

## **ELECTRICAL CONNECTOR ASSEMBLY HAVING INSERT MOLDED TERMINAL MODULES**

### **Background of the Invention**

This invention generally relates to the art of electrical connectors and, particularly, to an electrical connector assembly having an improved structure that facilitates its manufacture.

An electrical connector assembly typically includes some form of insulative, or dielectric, housing which supports a plurality of conductive terminals. The terminals typically have contact portions for engaging like portions of terminals of an opposing connector, along with tail portions for termination to either wires or to conductive traces on a printed circuit board or the like.

One type of electrical connector assembly incorporates very thin terminals mounted in a dielectric housing with a metal shield surrounding part of the mating portion of the connector assembly. The terminals may be stamped and formed of conductive sheet metal. An example of such connector assembly is a right-angled connector that mounts to a printed circuit board and which mates with an opposing connector. This connector includes a forwardly projecting mating end extending generally parallel to the circuit board, and a terminal body portion that supports tail portions that project rearwardly from a rear face of the housing. A metal shell surrounds the forwardly projecting mating end of the connector. The tail portions are bent generally at right angles downwardly for connection to an appropriate conductive circuit on a printed circuit board.

Problems are encountered in fabricating electrical connector assemblies of the character described immediately above. For instance, one method of manufacture involves stitching the terminals one at a time into the rear terminating face of the housing. This process is very slow and results in low terminal retention. In order to maintain the desired small size of the connector, the walls of the connector housing must be made very thin. Stitching of the terminals in such a housing may result in either bending of the terminals or breaking of the housing walls, both of which are undesirable.

Also, stitched terminals must have a minimum stiffness to prevent their buckling during insertion. The stiffness results in terminals having a considerable thickness and because the tail portions are left unprotected, they are often bent or displaced from their proper relative positions for connection to the conductive circuits on the printed circuit board.

Another method of manufacture involves the molding of a housing over all the terminals. One problem with this approach is that long portions of the terminals are contained within the molded housing, and this results often in quality problems and low quality yields because the terminals are difficult to support in their desired spacing. The flow of plastic into the mold is done with such force that often the terminals may shift their position. Another problem is the terminal tail portions are not adequately supported. The thinness of the terminals, along with the bends formed in the angled terminals, make it extremely difficult to insert mold all of the terminals in place. Finally, many connectors requires thin cantilevered portions that hold the contact portions of the terminals. Since the cantilevered portions are usually thin, they require additional support to prevent breakage.

The present invention is directed to solving these various problems and providing a unique structural combination which is simple and efficient to manufacture and provides considerable support for the terminals of the connector assembly.

### **Summary of the Invention**

A general object of the invention is to provide a new and improved electrical connector of the character described that facilitates the manufacture thereof.

In one embodiment of the invention, the connector assembly includes a pair of terminal modules, each supporting different sets of terminals that are insert molded in the modules. The molding of these terminal modules reduces alignment problems and facilitates the support of the terminals within each module. The use of two, interengaging terminal modules allows more freedom in the width and location of the terminals. A metal shell extends around portions of the modules to form a subassembly. A dielectric body is molded about portions of the terminal modules and a portion of the shell, i.e., the subassembly, to hold the modules and shell together as a single unit.

The terminals of the terminal modules have contact portions that are enclosed within the metal shell and tail portions that extend outwardly from the modules to engage appropriate conductive circuits on a printed circuit board. Both the metal shell and the molded housings of the terminal modules may have locking projections molded by the body to facilitate holding the shell and modules in assembly. Complementary interengaging positioning members are provided on the two terminal modules that maintain the modules in proper relative positions in the subassembly. The housing of one module may include a

polygonal mounting post that is received within a complementary shaped hole in the other module.

In accordance with one principal aspect of the present invention, the modules cooperate to form a combined connector housing with two forwardly projecting mating portions. The metal shell serves as a shroud that surrounds these mating portions. In the preferred embodiment, the terminal modules each include a forwardly projecting cantilevered leaf, and together the two modules cooperatively define a mating portion of the connector assembly. The leaves are spaced from each other to form a receptacle therebetween for receiving a plug portion of an opposing connector. The cantilevered leaves have interior opposing faces, and the terminals contact portions are exposed on these faces. Locating means, such as notches or recesses, are provided on the cantilevered leaves that engage the outer shell to hold the leaves in their respective positions.

According to another aspect of the invention, the terminals have tail portions projecting from the rear faces of the housings of the terminal modules. The housings include retention portions that are partially molded about the tail portions to hold the tail portions in proper relative positions.

Other objects, features and advantages of the invention will be apparent from the following detailed description taken in connection with the accompanying drawings.

### **Brief Description of the Drawings**

The invention, together with its objects and the advantages thereof, may be best understood by reference to the following description taken in conjunction with the accompanying drawings, in which like reference numerals identify like elements in the figures and in which:

FIG. 1 is a perspective view of an electrical connector assembly constructed in accordance with the principles of the present invention;

FIG. 2 is a rear perspective view of the connector assembly of FIG. 1;

FIG. 3 is the same view as FIG. 1, but with the molded rear body portion removed for clarity, and illustrating a connector subassembly;

FIG. 4 is a rear perspective view of the subassembly of FIG. 3, with the metal shield removed for clarity;

FIG. 5 is an exploded view of the connector subassembly of FIG. 4, illustrating the terminal modules separated and vertically spaced apart from each other;

FIG. 6 is the same view as FIG. 5, but taken from the top;

FIG. 7 is a sectional view taken along line 7-7 of FIG. 1;

FIG. 8 is a rear perspective view of the top terminal module, with an alternative configuration of the tail portions of the terminals;

FIG. 9 is a perspective view of the top terminal module of FIG. 8;

FIG. 10 is a side elevational view of the top terminal module of FIG. 8; and,

FIG. 11 is a perspective view of an the steps involved in assembling the connector of the invention together.

### **Detailed Description of the Preferred Embodiments**

Referring first to FIGS. 1 and 2 the invention is illustrated as a electrical connector, generally 14, which is assembled from a plurality of distinct elements. The connector 14 is illustrated as a right-angled receptacle connector, although it will be understood that the principles of the present invention may be incorporated into other forms and styles of connectors.

The connector elements include a pair of terminal modules, or half-housings 30, 32, (FIG. 3) which are partially enclosed by an exterior metal shell 16. A body portion 18 is molded over portions of the modules 30, 32 and the shell 16 in order to hold the modules and shell together as a single assembly. This body portion 18, as illustrated in FIGS. 1, 2 and 7 defines the rear of the connector and it also encloses portions of the conductive terminals of the connector. The terminal modules 30, 32 have portions that project forwardly to define mating portions of the connector. The connector 14 illustrated is a right-angled connector adapted for mounting on a printed circuit board. Therefore, the cantilevered mating portions 20 and their associated metal shell 16 preferably extend above, preferably parallel to the circuit board, while the housing body portion 18 may include a plurality of mounting posts 22 for insertion into appropriate mounting holes in the circuit board (not shown). The shell 16 may include a pair of mounting feet 24 which extend through the body portion 20 and which project rearwardly thereof for connection, as by soldering, to appropriate ground circuit traces on the circuit board for grounding the shell. Each of the two terminal modules 30, 32 also support a plurality of conductive terminals in two distinct sets of terminals, each terminal of

which preferably includes mounting tails 26 (FIG. 2) for connection, as by soldering, to appropriate circuit traces on the circuit board.

FIG. 3 illustrates a connector subassembly 28 that is formed by assembling the terminal modules 30, 32 and the shell 16 together. FIG. 4 illustrates the connector subassembly 29 with the shell 16 removed for clarity. FIGS. 5 and 6 show the two terminal modules 30, 32 separated from each other. For purposes herein, module 30 will be referred to as the "top" module, and module 32 will be referred to as the "bottom" module, although it will be understood that these positions merely occur in the embodiment illustrated and that the terminal modules may be utilized in "right" and "left" and other orientations in connectors of the invention.

The shell 16 may be stamped and formed from sheet metal and complementary interengaging locating means are provided between the shell 16 and the two module cantilevered portions 44 to hold the portions spaced from each other. Specifically, as seen best in FIGS. 5 and 6, the module cantilevered portions 44 have notches 46 molded, or otherwise formed therein at the distal (free) ends thereof. (FIG. 5.) As best seen in FIGS. 1 and 3, the shell 16 is also preferably formed with inwardly bent locating tabs 48 which move into notches 46 when the shell is positioned over the cantilevered portions 44. The notches 46 preferably include shoulder portions 46a formed therewith (FIG. 4) that engage the locating tabs 48 to maintain the cantilevered portions 44 in their relatively spaced positions. This allows the cantilevered portions 44 to have a small thickness which helps to keep the overall size of the connector small. The shell tabs 48 are preferably biased inwardly and thereby exert a compressive force thereon that assists in maintaining the cantilevered portions 44 in place within the shell 16 in both mated and unmated conditions.

As best seen in FIGS. 1 and 3, the metal shell 16 may further include a dove-tail configured seam 50 that maintains the shell in its shroud configuration as it fits over the two cantilevered portions 44 of the terminal modules 30, 32. The shell is preferably coined as at 52, in order to expand the metal shell in a localized area so as to provide a tight fit at the dove-tail seam. Spring arms 54 are stamped and formed out of the sides 16a of the shell 16 and will engage the shield of an opposing connector inserted into the receptacle defined by the cantilevered portions of the two terminal modules and the shell 16. FIG. 3 also shows that the shell 16 may include a pair of retainers, that are illustrated as vertical projections 56 that are formed on opposite sides of the seam 50 and along the rear portion of the shell.

These retainers 56 are received in a key, or slot, 58 formed in the top terminal module housing 34.

As seen in FIG. 1, the body portion 18 that is preferably molded over the shell and terminal modules covers the shell retainers 56 to not only hold the shell to the assembly, but also to assist in holding the seam 50 together. The housing portion 34 of the top terminal module 30 may include a pair of upwardly projecting locking projections (shown as posts 60) which are surrounded by the body portion 18 as seen in FIGS. 1 and 7, to further facilitate holding the terminal module in place within the connector.

As best seen in FIG. 5, the terminals 36 of the top terminal module 30 include contact portions 36a which are exposed on an inside face 62 of the cantilevered portion 44. The terminals are preferably stamped and formed of thin sheet metal and, during molding of housing 34 about the terminals, part of the contact portions 36a are embedded in the inside face of the cantilevered portion so that the contact portions are preferably flush therewith. Terminals 36 have body portions 36b that preferably extend at an angle to their contact portions 36a as seen in FIGS. 5 and 6. The terminals 36 each end in a tail portion 26 as described above for connection to circuits on a circuit board.

The invention contemplates that terminal body portions 36b are supported by the plastic material of the terminal module housing 34. To that end, FIGS. 5 and 6 also show plastic material 64 interspersed between the body portions of adjacent terminals. In addition, a transverse support bar 66 (FIG. 6) may be provided by molding a bar-like member across the rear of all of the tail portions of the top terminal module in order to add support thereto during the insert molding process. This support bar 66 facilitates the forming of the terminals as they are formed so that their tail portions may align with the tail portions of the bottom module terminals. The support bar 66 maintains the terminals in the spacings in which they are formed, and portions 64 of the support bar 66 and housing fill the intervening spaces 64 between the terminals with housing molding material. Alternatively, the intervening spaces may be filled with molding material before the terminals are formed so that the top set of terminals and support bar may be moved during the bending thereof as a single unit. Additionally, the housing material 64 that lies between the terminal may affect the impedance of the connector because the housing material will typically have a dielectric constant greater than 1. The dielectric material will increase capacitive coupling between terminals, which will tend to lower the impedance of the connector.

As best seen in FIG. 6, the terminals 38 of the bottom terminal module 32 also have contact portions 38a that are partially embedded in cantilevered portion 44 of the module 32. Surfaces of the contact portions 38a are exposed and are disposed substantially flush with the inside surface 62 of the cantilevered wall. The lower terminals 38 have their body portions 38b extend at angles to their contact portions 38a, with the body portions terminating in the tail portions 26. The plastic housing 34 of the bottom terminal module 32 is molded over portions of the terminals and has what may be considered as a large support bar 68 which surrounds part of the terminal body portions 38 to support and hold the terminals, especially the tail portions, in place in the bottom terminal module and the overall connector. The housing 34 of the bottom terminal module 32 preferably includes a pair of cavities, or recesses, 69 which may become filled with the material of the molded body portion 18 when the body portion 18 is formed. These recesses 69 and the posts 60 of the top terminal module 32 cooperatively provide means for engaging and anchoring the body portion to 18 to the connector.

From the foregoing, and particularly as seen in FIG. 6, while the tail portions 36b, 38b of the thin terminals project rearwardly from rear terminating faces 70 of housings 34, the plastic support portions 64, 66 and 68 of the module housings provide complete support for the tail portions 26, of the terminals 36, 38. After the terminal modules 30 and 32 are assembled as seen in FIG. 4, and after the metal shell 16 is mounted to the cantilevered portions 44 of the terminal modules (FIG. 3), the connector body portion 18 is molded over the same to form the connector as shown in FIGS. 1 and 2. As seen best in FIGS. 2 and 7, the molded body portion 18 provides further support for the body portions 36b and 38b of the thin terminals. This molded body portion 18 is also important because it interacts with the retainers 56 of the outer shell 16 and prevents the shell from moving, or rotating, with respect to the two terminal modules 30, 32 during the assembly process and during mating cycles with an opposing connector. The body portion 18 also supports the tail portions of the terminals in their orientation on the connector subassembly (*i.e.*, the terminal modules) and may maintain the ends of the tail portions in a coplanar arrangement for surface mounting to a circuit board. As illustrated best in FIG. 4, the tail portions of the terminals of both first and second terminal modules lie in a common plane in opposition to the surface of the circuit board. Additionally, the terminal tail portions 26 of the terminals of the top terminal module 30 lie between adjacent terminal tail portions 26 of the bottom terminal module 32.

The terminal modules 30, 32 may include additional notches, or irregular openings 110 that provide the modules with an irregular configuration. These openings 110 are filled with material from which the body portion 18 is formed, and they assist in holding the two terminal modules together as a single unit. The bottom terminal module 32 may also be formed with a recess, or notch 58 (FIG. 5) like that of the top terminal module, which receive a tab or projecting portion 56 of the metal shell 16. (FIG. 7.)

FIGS. 4-6 show that the body portions 36b of terminals 36 are held by the top terminal module housing 34 so that they lie in a common plane. However, as illustrated in FIGS. 8-10, the body portions of the terminals of the two terminal modules 30, 32 lie in two different, spaced-apart planes. As shown in the drawings these two planes are vertical planes. It is desirable in many electrical connectors to be able to vary the impedance and capacitance of the connector. However, this often is very difficult due to the high density and miniaturization of the various connector components and the use of thin terminals. In the embodiment of FIGS. 8-10, because of the molding aspect of the invention, it is fairly simple to position and support the body portions of the terminals in different planes at a desired horizontal spacing between the body portions of terminals of the top terminal module and the bottom terminal module. By varying the relative vertical positions of the terminal body and tail portions, a desired capacitance may be obtained, which may result in the lowering of the overall impedance of the connector.

FIG. 11 illustrates how the connectors of the invention are made. The sets of terminals 36, 38 may be stamped and formed from a blank of metal, illustrated as a carrier strip 90. The two sets of terminals 36, 38 may be stamped at different locations on the carrier strip 90 as shown. The terminal modules 30, 32 are formed next, with each set of terminals being inserted into two respective molds. Molten plastic, or another dielectric or insulative material is then injected into the cavities of the molds, and this material contacts and flow around desired portions of the terminal sets 36, 38 in a desired manner. The terminals are divided into two different sets, each of which has a reduced number of terminals compared to all of the terminals in the connector. Thus, the terminals may be spaced closer together and better retained in place during the molding process and their cantilevered structure will not adversely affect the forming of the connector, because it is held in place.

The terminal modules 30, 32 may be separated from a common, or individual carrier strips, and then assembled together with their respective projections and cavities mating with

each other. The outer metal shell 16 is then applied to the terminal module cantilevered portions 44 to form a connector subassembly. The subassembly is subsequently inserted into a mold and the connector housing body portion 18 is molded over parts of the modules 30, 32, the shell 18 and the terminals 36, 38. The body portion 18 may, as illustrated, extend down to the lower level of the terminal tail portions 36, 38b so as to maintain them in a common place to facilitate the mounting of the connector on a circuit board.

Lastly, an exterior, or second shell 91, may then be applied that is at least partially supported by the body portion 18 and which extends around both the body portion 18 of the connector and its interior shield 16.

Importantly, as shown in FIG. 3, the present invention may be utilized to maintain the terminals of a differential pair terminal set in proper alignment to ensure proper capacitive coupling among the terminals, which will tend to lower the impedance of the terminals through the connector. In the embodiments shown, a pair of differential signal terminals 38a lie along the surface of the bottom terminal module. By differential signal terminals it is meant that the two terminals will carry the same magnitude of voltage, but of different polarity, i.e., +0.5 and -0.5 volts. These two terminals are spaced apart from each other and from an associated ground terminal 36a (FIG. 5) that is supported by the top terminal module in alignment with and above the two differential signal terminals 38a, preferably such that the centerline of the ground terminal 36a coincides with a centerline that separates the two differential signal terminals. The end result of this arrangement is that an imaginary triangle (shown in phantom) is formed. This triangular relationship is also maintained throughout the body portions 36b that extend vertically at an angle from the contact portions, by way of the support bar 66 and the plastic that fills the intervening spaces between the terminal body portions. The benefits of this triangular relationship are set forth on U.S. Patent No. 6,280,209, issued August 28, 2001 to Molex Incorporated, the assignee of the present invention and the disclosure of which is hereby incorporated by reference.

It will be understood that the invention may be embodied in other specific forms without departing from the spirit thereof. The present examples and embodiments, therefore, are to be considered in all respects as illustrative and not restrictive, and the invention is to be limited only by the claims.

**CLAIMS:**

1. An electrical connector, comprising:

first and second interengaging terminal modules, the first terminal module including a first insulative inner housing with a plurality of first conductive terminals supported thereby, the second terminal module including a second insulative inner housing with a plurality of second conductive contacts supported thereby, each of said first and second terminals including a contact portion for contacting opposing terminals of a mating connector and a tail portion for connecting said terminal to a conductive trace on a circuit board, the contact and tail portions being disposed at opposing ends of said terminal;

a first conductive metal shell enclosing portions of each of said first and second terminal modules to define a receptacle for receiving a portion of a mating connector therein, the contact portions of said first and second terminals being contained within the receptacle; and,

an outer insulative housing disposed over portions of both said first and second terminal modules and said first metal shell, the outer housing retaining said first and second terminal modules and said first metal shell together as a unit.
2. The connector of claim 1, wherein each of said terminals includes a body portion that interconnects the contact and tail portions thereof, the body portion of said first and second terminals being enclosed within said outer housing.
3. The connector of claim 1, wherein one of said first and second terminal modules includes at least one post extending therefrom and the other of said first and second terminal modules includes at least one cavity disposed therein for receiving said post so that said first and second terminal modules may be interengaged together.
4. The connector of claim 3, wherein the post includes at least one polygonal mounting post and said cavity includes a complementary shaped polygonal cavity.

5. The connector of claim 1, wherein each of said first and second terminal modules include cantilevered portions that extend forwardly therefrom, the first and second terminal module cantilevered portions being spaced apart from each other and supporting said first metal shell thereon.
6. The connector of claim 5, wherein said first and second terminal contact portions are respectively partially molded in said first and second terminal module cantilevered portions.
7. The connector of claim 2, wherein said first and second terminal tail portions lie in a common plane.
8. The connector of claim 1, wherein said first terminal module is disposed on top of said second terminal module and said first terminal tail portions lie between said second terminal tail portions.
9. The connector of claim 1, wherein said first metal shell includes at least one projection that extends therefrom and said body portion is molded over the first shell projection.
10. The connector of claim 9, wherein said first metal shell includes a second projection that extends therefrom, the first shell projection and second projection being spaced apart from each other, and said body portion being molded over both said first shell projection and second projection.
11. The connector of claim 10, wherein said first terminal module includes a recess formed therein and said second terminal module includes a recess formed therein, said first shell projection being received within the first terminal module recess, and said first shell second projection being received within said second terminal module recess.

12. An electrical connector for providing a connection between differential signal pairs of terminals in a mating connector and differential signal traces on a circuit board, the connector, comprising:

a first terminal module, the first terminal module including a first insulative housing and a plurality of conductive first terminals disposed thereon, at least two of the terminals being differential signal terminals for connecting to a differential signal circuit on the circuit board, the differential signal terminals lying adjacent to and spaced apart from each other in said first terminal module housing, each of the first terminals including a contact portion, a tail portion and an interconnecting body portion, said terminal contact and body portions extending in two different planes;

a second terminal module, the second terminal module including a second insulative housing and a plurality of conductive second terminals disposed thereon, at least one of the terminals being a ground terminal differential signal terminals for connecting to an associated ground circuit on said circuit board, each of the second terminals including a contact portion, a tail portion and an interconnecting body portion;

the first and second terminal modules having means for engaging each other in a manner such that said second terminal module housing lies on top of said first terminal module housing, said differential signal and associated ground terminals being respectively disposed on said first and second terminal modules in different positions such that when said second terminal module is assembled on top of said first terminal module, said associated ground terminal lies above and spaced apart from said differential signal terminals to form a triangular arrangement of said differential signal and associated ground terminal contact portions, and,

a conductive metal shell extending around portions of said first and second terminal modules, the shell and said first and second terminal module portions cooperatively defining a receptacle for said mating connector.

13. The connector of claim 12, further including an insulative connector housing extending over portions of said first and second terminal module housings and said shell.

14. The connector of claim 12, wherein said first and second terminal module engagement means includes at least one post formed in one of said first and second terminal modules and a cavity formed the other of said first and second terminal modules.
15. The connector of claim 13, wherein said metal shell includes at least one projection extending therefrom that extends into said connector housing which assists in holding said shell in place around said first and second terminal module portions.
16. The connector of claim 15, wherein at least one of said first and second terminal modules includes a projection that extends into said connector housing which assists in holding said connector housing in place over said first and second terminal module portions.
17. The connector of 13, wherein said terminal body portions of said first and second terminals are spaced apart from each other in two different vertical extents.
18. The connector of claim 12, wherein said terminal body portions of said second terminals are aligned in a common plane and are further spaced apart from each other within said common plane and are separated from each other by intervening spaces, and said second terminal module housing is molded over portions of said second terminal contact portions and between said second terminal body portions such that the intervening spaces therebetween are filled with material from which said second terminal module is molded.
19. The connector of claim 12, wherein each of said first and second terminal module housings include a cantilevered terminal support that extend forwardly of said terminal modules, and said metal shell extends around the cantilevered supports.