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.

[0003]

An example of such an electrical connector with CPA is discussed in U.S. Patent No. 5,720,623.

[0004]

Figure 10 is an external perspective view of the electrical connector illustrated in this U.S. Patent.

[0005]

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.

[0006]

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.

[0007]

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.

[0008]

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.

[0009]

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.

[0010]

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.

[0011]

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. This implies that locking mechanism and the CPA must be accurately assembled so as to ensure proper physical connection. In conclusion, 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.

[0012]

After the full-mated state of the connectors is detected and followed by the full insertion of the CPA, the locking mechanism of the two connectors are maintained in that locked state by the CPA by continuously exerting a reaction force on the locking arm. Should there be any reduction of this reaction force due to environmental conditions, secular factors or similar factors, this will compromise the effectiveness of the reaction force in maintaining the locked state. Furthermore, in order to ensure a proper functioning of the locking system, the relative position of the locking arm of the connector housing with the front projection of the CPA needs to be accurately aligned. In the case of these two electrical connectors, the CPA is not directly coupled onto the locking arm; the CPA is instead only guided by the two side walls of the cover and latched by two sets of first and second latching holes. As a result, it will be difficult to assure the precise alignment of the moving parts should there be any assembly error

or dimensional irregularity.

SUMMARY

[0013]

One advantageous aspect of the present invention is to offer an electrical connector system where the interaction between the CPA and the connector locking mechanism is rendered easier.

[0014]

Another advantageous aspect of the invention is to offer an electrical connector where the connector locking mechanism remains effective by maintaining the reaction force exerted by the CPA on the locking arm even when subjected to environmental conditions, secular factors or similar factors.

[0015]

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 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 (where the first locking portion of the first connector will be latched at full-mated state) and a CPA installation space to accommodate the CPA. The housing lock space is where the locking arm (a flexible tongue-like structure) can be found. The posterior end of the locking arm is fixed to the inner housing and the anterior end a free end. The gap space between the locking arm and the inner housing is where the first locking portion of the first connector will be inserted. The gap space between the locking arm and the cover housing is where the latching arm of the CPA will be inserted. The locking arm has a pair of projections that serve as guides on both its

longitudinal sides. There is a cut-out slot that originates some distance from the tongue-tip of the locking arm and extended forwards to engage with the latching "claw" of the CPA. A second locking portion starting further from the tongue-tip and extending backwards is where the first locking portion of the first connector will be latched in. The CPA is a U-shaped structure where there is a pair of framing arms running parallel to each other at a particular spacing; the two framing arms are connected at one end to a connecting frame with the other ends free. On the faces of the framing arms that are facing inwards and opposing to each other, guiding slots can be found in which the guiding projections of the locking arms will sit. A latching arm can be found along the centerline of the U-frame extending from the inner surface wall of the connecting frame towards the free end, in the same direction of the arms mentioned in the last sentence. At the end of the latching arm, a latching "claw" can be found. Any forward movement (in the direction of the insertion direction) of the latching "claw" is stopped (pre-lock) by the guiding slot where the first locking portion of the first connector is being latched by the second locking portion of the locking arm. When the first connector is fully mated with the second connector, the latching "claw" will be pushed upward by the first locking portion of the first connector and thus disengage from the pre-lock position. This disengagement from the pre-lock state enables the CPA to be pushed forwards into the final locking position where the latching "claw" will latch into the designated cut-out slot at the tongue-tip of the locking arm.

[0016]

Such setup, where the CPA slides with its guiding slots longitudinally along the projection guides of the locking arm of the second connector, allows better and more accurate control over the positioning and operation of the CPA. After the fully mated state between the first and second connectors is detected, the latching "claw" goes over the locking arm and latches itself into the designated cut-out slot at the tip of the locking arm. Although the latching arm of the CPA is elastically deformed during the transition period from pre-lock to final lock of the CPA, the latching arm recovers its original state by latching into the designated cut-out slot at the tongue-tip of the locking arm (returning to the initial shape of the CPA i.e. no residual stress state at the end of the full insertion). Unlike the connector systems discussed earlier where the locked state of the connectors is maintained by a continuous application of a reaction force on

the locking arm or equivalent, the present invention offers a system where the potential loss of the locking capability of the latching arm due to a loss of the reaction force under the influence of secular factors or equivalent can be avoided. With the latching "claw" firmly latches into the designated cut-out slot at the end of the insertion, CPA will not disengage when the first connector is fully mated with the second connector.

[0017]

It is preferable for the CPA to have a cut-out slot at the tip of the tongue-like locking arm into which the latching "claw" of the CPA will be latched.

[0018]

By having the cut-out slot, the latching "claw" will firmly latch into the slot and thus CPA will not be easily disengaged while maintaining the full-mated state of the first and second connectors.

[0019]

It is preferable for the latching arm of the CPA, extending from the inner wall of the connecting frame to the open end (towards insertion direction), to be a broad, elongated and spring-like plate flanked by two reinforcement "fingers" and with a latching "claw" at the end of the tip of the free end.

[0020]

By adopting this shape, the mechanical integrity of the latching arm is thus raised.

[0021]

It is preferable for the CPA to have guiding ribs on the underside so that the CPA can align and sit inside the guiding slot found between the two arms of the locking arm.

[0022]

The interaction between the guiding ribs on the underside of the CPA and the guiding slot (between the two arms) of the locking arm, together with the interaction between the guiding slots of the CPA and the guiding projections of the locking arm, further assures that the CPA is properly and accurately aligned inside the locking arm.

[0023]

It is preferable for the CPA to have its latching arm centrally positioned extending from the inner surface of the connecting frame, which is in turn flanked by a pair of latching

"fingers" one on each side with a gap interposed. These latching "fingers" will be latched onto the latching hooks found on top of the locking arm.

[0024]

With the centrally positioned latching arm, flanked by a pair of guiding ribs on the underside of the latching arm, the CPA can be securely installed inside the connector housing of the second connector.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025]

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.

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 4C also shows the underside of the CPA but at a different angle.

Figure 5 is a cross sectional view of the electrical connector assembled with CPA, along line V-V.

Figure 6 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 7 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 8 is a cross section view of the intermediate state of the mating process where the male connector is being further inserted into the female connector and the latching "claw"

of the latching arm of the CPA is being unlatched from its pre-lock position.

Figure 9 is a cross sectional view of the final state of the mating process when the male connector is fully mated with the female connector, and the latching "claw" of CPA has crossed over the locking arm and latched into the designated cut-out slot (final lock for CPA).

Figure 10 is a perspective exploded view of the electrical connector that is the prior art in relative to the present invention.

DESCRIPTION OF EXEMPLARY EMBODIMENT

[0026]

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.

[0027]

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. 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.

[0028]

Figures 1 to 3 illustrates 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 installed inside the female housing 3 of the female connector 2 to assure and maintain the full-mated state with the male connector 9.

[0029]

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.

[0030]

Firstly, the male connector 9 will be discussed, with reference to Figures 1 to 5.

[0031]

Figure 5 is a cross sectional view of the electrical connector assembled with CPA, along line V-V.

[0032]

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 connector 9 is plastic-molded with electrically insulated synthetic resin. 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. 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.

[0033]

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

[0034]

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 Figure 5 to 9.

[0035]

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 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.

[0036]

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 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.

[0037]

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. 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.

[0038]

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 joined to the posterior portions 4f & 4g of the inner housing 4. On the left 5c and right 5d walls of the outer housing 5, a pair of guiding grooves 54 can be found longitudinally into which the guiding rails (11c' & 11d') of the male connector 9 are inserted.

[0039]

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 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 5 side

walls of the outer housing 5 to form a cavity 5 that is opened at the anterior and posterior ends. The cavity S is divided at the step 4a2 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 that CPA 8 is assembled into the female housing 3.

[0040]

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.

[0041]

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. On the front wall 7e, there is a cut-out slot 73. The latching "claw" 82c' on the latching arm 82 of the CPA 8 will be latched into this cut-out slot 73 upon full insertion of the CPA 8. Just before the male connector 9 has fully mated with the female connector 3, the latching arm 82 of the CPA 8 will be elastically deformed upwards by the first locking portion 12 of the male housing 11. At fully mated state, the first locking portion 12 is latched into the second locking portion 74a. Once the CPA 8 detects the full-mated state of the first connector 2 and second connector 9, the latching "claw" 82c' on the latching arm 82 of the CPA 8 latches into the cut-out slot 73 at the tongue-like tip of the locking arm 7 after the full insertion of the CPA 8, resulting the once elastically deformed latching arm 82 to return to its original shape. In comparison, the locked state of the locking mechanisms in the related art is being maintained by the continual application of a counter force by the latching arm of the CPA on the connector lock. By not adopting what is practiced in the related art, the potential problem of inability to maintain the locked state due to diminishing resilience of the latching

arm of the CPA i.e. a loss of the pressing force due to ambient conditions or secular change to maintain the locked state, is avoided. In addition, with the locking of the latching "claw" of the latching arm of the CPA into the cut-out slot of the tongue-like tip of the locking arm, the CPA will not be unintentionally disengaged when the first and second connectors are in full-mated state.

[0042]

An elongated guiding slot 74 is longitudinally and centrally formed along the locking arm 7, consisting of a narrower 74_1 starting slightly posterior to the second locking portion 74a and extends for a particular length before it is joined by a broader 74_2 that extends till the base point 7f. At pre-lock position of the CPA 8, the latching "claw" 82c' of the latching arm 82 of the CPA 8 sits inside the narrower 74_1 ; the latching arm 82 flanked by the guiding ribs 83L & 83R on both sides sit inside the broader 74_2. 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, and will sit inside the pair of guiding slots 8d' on the framing arms 8L & 8R of the CPA 8. The movement of the CPA 8 with respect to the locking arm 7 is thus governed by the interaction between the guiding projections 71 of the locking arm 7 and the guiding slots 8d' of the CPA 8. Such interaction further enhances the positional alignment of the CPA 8 i.e. will be more accurate and smoother. In addition, with the guiding ribs 83L & 83R of the CPA 8 sitting inside the guiding slot 74_2 of the locking arm 7, it further renders the positional alignment of the CPA. A pair of latching hooks 72 is found on top of the pair of base points 7f i.e. one latching hook on one base point that is joined to the inner housing 5. At pre-lock position of the CPA 8, the latching "claws" 83L' & 83R' on the latching "fingers" 81L & 81R of the CPA 8 will each be latched on the latching hooks 72 on the locking arm 7.

[0043]

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.

[0044]

The physical profile of the CPA 8 that will be assembled into the female connector 2

will be discussed next with reference to Figures 4A to 4C. Figure 4A shows the perspective view, Figure 4B an underside view and Figure 4C another underside view at a different angle of the CPA 8.

[0045]

The CPA is molded with an electrical insulating synthetic resin and has a U-shaped structure 8A where there is a pair of framing arms 8L & 8R running parallel to each other at a particular spacing W1; one end of the two framing arms 8L & 8R are connected to a connecting frame 8J with the other end free. The U-shaped frame has a longitudinal length of L1 that is shorter than that of cavity S; its width (orthogonal to the longitudinal length) is enough for the CPA 8 to insert into the cavity S. A latching arm 82 can be found along the centerline of the U-frame extending from the inner surface wall of the connecting frame 8J towards the free ends. At the tip of the latching arm 82, a latching "claw" 82c' can be found.

[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. The width of the guiding slot 8d' 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.

[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, 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]

Extending from the inner surface 8j of the connecting frame 8J, facing the open end 8G, a latching arm 82 flanked by two latching "fingers" 81L & 81R with a particular spacing in-between. More precisely, the latching "fingers" 81L & 81R are each found in each gap W11 i.e. the gap between the framing arm 8L/8R and the latching arm 82 (extending from the centerline of the inner surface 8j). The length L12 of the pair of latching "fingers" 811 & 81R is shorter than that L13 of the latching arm 82 and on the tip of each latching "finger", a latching "claw" is found i.e. 83L' on 81L and 83R' on 81R. The latching "claws" 83L' & 83R' will be latched onto the latching hooks 72 of the locking arm 7. The latching arm 82 is an elongated resilient plate-like structure of a particular width L2 and length L13 where the base portion of the arm 82 is integrally joined to the inner surface of the inner surface 8j and a latching "claw" 82c' is formed at the tip. On the underside of the latching arm 82, a pair of guiding ribs 83L & 83R is formed in the longitudinal direction.

[0050]

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

[0051]

The female contact terminals (omitted in the drawings) 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 & 2.

[0052]

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 72 of the locking arm 7 can fit into. At the same time, the latching arm 82

flanked by the guiding ribs 83L & 83R are inserted into the broader guiding slot 74_2. The CPA 8 is further pushed in with all these alignments are in force. Upon further insertion of the CPA 8 that is guided by the pair of guiding ribs 83L & 83R along the guiding slot 74, the latching "claw" 82c' of the latching arm 82 enters the narrower guiding slot 74_1 and the smaller latching "claws" 83L' & 83R' of the latching "fingers" 81L & 81R latch onto the latching hooks 72 of the locking arm 7. The anterior-posterior movement of the CPA 8 within the female housing 3 is thus regulated.

[0053]

The CPA 8- assisted assembly of the female connector 2 with the male connector 9 will be next discussed, with reference to Figures 5 to 9 that illustrate the mating process of the male 9 and female 2 connectors. Figure 5 is a cross sectional view of the electrical connector assembled with CPA, along line V-V. Figure 6 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 7 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 8 is a cross section 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 latching "claw" 82c' of the latching arm 82 of the CPA 8 is being unlatched from its pre-lock position. 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, and the latching "claw" 82c' of CPA 8 has crossed over the locking arm 7 and latched into the designated cut-out slot 73 (final lock for CPA 8).

[0054]

Just before the male connector 9 has fully mated with the female connector 2, the latching arm 82 of the CPA 8 will be elastically deformed upwards by the first locking portion 12 of the male housing 11. At full-mated state, the first locking portion 12 is latched into the second locking portion 74a. Once the CPA 8 detected the full-mated state of the first connector 2 and second connector 9, the CPA 8 slides forward into its final lock position i.e. the latching "claw" 82c' on the latching arm 82 of the CPA 8 latches into the cut-out slot 73 at the

tongue-like tip of the locking arm 7 after the full insertion of the CPA 8, resulting the once elastically deformed latching arm 82 to return to its original shape. In comparison, the locked state of the locking mechanisms in the related art is being maintained by the continual application of a counter force by the latching arm of the CPA on the connector lock. By not adopting what is practiced in the related art, the potential problem of inability to maintain the locked state due to diminishing resilience of the latching arm of the CPA i.e. a loss of the pressing force due to ambient conditions or secular change to maintain the locked state, is avoided. In addition, with the locking of the latching "claw" of the latching arm of the CPA into the cut-out slot of the tongue-like tip of the locking arm, the CPA will not be unintentionally disengaged when the first and second connectors are in full-mated state.

[0055]

The assembly into and movement of the CPA 8 within the female housing 3 are coordinated by the sliding motion of the guiding projections 72 of the locking arm 7 inside the guiding slots 8d' on the framing arms 8L & 8R of the CPA 8 as well as the guiding offered by guiding slot 74 of the locking arm 7 to the guiding ribs 83L & 83R on the underside of the CPA 8. By adopting this sliding and properly guided motion, the positional alignment during the installation of the CPA 8 can be more accurate and the detection of full-mated state of the connectors easier.

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 mated state when the first and second connectors are fully mated together;

the first connector having a first locking portion on its outer wall surface of the first connector housing, and an insertion opening into which an inner housing of the second connector is inserted;

the second connector having a second connector 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. 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 (where the lock protrusion of the first connector will be latched at full-mated state) and a space to accommodate the CPA;

the lock space, between the topmost outer surface of the inner housing and inner wall of the outer housing, is where the locking arm (a resilient tongue-like structure) is housed with one end of the locking arm fixed onto the inner housing and the other end free. The locking arm is separated from the inner housing by a first gap where the first locking portion of the first connector is inserted, and from the outer housing by a second gap were he latching arm of the CPA is inserted. The locking arm has a pair of guiding projections along the longitudinal lateral edges, a guiding slot starting at a distance from the tongue tip of the locking arm and extended

towards the rear end, and a second locking portion near the tongue tip of the locking arm to engage the first locking portion of the first connector;

the CPA, a U-shaped structure where there is a pair of framing arms running parallel to each other at a particular spacing; the two framing arms are connected at one end to a connecting frame with the other end free. On the faces of the framing arms that are facing inwards and opposing to each other, guiding slots can be found in which the guiding projections of the locking arms will sit. A latching arm can be found along the centerline of the U-frame extending from the inner surface wall of the connecting frame towards the free ends, with a latching "claw" at the tip of the latching arm;

the guiding projections of the locking arm inserted into the guiding slots in the framing arms of the CPA. Any forward movement (in the direction of the insertion direction) of the latching "claw" is stopped (pre-lock) by the guiding slot where the first locking portion of the first connector will be latched by the second locking portion of the locking arm. When the first connector is fully mated with the second connector, the latching "claw" will be pushed upwards by the first locking portion of the first connector and thus disengage from the pre-lock position. This disengagement from the pre-lock state allows the CPA to be pushed forwards into the final locking position where the latching "claw" will latch into the designated cut-out slot at the tongue-tip of the locking arm;

2. The electrical connector, as described in claim 1, has a locking arm where there is cut-out slot formed at the tongue tip into which the latching "claw" of the latching arm of the CPA will be latched.

3. The electrical connector, as described in claim 1, has a CPA with a broad, elongated resilient plate-like latching arm that extends from the inner surface of the connecting frame to the open end with a hook-like latching "claw" at the tip of the latching arm.

4. The electrical connector, as described in claim 1, has a CPA that has pair of guiding

ribs on the underside that fits into the guiding slot formed along the centerline of the locking arm.

5. The electrical connector, as described in claim 1, has a CPA with a latching arm extending along the centerline from the inner surface of the connecting frame and is flanked by a pair of latching "fingers" with a gap interposed. These latching "fingers" with latching "claws" at the tip latch onto the latching hooks provided on the top of the locking arm.