a mating detent securing means to join with the detent securing means of the female element to secure said elements in assembled relation with a force sufficiently high to prevent unintended separation.

30 Claims, 16 Drawing Figures



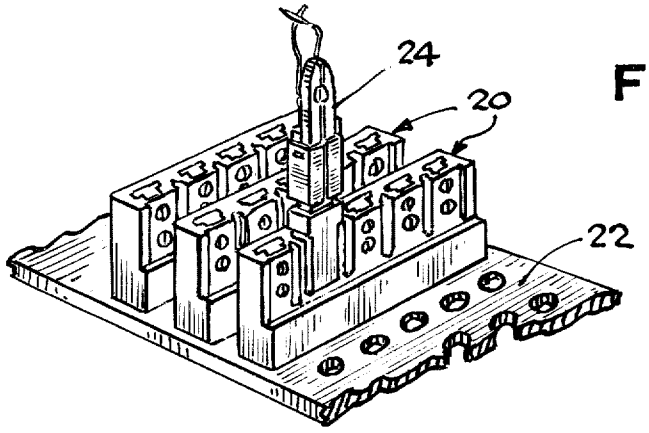


FIG. 1

FIG. 3

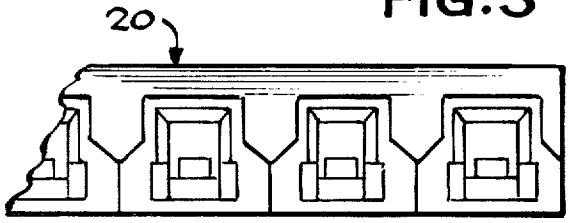


FIG. 4

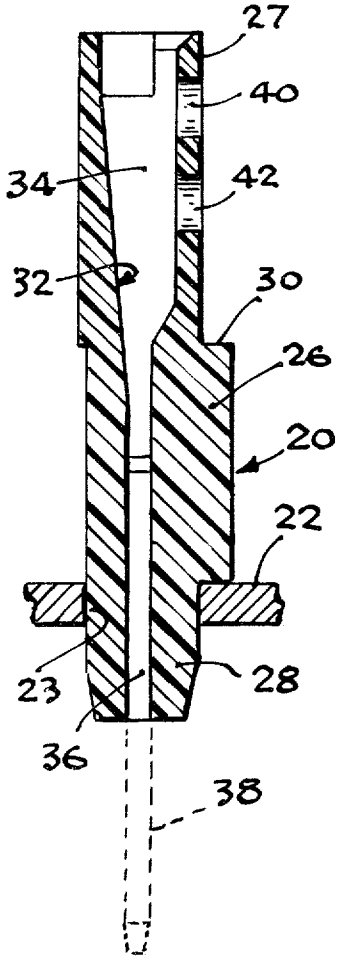


FIG. 2

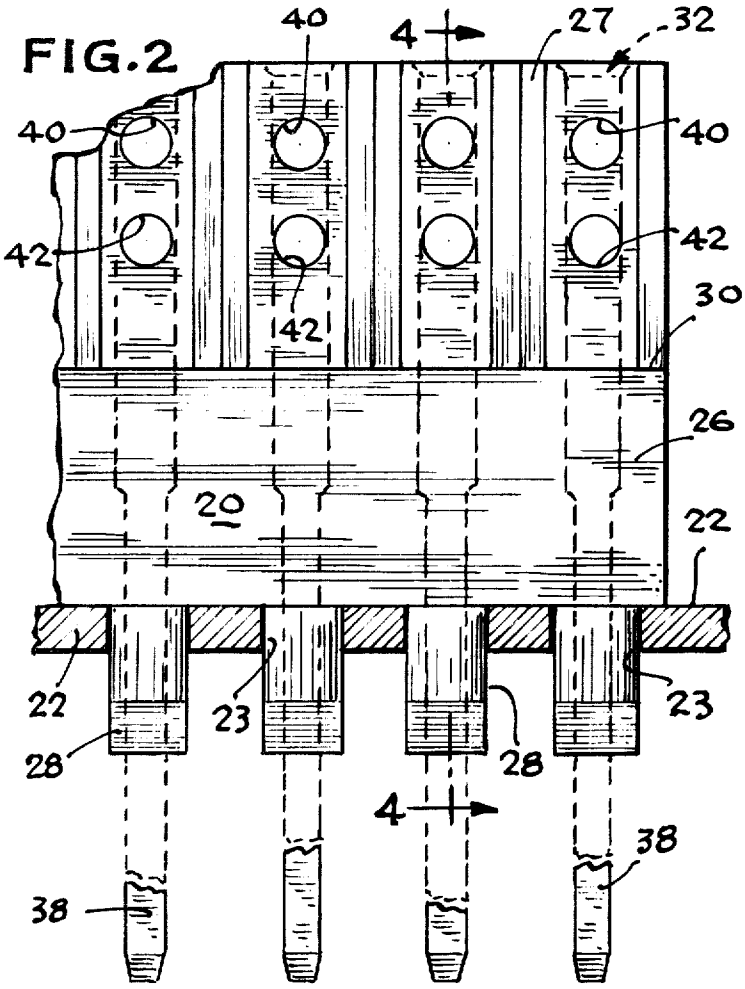


FIG.5

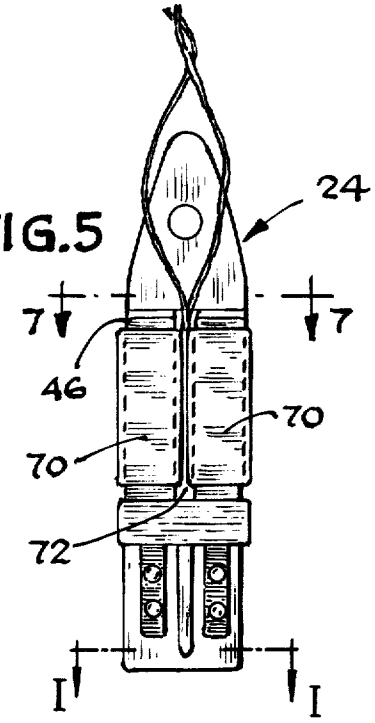


FIG.7

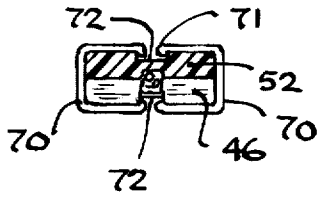


FIG.6

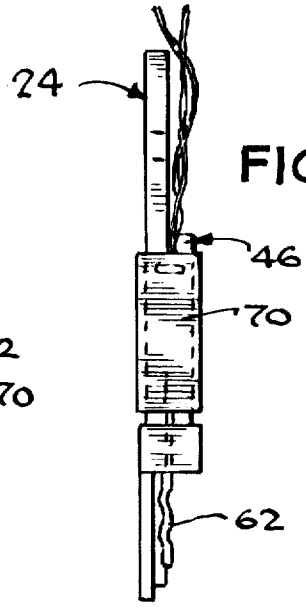


FIG.8

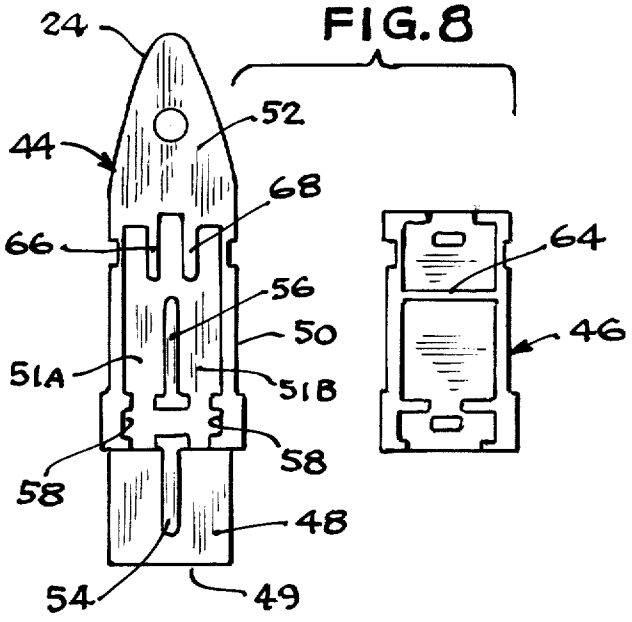


FIG.9

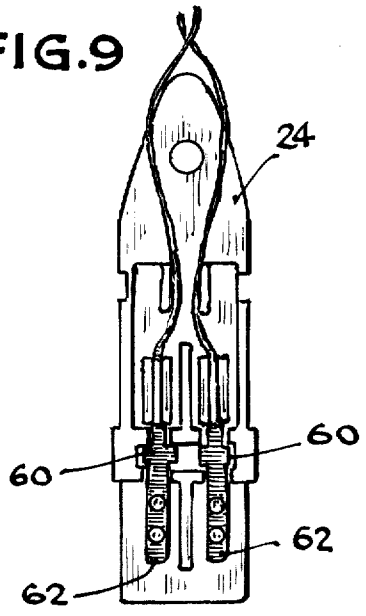


FIG. 10

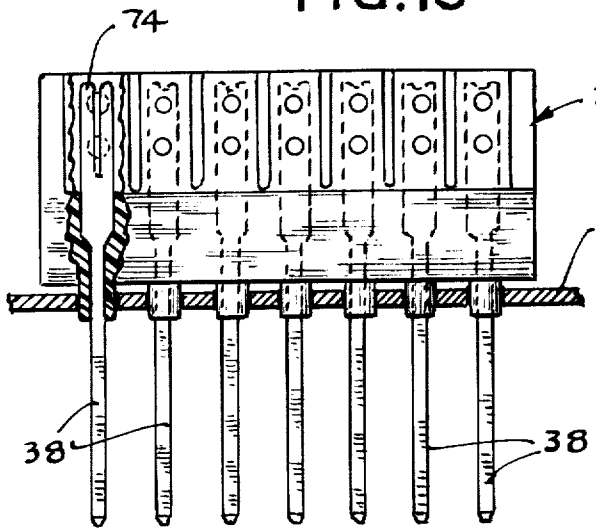
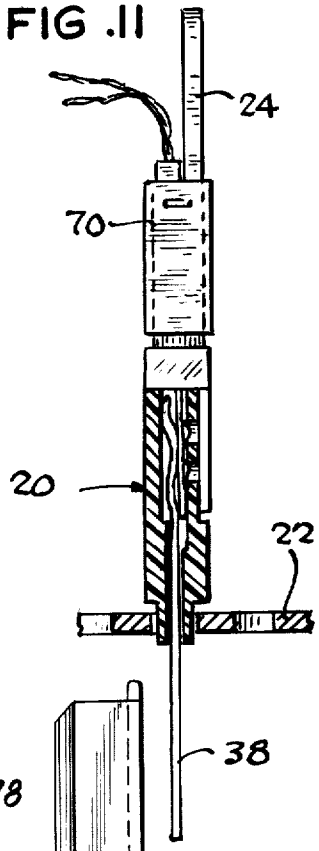


FIG. 11



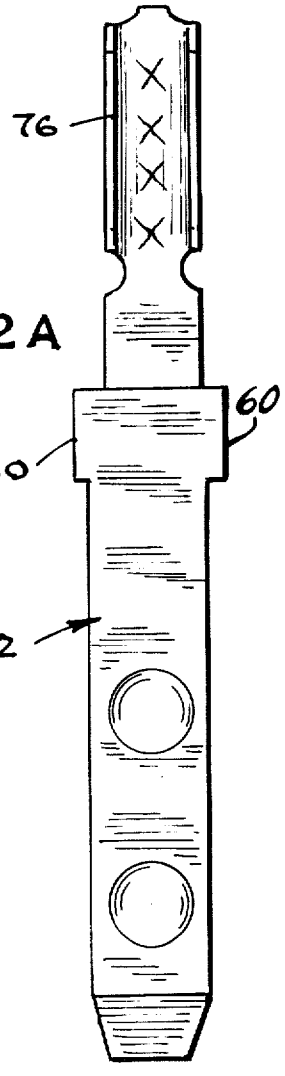


FIG. 12A

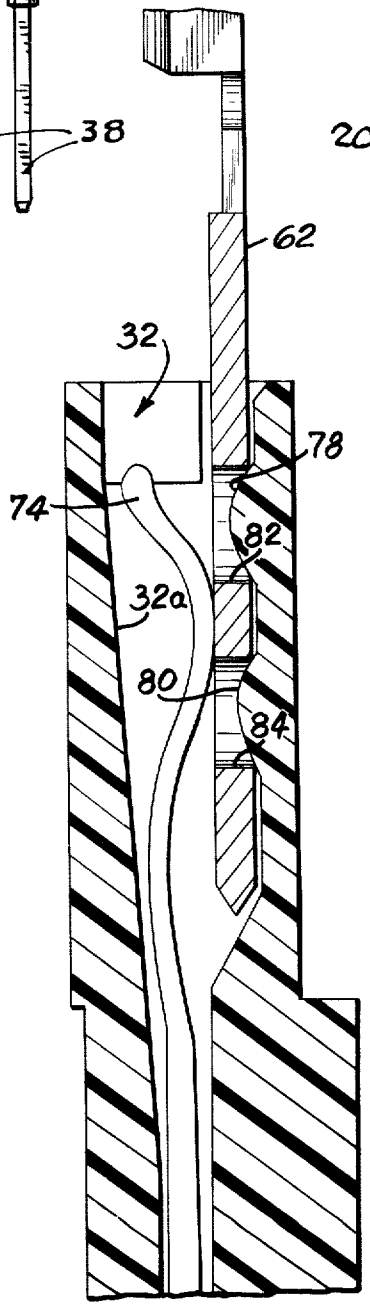


FIG. 16

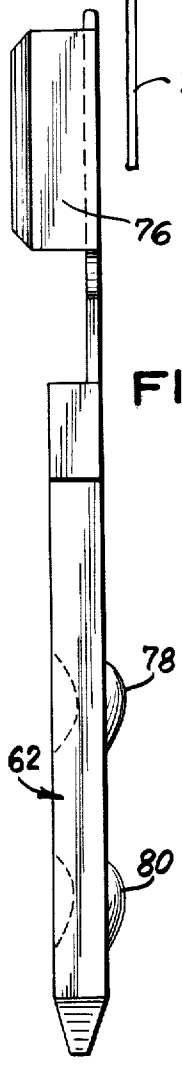
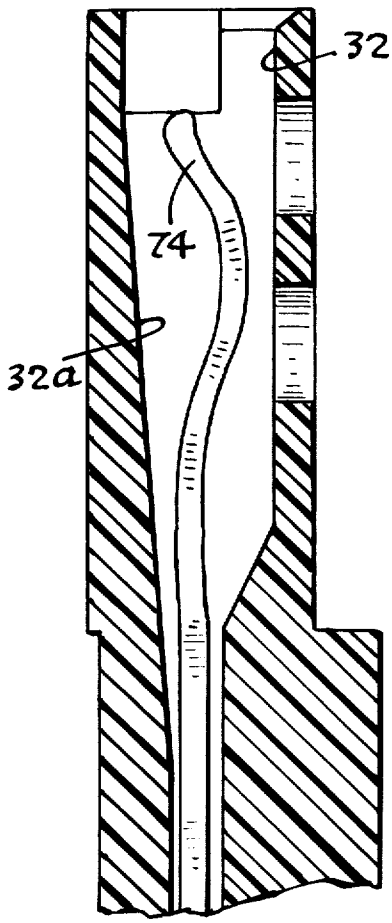


FIG. 12

FIG. 13



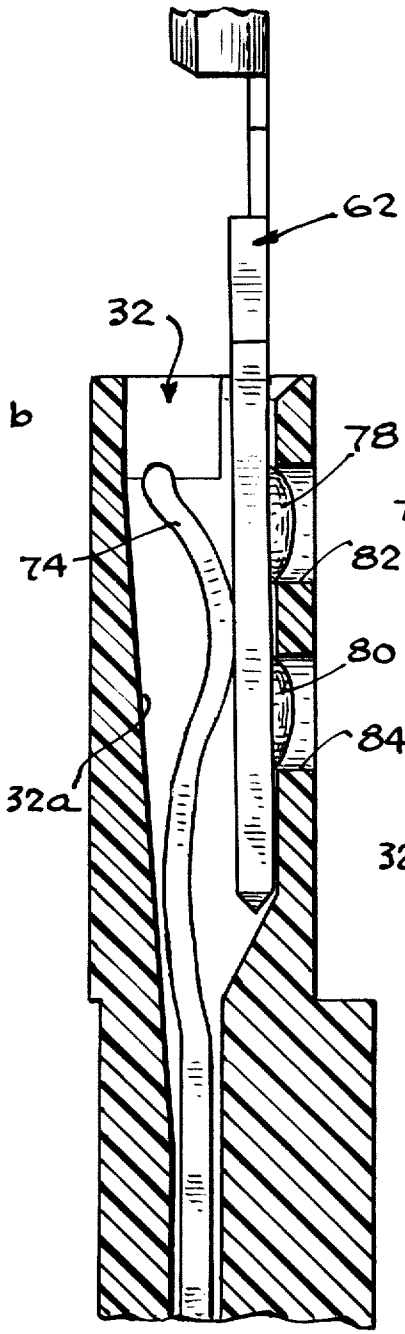


FIG. 14

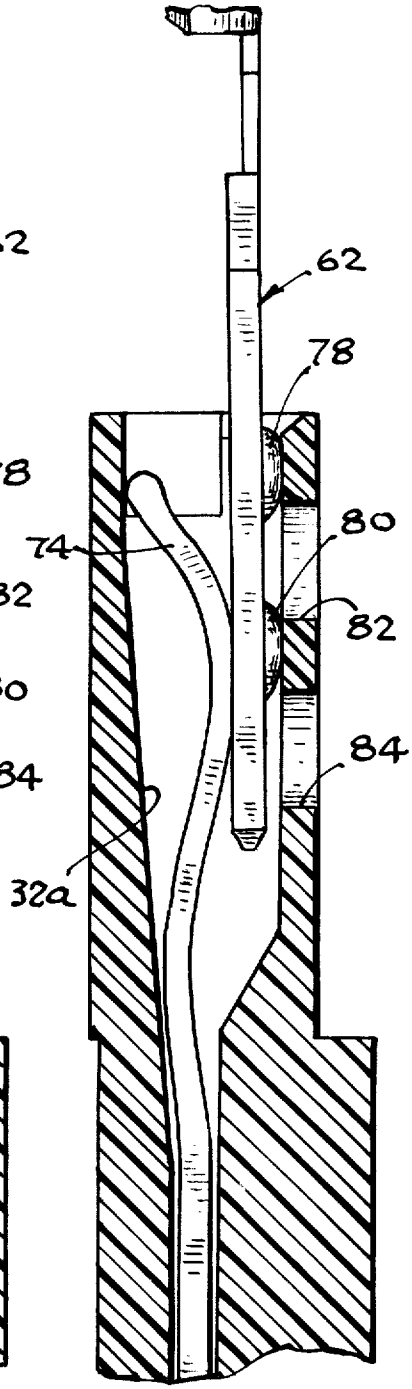


FIG. 15

CONTROLLED RETENTION FORCE CONNECTOR WITH DETENT

The present invention is related to an improved connector assembly and more particularly to a connector assembly having detent retention means to hold the elements of the assembly securely in assembled relation with a predetermined force.

Function or connector assemblies generally are extremely varied and many types are common with regard to means to define electrical continuity between circuits to be joined. It should be noted, however, that there are significant problems in the functional aspects of interconnections of various circuits that require the application of varied structural concepts to define means for positive control of the variable encountered in the manufacture and use of said connector assemblies.

Wires in a functional circuit may commonly be joined with a simple splice. It also is recognized that there are numerous concepts and structures in existence for the joinder of functional circuit elements.

The present invention is directed to the provision of an improved connector assembly wherein the assembly is securely held in assembled relation until a disconnect is deliberately made. Many prior art connector assemblies are of the type which rely upon frictional engagement between the male and female contact elements of the connector assembly. This, generally, includes some problems in that the contact areas are directly involved in the mechanical interengagement necessary to maintain integrity between the circuits. This, of course, dictates that the contact elements be brought into greater physical contact than would be necessary to assure circuit continuity. The additional mechanical force required results in increased wear of the contact surfaces and in increased probability of failure in use.

In addition to the above difficulties it must be noted that contact wear directs a limitation on physical contact and, therefore, the force securing the members in assembled relation must be limited. Accordingly, connector assemblies of this type usually may easily be disconnected.

The concept disclosed herein does not rely upon contact-to-contact engagement to hold the elements in assembled relation. The concept does provide for a positive, controllable locking force to prevent unintended disconnect.

The concept set forth herein is preferable to the use of assemblies requiring frictional engagement between contact elements to assure contact and assembly. It should be noted that when you require frictional engagement between contact elements you will experience some degree of wear. There is a relatively small contact area on the so-called miniature connectors employed in circuits commonly in use and the small area and high contact force combinations are highly undesirable.

Another desirable aspect of the concept set forth herein resides in the fact that the connector assemblies may be arranged such that connection may be made only in the manner desired to avoid circuit confusion. This, of course, is characterized as polarization wherein the male element may be inserted into the female in only one mode.

An additional characteristic of the present concept may be noted in the fact that the connector elements

of the assembly are held in assembled relation even though the elements may be rocked or pivoted with respect to each other, due to the unique construction and inter-relation of the elements of the assembly.

It is, accordingly, a general object of the inventive concept set forth herein to provide an improved connector assembly wherein the elements of the assembly are secured in assembled relation by a unique detent means in the assembly.

Other objects and advantages of the invention reside in the provision of an improved connector assembly wherein the contact element of one unit of the assembly is physically locked to the insulating body of the other element of the assembly; wherein a detent means is employed to hold the units of the assembly in secured inter-relation; wherein detent locking means is provided which will secure the assembly even when units are pivoted with respect to each other; which is economical to manufacture, easy to use and readily repairable, maintained or modified in use.

The novel features which are believed to be characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, together with further objects and advantages thereof will best be understood by reference to the following descriptions taken in connection with the accompanying drawings, in which:

FIG. 1 is a fragmentary view, in perspective, of a connector assembly as set forth herein illustrating the mounting of female connector units on a mounting board and a male connector unit associated therewith as an illustrative embodiment;

FIG. 2 is a side elevation, in section, of the assembly of FIG. 1 showing the female units;

FIG. 3 is a fragmentary top view of a portion of one array of female units showing the skirt and rib of the male connector unit in section through I—I of FIG. 5;

FIG. 4 is a side elevation, in section, of one female connector unit;

FIG. 5 is a front elevation of the male connector unit of the assembly illustrating the smoothly shaped top portion, depending skirt and body section joined to top and skirt portions;

FIG. 6 is a side view of the unit of FIG. 5;

FIG. 7 is a view taken along lines 7—7 of FIG. 5;

FIG. 8 is a view of the male connector unit of FIG. 5 showing the sub-elements of the connector unit in an exploded view;

FIG. 9 is a view of one portion of the male connector unit of FIG. 5 with the cover removed showing the male contact elements in assembled relation therein with the electrical leads extending from the contact elements and upwardly of the unit;

FIG. 10 is an elevation of the female connector unit assembly showing an array of female connector units with the female contact elements in assembled relation therein and with the wire wrap tails extending below the mounting board of the assembly;

FIG. 11 is an illustrative view of the assembly of the present invention showing the male and female connector units in assembled relation on the mounting board;

FIG. 12 is an enlarged view of the male contact element illustrating the detents extending from the contact portion of the element;

FIG. 12A is a front view of the male contact element illustrated in FIG. 12;

FIG. 13 is a substantially enlarged, sectional fragmentary illustrative view of the female connector unit of the present invention showing the configuration of the upper portion of the female contact element as disposed in the insulating body of the female connector unit;

FIG. 14 is an illustrative view of the female and male contact elements in assembled relation in the embodiment of the inventive concept set forth herein;

FIG. 15 is a view of the connector elements set forth herein disclosing the force application during assembly during the male connector unit into the female connector unit of the device set forth herein.

The present invention is directed to the provision of an improved electrical connector device which is adapted to define continuity or electrical contact between selected electrical circuits wherein high retention forces are defined between mating connector units of the assembly to secure them in assembled relation and to prevent unintended separation of the units of the connector assembly.

As noted above, many connector assemblies have been provided for defining circuit continuity. Most of these assemblies rely upon frictional engagement of the contact elements associated with the male and female units of the assembly. It must be acknowledged that such engagement gives rise to a condition wherein considerable wear will occur on the contact surfaces of the contact elements. In the miniature contact elements disclosed herein the contact area itself is relatively small so that a high retention force required to assure integrity of the circuits in assembled relation will give rise to significant wear of the surfaces of the contact elements during use.

In the following discussion, certain forces will be mentioned as relating to mating of male and female units. Normal forces refer to the pressure of one contact element against another and are generally perpendicular to the axis or direction of insertion. Referring to FIG. 15, the normal force is left to right, and the axis or direction of insertion is up and down. Normal force can and does contribute to securing against unintended disassembly, but is more importantly related to maintaining electrical contact. The limits of normal force are dictated by considering the force necessary to maintain electrical contact against the force which would wear the elements and especially the plating by friction, galling and abrasion.

The axial force also referred to as the retention force is established in consideration, for example, of the size and weight of the elements, the direction of mounting when gravity is a factor, the risk and consequences of accidental disassembly. The assembly herein relies upon means separate from the normal force of the contact elements to provide resistance to axial movement.

It has been noted that a minimum normal contact force between connector elements of approximately 100 grams should be maintained as a desired level of interengagement to assure that the units will be maintained in assembled relation. This level of force, of course, is difficult to assure or secure at all times. Generally, a range is set at somewhere between 100 grams and 400 grams as the force level to be maintained in securing male and female connector units with respect to each other. The 400 gram upper limit is the upper extent defined at which the wear on the contact elements will be excessive and is a level which preferably should not be exceeded. It should be noted that contact elements of the type noted herein generally are plated with a gold metal and removal of this surface will result in exposure of the brass base metal. It is well noted that oxidation of copper, one of the elements of the brass alloy, results in production of an oxide which is a dielectric material that, of course, is nonconductive. Accordingly, excessive frictional engagement which would result in removal of the gold surface on the contact element would be undesirable.

The structure of the present invention involves a means for securing the male and female connector units of the assembly in assembled relation by a metal-to-plastic inter-engagement of the units. Devices have been developed which involve the locking of one unit to the other by engagement of the insulating bodies of the male and female unit. These devices have involved structures wherein a shelf or latch on one unit engages an undercut or mating shelf in the opposing unit to provide for engagement of said units. These devices have some deficiencies in that the plastic itself may be broken or in that the structure is relatively fragile in view of the necessity of keeping the engagement pressures sufficiently low to provide for easy removal when desired.

Normally, the retention force desired to secure the male and female connector units of the assembly can vary from a very small force up to, for example, 12 pounds depending on the application as mentioned above. Normally a range of about 8 to 12 pounds will be appropriate. With the present invention, in miniaturized applications such as telephone back panels, a range of 5–10 pounds is accomplished. This retention force level assures that the male and female units of the assembly will be maintained in assembled relation until they are deliberately separated. Usually, the forces encountered during working on the assembly by accidental force application to the unit will be substantially less than the level noted herein.

Referring more particularly to the drawings the inventive concept is illustrated generally in FIG. 1 of the drawings with the female connector units **20** illustrated in assembled relation on the mounting board **22** of the assembly. A male connector unit **24** is illustrated in assembled relation to the female connector unit **20** of the assembly to define circuit interconnection between circuits associated with the respective units.

The connector assembly of the present invention may, of course, be employed to join any electrical circuit. However, the assembly is particularly useful for joining circuits utilized in the communications field and particularly in the telephone communications field. It is well known that in the telephone communications field circuit interconnections of the type noted here are made by the millions. Accordingly, any concept which may be economically utilized to make these connections is highly desirable. In the telephone communications field, and particularly on the so-called back panel assemblies, the wires leading from one connector to another generally are placed in an enclosed channel for protection and for reasonable organization of the area so that thousands of wires are not loosely disposed in the area. When a plug assembly is changed the plugs must be pulled through these channels by the wires. It can readily be seen that the smoothly contoured, teardrop shape of the upper portion of the male connector

unit 24 is highly desirable for moving the plug through a conduit box where there are a number of other wires. A plug having sharp edges would very likely be caught in the number of wires in the conduit box whereas the smoothly contoured shape of the plug assembly set forth herein may smoothly be pulled through.

The female connector unit 20 of the assembly is defined by an insulating body 26 which may be made from any suitable plastic material. One such material would be a glass filled nylon. However, it should be noted that any suitable thermoplastic may be employed other than the material specifically noted above. The insulating body 26 includes a lower portion 28 which is adapted to be received within openings 23 of the mounting board 22 for positioning and mounting of the female connector units 20 with respect to the mounting board 22. The remainder of the insulating body 26 of the female connector unit 20 extends above the mounting board 22 as schematically illustrated in FIGS. 2 and 4.

The insulating body 26 is provided with a shoulder or ledge 30 at approximately mid section of the unit 20. A row of openings indicated generally at 32 extend through the insulating body 26 of the female connector unit 20 to receive and secure a female contact element therein and to accomodate insertion of the male contact element within the insulating body 26. The upper portion 34 of the opening 32 is substantially larger than the lower portion 36 thereof. The male contact element is placed into circuit contact engagement with the female contact element in the upper portion 34 of the opening 32. The female contact element (described below) may be provided with a conventional wire wrap tail or post which extends through the lower opening 36 and is secured therein and extends for a predetermined distance beyond the lower terminal of the portion 28 of the connector unit as schematically illustrated at 38.

In the specific embodiment of the connector assembly set forth herein the insulating body 26 of the female connector unit is provided with a pair of openings 40 and 42 extending through the longitudinal wall 27 of the insulating body with the axis of the openings 40 and 42 being generally normal to the general longitudinal axis of the female connector unit 20. It should be noted that any number of openings similar to the openings 40 and 42 may be provided in the structure for the purpose set forth herein below. However, for purposes of illustration of the inventive concept set forth herein the illustrative embodiment includes just the pair of openings to describe the principle involved.

The male connector unit 24 is defined as a two-part structure including a first portion 44 and a second portion 46. The portion 44 of the male connector unit 24 includes a depending skirt section 48 a central body 50 and an upper gripping area 52. The male connector unit insulating body is made from any simple plastic resin or other dielectric material appropriate for this purpose.

The lower skirt portion 48 of the unit 24 is provided with a polarizing rib 54 which extends outwardly from the face of the skirt and terminates at a point spaced from the bottom terminal 49 of the skirt 48. The polarizing rib 54 is provided to assure proper orientation of the male connector unit 24 with respect to the female connector unit 20, as noted below.

The central body area 50 of the male unit 24 is provided with a predetermined recessed configuration schematically illustrated in the left portion of FIG. 8 of the drawings. The recess 51A is adapted to receive a male contact element therein as illustrated generally in FIG. 9 while the recess 51B is adapted to receive a mating male contact element again as illustrated in FIG. 9 of the drawings. An elevated rib section 56 extends between the recesses 51A–51B to provide a barrier between the terminals disposed therein so that an electrical path will not be defined between the two terminals or the electrical leads associated therewith.

Any convenient means may be employed for capturing the male contact elements within the insulating body of the male connector unit 24. In the present instance recessed portions 58 are defined within the insulating body in the central area 50 to receive the shoulder portions 60 of the male contact elements 62 of the assembly. It can readily be seen in viewing the illustrative drawing of FIG. 9 that the male contact element is placed into the recesses 51A and 51B of the insulating body of the male connector unit 24 with the shoulders 60 resting within the recess 58 to position and capture the male contact elements 62 with respect to the insulating body. When the second portion 46 of the connector unit 24 is placed over the portion 44 the male contact elements 62 will be captured within the recesses 51A–51B and securely held in assembled relation in the male connector unit 24. The portion 46 is provided with a transverse rib 64 which extends across the area "y" of the first portion 44 when the portion 46 is in assembled relation with the portion 44 of the male connector unit 24. It can readily be seen that the leads which extend from the male contact elements 62 of the unit 24 will be captured between the rib 64, the first portion 44 of the unit 24 and the downwardly projecting rib sections 66 and 68 of the portion 44. Capturing of the electrical leads in this manner defines a means for isolating any application of force to the leads externally of the plug at this point and transfers the force or load on the leads to the insulating body of the male connector unit 24 rather than to the juncture of the leads with the male contact elements 62. This, of course, is important in that the application of a force to the leads if transferred to the male connector elements 62 would very likely result in the leads being physically pulled out of engagement with the elements 62 to terminate the physical and electrical contact defined there between. The concept disclosed herein provides for a so-called strain relief means in this respect in that the force application to the leads is transferred fully to the insulating body where it can readily be absorbed and the male connector unit 24 can be removed from female connector unit 20 by simply pulling on the leads extending from the male connector unit 24. Generally this type of removal of the male unit would not be recommended but in this instance the units are relatively small and it is much easier to withdraw said units by pulling on the leads when necessary. Accordingly, the present structure provides for absorption of any force on the leads by the insulating body so that the limiting factor will not be the juncture between the leads and the male contact element 62 but rather the tensil strength of the leads themselves.

The portions 44 and 46 of the male connector unit 24 are joined together in manufacture by any suitable welding process such as ultrasonic bonding, ther-

mobonding, cement, or the like. One of the advantages of the structure set forth herein, however, is that it is repairable in the field. That is, the sections **44** and **46** may be separated by interruption along the welded seam to remove the section **46** from assembled relation with section **44** so that the contact elements **62** or the electrical leads may be repaired or replaced as required. This is an aspect of flexibility of devices here noted which render the assembly adaptable to any modification in use. It would, of course, be difficult to utilize ultrasonic bonding to re-weld the parts after the modification or repair has been made. Accordingly, field repair kits are separately provided for reassembly of the elements **44–46** of the male connector unit. This is a simple and straightforward approach which involves the use of U shaped channel members **70.** The channel members **70** are provided with inwardly extending short projections at the open ends thereof. The projections **71** are adapted to be received within grooves defined in the central portion of the outer walls of the sections **44** and **46.** Accordingly, the members **70** are simply telescopically received over the assembled members **44** and **46** and placed into position so that the inwardly extending projections **71** extend into the grooves **72** thereby holding the sections **44** and **46** in assembled relation without the need for welding or bonding of the sections after repair. These metal clips **70** may be provided as a part of a repair or maintainance kit for the user of these devices.

The female connector unit **20,** mounting board **22** and female contact elements **74** with associated wire wrap posts **38** are shown in assembled relation in the schematic illustration of FIG. **10** of the drawings. The female contact elements **74** may be captured within the opening **32** of the female connector unit **20** by any suitable means for this purpose. The wire wrap tails **38,** of course, extend substantially below the surface of the mounting board **22** to provide access for wrapping of electrical leads around the posts defined thereby as is known in the art.

The assembly of FIG. **10** is shown in combination with the male connector unit **24** in the schematic illustration in FIG. **11** wherein the male and female contact elements are in electrically defined inter-engagement to define circuit continuity between the circuit associated with the male unit **24** and the circuit associated with the female unit **20.** It can be seen from the drawing of FIG. **11** and illustrated in better detail in the drawing of FIG. **14** that the shaped projections on the lower portion of the male contact element **62** extend into the openings **40** and **42** of the female connector unit **20.** The action and function of this will be described in detail below.

The male contact element is schematically illustrated in enlarged form in the drawings of FIGS. **12** and **12A.** As illustrated, the male contact element **62** includes, as noted above, the shoulders **60** extending from either side thereof as illustrated in FIG. **12A** (front view). The upper portion of the male contact **62** defines a generally U-shaped section which is adapted to receive the electrical lead to be secured thereto. The U-shaped section **76** is provided for the purpose of physically securing the electrical lead thereto. It can readily be seen that the lead is placed within the cradle defined by the section **76** and the legs of the section **76** then are folded over or wrapped about the lead disposed within the cradle defined thereby to physically capture the lead and to establish electrical contact between the lead and the conductive male contact element **62.** It should observed, of course, that insulation which may be disposed about the lead must be removed prior to placing the lead within the cradle defined by the U-shaped section so that electrical contact will be secured. The lower portion of the male contact element **62** is provided with formed protrusions extending outwardly from the general planar surface of the contact elements as seen at **78** and **80** in FIG. **12.** These protrusions **78** and **80** may take any particular shape desired to provide the pre-determined retention force required for the assembly. In the particular form shown they are characterized by an assymetrical shape which is generally smoothly arcuate at the lower portion thereof and flows into a sharply angled portion at the upper section thereof. The smooth, shallow lower portion permits ease of entry of the male contact element into the openings **40** and **42** of the insulating body of the female connector unit **20** while the sharply defined radius of the upper portion of the protrusions **78** and **80,** respectively, provide for the desired locking or retention force of the male contact element **62** with respect to the insulating body **26** to define the desired retention force for the related assemblies.

The protrusions **78–80** in the male contact elements **62** may be defined during the forming operation of the elements **62** by stamping, pressing, or any other suitable means for displacing the metal of the contact elements **62** slightly outward as schematically illustrated in the drawings.

The male and female connector units of the assembly are placed in assembled relation in conventional fashion by bayonet insertion of the male unit into the opening in the insulating body of the female connector unit as is commonly known in the art.

Connector assemblies generally are held in assembled relation by engagement of the male and female contact elements of the assembly. That is, the frictional engagement between male and female contacts defines the force holding the male and female connector means together. In such instances it is essential to keep the contact pressures relatively light since galling or abrading of the surface of the contact elements may otherwise occur. Generally, contact elements of the type noted here are employed in areas where it is desired that they maintain circuit integrity and not be subject to chemical detioration when exposed to ambient conditions. Accordingly, the contact surfaces usually are gold plated to define a relatively chemically inert surface in use. Excessive contact engagement forces will, of course, result in abrasion or galling of the gold from these surfaces and the precautions taken in placing this surface on the contacts will be negated. Usually the thickness of the gold on the contact surfaces is in the range of 30 to 100 millionths of an inch, depending upon the particular application involved, the connector, the normal life of the unit, and various other factors. It can readily be seen that this surface thickness may readily be removed if abused.

If the protective gold plating is removed an oxide of the alloy employed in manufacture of the contact elements will develop upon exposure to the atmosphere. This oxide, in effect, is a dielectric and this condition must be avoided.

In view of the problems with metal-to-metal engagement of connector elements other means have been de-

vised for holding the elements in assembled relation. Some of these developments involve physically clamping the elements together; use of the insulating bodies to secure engagement; and other related mechanical devices or means for defining assembly.

The device set forth herein involves, as noted, the use of protrusions on the male contact elements the protrusions being in the form of smoothly flowing extensions so that no sharp edges are presented in assembly of the connector elements. Basically, the concept set forth involves use of a wedge means to secure the elements in assembled relation. The disadvantage of a wedge, per se, or any other sharply defined member involves the tendency that would arise to tear or rend the insulating body in removal of one connector element from the other. The smoothly flowing form of the concept set forth herein avoids this problem by providing a smooth surface which rides over the insulating body or any other body in the path of insertion and removal of the contacts.

The assymetrical shape of the projections **78** and **80** was selected to provide the smoothly contoured surface necessary to avoid injury to any of the parts over which the projections move and the sharply curved portion to define the "wedge" conformation to lock or secure the mating elements in assembled relation.

It should be noted that the shape of the projections **78** and **80** may be varied as desired to provide the necessary locking force for the mating elements. The projections, for example, may be in the form of a portion of a sphere, rather than assuming the assymetrical shape illustrated. The radius of the portion of the sphere may be varied to adjust the retention force. The proper radius or shape would be a function of the retention force required and of the form necessary to avoid injury to any members contacted by the projections.

As noted above, the connector assemblies are designed to provide a normal force in the range of 100 to 400 grams. The minimum force of 100 grams would be desirable as a sufficient force to assure maintenance of electrical contact while minimizing wear characteristics. However, manufacturing tolerances and requirements for the production of units of this type on a mass basis while providing for a unit that is economical to manufacture and to use led to the development of an upper limit of about 400 grams for the normal force. Accordingly, a force of 100 grams is desired and in the range to assure good electrical contact between the elements. A force over 400 grams would increase wear on the contact elements to an unacceptable level.

The projections or protrusions **78** and **80**, when in assembled relation are received within the openings **82** and **84** defined in the insulating body, as illustrated in FIG. **14** of the drawings. When the projections **78** and **80** are disposed within the openings **82** and **84** the mating contact element **74** will apply the locking force to keep the projections within the openings as schematically illustrated in FIG. **14**.

Two projections and openings are employed in the connector assembly defined herein instead of one with a large projection in that only a small deflection is required upon insertion or removal in contrast the larger deflection that would occur with a single, large projection. Accordingly, if the connector element is rocked or rotated at least one of the two projections must always be in locking engagement with the associated opening in the insulating body to assure maintenance of the assembly. It is not possible to disengage both the projections at the same time with a rocking movement or by rotation. Both elements may be disengaged deliberately, of course, upon application of an axial force to affect removal of the male connector element from the female connector element. It should be noted also that the projections **78** and **80** are preferably positioned in relation to the point of application of force of the female element **74** such that they are between the projections.

Insertion of the male connector unit into the female connector unit, as noted above, is accomplished by placing the male contact elements **62** within the openings **32** defined in the female contact elements **20.** The male contact, in the form illustrated herein, is provided with projections **78** and **80** and the unit is inserted such that the projections extend into the openings **32** along the wall within which the openings **82** and **84** are defined. The openings **83** and **84** are generally circular as illustrated but may be of any appropriate geometric configuration as long as the top portion of the opening defines means against which the upper portion of the projections **78** and **80** may rest to secure the elements in assembled relation.

As the male contact element is inserted into the opening **32** it will come into contact with the arc-like projection on the female contact element **74.** In a static, undisturbed state the female contact element **74** is positioned as schematically represented in FIG. **13** with the free end of the element in spaced relation to the wall **32***a* of the recess **32.** When the male contact **62** engages the female contact **74** it will be deflected toward the wall **32***a* to provide room in the opening **32** for the male element to clear the wall **32***b*. This deflection arises because the projections **78** and **80** move the elements **62** and **74** toward the wall **32***a* so that the projections will clear the wall **32***b* upon insertion. When the male element **62** is in position illustrated in FIG. **15,** the female contact element **74** will be moved toward the wall **32***a* so that the free end of the element **74** will be in engagement with the wall and the arched projection of the element **74** will be slightly deflected rearwardly toward the wall **32***a*. The arc portion of the element **74** is provided as a means for holding the projections **78** and **80** within the openings **82** and **84,** as noted above. The transient insertion force should be less than the maximum level of force which can be tolerated by the contact elements before the gold surface coating is abraded by frictional engagement of the elements. The connector assembly defined herein is designed such that the normal force will be in the range of 100 to 400 grams and transient additional normal forces during insertion and removal should be of a level which will not exceed the slightly higher force which would result in impairment of the protective surface on the contacts. The deflection of the spring-like arch of the element **74** is adapted to accomplish this protective function in yielding to permit ease of insertion yet providing normal force loads when the units are in assembled relation to lock them in assembled relation.

After the projections **78** and **80** pass over the wall portions **32***b* they will drop into the openings **82** and **84** defined in the wall **32***b*. As the projections drop into the openings **82** and **84** the inherent characteristic of the female contact element **74** to return to an unstressed condition will force the male element **62** toward wall

32*b* and the projections **78** and **80** into the openings **82** and **84** to lock the projections within the openings. The retention force will be in the range of 5 – 10 pounds. The normal force, of course, contributes slightly to the retention force, but the detent action of the projections **78** and **80** in the recesses **40, 42** is the main factor. Some upward variation from the 5 – 10 pounds range may be observed.

In the embodiment illustrated herein a axial force of approximately **6** to **8** pounds will be required to remove the male connector unit from engagement with the female connector unit. It is necessary, of course, to cause the projections **78** and **80** to move out of engagement with the openings **82** and **84** of the female connector unit. To do this the female element **74** must first be moved toward wall **32***a* to permit the projections to clear the openings and move up along the wall **32***b*. Also the upper portion of the projections **78** and **80** define a frictional, locking engagement with the openings **82** and **84** such that a predetermined force must be exerted before they will begin to move after having overcome this retention force. Only after they begin to move out of the openings will the additional force application to deflect the element **74** be required.

Another characteristic of the inventive concept set forth herein resides in the fact that the connector assembly may be readily adapted to assure proper mating of male and female connector elements in the assembly. It can readily be seen that a large array of female units **20** may be mounted on the board **22**, each of the female units **20** having connector elements **74** therein associated with various circuit elements. It is essential, of course, to have the male connector elements **62** connected with the female connector elements **74** such that the appropriate circuit continuity is defined. Accordingly, the male elements may be connected to the female elements in only one way to realize the desired circuitry.

Since there are many thousands of connections made with this type of equipment it is important that some means be provided which will assure proper mating of the male units with the female. An array of male connector units may have **1, 2, 5, 10** or any suitable number of male contact units and associated insulating bodies in a single unit. One of the common problems in correctly connecting a circuit is known as "polarization", usually meaning that the plug may not be inserted incorrectly turned around. Polarization could also refer to the problem of stepping over one or more positions in a row, but in this discussion, it will only refer to turning around orientation. In the art, a polarized plug can only be inserted in the correct orientation. In the present invention, polarization is achieved by the rib **54** carried by the skirt **48** of the male connector body being received in the groove **81** of the female insulating body **20** as shown in FIG. **3**. The male unit cannot be incorrectly inserted because in such case the rib **54** would hit the upper edge of the female insulating body. The single male unit then is adapted for insertion into the female units of the assembly. To block or, isolate the assembly so that the male unit will be inserted in the position desired, an insulating body defining a gate may be slidably inserted between the female insulating bodies as schematically represented at B in FIG. **1** so that the male connector unit **24** when inserted against this gate will automatically be in the proper position to define the desired circuit. It should be noted that the gates B may be inserted in any slot or at any position in the assembly to define only one position in which a contact may be inserted thereby minimizing the possibility for error in positioning of the male element with respect to the female.

The gates, thus are helpful in blocking or insulating the assembly to control the position of the plug in the circuit.

It should be apparent that other modifications of the assembly illustrated herein may be employed without significant departure from the inventive concept disclosed herein. For example as shown in FIG. **16**, the projections **78** and **80** disclosed herein may be contained on the insulating body rather than on the metal contact with the openings **82** and **84** being defined in the contact elements so that the projections of the insulating body will be captured in the openings of the contact elements of the mating structure to lock the units of the assembly in assembled relation. It should be noted also that the number of projections and mating openings may be varied, as desired, to provide a predetermined locking force although preferably two or more projections would be desired for the reasons noted above. In addition to the above, other variations may be realized to accomplish the locking function with a pre-determined retention force. Such variations may involve changing the shape of the projections from a spherical configuration to some other geomectic shape such as a wedge or inclined plane.

While we have shown and described a specific embodiment of the present invention it will, of course, be understood that other modifications and alternative constructions may be used without departing from the true spirit and scope of this invention. We therefore intend by the appended claims to cover all such modifications and alternative constructions as fall within their true spirit and scope.

What we intend to claim and to secure by Letters Patent, is:

1. An improved electrical connector device adapted to define electrical contact between pre-determined electrical circuits wherein high retention forces are defined between the mating connector units of said device securing them in assembled relation to prevent unintended separation, the device comprising:

a female connector unit defined in part by an insulating body with said body having walls defining a row of spaced apart contact receiving recesses therein for receiving a male contact element in each recess along an insertion axis;

an electrical contact element mounted within each recess in said insulating body of the female connector unit;

the insulating body having associated with one of its walls which extends longitudinally of the row a plurality of discrete locking means in each contact receiving recess which are spaced apart theron along the insertion axis and adapted to interengage with locking means on a mating male contact element of the device, and

a mating male connector unit defined in part by an insulating body having at least one male contact element mounted within said body, said male connector unit adapted for mating operative engagement with said female connector unit by insertion along the insertion axis of a male contact element into a recess in the female insulating body to bring

the contact elements of each of said units into physical contact to define electrical engagement therebetween, a plurality of discrete locking means on the male contact element spaced apart along the insertion axis to interengage with the locking means on the insulating body of the female connector unit to define interlocking engagement therebetween and between said male and female units to secure them in assembled, mating relation.

2. The connector of claim 1 wherein the male and female units of the connector are held in locked, mating relation by the locking means with a predetermined retention force in the range of about 5–10 pounds.

3. The device of claim 1 wherein gates are adapted to be slidably inserted into slots within the female unit to define means for isolating the assembly wherein insertion of the male connector unit may be made in relation to said gates and in a predetermined manner to provide for the desired interconnection between circuits associated with the connector units.

4. The connector of claim 1 wherein each of the locking means of the female unit is a locking recess opening into each contact receiving recess to receive and capture the locking means on the mating male contact element.

5. The connector of claim 4 wherein each of the locking means on the male element is defined in the form of a projection adapted to be received within the locking recess of the female unit to hold the units in assembled relation.

6. The device of claim 5 wherein the locking means of the male contact element are defined by smoothly contoured projections.

7. The connector device of claim 5 wherein the female connector unit is provided with an electrical contact element in each contact receiving recess which has a portion in close spaced proximity to the locking recesses of the female unit for maintaining the male contact element toward the wall of the female insulating body which carries the locking recesses to cause the locking means of the male contact element to reside in the locking recesses.

8. The device of claim 7 wherein the plurality of locking recesses are defined by openings which extend through the wall of the insulating body of the unit.

9. The device of claim 7 wherein the plurality of projections on the male contact element are shaped to present an angled detent surface adapted to be received within the locking recess in the insulating body of the female unit to be captured therein with a predetermined force to assure maintenance of the assembly during use.

10. The device of claim 9 wherein the locking means of the male contact element are defined by hemispherical projections extending outwardly from one wall of the contact element and in spaced apart relation to be received within the locking recesses of the female connector unit.

11. The device of claim 9 wherein the locking means of the male contact element are defined by assymetrical projections having a smooth, flowing contour and extending outwardly from one wall of the contact element and in spaced apart relation to be received within the openings of the female connector unit.

12. The device of claim 9 wherein the portion of the female contact element in close spaced proximity to the recessed portion of the female unit is provided by defining an arcuate section in the female contact element extending within said recesses and wherein the apex of the arcuate section is disposed substantially at the midpoint between the recessed portions of the female unit.

13. The device of claim 12 wherein the arcuate section is pressed against the mating face of the male contact element when the elements are in assembled relation to define a normal force to hold the projections of the male element within the recessed portions of the female unit thereby defining a component of a predetermined retention force to hold the units in assembled relation.

14. The device of claim 5 further comprising means for urging the male contact element toward the wall of the female insulating body which carries the locking recesses to cause the projections of the male contact element to reside in the locking recess of the female insulating body.

15. The device of claim 14 wherein the means for urging the male contact element toward the wall of the female insulating body comprises a portion of the female contact element being in close proximity to the locking recess of the female unit and bearing against the male contact element which is between it and the wall of the female body.

16. The device of claim 14 wherein the projections on the male contact element are assymetrical presenting, relatively, fowardly a less steeply sloped surface and rearwardly a more steeply sloped surface.

17. The device of claim 14 further comprising a skirt depending from the body of the male connector unit toward the female insulating body and along the outside thereof, in a plane parallel to the male contact element.

18. The device of claim 17 wherein the male insulating body has a plurality of male contact elements mounted therein each for engagement with a female contact receiving recess, at least one of the male contact elements carrying the projections and wherein the skirt carries a rib engageable with a groove in the female insulating body whereby assembly is polarized.

19. The device of claim 1 wherein the locking means of the male contact element of the assembly is defined by recessed portions defined therein.

20. The device of claim 19 wherein the locking means of the female connector unit is defined by projections extending from the body of the unit and adapted to be in mating interlocking relating with the recessed portions in the contact elements of the male unit when the units are in assembled relation to lock said units in assembled relation with a predetermined force.

21. The device of claim 20 wherein the locking means of the female connector unit are defined by smoothly contoured projections.

22. The device of claim 20 wherein the female connector unit is provided with electrical contact elements which have a portion in close spaced proximity to the projections of the female unit.

23. The device of claim 22 wherein the portion of the female contact element in close spaced proximity to the projections of the female unit is provided by defining an arcuate section in the female contact element extending within said recesses and wherein the apex of the arcuate section is disposed at a point between the projections of the female unit, the arcuate section

adapted to be pressed against the mating face of the male contact element when the elements are in assembled relation to define a normal force to hold the projections of the female unit within the recessed portions of the male unit thereby defining a component of a pre-determined retention force to hold the units in assembled relation.

24. The device of claim **20** wherein the recessed poritons are defined by openings which extend through the male contact element.

25. The device of claim **24** wherein the locking means on the female contact unit are shaped to present an angled detent surface adapted to be received within the recessed portions in the male contact element to be captured therein with a pre-determined force to assure maintenance of the assembly during use.

26. An improved electrical connector device adapted to define electrical contact between pre-determined electrical circuits wherein high retention forces are defined between the mating connector of said device securing them in assembled relation to prevent unintended separation, the device comprising:

a female connector unit defined in part by an insulating body with said body having walls defining a row of elongated recesses therein,

an elongated electrical contact element mounted in each recess,

a mating male connector unit defined in part by an insulating body having at least one elongated male contact element mounted on the male connector unit, said male connector unit adapted for mating operative engagement with the female connector unit by insertion of the male contact into the recess in the female insulating body to bring the contact elements of each of said units into physical contact to define electrical engagement therebetween,

at least two projections extending from at least one of the male contact elements spaced apart along the axis of elongation and extending toward a wall of the recess of the female insulating body,

recesses in a longitudinally extending wall of the female insulating body, spaced apart for receiving therein the projections when the units are in engagement to define interlocking engagement therebetween to secure the units in assembled, mating relationship.

27. The device of claim **26** wherein the projections on the male contact element are assymetrical, presenting a more steeply sloped surface rearward of the direction of insertion for resisting disassembly by engagement with the recess in the wall of the female insulating body and a less steeply sloped surface forward of the direction of assembly to facilitate assembly.

28. The device of claim **26** further comprising;

polarizing means on the male connector unit and on the female connector unit cooperating to permit assembly in only one orientation.

29. The device of claim **28** wherein the polarizing means on the male connector unit is a rib extending toward the female unit for operative contact therewith in the assembled condition and on the female connective unit, a groove for receiving the rib.

30. The device of claim **29** wherein the rib extends from a depending skirt.

* * * * *