ELECTRICAL CONNECTOR

TECHNICAL FIELD

[0001]

The present invention relates to an electrical connector that is made up of a male connector and a female connector. More particularly, it relates to an electrical connector with a connector position assurance (hereafter referred as "CPA") means that maintains and assures the full-mated state of the two connectors.

BACKGROUND ART

[0002]

Electrical connectors, consist of a male connector and a female connector, are usually provided with a locking mechanism so that the two connectors will not accidentally come apart from its full-mated state. Under certain circumstance, the contact terminals of the two connectors can be electrically connected when the two connectors are partially/half-mated together. In such half-mated state, the two electrically connected connectors may accidentally come apart during operation. Therefore, electrical connectors with a CPA have been proposed to prevent any occurrence of half-mating, thus maintain and assure the full-mated state of the two connectors. An example of such an electrical connector with CPA is discussed in U.S. Patent No. 5,720,623.

[0003]

Figure 18 is an external perspective view of the electrical connector illustrated in this U.S. Patent.

[0004]

This electrical connector 25 establishes electrical connection by mating a first connector 26 and a second connector 27 together. The second connector 27 has a cavity 30 of a particular size running longitudinally that is bordered by the connector body 28 and cover 29. A locking arm 31 and a CPA 32 can be found inside this cavity 30.

[0005]

The locking arm 31 is a rectangular resilient arm of a particular width and length. The rear end of this resilient arm 31 is fixed to the rear of the housing; the front end extends forward towards the insertion opening. The arm 31 can be elastically deformed in the vertical direction within a gap of a particular size formed between the connector body 28 and the cover 29. A slot 31a of a particular width and length is made lengthwise along the locking arm 31. The front projection 33 of the CPA 32 is inserted in this slot 31a. The cover 29 has two pairs of first and second latching holes 29_1 & 29_2 with each pair formed lengthwise on each side wall.

[0006]

The CPA 32 consists of a front projection 33, a pair of the side arms 35, 35 with a pair of locking protrusions 34, 34 i.e. one on each side arm, and a thumb tab 36. During the insertion (to full-lock) or the release (to pre-lock) of the CPA 32, the pair of locking protrusions 34, 34 of CPA 32 engages with the two pairs of latching holes 29_1 & 29_2 found on the cover 29.

[0007]

We shall now discuss how the CPA 32 maintains and assures the full-mated state. The CPA 32 is pre-installed into the cavity 30 of the second connector 27 (pre-lock position). When the CPA 32 is in this pre-lock position, the front projection 33 of the CPA 32 is prevented from further insertion by the end of the slot 31a of the locking arm 31. At the same time, the locking protrusions 34, 34 are engaged with the first pair of latching holes 29_1, 29_1. The first connector 26 is then inserted into the second connector 27 till the latching protrusion 26a of the first connector 26 comes into contact with the underside of the locking arm 31. As the first connector 26 is further inserted, the latching protrusion 26a enters the slot 31a of the locking arm 31. At the same time, the front protrusion 33 is being pushed upwards till it becomes unlatched i.e. it becomes possible for the CPA 32 to be pushed into until the locking protrusions of the CPA 32 engage the second pair of latching holes 29_2, 29_2 on the cover 29. The full-mated state of the first 26 and

second 27 connectors is then maintained and assured. Another example of electrical connectors with CPA is documented in the European Patent Application Publication EP0840398A1 where the latching element is in the form of a resilient stop wing integrally installed on the top surface of the connector housing. When the full-mated state is detected, the CPA will slide over the latching element and thus the full-mated state of the connector is maintained and assured. Another electrical connector with CPA can also be found in U.S. Patent No. 6,077,101.

[0008]

In the electrical connectors documented in U.S. Patent No. 5,720,423 and European Patent Application Publication EP0840398A1, the CPA in both cases is pre-installed on either the first connector housing or the second connector housing. When the full-mated state of the first and second connectors is detected, the full insertion of CPA only then becomes possible and executed. On the other hand, if the connectors are detected to be in partial/half mated condition, the CPA will either not being able to further pushed in to full-insertion or the CPA will only be able to push in half-way. Both these electrical connectors are designed in such a way that the effectiveness of the locking mechanism of the first and second connectors is closely dependent to the CPA that is installed on the first or the second connector. Due to the close relationship between the connectors and the CPA, several intrinsic issues require our close attention.

[0009]

One issue is such that due to the fact that the CPA is integrally designed into the connector locking mechanism i.e. the installation location of the CPA is restricted by the connector lock, should there be any request from the users to change or modify the CPA installation location will not be desirable or possible.

[0010]

Another issue is should there be any need to change the installation location of the CPA, a change in the structure of the affected connector is required to facilitate the change of the CPA location; such change will bring about more new parts and thus result in higher production cost.

[0011]

Final issue is that in order to ensure proper physical connection between the connector lock and the CPA, it becomes crucial to ensure the dimensional precision of each part forming the assembly as well as the accuracy in the assembly process of all the parts, and all these contribute more constraints in the assembly and future adjustments.

SUMMARY

[0012]

One advantageous aspect of the present invention is to offer an electrical connector system in which the CPA installation location in one connector can be changed without changing the structure of the complementary mating connector.

[0013]

The present invention consists of a first connector (a first connector housing assembled with first contact terminals), a second connector (a second connector housing assembled with second contact terminals that are electrically compatible to the first contact terminals) and a CPA to maintain and assure the full-mated state of the first and second connectors. The first connector has a first locking portion on its outer wall surface of the first connector housing and an insertion hole at the front through which the inner housing of the second connector is inserted. The second connector has a second connector housing with an inner housing (in which the second contact terminals are housed) and an outer cover housing, between which a particular gap space is interposed. The gap space bordered by the topmost outer surface of the inner housing and the inner surface of the top wall of the outer housing is divided into a housing lock space (in the anterior where the first locking portion of the first connector will be inserted) and a CPA installation space (in the posterior) to accommodate the CPA i.e. with first latching portions into which the CPA will be latched. The housing lock space is where the locking arm (a flexible tongue-like structure) can be found and provides a second locking portion into the first locking portion of the first connector

housing will be latched. The CPA provides the second latching portions that will latch onto the first latching portions of the inner housing of the second connector housing; at full-mated state between the first and second connectors, the pre-lock condition (the second latching portions of CPA latches onto the first latching portions of the inner housing) will be disengaged by the front edge of the first connector housing bordering the insertion hole of the first connector i.e. the movement of CPA into the in designated final position is thus enabled to assure the mated state of the connectors.

[0014]

Such setup separates the CPA from the connector locking mechanism i.e. the CPA installation position can be independently (from the connector lock) designed. To elaborate, the CPA in this context will be latched onto the outer wall surfaces of the inner housing that provides the first latching portions (for the pre-lock condition of the CPA) and this condition at full-mated state will be disengaged by the front edge of the first connector housing bordering the insertion hole of the first connector; the location of these latching portions can be shifted to any part of the outer wall surfaces. Such change can be implemented without altering the structure of the first connector and kept any necessary change to the second connector to the minimum. Overall, the connector structure can be simplified and the degree of freedom in designing the mating process can be increased.

[0015]

It is preferable to assign spaces within the gap space for the housing of the housing lock and the CPA (where both spaces can be either on the same side or different side of the outer wall surface of the inner housing of the second connector) as discussed earlier, and that the first latching portions in the CPA installation space are provided by the inner housing.

[0016]

With such configuration, the CPA structure can be independent of the connector locking and this independence allows the space allocation for the

housing lock and the CPA installation to be either on the same side or different side of the outer wall surface of the inner housing of the second connector. Once again, the degree of freedom in the connector design is enhanced.

[0017]

It is preferable for the CPA to adopt a U-shape framework where a pair of framing arms running parallel to each other separated by a particular spacing; the two framing arms are connected at one end to a connecting frame with the other ends free. A pair of second latching portions (that latches onto the pair of first latching portions provided on the outer wall surface of the inner housing in the CPA installation space) is found on the wall surfaces of the framing arms.

[0018]

By adopting this configuration, at the pre-lock condition of the CPA, the second latching portions of the CPA will engage with the first latching portions provided on the inner housing in the CPA installation space i.e. the CPA is secured at two points and thus renders stability to the installation of the CPA.

[0019]

It is preferable for the first latching portions to be formed as projections arising from the outer wall surface of the inner housing, and the second latching portions of the CPA to be in the form of latching projections that will in turn latch onto the corresponding first latching projections.

[0020]

With such configuration i.e. with the latching of the second latching projections of the CPA onto the first latching projections on inner housing, the movement of the CPA in the longitudinal direction of the second connector housing will be stably restrained. The latching projections of the CPA also assure and maintain the full-mated state of the connector by pushing the CPA forward along the longitudinal direction of the second connector housing.

[0021]

It is preferable for the second latching portions of the CPA to be formed as resilient latching arm that will in turn latch on the first latching projections on the

outer wall surface of the inner housing.

[0022]

Besides the latching of the second latching projections of the CPA onto the first latching projections on the inner housing that restrains the longitudinal movement of the CPA inside the second connector housing (renders stability to the installation of the CPA), by having the second latching projections as resilient arm, the resilient property of the latching arm further renders the firmness of the latching onto the first latching projections. The resiliency of the latching arm also facilitates the unlatching. By adopting the concept of a CPA with such latching arms, the electrical connector can have a slightly different method of manipulating the CPA to assure and maintain the full-mated state of the connector i.e. pulling the CPA towards the posterior end along the longitudinal axis o the second connector housing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023]

The invention will be described with reference to the accompanying drawings, each element of interest is accordingly numbered and the same numbering will be used throughout.

Figure 1 is an exploded view of the preferred embodiment electrical connector of the present invention before assembly.

Figure 2 is a perspective view of the connector housing of the second connector (female) shown in Figure 1 with the top wall partially sectioned for illustration of the interior.

Figure 3 is a cross sectional view of the second connector housing (female) as shown in Figure 1, along line III-III.

Figure 4 shows the CPA that will be assembled to the female housing as shown in Figure 1. Figure 4A is a perspective view of the CPA. Figure 4B shows the underside of the CPA.

Figure 5A is the front view of the CPA. Figure 5B is a cross sectional view of

the CPA as shown in Figure 5B, along line VB-VB.

Figure 6 is a cross sectional view of the electrical connector (as shown in Figure 1) assembled with CPA, along line VI-VI.

Figure 7 is a cross sectional view of the initial state of the mating process where the first locking portion of the first connector (male) just touches the tongue-tip of the locking arm of the second connector (female).

Figure 8 is a cross sectional view of the intermediate state of the mating process where the male connector is being further inserted into the female connector and the locking arm is being pushed upwards by the first locking portion.

Figure 9 is a cross sectional view of the final state of the mating process.

Figure 10 is a perspective exploded view of an electrical connector of another embodiment of the invention before assembly.

Figure 11 is a perspective view of the connector housing of the second connector (female) shown in Figure 10 with the top wall partially sectioned for illustration of the interior.

Figure 12 is a cross sectional view of the second connector housing (female) as shown in Figure 10, along line XII-XII.

Figure 13 shows the CPA that will be assembled to the female housing as shown in Figure 10. Figure 13A is a perspective view of the CPA. Figure 13B shows the underside of the CPA.

Figure 14A is the front view of the CPA. Figure 14B is a cross sectional view of the CPA, along line XIVB-XIVB as shown in Figure 14A. Figure 14C is a cross sectional view of the CPA, along line XIVC-XIVC as shown in Figure 14A.

Figure 15 is a cross sectional view of the electrical connector (as shown in Figure 10) assembled with CPA, along line XV-XV.

Figure 16 is a cross sectional view of the intermediate state of the mating process where the male connector is inserted into the female connector and the front end portion (edge) of the male connector housing hits the pre-lock claws of the CPA.

Figure 17A is a cross sectional view of the final state of the mating process where the male connector has fully inserted into the female housing. Figure 17B is a cross sectional view of the region XVIIB (as shown in Figure 17A) sectioned to show the central region of the CPA.

Figure 18 is a perspective exploded view of an electrical connector that is the prior art in relative to the present invention.

DESCRIPTION OF EXEMPLARY EMBODIMENT

[0024]

An exemplary embodiment of the invention will now be described with reference to the accompanying drawings. The description should be understood by the fact that the embodiment being discussed intends to highlight an example of an electrical connector realizing the technical concepts of the invention, and not to limit the invention only to this particular electrical connector. The invention can equally well be applied to produce other embodiments without deviating from the scope and the spirit of claims.

[0025]

An electrical connector of an embodiment of the invention will be discussed with reference to Figures 1 to 9. Figure 1 is an exploded view of the preferred embodiment electrical connector of the present invention before assembly. Figure 2 is a perspective view of the connector housing of the second connector (female) shown in Figure 1 with the top wall partially sectioned for illustration of the interior. Figure 3 is a cross sectional view of the second connector housing (female) as shown in Figure 1, along line III-III.

[0026]

Figures 1 to 3 illustrate that the electrical connector 1 has a female connector 2 comprising of a female connector housing 3 (hereafter referred as "female housing") in which multiple female contact terminals are housed, a male connector 9 comprising of a male connector housing 11 (hereafter referred as "male housing") in which multiple male contact terminals 10 are housed, and a

CPA 8 installed inside the female housing 3 of the female connector 2 to assure and maintain the full-mated state with the male connector 9. The female connector 2, the CPA 8 and the male connector 9 that makes up the electrical connector will be individually discussed in the following, with reference to the accompanying drawings.

[0027]

Firstly, the male connector 9 will be discussed, with reference to Figures 1 to 6.

[0028]

Figure 6 is a cross sectional view of the electrical connector (as shown in Figure 1) assembled with CPA 8, along line VI-VI.

[0029]

The male connector 9 is designed to have a male housing 11 which is in turn housing multiple male contact terminals 10. As shown in figure 1, the male housing 11 consists of a rectangular block with top 11a & bottom 11b walls, left 11c & right 11d walls, front 11e & rear 11f walls, and of a size that can be inserted into the insertion opening 5g of the female housing 3. The male housing 11 is plastic-molded with electrically insulated synthetic resin. As shown in Figure 6, inside the male housing 11, a cavity 11s of a size that allows the inner housing 4 of the female housing 3 to fit into can be found. The cavity 11s has an opening 11g in the front wall 11e and the recessed hollow is extending to a particular depth towards the rear wall 11f. The opening 11g is an insertion hole of the male connector 9. The outer edge 11e' of the front wall 11e that forms the insertion hole, has the function of engaging the first latching projections 8b1 of the CPA 8 by pushing the projections upwards during the mating process with the female connector 2. Multiple male contact terminals 10 are arranged inside the cavity 11s and fixed into the rear wall 11f (innermost part of the cavity 11s). Lead wires (hereby omitted from the drawings) connecting to the male contact terminals 10 are drawn out through the rear wall 11f.A first locking portion 12 can be centrally found on the top wall of the male housing 11. It is preferable for the first locking

portion 12 to have a sloping face 12a inclining towards the front face 11e at a particular angle. By having the inclined face 12a, it ensures that the engagement with the locking arm 7 will be smooth. In Figure 1, guiding rails (11c' & 11d') in the form of protrusion walls longitudinally extended are found on the side walls (11c & 11d) of the male housing 11. During the mating process with the female connector 2, these guiding rails (11c' & 11d') will be inserted into the guiding grooves 54 of the female housing 3. In the wording of the claims, the male connector is referred as the first connector, the male contact terminals the first contact terminals, the male connector housing that houses the first contact terminals the first connector housing, the locking protrusion of the first connector the first locking portion, the female connector the second connector, the female contact terminals the second contact terminals, and the female connector housing that houses the female contact terminals the second connector housing.

[0030]

Next, the female connector 2 will be discussed, with reference to Figures 1 to 3.

[0031]

Figure 1 shows that the female connector 2 consists of a female housing 3 that houses multiple female contact terminals, a CPA 8 that is assembled inside the female housing 3, and a terminal position assurance (hereafter referred as "TPA") that assures and maintains the female contact terminals in its full-mated position inside the female housing 3. The female contact terminals and TPA are shown in Figure 1, assembled into the female housing 3 but are omitted in Figure 3 and Figures 6 to 9.

[0032]

The female housing 3 has an inner housing 4 that houses multiple female contact terminals and an outer housing 5 that covers the outer wall surfaces of the inner housing 4 except the front and rear wall surfaces. The inner housing 4 and the outer housing 5 have a particular gap space in between, and are integrally joined at their rear ends. The female housing 3 is plastic-molded with an

electrically insulated synthetic resin. At the rear end of the female housing 3, there is a waterproofing cover (omitted from the drawings) attached to prevent entry of water.

[0033]

Figures 1 to 3 show that the inner housing 4 has top 4a & bottom 4b walls, left 4c & right 4d side walls, and front 4e & rear 4f walls; it consists of a rectangular solid with a roughly square cross-section when section in a direction perpendicular to the longitudinal axis. Figure 3 shows that the inner housing 4 is integrally joined to the outer housing 5 at the rear portion 4g. The inner housing 4 contains multiple terminal cavities 41 that extend throughout from the front wall 4e longitudinally to the rear end in which the female contact terminals will be housed. The female contact terminals will be inserted from the rear end of the inner housing 4 into the terminal cavities 41. Figure 3 also shows that there is a TPA installation slot 43 for TPA (omitted in the drawings) at the bottom wall 4b of the inner housing 4. When the female contact terminals have fully inserted into the terminal cavities 41, the TPA (omitted in the drawings) is inserted into the TPA installation slot 43 to assure that the female contact terminals are properly and fully inserted into the terminal cavities 41. The use of a TPA to assure the full insertion of the female contact terminal is an already-known technology and the same technology is employed in this embodiment.

[0034]

As shown in Figure 3, the topmost outer wall 4a of the inner housing 4 has a low-level flat surface 4a1 on the anterior half and a high-level flat surface 4a3 on the posterior half with a step 4a2 at the junction. On the step 4a2, a pair of vertical projections 42 separated by a particular spacing can be found. Only one vertical projection 42 is shown in Figures 1 and 2; the other of the pair can be found on the side of the side wall 5c. Prior to full-mated state, the first 8b1 and second 8b2 latching projections of the CPA 8 will be latched onto these vertical projections 42 situated on the top wall surface 4a; the CPA 8 will slide over the top wall surface 4a when the latching is disengaged at full-mated state. The outer wall surface

where the vertical projections 42 are formed is thus the installation location of the CPA 8. In the wording of the claims, the vertical projections 42 are referred as the first latching portions and the first 8b1 & second 8b2 latching projections the second latching portions.

[0035]

Although the vertical projections 42 are presented in this embodiment to be on the top wall surface 4a, the location of the vertical projections 42 can be implemented on other wall surfaces e.g. right side wall, bottom wall surface, etc. In other word, any wall surface that provided the vertical projections will become the installation location for the CPA 8 i.e. the installation location of the CPA can be changed; this change can be executed without making changes to the connector locking mechanism that hold the male 9 and female 2 connectors together at full-mated state. Hence, degree of freedom in designing the connector has increased such that the installation location of the CPA 8 can be changed according to users' requirements.

[0036]

When in use, a resilient seal ring (omitted in the drawings) will sit on the flat face 4a1 in the region between the step 4a' and the TPA installation slot 43. From the rear wall 4f, there is a recess 4f', wherein a waterproofing member sealing the lead wires (that in turn connect to the female contact terminals) is installed. The installation of the resilient seal ring and this waterproofing member will prevent any entry of water into the female housing 3.

[0037]

The outer housing 5 as shown in Figures 1 to 3 has top 5a & bottom 5b, left 5c & right 5d, and front 5e & rear 5f walls offering a covering for the outer surfaces of the inner housing 4 with a particular gap space in between; it is tubular-shaped and when a cross section done orthogonally to the longitudinal direction will review an oblong rectangular opening. On the front wall 5e of the outer housing 5, there is an insertion opening 5g into which male housing 11 of the male connector 9 will be inserted. The posterior portion 5h of the outer housing 5 is integrally

joined to the posterior portions 4f & 4g of the inner housing 4.

[0038]

A gap H1 as shown in Figure 3 is sandwiched between the inner surface 5a' of the top wall 5a of the outer housing 5 and the topmost outer surface 4a of the inner housing 4, and this gap H1 is much larger than other circumferential gaps i.e. the gap H2 found between the inner surface of the bottom wall 5b and the bottom outer surface 4b of the inner housing 4. Besides bordered by the inner surface of the top wall 5a of the outer housing and the top outer surface 4a of the inner housing 4, the gap H1 is furthered bordered by left 5c and right 5d side walls of the outer housing 5 to form a cavity S that is opened at the anterior and posterior ends. The cavity S is divided at the step 4a' of the inner housing 4, into a locking space S1 (in the anterior) that houses the locking arm 7 and a CPA installation space S2 (in the posterior) that houses the CPA 8. The CPA installation space S2 is open both at the rear and posterior half of the top wall 5a of the outer housing 5. It is through this opening 6 that CPA 8 is assembled into the female housing 3. On the inner surface 5a' of the top wall 5a, a pair of latching steps portions (first 51 and second 52) can be found centrally along the longitudinal direction of the connector housing and separated by a particular spacing, onto which the latching tabs 8t of the CPA 8 latch. The second latching step portion 52 is located nearer to the front wall and first latching step portion 51 further inwards.

[0039]

The locking space S1 houses the locking arm 7. As shown in Figures 2 & 3, the locking arm 7 is in the form of a resilient tongue-like plate, having a width smaller that the spacing bordered by the left 5c and right 5d walls of the outer housing 5 and of a particular thickness and length; it is separated from the inner surface 5a' of the top wall 5a of the outer housing 5 by a gap H11 and from the topmost surface 4a1 of the inner housing 4 by a gap H12. The locking arm 7 is joined to the posterior portion of the inner housing 4 at the base point 7f. The CPA 8 will be seated inside the gap H11 and the male housing 11 of the male connector 9 will be inserted into the gap H12 during mating.

[0040]

In Figure 2, the locking arm 7, a plate-like structure, has top 7a & bottom 7b walls, left 7c & right 7d walls, and a front wall 7e. Along the lateral edges (left & right) of the top wall 7a of the locking arm 7, a pair of guiding projections 71 extending sideward and longitudinally. The thickness of the guiding projections 71 is smaller than that of the left 7c and right 7d walls of the CPA 8, and will sit inside the pair of guiding slots 8d' on the framing arms 8L & 8R of the CPA 8. An elongated slot 74 is longitudinally and centrally formed along the locking arm 7, extending from a distance off the front wall 7e towards the posterior end. At the anterior end of the slot 74, a locking ledge 74a is formed. During the mating process with the male connector 9, the locking arm 7 is being pushed upwards by the first locking portion 12 of the male housing 11 and the first locking portion 12 will be latched onto the locking ledge 74a upon fully mated. In the wording of the claims, the locking ledge 74a is referred as the second locking portion.

[0041]

On the bottom wall 5b of the outer housing 5, there is a TPA installation opening 53 through which the TPA will be inserted (as shown in Figure 3). This TPA installation opening 53 of the outer housing 5 is inline with the TPA installation slot 43 of the inner housing 4. As shown in Figure 1 and 2, the left 5c and right 5d side walls of the outer housing 5 each has one guiding groove 54 into which the guiding rails (11c' & 11d') will be inserted during mating.

[0042]

As presented in this embodiment, the locking space S1 and the CPA installation space S2 are formed and allocated inside the gap H1; the location of S1 and S2 can be changed, depending on the location of the vertical projections 42 of the inner housing 4. For example, if the vertical projections 42 are formed on the side wall surface 4c of the inner housing 4, the location of S2 will change to the gap between the inner face of the side wall 5c and the side wall surface 4c of inner housing 4 and S1 may continue to sit in gap H1. In other word, the location of CPA installation space S2 is dependent on the location of the vertical

projections 42 and the locking space S1 may either share the same gap with the S2 or in another gap. All these changes can be implemented without altering the structure of the male connector 9. Note that the locations of the guiding grooves 54, TPA installation slot 43 and any features that are based on the outer housing 5 will be affected in response to a change in the CPA installation space S2. The size of the gap housing the locking space S1 and the CPA installation space S2 will be adjusted accordingly to accommodate the features.

[0043]

The physical profile of the CPA 8 that will be assembled into the female connector 2 will be discussed next with reference to Figures 4 and 5.

[0044]

Figure 4 shows the CPA that will be assembled to the female housing as shown in Figure 1. Figure 4A is a perspective view of the CPA. Figure 4B shows the underside of the CPA. Figure 5A is the front view of the CPA. Figure 5B is a cross sectional view of the CPA as shown in Figure 5B, along line VB-VB.

[0045]

The CPA has a pair of framing arms 8L & 8R running parallel to each other at a particular spacing W1; one end of the framing arm is connected to a connecting frame 8J with the other end free. The U-shaped frame is plastic-molded with an electrically insulating synthetic resin. The width of the gap 8G (between the pair of framing arms 8L & 8R) is W1 which is approximately the same width as that of the locking arm 7.

[0046]

The two framing arms 8L & 8R are the exact mirror image of each other, and thus one of the pair i.e. 8L will be selected and discussed in detail in the following.

[0047]

The framing arm 8L has top 8a & bottom 8b, left 8c & right 8d and a front 8e wall; the arm is of a particular width and relatively long, and has an almost rectangular cross section when section orthogonally to the longitudinal direction.

The rear portion 8f of the framing arm 8L is integrally joined to the connecting frame 8J. On the right wall 8d, a guiding slot 8d' (a flat bottomed groove) is formed lengthwise along the framing arm 8L. As illustrated in Figure 5B, the guiding slot 8d' begins from the front wall 8e extending towards the posterior end which is joined mid-way by a relatively broader slot K1 with one of the side wall parallel to the top surface 8a and the other to the bottom surface 8b. K1 is then joined relatively narrower guiding slot K2 running parallel to the bottom wall 8b till the end of the slot. The width of the guiding slot segment K1 is slightly larger than the thickness of the guiding projections 71 of the locking arm 7 so that the CPA 8 can smoothly slide along the guiding projections 71. Due to the fact that the guiding slot 8d' is formed mainly by the almost horizontal guiding slot segment K1 and the inclining slot (at a particular angle with respect to the top wall 4a of the inner housing) segment K2, the sliding direction of the guiding projections 71 inside the guiding slot 8d' will change from K1 to K2 during the insertion of the CPA and vice versa during the un-mating of the CPA. For an example, when the guiding projections transits from K1 to K2, the whole CPA 8 structure will be rotated to the extent as defined by the angle of inclination of K2 with respect to the top wall 4a. On the posterior portion of the bottom side 8b of the framing arm 8L, a pair of first 8b1 and second 8b2 latching projections separated by a particular spacing is formed and the size of this spacing is in which the vertical projections 42 on inner housing 4 can fit. When the pair of latching projections 8b1 & 8b2 engages the vertical projections 42, the first latching projection 8b1 acts as a stopper preventing the CPA 8 from being pulled out in the posterior direction; the second latching projection 8b2 acts as a stopper to prevent any unintentional pushing the CPA 8 further inwards. It is preferable for the front facing faces (towards the front wall 8e) of the latching projections 8b1 and 8b2 to be inclined surfaces (with obtuse angles) to facilitate the disengagement of the CPA from the vertical projections 42 (from the pre-lock position).

[0048]

The connecting frame 8J is a relatively broad plate-like structure that

integrally joins to the rear portions 8f of the two framing arms 8L & 8R. On the top surface of the connecting frame 8J that is continuous with that 8a of the framing arms (8L & 8R), a stopper projection 8T projecting into the gap 8G is formed. The stopper projection 8T consists of a resilient piece projecting at an angle towards the front from the connecting frame 8J; latching tabs 8t are provided along the front edge of the stopper projection 8T. On the top surface of the connecting frame 8J, a grip portion 8p is formed to provide the ease of grip for the fingertip i.e. to facilitate the insertion of the CPA 8 into the CPA installation space S2 of the female housing 3 as well as the manipulation of the CPA 8.

[0049]

The assembly of the female connector 2 will be next discussed, with reference to Figures 1 to 5.

[0050]

The female contact terminals are installed into the female housing 3 by inserting into the terminal cavities 41 from the rear end of the inner housing 4. After the female contact terminals are fully seated inside the terminal cavities 41, the TPA (omitted in the drawings) is fully inserted from its pre-lock position into the TPA installation slot 43 to assure and maintain the fully seated positions of the female contact terminals. This completes the installation of the female contact terminals into the female housing 3. Female contact terminals are omitted in Figure 3 and from Figures 5 to 9; the terminals are installed inside the female housing 2 in Figure 1.

[0051]

The assembly of the CPA 8 into the female housing 3 will be discussed. This is done firstly by positioning the CPA 8 at the rear end of the female housing 3, and followed by aligning framing arms 8L & 8R within the opening entrance 6 of the CPA 8 and then inserting into the CPA installation space S2. The guiding slots 8d' of the CPA 8 are aligned so that the guiding projections 71 of the locking arm 7 can fit into. As the CPA is pushed into the female housing 3, the stopper projection 8T is elastically deformed and pushed into the inner surface 5a' of the

top wall 5a of the outer housing 5, and the latching tabs 8t latch onto the first latching step portion 51. Almost at the same time, the vertical projections 42 sit into the locking gap between the first 8b1 and second 8b2 latching projections of the framing arms (8L & 8R). The CPA 8 as a result is latched in place (at pre-lock state) by both the pair of latching projections (8b1 & 8b2) and the stopper projection 8T i.e. any forward-backward motion of the CPA 8 along the longitudinal direction is restrained.

[0052]

The CPA 8- assisted assembly of the female connector 2 with the male connector 9 will be next discussed, with reference to Figures 6 to 9 that illustrate the mating process of the male 9 and female 2 connectors. Figure 6 is a cross sectional view of the electrical connector assembled with CPA, along line VI-VI Figure 7 is a cross sectional view of the initial state of the mating process where the first locking portion of the first connector (male) just touches the tongue-tip of the locking arm 7 of the female connector 2 . Figure 8 is a cross sectional view of the intermediate state of the mating process where the male connector 9 is being further inserted into the female connector 2 and the locking arm 7 is being pushed upwards by the first locking portion 12. Figure 9 is a cross sectional view of the final state of the mating process when the male connector 9 is fully mated with the female connector 2.

[0053]

The CPA 8 is pre-installed inside the female housing 3 of the female connector 2. The installation of the CPA 8 into the female housing 3 will be discussed in detail as follow. As shown in Figure 1, the CPA 8 is first positioned at the rear of the female housing 3 from which the framing arms (8L & 8R) and the stopper projection 8T are inserted through the entrance opening portion 6 of the CPA installation space S2. With the CPA 8 at this position, the guiding projections 71 are inserted into the horizontal guiding slot segment K1 of the guiding slot 8d' of the framing arms (8L & 8R). Almost at the same time, the latching tabs 8t of the stopper projection 8T are latched onto the first latching step portion 51. The

CPA 8 as a result is latched in place (at pre-lock state) by both the pair of latching projections (8b1 & 8b2) and the stopper projection 8T i.e. any forward-backward motion of the CPA 8 along the longitudinal direction is restrained.

[0054]

The male housing 11 of the male connector 9 is inserted into the female connector 2 (pre-installed with CPA 8) through the insertion opening 5g of the female housing 3. As shown in Figure 7, the locking protrusion 12 (first locking portion) of the male housing 11 will strike against the front wall 7e of the locking arm 7 to mark the beginning of the locking process. As the male connector 9 is further pushed inwards, the first locking portion 12 of the male housing 11 pushes the front wall 7e portion of the locking arm 7 upwards i.e. the locking arm 7 is elastically deformed while the first locking portion 12 continues to move inwards (as shown in Figure 8). Just before the end of the insertion, the first locking portion 12 of the male housing 11 will be latched by the locking ledge 74a of the female connector 2. Almost at the same time, the outer edge 11e' (front portion of the insertion opening 11g of the male connector 9) of the male housing 11 strikes against and pushes the first latching projections 8b1 of the framing arms (8L & 8R) upwards i.e. unlatches the first 8b1 and second 8b2 latching projections from the vertical projections 42 of the inner housing 4 (disengage from pre-lock position). Once the first 8b1 and second 8b2 latching projections have unlatched from the vertical projections 42, the CPA 8 can be pushed towards the front with the latching tabs 8t latching onto the second latching step portion 52. With such electrical connector of this embodiment where the second latching portion is unlatched from the first latching portion by the front edge 11e' of the first connector 9 at the full-mated state of the connectors, one can observe that the location of the first latching portions of the second connector can change without making any modification to the existing first connector. By adopting such design principle, the connector structure can be simplified and the degree of freedom in designing the mating configuration can be increased.

[0055]

With such sliding motion of the CPA 8, the CPA 8 can assure and maintain the full-mated state of the connectors i.e. any half-mated state of the connectors will be detected and avoided.

[0056]

By adopting such embodiment of the electrical connector, the assurance and maintenance of the full-mated state of the connectors by the CPA 8 is not dependent to the locking mechanism between the male 9 and the female 2 connectors, and thus the CPA installation location can be independently designed. In other word, the CPA installation space can be one of the outer wall surfaces of the inner housing that in turn provides the vertical projections to be latched by the latching projections of the CPA i.e. the degree of freedom in designing the connector is increased and such change can be implemented without changing the locking mechanism of the first and second connectors. By adopting such design principle, the connector structure can be simplified and the degree of freedom in designing the mating configuration can be increased.

[0057]

An electrical connector of another embodiment of the invention will now be discussed with reference to Figures 10 to 17. Figure 10 is a perspective exploded view of an electrical connector of another embodiment of the invention before assembly. Figure 11 is a perspective view of the connector housing of the second connector (female) shown in Figure 10 with the top wall partially sectioned for illustration of the interior. Figure 12 is a cross sectional view of the second connector housing (female) as shown in Figure 10, along line XII-XII.

[0058]

The difference between the electrical connector of this embodiment 1A and that of the previously documented embodiment 1 is only a small portion of the female housing and the CPA while maintaining the design of the rest of the structure. Structural elements that are common to both embodiments are assigned the same reference numbers and will not be discussed in detail, and only elements that are different will be described in detail.

[0059]

As shown in Figures 10 to 12, the electrical connector 1A has a female connector 2A with a female housing 3A housing the multiple female contact terminals, and a male connector 9 with a male housing 11 housing the multiple male contact terminals that will be electrically connected to the female contact terminals. The female housing 3A has a structure in which a CPA 8A will be installed to assure and maintain the full-mated state with the male connector 9.

[0060]

The female housing 3A has an inner housing 4A that houses multiple female contact terminals and an outer housing 5A that covers the outer wall surfaces of the inner housing 4A except the front and rear wall surfaces. The inner housing 4A and the outer housing 5A have a particular gap space in between, and are integrally joined at their rear ends. The female housing 3A is plastic-molded with an electrically insulated synthetic resin.

[0061]

As shown in Figure 12, the topmost outer wall 4a of the inner housing 4A has a low-level flat surface 4a1 on the anterior half and a high-level flat surface 4a2 on the posterior half with a step 4a' at the junction. On the step 4a2, a pair of vertical projections 42A separated by a particular spacing can be found and within this spacing along the centre, a CPA restraining protrusion 4a4 is formed as shown in Figure 17B. Although only one vertical projection 42A is shown in Figure 10, the other one of the pair can be found on the side wall 5c side. These vertical projections 42A will be latched by the latching claws 82c' of the framing arms (80L & 80R) of the CPA 8. As shown in the previous embodiment 1, the outer wall surface of the inner housing provides the platform to form the vertical projections 42A and in turn become the CPA installation space. As a result, similar advantage enjoyed in the previous embodiment is also achieved in this alternate embodiment.

[0062]

A gap H1 as shown in Figures 11 & 12 is sandwiched between the inner

surface of the top wall 5a of the outer housing 5A and the topmost outer surface 4a1 of the inner housing 4, and this gap H1 is much larger than other circumferential gaps i.e. the gap H2 found between the inner surface of the bottom wall 5b and the bottom outer surface 4b of the inner housing 4. Besides bordered by the inner surface of the top wall 5a of the outer housing and the top outer surface 4a of the inner housing 4, the gap H1 is furthered bordered by left 5c and right 5d side walls of the outer housing 5A to form a cavity SA that is opened at the anterior and posterior ends. The cavity SA is divided at the step 4a' of the inner housing 4, into a locking space S1A (in the anterior) that houses the locking arm 7A and a CPA installation space S2A (in the posterior) that houses the CPA 8A. On the inner wall surfaces of the side walls (5c & 5d), guiding grooves 5c' & 5d' are formed to guide the motion of the CPA 8A by its guiding rails 83a & 83b. The CPA installation space S2A is open both at the rear and posterior half of the top wall 5a of the outer housing 5A. It is through this opening 6A that CPA 8A is inserted into the female housing 3A with the guide railing (83a & 83b) inserted into the guiding grooves (5c' & 5d').

[0063]

The locking space S1A houses the locking arm 7A. As shown in Figure 11, the locking arm 7A is in the form of a resilient tongue-like plate, having a width smaller that the spacing bordered by the left 5c and right 5d walls of the outer housing 5 and of a particular thickness and length; it is separated from the inner surface 5a' of the top wall 5a of the outer housing 5A by a gap H11 and from the topmost surface 4a1 of the inner housing 4A by a gap H12. The locking arm 7A is joined to the posterior portion of the inner housing 4 at the base point 7f and then joined by a bridge part 5h at the posterior end of the outer housing 5A. The CPA 8 will be seated inside the gap H11 & H12 and the male housing 11 of the male connector 9 will be inserted into the gap H12 during mating.

[0064]

In Figure 11, the locking arm 7A, a plate-like structure, has top 7a & bottom 7b walls, left 7c & right 7d walls, and a front wall 7e. The bridge part 5h is

between the posterior portion of the left 5c and right 5d side walls of the outer housing 5A, and it is elevated at a particular gap from the high level surface 4a2 of the inner housing 4A, as shown in Figure 12. An elongated slot 74 is longitudinally and centrally formed along the locking arm 7A, extending from a distance off the front wall 7e towards the posterior end. At the anterior end of the slot 74, a locking ledge 74a is formed. During the mating process with the male connector 9, the locking arm 7A is being pushed upwards by the first locking portion 12 of the male housing 11 and the first locking portion 12 will be latched onto the locking ledge 74a upon fully mated.

[0065]

The physical profile of the CPA 8A that will be assembled into the female connector 3A will be discussed next with reference to Figures 13 and 14. Figure 13 shows the CPA that will be assembled to the female housing as shown in Figure 10. Figure13A is a perspective view of the CPA. Figure 13B shows the underside of the CPA. Figure 14A is the front view of the CPA. Figure 14B is a cross sectional view of the CPA as shown in Figure 14A, along line XIVB-XIVB. Figure 14C is a cross-sectional view of the CPA as shown in Figure 14A, along line XIVC-XIVC.

[0066]

As shown in Figure 13A, the CPA has a pair of framing arms 80L & 80R running parallel to each other at a particular spacing; one end of the framing arm is connected to a connecting frame 80J with the other end free. The U-shaped frame is plastic-molded with an electrically insulating synthetic resin. The width of the gap between the pair of framing arms 80L & 80R is W2 which is slightly larger than that of the locking arm 7A. The two framing arms 80L & 80R are the exact mirror image of each other, and thus one of the pair i.e. 80L will be selected and discussed in detail in the following.

[0067]

As shown in Figures 13A and 14C, the framing arm 80L has a base part 81 (a columnar body of a particular thickness) that is extended downwards from the connecting frame 80J and the base part 81 is in turn joined at the bottom end with

a latching arm 82 that extends horizontally towards the front. The latching arm 82 is joined to the base part 81 in such a way that it can be elastically deformed. The latching arm 82 has a connecting part 82a that runs horizontally from the bottom end of the base part 81, followed by a vertical part 82b extended from the end of the connecting part 82a, and lastly joined by a latching part 82c that extends outwards from the top end of the vertical part 82b. At the end of the latching part 82c', hook-like latching claw 82c' is formed. Between the base part 81 and the vertical part 82b, they are separated by a gap G1 that provides the space for the elastic deformation of the latching arm 82.

[0068]

The connecting frame 80J as illustrated in Figure 13A is a rectangular plate-form body 83 of a particular width and length. On the top surface of the connecting frame 80J, a grip portion 84 is formed to provide the ease of grip for the fingertip; on the underside, a housing lock restraint 85 is formed. The plate-form body 83 has a width small enough to fit into the opening portion 6A of the CPA installation space S2A of the outer housing 5A and a length similar or slightly longer than the horizontal length of the latching arm 82 of the framing arms (80L & 80R). Along the lateral edges of the plate-form body 83, a pair of guiding rails (83a & 83b) runs along the edges. In Figure 14B, the housing lock restraint 85 consists of a support piece 85a that extends from the underside of the plate-form body 83 and a resilient approximately U-shaped piece 85b integrally joined to the end of the support piece 85a with the opening of the U-shaped cavity facing in the same direction in which the latching arm 82 is extended.

[0069]

The CPA 8A- assisted assembly of the female connector 2A with the male connector 9 will be next discussed, with reference to Figures 15 to 17.

[0070]

Figures 15 to 17 illustrate the mating process of the male and female connectors. Figure 15 is a cross sectional view of the electrical connector (as shown in Figure 10) assembled with CPA, along line XV-XV. Figure 16 is a cross

sectional view of the intermediate state of the mating process where the male connector is inserted into the female connector and the front end portion (edge) of the male connector housing hits the pre-lock claws of the CPA. Figure 17A is a cross sectional view of the final state of the mating process where the male connector has fully inserted into the female housing. Figure 17B is a cross sectional view of the region XVIIB (as shown in Figure 17A) sectioned to show the central region of the CPA.

[0071]

The CPA 8 is pre-installed inside the female housing 3A of the female connector 2A. The installation of the CPA 8A into the CPA installation space S2A of the female housing 3A will be discussed in detail as follow. As shown in Figure 10, the CPA 8A is first positioned at the rear of the female housing 3A and from which the framing arms (80L & 80R) are inserted through the entrance opening portion 6A of the CPA installation space S2A. On the inner wall surfaces of the side walls (5c & 5d), guiding grooves 5c' & 5d' are formed to guide the motion of the CPA 8A by its guiding rails 83a & 83b. The CPA installation space S2A is open both at the rear and posterior half of the top wall 5a of the outer housing 5A. It is through this opening 6A that CPA 8A is inserted into the female housing 3A and with the guide railings (83a & 83b) inserted into the guiding grooves (5c' & 5d'). The CPA 8 as a result is latched in place (at pre-lock state) by the pair of latching claws 82c' of the latching arms 82 of the framing arms (80L & 80R) latch onto the vertical projections 42A i.e. any forward-backward motion of the CPA 8 along the longitudinal direction is restrained. Figure 15 shows the latching of one of the latching claws 82c' onto the vertical projection 42A. By adopting this latching design, the latching arms 82 will be stress-free and not subjected to any problem pertaining to a decline of resilient property due to environmental factors.

[0072]

The male housing 11 of the male connector 9 is inserted into the female connector 2A (pre-installed with CPA 8A) through the insertion opening 5g of the female housing 3A. As shown in Figures 15 & 16, the locking protrusion 12 (first

locking portion) of the male housing 11 will strike against the front wall 7e of the locking arm 7A to mark the beginning of the locking process. As the male connector 9 is further pushed inwards, the first locking portion 12 of the male housing 11 pushes the front wall 7e portion of the locking arm 7A upwards i.e. the locking arm 7A is elastically deformed while the first locking portion 12 continues to move inwards. Just before the end of the insertion, the first locking portion 12 of the male housing 11 will be latched by the locking ledge 74a of the female connector 2A. Almost at the same time, the outer edge 11e' (front portion of the insertion opening 11g of the male connector 9) of the male housing 11 strikes against and pushes the latching claws 82c' of the framing arms (80L & 80R) upwards (in a direction as indicated by the arrow 'A' in Figure 16) i.e. unlatches the latching claws 82c' from the vertical projections 42A of the inner housing 4A (disengage from pre-lock position). Once the latching claws 82c' have unlatched from the vertical projections 42A, the CPA 8A can be pulled towards the rear of the female housing 3A. Such pulling of the CPA 8A is only possible at full-mated stated and so the full-mated of the connectors is assured. When the CPA 8A is pulled back to the rear, the housing lock restraint 85 will mount and stopped at the CPA restraint protrusion 4a4 found on the top wall surface of posterior portion of the inner housing 4A. Any further movement of the CPA 8A is thus restrained, and so the full-mated state of the connectors are assured and maintained. By adopting this latching design, the latching arms 82 will be stress-free and not subjected to any problem pertaining to a decline of resilient property due to environmental factors.

[0073]

In this embodiment, the first latching portions is in the form of vertical projections and the second latching portions of the CPA in the form of latching arms with latching claws. The latching of the latching arms of the CPA onto the first latching projections restrains the longitudinal movement of the CPA inside the second connector housing, and thus renders stability to the installation of the CPA. Due to the resilient nature of the latching arms, the resilience is made use in the

latching onto the first latching projections as well as the unlatching of the latching arms. By having a pair of resilient latching arms, the full-mated state can be assured and maintained by pulling the CPA towards the rear along the longitudinal direction of the second connector housing. As a result, the electrical connector has offered an alternate, different method of implementing and manipulating the CPA.

What is claimed is:

1. An electrical connector comprising of:

a first connector having a first connector housing in which first contact terminals are installed;

a second connector having a second connector housing in which second contact terminals that electrically connected to the first contact terminals are installed;

a connector positional assurance (CPA) that assures and maintains the full-mated state when the first and second connectors are fully mated together;

the first connector having a first connector housing in which the first contact terminals that will be electrically connected to the second contact terminals are installed. The connector housing has an insertion opening at the front of the first connector housing into which an inner housing of the second connector is inserted and a first locking portion on outer wall surface of the first connector housing;

the second connector having a second connector housing with an inner housing in which the second contact terminals are installed and is covered by an outer housing with a particular gap space interposed except the region in which the first connector will be inserted. The gap space bordered by the topmost outer surface of the inner housing and the inner surface of the top wall of the outer housing is divided into a locking space (in the anterior portion where the lock protrusion of the first connector will be latched at full-mated state) and a space (in the posterior portion) to accommodate the CPA;

the locking space is where the locking arm (a resilient tongue-like structure)

is housed and the locking arm has a second locking portion near the tongue tip to engage the first locking portion of the first connector;

the CPA installation space has a pair of first latching portions on the outer wall surface of the inner housing onto which the CPA will be latched;

the CPA has a pair of second latching portions that latch onto the first latching portions of the inner housing. This latching will be released at the full-mated state of the first and second connectors by the front end portion of the first connector housing where the insertion hole is formed;

when the CPA is installed into the CPA installation space in the second connector housing, the second latching portions latch onto the first latching portions and when the first and second connectors are fully mated together, the second latching portions will be unlatched from the first latching portions by the front end portion of the first connector housing that forms the insertion hole. The unlatching at full-mated state enables the movement of the CPA and thus the full-mated state is assured.

2. The electrical connector, as described in claim 1, has a locking space and a CPA installation space allocated within a specified gap that corresponds to the same side of the outer wall surface or another wall surface where the first latching portions are formed (becoming the CPA installation space).

3. The electrical connector, as described in claim 1, has a U-shaped framework with a pair of framing arms running parallel to each other at a particular spacing; one end of the framing arm is connected to a connecting frame with the other end free;

a second latching portion that latches onto a first latching portion and it is

formed on the wall surface of the framing arms;

first latching portions onto which the second latching portions are latched are formed on the outer wall surface of the inner housing in the CPA installation space.

4. The electrical connector, as described in claim 3, has a CPA that has pair of first latching portions formed as projections protruding from the outer wall surface of the inner housing, and the second latching portions of the CPA as a pair of resilient latching projections that are latched onto the ends of the first latching portion projections.