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(71) Applicant: **J.S.T. Mfg. Co., Ltd.**
Osaka 541-0045 (JP)

(72) Inventor: **STROEYKENS, Erik**
B-3190 Boortmeerbeek (BE)

(74) Representative: **D Young & Co LLP**
120 Holborn
London EC1N 2DY (GB)

(54) **ELECTRICAL CONNECTORS, TERMINAL POSITION ASSURANCE PART AND METHODS**

(57) A male connector for connecting to a female connector to provide an electrical connection between conductors of the male connector and the female connector is provided. The male connector comprises a header part configured to connect to the female connector. The header part comprises an socket providing an engagement region for receiving the female connector and for housing one or more electrical pins configured to be received by one or more female terminals of the female connector to provide the electrical connection when the header part and the female connector are connected. The male connector also comprises a terminal position assurance, TPA, part configured to be received by the engagement region of the socket of the header part and to guide the one or more electrical pins through one or more holes in the TPA part and into the engagement region of the socket. The TPA part is configured to constrain the one or more electrical pins in the engagement region of the socket.

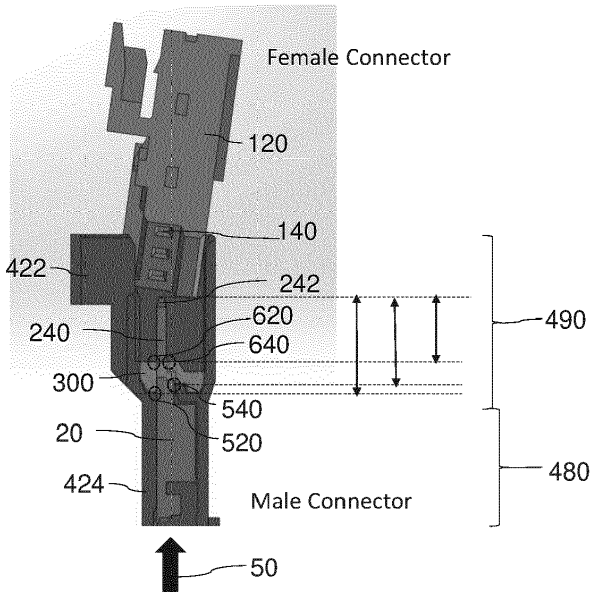


FIG. 10

EP 4 160 829 A1

Description

BACKGROUND

Field

[0001] The present disclosure relates to a male connector forming part of an electrical connector, electrical connectors comprising male and female connectors and a Terminal Position Assurance (TPA) part, and methods of assembling electrical connectors with a TPA part.

Description of Related Art

[0002] The "background" description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description which may not otherwise qualify as prior art at the time of filing, are neither expressly or impliedly admitted as prior art against the present invention.

[0003] Electrical connectors are commonly used in electrical products for connecting electrical wires or cables to form electrical connections with other wires or components. A type of electrical connector used depend on a complexity, size, safety and manufacturing requirements of an electrical product of which the electrical connector forms part. For complex electrical components such as automobiles, there are typically a large number of electrical connectors which may have different features depending on their specific application. For example, electrical connectors used for safety applications such as airbag inflation or seatbelt deployment may incorporate advanced safety features such as coding, Connector Position Assurance (CPA), sealing, and Kojiri-safe features (scoop-proofing) and the like. On the other hand, vehicles may also use electrical connectors with reduced complexity for non-critical applications such as for cabin lighting which avoid a use of advanced safety features to reduce costs. Some manufacturers have found that, particularly for non-critical applications in automobiles, electrical connectors originally designed for small household appliances can provide a sufficiently reliable electrical connection at a low enough cost to meet manufacturer and customer requirements. Such electrical connectors are typically associated other features which are desirable for automobiles such as compactness, an ability to fit a retainer, an ability to be panel mounted and the use of relatively inexpensive standard materials. There has therefore been interest in re-purposing electrical connectors designed for small household appliances for use in automobiles.

[0004] However, re-purposing electrical connectors may lead to the connectors being subjected to a harsher assembly environment than they are designed to withstand. In view of the above, there is therefore a need for improved electrical connectors for automobiles which can provide a cost-effective and reliable electrical connection.

SUMMARY

[0005] The present disclosure can help address or mitigate at least some of the issues discussed above.

[0006] Example embodiments of the present technique can provide a male connector for connecting to a female connector to provide an electrical connection between conductors of the male connector and the female connector. The male connector comprises a header part configured to connect to the female connector. The header part comprises a socket providing an engagement region for receiving the female connector and for housing one or more electrical pins configured to be received by one or more female terminals of the female connector to provide the electrical connection when the header part and the female connector are connected. The male connector also comprises a terminal position assurance, TPA, part configured to be received by the engagement region of the socket and to guide the one or more electrical pins through one or more holes in the TPA part and into the engagement region of the socket. The TPA part is configured to constrain the one or more electrical pins in the engagement region of the socket. The TPA part constrains the one or more electrical pins in the engagement region to a greater extent than without the TPA part in which a greater freedom of movement can cause the one or more electrical pins to be distorted and/or prevents them from engaging with the female terminals.

[0007] Other example embodiments can provide a method for assembling the male connector. The method comprises providing the header part of the male connector, and arranging the TPA part in the engagement region of the socket of the header part.

[0008] Other example embodiments can provide an electrical connector including a female connector, a male connector and a TPA part. The female connector comprises one or more female terminals. The male connector comprises a header part configured to connect to the female connector. The header part comprises a socket providing an engagement region for receiving the female connector and for housing one or more electrical pins. The one or more electrical pins are configured to be received by the one or more female terminals to provide an electrical connection between conductors of the male connector and the female connector when the header part and the female connector are connected. The TPA part is configured to be received by the engagement region of the socket, to guide the one or more electrical pins through one or more holes in the TPA part and into the engagement region of the socket, and to constrain the one or more electrical pins in the engagement region of the socket.

[0009] Other example embodiments can provide a method of assembling the electrical connector including the female connector, the male connector and the TPA

part. The method comprises providing the female connector, providing the male connector and arranging the TPA part in the engagement region of the socket of the header part of the male connector.

[0010] Other example embodiments relate to the TPA part for the male connector.

[0011] Some example embodiments relate to methods of assembly of electrical connectors in an automobile. In other words, example embodiments include electrical connectors which are assembled as part of an automobile assembly process. As mentioned above, the re-purposing of electrical connectors originally designed for small-household products for use in automobiles may lead to the connectors being subjected to a harsher assembly environment than they are able to withstand. Automobiles have a large number of electrical connectors per product which means a large volume of parts must be produced over a short time scale. This rate of production leads to decreased control over the assembly process and an increased risk of faults developing in electrical connectors, for example: higher volume throughput of crimping increases the risk of pins becoming tangled or damaged during the crimping and subsequent mating of the electrical connectors; wires are typically kept short to save weight and cost therefore tight bends are often employed. After assembly of the male and female connectors, "Blind Mating" processes are often employed in automobiles where male and female connectors are joined out of sight of the operator, which may further increase the risk of pin damage, and may ultimately lead to connection failure. In accordance with example embodiments, a male connector with a TPA part is provided which can, firstly, guide electrical pins into an engagement region provided by a socket of the male header and, secondly, constrain the electrical pins in the engagement region. Therefore, it is possible to prevent pins which exceed an allowed bending tolerance from entering the engagement region during an assembly of the male connector, and reduce the ability of pins which have successfully entered the engagement region of the socket to bend in the engagement region during subsequent mating of the male and female connectors. In this way, example embodiments can provide an electrical connector based on a connector originally designed for small household appliances which can provide a cost-effective and reliable electrical connection.

[0012] Although example embodiments are described in terms of electrical connectors adapted for automobiles, it will be appreciated that the electrical connectors described herein are equally suitable for any other application which has a demanding assembly environment.

[0013] It will be appreciated that references to an "allowed bending tolerance" may be referring to either a bending tolerance for pins entering the engagement region or pins which have already entered the engagement region. For example, an allowed bending tolerance for pins entering the engagement region is a maximum bending allowed in a pin for it to successfully enter the engagement region via a hole in the TPA part. This bending may result from crimping the pins onto wires. Conversely, an allowed bending threshold for pins in the engagement region is a maximum bending allowed in a pin which has already successfully entered the engagement region. This bending may be due to a misaligned connection between the male connector and the female connector. The allowed bending tolerances may be set by the manufacturer.

[0014] Respective aspects and features of the present disclosure are defined in the appended claims.

[0015] It is to be understood that both the foregoing general description and the following detailed description are exemplary, but are not restrictive, of the present technology. The described embodiments, together with further advantages, will be best understood by reference to the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] A more complete appreciation of the disclosure and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein like reference numerals designate identical or corresponding parts throughout the several views, and:

Figures 1A and 1B schematically represent a male and female connector designed for use in small household products;

Figure 2 schematically represents a sectional view of a male connector designed for use in small household products;

Figure 3 schematically represents bending of electrical pins which can occur due to incorrect manipulation of the female connector;

Figure 4 schematically represents a Terminal Positon Assurance (TPA) part according to example embodiments;

Figure 5 schematically represents a sectional view of a TPA part arranged in a male connector according to example embodiments;

Figure 6 schematically represents a male header of a male connector with an extended socket according to example embodiments;

Figure 7 schematically represents a sectional view of a TPA part arranged in a male connector with electrical pins guided through the TPA part according to example embodiments;

Figures 8A and 8B schematically represent sectional views of a TPA part arranged in a male connector with electrical pins guided through the TPA part according to example embodiments;

Figure 9 schematically represents a near-plan view of a TPA part arranged in a male connector with elec-

trical pins guided through the TPA part according to example embodiments;

Figure 10 schematically represents a sectional view of a mating between a female connector and a male connector with electrical pins guided through a TPA part according to example embodiments;

Figure 11 is a flow diagram illustrating a method of assembling a male connector according to example embodiments;

Figure 12 schematically illustrates dimensions of a male connector and a female connector designed for use in small household appliances.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0017] As explained above, electrical connectors originally designed for small household appliances, such as vacuum cleaners, irons, rice cookers, refrigerators, vending and air-conditioning, may be re-purposed for use in automobiles. However, those electrical connectors may have been designed with the knowledge that the assembly of the electrical connectors can be tightly controlled. This is because small household appliances have few electrical connectors so that more time and individual attention can be given to the assembly of each electrical connector. For example, there may be an allowed tolerance of pin bending which results from crimping electrical terminals onto the ends of wires. For the assembly of small household appliances, the crimping process can be carefully controlled to ensure that pins are not produced which exceed an allowed bending tolerance. However, in a demanding assembly environment such as assembling electrical connectors for automobiles, the increased rate of production may mean that it is more difficult to control pin bending during crimping. Therefore it is more likely that pins which exceed an allowed bending tolerance are produced. As will be explained in more detail below, this may lead to increased risk of pin damage during subsequent mating of electrical connectors and, ultimately, connection failure.

[0018] Figure 1A illustrates a conventional male and female wire-to-wire electrical connector originally designed for providing an electrical connection in small household appliances. A female connector 100 comprises a female housing 120 for housing female electrical terminals (not shown in Figure 1A) which are configured to receive male electrical terminals or pins 240 housed in a male header 220 of a male connector 200. When the male 200 and female 100 connectors are mated together in a mating process, the male pins 240 engage with the female electrical terminals to form an electrical connection between conductors of the male connector 200 and the female connector 100. For example, although not shown in Figure 1A, one or more electrical cables or wires typically extend from the male connector 200 and the female connector 100. The male 200 and female 100 connectors electrically interconnect those wires to provide an electrical connection.

[0019] The male header 220 comprises a socket 222 configured to receive the female connector 100 which includes four walls 272, 274, 276, 278 including two side walls, 272, 274, a front wall 276 and a rear wall 278. The socket 222 provides a region (an "engagement region" as explained in more detail with reference to Figure 2) for housing the pins 240. During a connection of the male connector 200 and the female connector 100, the socket 222 is configured to receive the female connector 100 in the "engagement region" so that the pins 240 engage with corresponding female terminals in the female connector 100. The pins 240 may access the female terminals of the female connector 100 through a plurality of holes in the female connector 100 (visible in Figure 10).

[0020] The male header 220 also comprises a wire housing 224. The wire housing 224 is configured to house wires attached to the pins 240 when the pins 240 are in the engagement region of the socket 222. For example, the pins 240 may be crimped onto the ends of wires (visible in Figure 2), and the housing 224 may house the wires which have been crimped onto the pins 240 as will be explained in more detail below. As will be appreciated by one skilled in the art, crimping is a solderless means of attaching electrical terminals and wires which typically results in pins 240 with increased flexibility. The male connector 200 shown in Figures 1A and 1B is an example of a XARP-()V-() header designed for use in small household appliances, which is manufactured by JST Mfg. Co. Ltd. (https://www.jstmfg.com/product/pdf/eng/eXA2.pdf). The XARP-()V-() header is an example of a 10 pole header because it can accomodate 10 electrical pins as shown in Figure 1A. The female connector 100 shown in Figures 1A and 1B is an example of the XARR-()V()-() header designed for use in small household appliances.

[0021] Figure 1B schematically represents the female housing 120 and the male header 220 when the male connector 100 and the female connector 200 have been combined in a connected or mated state. In the connected state shown in Figure 1B, the pins 240 are engaged with corresponding female terminals in the female housing 120 to provide an electrical connection between conductors of the male connector 200 and the female connector 100. The dimensions of the male 200 and female 100 electrical connectors are shown in Figure 12 in the Annex.

[0022] As mentioned above, the male 200 and female 100 connectors shown in Figure 1A are examples of electrical connectors which were designed for use in small household appliances. The connectors 100, 200 shown are compact, have a 250V/3A rating, facilitate the fitting of a retainer which is a clip to help lock the pins 240 into the female housing 120 after insertion, and can be panel mounted, which are all features advantageous to connectors in automobiles. Although rated at 250V/3A, automotive applications are typically within a range of 12V to 16V and so such connectors can be used for such applications. Additionally, the connectors 100, 200

shown use relatively inexpensive standard materials which, though restricting the temperature range at which the connectors can be used, may be suitable for ambient environments such as in cabin lighting. The absence of advanced safety features also means that costs can be kept low. Nevertheless, as will be explained in more detail below, when the connectors 100, 200 shown are assembled in an automobile assembly environment, there may be a high risk of pin damage both during the assembly of the connectors 100, 200 and/or during subsequent mating of the connectors 100, 200.

[0023] Figure 2 is a cut-away sectional view of the male connector 200 shown in Figure 1A. As shown in Figure 2, the pin 240 extends from the end of a wire 20. In particular, the wire 20 and pin 240 have been inserted into a insertion region 280 provided by the wire housing 224 of the male header 220 such that the pin 240 extends into an engagement region 290 provided by the socket 222 of the male header 220. The insertion region 280 is a space inside the wire housing 224 of the male header 220 for housing the wires 20 attached to the pins 240 when the pins 240 are configured in the engagement region 290 provided by the socket 222. As explained in more detail below, the pins 240 may be initially inserted into the wire housing 224 in an insertion direction 50, and through the insertion region 280, before eventually reaching the engagement region 290. The engagement region 290 is a space inside the socket 222 in the male header 220 in which the pins 240 are housed. The engagement region 290 is also configured to receive the female connector 200 during a mating process between the male 200 and female 100 connectors so that the pins 240 engage with corresponding female terminals in the female connector 100. It will be appreciated that although the insertion region 280 and the engagement region 290 are shown as distinct regions in Figure 2, these regions may overlap at least partially. As shown in Figure 2, the insertion region 280 may have a width 282 which is smaller than a width 292 of the engagement region 290. In some embodiments, the width of the insertion region 280 may closely match the width of the wire 20 so that the wire 20 is tightly held in the insertion region 280 of the wire housing 224. If the width of the wire 20 is non-uniform along its length (as shown in Figure 2), then the width 282 of the insertion region 280 may closely match the largest width of the wire 20 along its length to ensure the wire 20 is tightly held in the insertion region 280. Typically, a width 244 of the pin 240 is less than the width of the wire 20. Therefore, even if the width 282 of the insertion region 280 closely matches the width of the wire 20, there will be space available in the insertion region 280 to receive pins 240 which are bent with respect to the insertion direction 50. This may therefore mean that there is space available at an interface between the insertion region 280 and the engagement region 290 in which bent pins 240 can be received into the engagement region 290. For example, pins which exceed an allowed bending tolerance can be inserted into the engagement region 290 through the gap 40 formed at the interface between the insertion region 280 and the engagement region 290. If bent pins are permitted to be inserted into engagement region 290, then a likelihood of pin damage during subsequent mating of the connectors 100, 200 may be increased as will be explained in more detail below.

[0024] As mentioned above, the pin 240 may be crimped onto the end of the wire 20, rendering the pin 240 flexible. The crimping process may also result in pins which are bent with respect to the insertion direction 50. For small household appliances, crimping processes can be tightly controlled to ensure that the pin 240 does not exceed an allowed bending tolerance such as 3 degrees, for example, from an axis defined by an insertion direction 50. However, in automobile production, the decreased ability to control the crimping process may mean that pins 240 are produced which exceed the allowed bending tolerance. Furthermore, the gap 40 may be sufficiently large to permit pins with bends of more than 3 degrees from the axis defined by insertion direction 50 to enter the engagement region 290 provided by the socket 222. As will be explained in more detail below, the presence of pins 240 with bends exceeding the allowed bending tolerance may lead to an increased risk of pin damage during the mating of the male 200 and female 100 connectors, particularly if the female connector 100 is incorrectly manipulated.

[0025] An inner surface of the wire housing 224 of the male header 220 may extend into the insertion region 280 to form a wire block 230. The wire block 230 acts to prevent the wire 20 from being inserted into the engagement region 290. In other words, when the pin 240 attached to the wire 20 is inserted into the engagement region 290 along an insertion direction 50, the wire block 230 acts to prevent further insertion once the pin 240 is in the engagement region 290.

[0026] Figure 2 also illustrates the front 276 and rear 278 walls of the socket 222 of the male header 220, as well as one 272 of the side walls 272, 274. Although not shown in Figure 2, the height of the side walls 272, 274 may be approximately equal. As shown in Figure 2, the height of the side wall 272 is greater than a height of the front wall 276 and the rear wall 278. The difference in height between the front wall 276 and the side wall 272 results in the formation of a space 270a between the front wall 276 and the side wall 272. Similarly, the difference in height between the rear wall 278 and the side wall 272 results in the formation of a space 270b between the rear wall 278 and the side wall 272. In some examples, the height of the front wall 276 and the rear wall 278 are approximately equal. As will be explained in more detail with reference to Figure 3 below, the space 270a, 270b between the side walls 272, 274 and the front 276 and rear 278 walls may enable incorrect manipulation of the female connector 100 into the engagement region 280.

[0027] Figure 3 is a cut-away sectional view of the male 100 and female 200 connectors during a mating process in which the female connector 100 is incorrectly manip-

ulated. As explained above, there may be an increased likelihood of incorrect manipulation of the female connector 100 for automobiles where "blind mating processes" are often employed in which the male 200 and female 100 connectors are joined out of sight of the operator. As shown by arrow 80, the female connector 100 is approaching the male connector 200 at an angle to the insertion direction 50 of the wire 20. As will be appreciated, the space 270a, b formed between the side walls 272, 274 and the front 276 and rear 278 walls allow the female connector 100 to enter the engagement region 290 in the direction indicated by arrow 80. This incorrect manipulation of the female connector 100 may cause the pins 240 to bend, as indicated by arrow 60, in the engagement region 290. Such bending may cause damage to the pins 240 for example, the pins 240 may snap if the female connector 100 if pushed against the pins 240 with sufficient force. Alternatively, a pin 240 may be so bent that it does not enter a corresponding female terminal in the female connector 100. The bent pin 240 may therefore cause a perforation in the female housing 120 of the female connector 100, thereby damaging the pin 240 and the female housing 120. Although the pin 240 in Figure 3 is shown as being aligned with the insertion direction 50, it will be appreciated from the above explanations that the pin 240 may already have a bend in it resulting from the crimping process. In this case, the likelihood of damage to the male pins 240 resulting from incorrect manipulation of the female connector 100 is increased.

[0028] It has been explained above that the re-purposing of electrical connectors designed for use in small household appliances for use in automobiles can lead to an increased risk of pin damage during assembly and subsequent mating of the male 200 and female 100 electrical connectors, which may ultimately lead to connection failure. A technical problem therefore exists in providing cost effective and reliable electrical connectors for use in automobiles.

[0029] In view of the above, there is provided a male connector for connecting to a female connector to provide an electrical connection between conductors of the male connector and the female connector. The male connector comprises a header part configured to connect to the female connector. The header part comprises a socket providing an engagement region for receiving the female connector and for housing one or more electrical pins configured to be received by one or more female terminals of the female connector to provide the electrical connection when the header part and the female connector are connected. The male connector also comprises a terminal position assurance, TPA, part configured to be received by the engagement region of the socket and to guide the one or more electrical pins through one or more holes in the TPA part and into the engagement region of the socket. The TPA part can therefore guide electrical pins from an insertion region of a wire housing of the header part into the socket of the header part. Therefore, if pins which exceed an allowed bending tolerance have been inserted into the insertion region, the TPA part prevents or blocks those electrical pins from being inserted into the engagement region of the socket. In other words, the TPA part reduces an amount by which the pins can be deflected from an insertion direction. The TPA part is configured to constrain the one or more electrical pins in the electrical region of the engagement region of the socket. For example, the TPA part may reduce a space in the engagement region in which the one or more electrical pins are able to bend. For example, the TPA part may occupy space in the engagement region of the socket which was previously available for the electrical pins to bend in. This may reduce the ability of the pins which have been successfully guided through the holes of the TPA part to bend in the engagement region due to, for example, an incorrect manipulation of the female connector during mating of the male and female connectors. Therefore, embodiments can provide firstly a means of preventing pins which exceed a bending tolerance from entering the engagement region, and secondly, a means of reducing the ability of pins which have successfully entered the engagement region of the socket to bend during subsequent mating of the male and female connectors. A likelihood of pin damage can therefore be reduced when the male connector is subjected to demanding assembly environments.

[0030] Figure 4 illustrates a terminal position assurance (TPA) part according to example embodiments. The TPA part 300 shown in Figure 4 comprises a plurality of holes 320. The plurality of holes 320 are each configured to receive a respective one of the pins 240. Specifically, the TPA part 300 may be arranged in the engagement region 290 provided by the socket 222 of the male header 220 to guide the pins 240 into the engagement region 290 as will be explained in more detail below. In some embodiments, the plurality of holes 240 may have a cross sectional shape which has substantially the same dimensions as the cross section of the pins 240. The size and shape of the holes 320 may be configured to receive pins 240 of an allowed bending tolerance but to block pins 240 which exceed the allowed bending tolerance from entering the engagement region 290. In some embodiments, the allowed bending tolerance may be up to 3 degrees from the insertion direction 50. By preventing pins 240 which exceed an allowed bending tolerance from entering the engagement region 290 of the socket 222, a likelihood of the pins 240 successfully engaging with the female terminals during mating of the male 200 and female 100 connector is increased. Furthermore, as will be explained in more detail below, pins 240 which successfully enter one of the plurality of holes 320 can be prevented from subsequently bending beyond an allowed bending tolerance during subsequent mating of the male 200 and female 100 connector such as blind mating for example. This minimises pin damage and therefore reduces the risk of connection failure. In some embodiments, as shown in Figure 4, the TPA part 300 may comprise a plurality of clips 330 which are configured

to secure the TPA part 300 onto the male header 220.

[0031] Figure 5 illustrates an assembly of the TPA part 300 in the male header 220 of a male connector 200. As shown by arrow 30, the TPA part 300 may be slotted onto the one or more pins 240. That is, the pins 240 enter corresponding holes 320 in the TPA part 300. Although Figure 5 illustrates the TPA part 300 being slotted onto the pins 240, it will be appreciated (as shown in Figure 7), that the TPA part 300 may be assembled in the engagement region 290 of the socket 222 before the pins 240 are inserted into the engagement region 290 of the socket 222. In such cases, the TPA part 300 may prevent pins 240 which exceed an allowed bending tolerance from entering the engagement region 290 of the socket 222 as explained above.

[0032] As shown in Figure 5, the TPA part 300 may be arranged in the engagement region 290 provided by the socket 222 to reduce a space in which the pins 240 are able to bend. In other words, the TPA part 300 reduces the free space in which the pins 240 can bend. The pivot points 520, 540 are points in the socket 222 about which the pins 240 can bend if the TPA part 300 is not inserted. The pivot points 620, 640 are points on the TPA part 300 about which the pins 240 can bend when the TPA part 300 is inserted. It will be appreciated from Figure 5 that a distance between a free end 242 of the pins and each of the pivot points 620, 640 on the TPA part 300 is less than a distance between the free end 242 of the pins 240 and each of the pivot points 520, 540 in the socket 222. It will be appreciated that this distance can be reduced further by configuring a TPA part with a larger height in the engagement region 290. As a result, the pins 240 have a reduced ability to bend about the pivot points 620, 640 on the TPA part 300 than on the socket 222. In other words, a greater force is required to bend the pins 240 to a given angle when the TPA part 300 is inserted compared with when the TPA part 300 is not present. Therefore, if the female connector 100 is incorrectly manipulated during a blind mating process (such as that shown in Figure 3), a greater force is required to bend and damage the pins 240. The arrangement of the TPA part 300 in the engagement region 290 of the socket 222 may therefore reduce a likelihood of pin damage during mating.

[0033] As described above, example embodiments can provide a male connector 200 formed by an arrangement of a male header 220 and a TPA part 300 to improve connection reliability. In addition, the male connector 200 described above is compatible with existing female connectors 100 which saves costs for both manufacturers and customers.

[0034] However, as will be appreciated from Figures 2 and 3, the space 270a, 270b formed between the side walls 272, 274 and the front 276 and rear 278 walls of the socket 222 facilitate incorrect manipulation of the female connector 100. In other words, the presence of the space 270a, 270b allows the female connector 100 to be incorrectly manipulated so as to approach the pins 240 at an angle to the insertion direction 50 as indicated by arrow 80. Therefore, although the TPA part 300 can reduce the likelihood of pins 240 which exceed an allowed bending tolerance from entering the engagement region 290, which in turn may reduce the likelihood that an incorrectly manipulated female connector 100 will damage the pins 240, it is desirable to prevent incorrect manipulation of the female connector 100 in the first place. As will be explained in more detail below, example embodiments can provide a male header with an extended socket which reduces a likelihood of incorrect manipulation of the female connector 100.

[0035] Figure 6 schematically represents a male header 420 of a male connector with an extended socket 422 which is configured to reduce a likelihood of incorrect manipulation of the female connector 100. As with the male header 220 in Figure 1, the male header 420 shown in Figure 6 comprises a wire housing 424 which broadly corresponds to the wire housing 224 shown in Figure 1. However, the socket 422 in Figure 6 is extended with respect to the socket 222 shown in Figure 1. Specifically, a height of the side walls 472, 474, the front wall 476 and the rear wall 478 of the extended socket 422 are approximately equal. Therefore, in contrast to the socket shown in Figure 1, a space is not formed between the side walls 472, 474 and the front wall 476 or the rear wall 478 in the extended socket 422. Therefore, as is visible in Figure 10, the extended socket 422 prevents the female connector 100 from entering the engagement region 490 at large angles to the insertion direction 50. In other words, the extended socket 422 guides the female connector 100 into the engagement region 90 of the socket 422 of the male header 420. The male header 420 is an example of a 12 pole header because 12 electrical pins can be accommodated. This is visible from Figure 9. The dimensions of the male header 420 are also shown in Figure 6 for comparison with the conventional male header 220 and female connector 100 which are shown in Figure 12 of the Annex.

[0036] Figure 7 is a sectional view schematically representing a male connector 400 with the extended male header 420 and the TPA part 300 assembled in the engagement region 490 provided by the socket 422 of the extended male header 420. As explained above, in some embodiments, the TPA part 300 is assembled in the engagement region 490 of the socket 422 before the pins 420 and wires 20 are inserted. The arrangement of the TPA part 300 in the engagement region 490 allows the TPA part 300 to guide the pins 240 from the insertion region 480 into the engagement region 490. In some examples, the TPA part 300 is assembled in the engagement region 490 along the base of the socket 422. In other words, the TPA part 300 is arranged to extend along the base of the socket 422. Therefore, the TPA part 300 occupies space in the engagement region 290 which would otherwise be available for the pins 240 to bend in. A cross sectional shape of the TPA part 300 is not particularly limited, and may depend on the shape of the

interface between the insertion region 480 of the wire housing 424 and the engagement region 490 of the socket 422.

[0037] Figure 8A schematically illustrates the insertion of the pins 240 into the TPA part 300 which is assembled in the engagement region 490 of the socket 422. As will be appreciated from Figure 8A, the arrangement of the TPA part 300 in the engagement region 490 of the socket 422 allows the electrical pins 240 to be guided through the plurality of holes 320 in the TPA part and into the engagement region 490. As shown in Figure 8A, the socket 422 of the male header 420 may comprise a plurality of clips 426 configured to attach to the clips 330 on the TPA part 300 to secure the TPA part 300 to the base of the socket 422.

[0038] Figure 8B is a close-up view of Figure 8A. In particular, Figure 8B illustrates electrical pins 240 which have been guided through the holes 320 of the TPA part 300 and into the engagement region 490. It will be appreciated from Figure 8B that the width 244 of the pins 240 may be slightly less compared with a width 344 of the holes 320 of the TPA 300. The width 344 of the holes 320 should be at least as large as the width 244 of the pins 240 to allow the pins 240 to be received by the holes 320. It will be appreciated that the closer the match between the width 244 of the pins 240 and the width 344 of the holes 320, the greater the restriction on the ability of the pins 240 to bend in the engagement region 490. In other words, the closer the match between the width 244 of the pins 240 and the width 344 of the holes 320, the more tightly constrained the pins 240 are in the engagement region 290. It will be appreciated that an allowed bending tolerance for pins 240 entering the engagement region 490 from the insertion region 480 can be reduced by reducing the width 344 of the holes 320 of the TPA 300 and vice versa.

[0039] Figure 9 schematically illustrates a plan view of the male header 420 with the TPA part 300 assembled and the pins 240 inserted into the plurality of holes 320 in the TPA part 300. Although not visible in Figure 10, the TPA part 300 may be clipped onto the male header 420 using the clips 330 of the TPA part 300. In some example embodiments, the TPA part 300 is clipped onto the socket 422 of the male header 420. In some example embodiments, a length of the TPA part 300 may be approximately equal to a length of the engagement region 490 inside the socket 422 of the male header 420.

[0040] Figure 10 is a sectional view schematically representing a mating process between the male connector 400 and the female connector 100 when the TPA part 300 is assembled in the engagement region 490 provided by the socket 422 of the male header 420. As shown in Figure 10, the female housing 120 of the female connector 100 may comprise a plurality of holes 140 configured to receive the pins 240. During a connection of the male 400 and female 100 connectors, the pins 240 may enter the plurality of holes 140 of the female connector 100 to access and engage with corresponding female terminals in the female connector 100. If the TPA part 300 is not present, pins 240 which exceed an allowed bending tolerance may enter the engagement region 490 of the male header 420 as explained above. This may mean that the pins 240 do not adequately align with the plurality of holes 140 in the female housing 120 for receiving the pins 240. As explained above, this may lead to the pins 240 being bent beyond an allowed bending tolerance or damaged, or perforating the female housing 120. In some embodiments, as shown in Figure 10, the male header 400 is configured with an extended socket 422. As will be appreciated from Figure 2 and Figure 10, the presence of the extended socket 422 limits the range of angles of approach of the female connector 100. In other words, the extended socket 422 can prevent an incorrectly manipulated female connector 100 from approaching the pins 240 at angles which would cause the pins 240 to bend beyond an allowed bending tolerance. By guiding the female connector 100 into the socket 422 of the male header 420, the extended socket 422 reduces the likelihood of pin damage for pins which have been successfully guided into the engagement region 490 of the socket 422 by the TPA part 300, thereby improving the reliability of electrical connections.

[0041] Figure 11 is a flow diagram representing a method for assembling a male connector for connecting to a female connector to provide an electrical connection between conductors of the male connector and the female connector according to example embodiments. The method starts in step S1. In step S2, the method comprises providing a header part configured to connect to the female connector. An example of the header part is the male header 220 shown in Figure 1A or the male header shown in Figure 6 (with the extended socket 422).The header part comprises a socket which provides an engagement region for receiving the female connector and for housing one or more electrical pins configured to be received by one or more female terminals of the female connector to provide the electrical connection when the header part and the female connector are connected. In step S3, a terminal position assurance, TPA, part is arranged in the engagement region of the socket to guide the one or more electrical pins through one or more holes in the TPA part and into the engagement region of the socket. The arrangement of the TPA part in the engagement region of the constrains the one or more electrical pins in the engagement region of the socket. For example, the arrangement of the TPA part in the engagement region of the socket may reduce a space in which the one or more electrical pins are able to bend in the engagement region. In some embodiments, the TPA part may be assembled in the socket after the pins are inserted into the engagement region of the socket. However, in other embodiments, as illustrated in step S4, the electrical pins may be inserted into the engagement region of the socket after the TPA part has been assembled in the engagement region of the socket. As the pins which are initially inserted through an insertion region of a wire

housing of the header part reach the engagement region of the socket, the pins are forced through the holes in the TPA part so as to prevent pins which exceed an allowed bending tolerance from entering the engagement region of the socket. In step S5, the male and female connectors are connected during a mating process to provide an electrical connection. For example, the female connector may be inserted into the engagement region of the socket of the header part so that female electrical terminals in the female connector engage with the electrical pins housed in the socket. The arrangement of the TPA part in the engagement region of the socket may reduce a space in which electrical pins which have been successfully guided through the holes of the TPA part can bend. Therefore, if the female connector is incorrectly manipulated, and approaches the pins at an angle to the insertion direction, the arrangement of the TPA part in the engagement region of the socket reduces the ability of the pins to bend in the engagement region, thereby decreasing a likelihood that the pins will be damaged due to the incorrect manipulation of the female connector. In some embodiments, the header part may be configured with a header extension arranged to guide the female connector into the engagement region of the socket so that the likelihood of incorrect manipulation of the female connector is reduced. In step S6, the method ends.

[0042] Other example embodiments can provide a male connector for connecting to a female connector to provide an electrical connection between conductors of the male connector and the female connector is provided. The male connector comprises a header part configured to connect to the female connector. The header part comprises an socket providing an engagement region for receiving the female connector and for housing one or more electrical pins configured to be received by one or more female terminals of the female connector to provide the electrical connection when the header part and the female connector are connected. The male connector also comprises a terminal position assurance, TPA, part arranged in the engagement region of the socket of the header part to guide the one or more electrical pins through one or more holes in the TPA part and into the engagement region of the socket. The arrangement of the TPA part in the engagement region of the socket constrains the one or more electrical pins in the engagement region of the socket.

[0043] The following numbered paragraphs provide further example aspects and features of the present technique:

Paragraph 1. A male connector for connecting to a female connector to provide an electrical connection between conductors of the male connector and the female connector, the male connector comprising

a header part configured to connect to the female connector, the header part comprising a socket providing an engagement region for receiving the female connector and for housing one or more electrical pins configured to be received by one or more female terminals of the female connector to provide the electrical connection when the header part and the female connector are connected, and

a terminal position assurance, TPA, part configured

to be received by the engagement region of the socket,

to guide the one or more electrical pins through one or more holes in the TPA part and into the engagement region of the socket, and

to constrain the one or more electrical pins in the engagement region of the socket.

Paragraph 2. A male connector according to paragraph 1, wherein the TPA part is arranged in the engagement region of the socket to reduce a free space in which the one or more electrical pins are able to bend in the engagement region.

Paragraph 3. A male connector according to paragraph 1 or paragraph 2, wherein the TPA part is configured to prevent the one or more electrical pins from bending in the engagement region of the socket beyond an allowed bending tolerance.

Paragraph 4. A male connector according to paragraph 3, wherein the allowed bending tolerance is approximately 3 degrees from an insertion direction of the one or more pins into the engagement region of the socket.

Paragraph 5. A male connector according to any of paragraphs 1 to 4, wherein the TPA part is configured to prevent one or more other electrical pins which exceed an allowed bending tolerance from being guided into the engagement region of the socket.

Paragraph 6. A male connector according to any of paragraphs 1 to 5, wherein the TPA part is configured to reduce a distance between a free end of the one or more electrical pins and a pivot point about which the one or more electrical pins can bend in the engagement region.

Paragraph 7. A male connector according to paragraph 6, wherein the one or more electrical pins are configured to bend in the engagement region about a pivot point on the TPA part.

Paragraph 8. A male connector according to any of paragraphs 1 to 7, wherein the TPA part is configured

to reduce the space in which the one or more electrical pins can bend in the engagement region during a misaligned connection of the male connector and the female connector.

Paragraph 9. A male connector according to any of paragraphs 1 to 8, wherein front, rear and side walls of the socket of the male header are approximately equal in height.

Paragraph 10. A method for assembling a male connector for connecting to a female connector to provide an electrical connection between conductors of the male connector and the female connector, the method comprising

providing a header part configured to connect to the female connector, the header part comprising a socket providing an engagement region for receiving the female connector and for housing one or more electrical pins configured to be received by one or more female terminals of the female connector to provide the electrical connection when the header part and the female connector are connected,

arranging a terminal position assurance, TPA, part in the engagement region of the socket of the header part, the TPA part being configured

to be received by the engagement region of the socket,

to guide the one or more electrical pins through one or more holes in the TPA part and into the engagement region of the socket, and

to constrain the one or more electrical pins in the engagement region of the socket.

Paragraph 11. A method according to paragraph 10, comprising
guiding the one or more of the electrical pins through the one or more holes in the TPA part and into the engagement region of the socket.

Paragraph 12. A method according to paragraph 11, wherein the guiding the one or more of the electrical pins through the one or more holes in the TPA part and into the engagement region of the socket comprises
inserting the one or more electrical pins through one or more holes in the TPA part after the TPA part has been arranged in the engagement region of the socket.

Paragraph 13. A method according to paragraph 12, wherein the guiding the one or more of the electrical pins through the one or more holes in the TPA part and into the engagement region of the socket comprises

inserting the one or more electrical pins through one or more holes in the TPA part before the TPA part has been arranged in the engagement region of the socket, and

slotting the one or more holes of the TPA part over the one or more electrical pins.

Paragraph 14. A method of assembling a male connector for an automobile, comprising the steps according to any of method paragraphs 10 to 13.

Paragraph 15. An electrical connector comprising

a female connector comprising one or more female terminals,

a male connector comprising a header part configured to connect to the female connector, the header part comprising a socket providing an engagement region for receiving the female connector and for housing one or more electrical pins configured to be received by the one or more female terminals to provide an electrical connection between conductors of the male connector and the female connector when the header part and the female connector are connected, and

a terminal position assurance, TPA, part configured

to be received by the engagement region of the socket,

to guide the one or more electrical pins through one or more holes in the TPA part and into the engagement region of the socket, and

to constrain the one or more electrical pins in the engagement region of the socket.

Paragraph 16. A method of assembling an electrical connector comprising

providing a female connector comprising one or more female terminals,

providing a male connector comprising a header part configured to connect to the female connector, the header part comprising a socket providing an engagement region for receiving the female connector and for housing one or more electrical pins configured to be received by the

one or more female terminals to provide an electrical connection between conductors of the male connector and the female connector when the header part and the female connector are connected, and

arranging a terminal position assurance, TPA, part in the engagement region of the socket, the TPA part being configured

to be received by the engagement region of the socket,

to guide the one or more electrical pins through one or more holes in the TPA part and into the engagement region of the socket, and

to constrain the one or more electrical pins in the engagement region of the socket.

Paragraph 17. A method of assembling an electrical connector for an automobile, comprising the steps according to method paragraph 16.

Paragraph 18. A terminal position assurance, TPA, part for a male connector, the TPA part being configured

to be received by an engagement region provided by a socket of a header part of the male connector, the engagement region being provided by the socket for receiving a female connector and for housing one or more electrical pins configured to be received by one or more female terminals of the female connector to provide an electrical connection between conductors of the male connector and the female connector when the header part and the female connector are connected,

to guide one or more electrical pins of the male connector through one or more holes in the TPA part and into the engagement region of the socket, and

to constrain the one or more electrical pins of the male connector in the engagement region of the socket.

[0044] Various further aspects and features of the present technique are defined in the appended claims.

[0045] Further particular and preferred aspects of the present invention are set out in the accompanying independent and dependent claims. It will be appreciated that features of the dependent claims may be combined with features of the independent claims in combinations other than those explicitly set out in the claims.

[0046] Thus, the foregoing discussion discloses and describes merely exemplary embodiments of the present invention. As will be understood by those skilled in the art, the present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. Accordingly, the disclosure of the present invention is intended to be illustrative, but not limiting of the scope of the invention, as well as other claims. The disclosure, including any readily discernible variants of the teachings herein, define, in part, the scope of the foregoing claim terminology such that no inventive subject matter is dedicated to the public.

ANNEX

[0047] Figure 12 schematically represents dimensions of the male header 220 and female housing 100 designed for use in small household appliances for comparison with the dimensions of the male header 420 which is configured with an extended socket 422 shown in Figure 6. As shown in Figure 12, the height of the male header 220 is 21.60 mm, the width of the male header 220 is 6.50 mm, and the length of the male header 220 is 27.50 mm. Furthermore, the width of the female housing 120 is 8.20 mm. In Figure 6, the height of the male header 420 is 21.60 mm, the width of the male header 420 is 9.10 mm, and the length of the male header is 32.50 mm. Therefore, the male header 420 remains compatible for use with the female connector 100.

[0048] For ease of reference the following provides a summary of the reference numerals used for each of the parts shown in the drawings:

20 - Wire
30 - Slotting Direction of TPA Part
40 - Gap at Interface between Insertion Region and Engagement Region
50 - Insertion Direction
60 - Direction of Pin bending
80 - Direction of Female Connector Approach
100 - Female Connector
120 - Female Housing
140 - Hole(s) in Female Housing
200, 400 - Male Connector
220, 420 - Male Header
222- Socket of Male Header
224, 424 - Wire housing of Male Header
230 - Wire Block
240 - Pin(s)
242 - Free End of Pin(s)
244 - Width of Pin
270a - Space between Front Wall and Side Wall
270b - Space between Rear Wall and Side Wall
272, 274, 472, 474 - Side Walls of Socket
276, 476 - Front Wall of Socket
278, 478 - Rear Wall of Socket
280, 480 - Insertion Region of Wire Housing
282 - Width of Insertion Region
290, 490 - Engagement Region of Socket

292 - Width of Engagement Region
300 - TPA part
320 - Hole(s) in TPA part
330 - Clips on TPA part
344 - Width of Hole(s) in TPA part
426 - Clips on Socket of Male Header
422 - Extended Socket of Male Header
520, 540 - Pivots points in Socket
620, 640 - Pivots point on TPA part

Claims

1. A male connector for connecting to a female connector to provide an electrical connection between conductors of the male connector and the female connector, the male connector comprising

   a header part configured to connect to the female connector, the header part comprising a socket providing an engagement region for receiving the female connector and for housing one or more electrical pins configured to be received by one or more female terminals of the female connector to provide the electrical connection when the header part and the female connector are connected, and
   a terminal position assurance, TPA, part configured
   to be received by the engagement region of the socket,
   to guide the one or more electrical pins through one or more holes in the TPA part and into the engagement region of the socket, and
   to constrain the one or more electrical pins in the engagement region of the socket.

2. A male connector according to claim 1, wherein the TPA part is arranged in the engagement region of the socket to reduce a free space in which the one or more electrical pins are able to bend in the engagement region.

3. A male connector according to claim 1 or claim 2, wherein the TPA part is configured to prevent the one or more electrical pins from bending in the engagement region of the socket beyond an allowed bending tolerance.

4. A male connector according to claim 3, wherein the allowed bending tolerance is approximately 3 degrees from an insertion direction of the one or more pins into the engagement region of the socket.

5. A male connector according to any of claims 1 to 4, wherein the TPA part is configured to prevent one or more other electrical pins which exceed an allowed bending tolerance from being guided into the engagement region of the socket.

6. A male connector according to any of claims 1 to 5, wherein the TPA part is configured to reduce a distance between a free end of the one or more electrical pins and a pivot point about which the one or more electrical pins can bend in the engagement region.

7. A male connector according to claim 6, wherein the one or more electrical pins are configured to bend in the engagement region about a pivot point on the TPA part.

8. A male connector according to any of claims 1 to 7, wherein the TPA part is configured to reduce the space in which the one or more electrical pins can bend in the engagement region during a misaligned connection of the male connector and the female connector.

9. A male connector according to any of claims 1 to 8, wherein front, rear and side walls of the socket of the male header are approximately equal in height.

10. A method for assembling a male connector for connecting to a female connector to provide an electrical connection between conductors of the male connector and the female connector, the method comprising

    providing a header part configured to connect to the female connector, the header part comprising a socket providing an engagement region for receiving the female connector and for housing one or more electrical pins configured to be received by one or more female terminals of the female connector to provide the electrical connection when the header part and the female connector are connected,
    arranging a terminal position assurance, TPA, part in the engagement region of the socket of the header part, the TPA part being configured to be received by the engagement region of the socket,
    to guide the one or more electrical pins through one or more holes in the TPA part and into the engagement region of the socket, and
    to constrain the one or more electrical pins in the engagement region of the socket.

11. A method of assembling a male connector for an automobile, comprising the steps according to claim 10.

12. An electrical connector comprising

    a female connector comprising one or more female terminals,

a male connector comprising a header part configured to connect to the female connector, the header part comprising a socket providing an engagement region for receiving the female connector and for housing one or more electrical pins configured to be received by the one or more female terminals to provide an electrical connection between conductors of the male connector and the female connector when the header part and the female connector are connected, and

a terminal position assurance, TPA, part configured

to be received by the engagement region of the socket,

to guide the one or more electrical pins through one or more holes in the TPA part and into the engagement region of the socket, and

to constrain the one or more electrical pins in the engagement region of the socket.

13. A method of assembling an electrical connector comprising

providing a female connector comprising one or more female terminals,

providing a male connector comprising a header part configured to connect to the female connector, the header part comprising a socket providing an engagement region for receiving the female connector and for housing one or more electrical pins configured to be received by the one or more female terminals to provide an electrical connection between conductors of the male connector and the female connector when the header part and the female connector are connected, and

arranging a terminal position assurance, TPA, part in the engagement region of the socket, the TPA part being configured

to be received by the engagement region of the socket,

to guide the one or more electrical pins through one or more holes in the TPA part and into the engagement region of the socket, and

to constrain the one or more electrical pins in the engagement region of the socket.

14. A method of assembling an electrical connector for an automobile, comprising the steps according to method claim 13.

15. A terminal position assurance, TPA, part for a male connector, the TPA part being configured

to be received by an engagement region provided by a socket of a header part of the male connector, the engagement region being provided by the socket for receiving a female connector and for housing one or more electrical pins configured to be received by one or more female terminals of the female connector to provide an electrical connection between conductors of the male connector and the female connector when the header part and the female connector are connected,

to guide one or more electrical pins of the male connector through one or more holes in the TPA part and into the engagement region of the socket, and

to constrain the one or more electrical pins of the male connector in the engagement region of the socket.

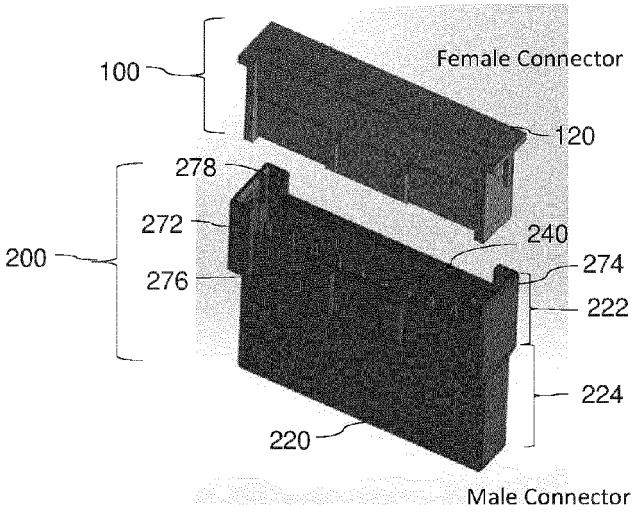

100
Female Connector
120
278
272
200
276
240
274
222
224
220
Male Connector

FIG. 1A

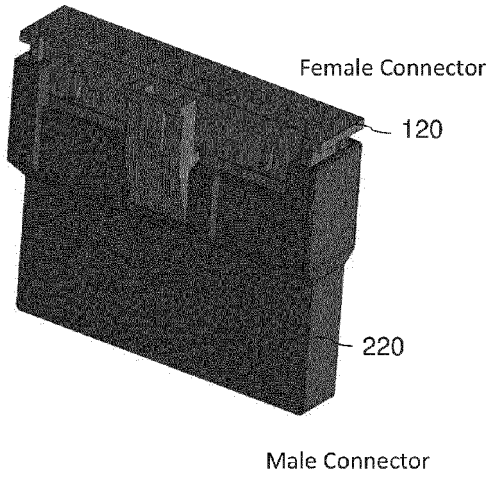

Female Connector
120
220
Male Connector

FIG. 1B

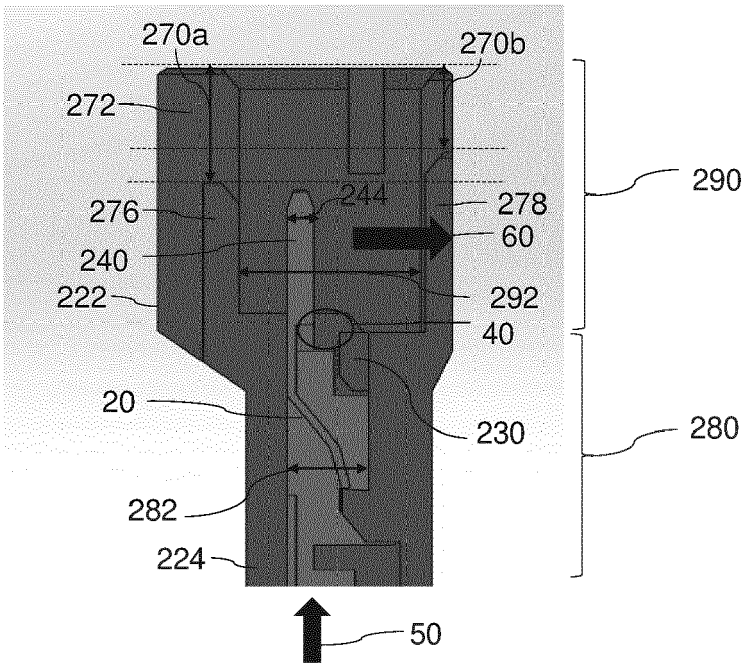

270a
270b
272
290
276
244
278
60
240
292
222
40
20
230
280
282
224
50

FIG. 2

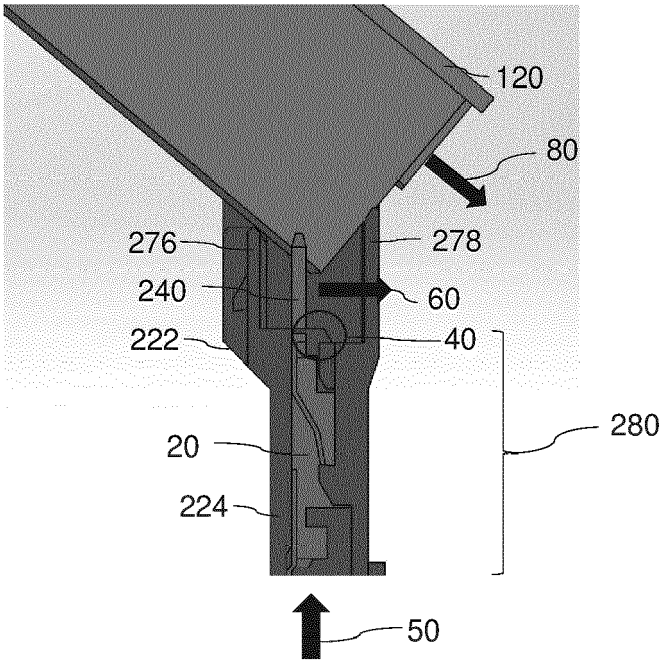


FIG. 3

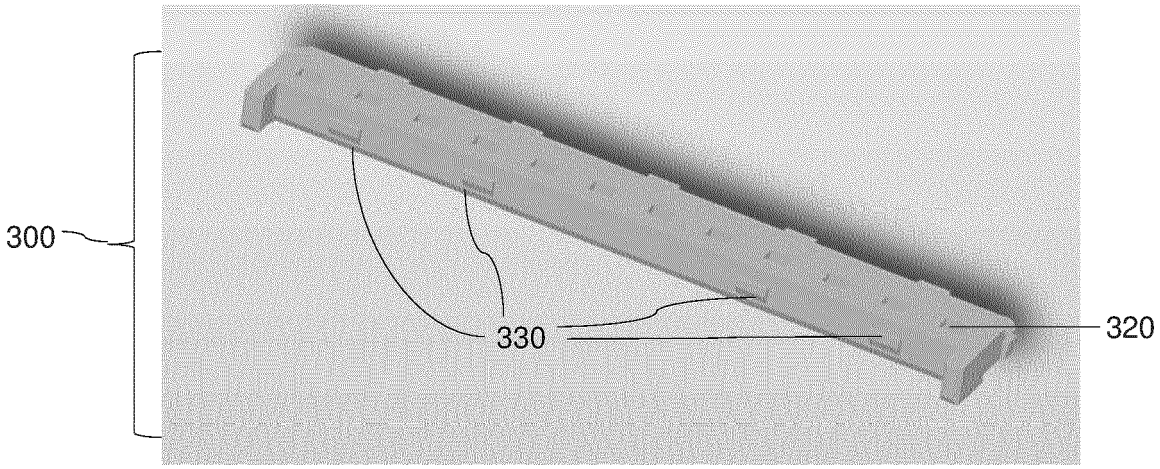


FIG. 4

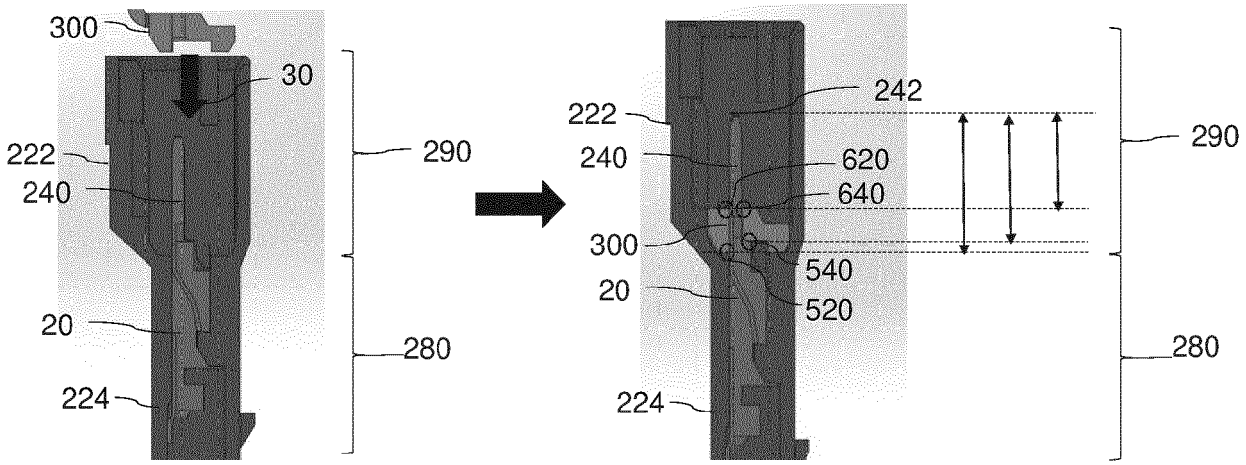
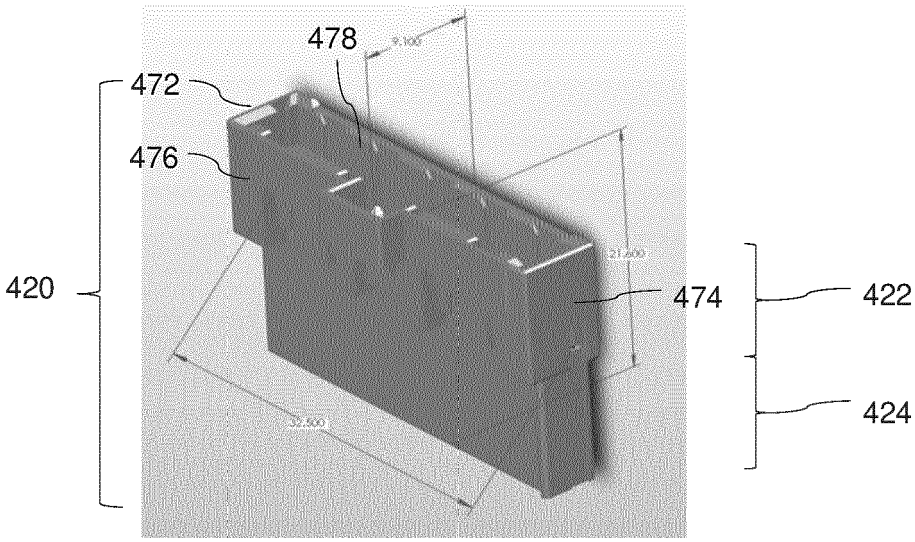

300
30
222
240
290
20
280
224
242
222
240
620
640
300
540
20
520
290
280
224

FIG. 5



Male Header with Extended Socket

FIG. 6

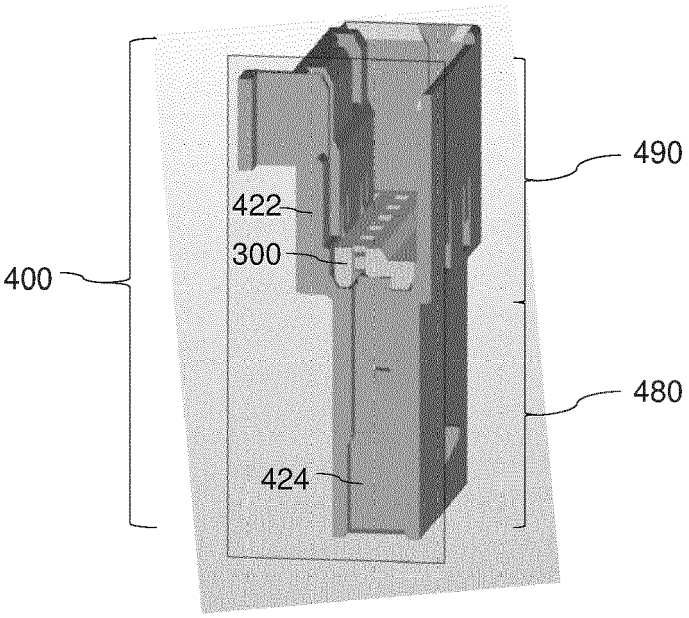


FIG. 7

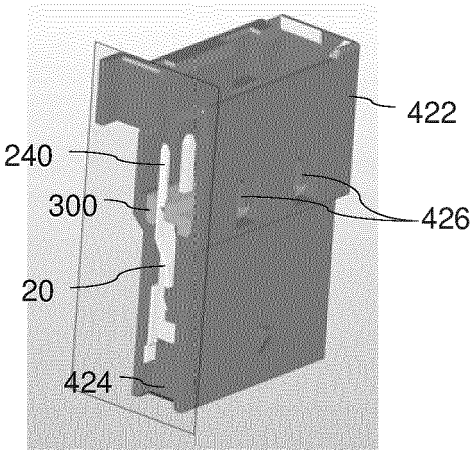


FIG. 8A

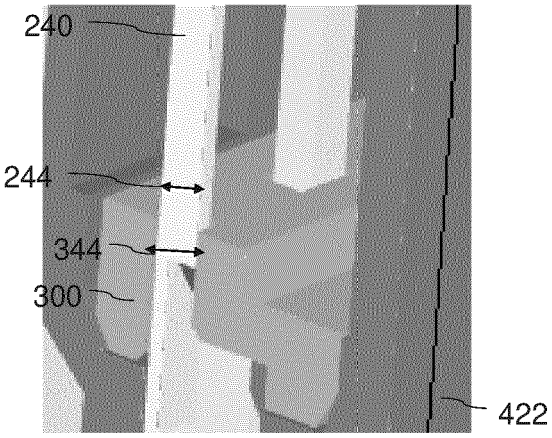


FIG. 8B

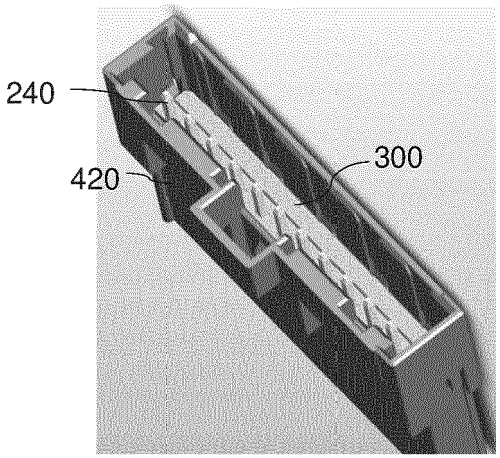


FIG. 9

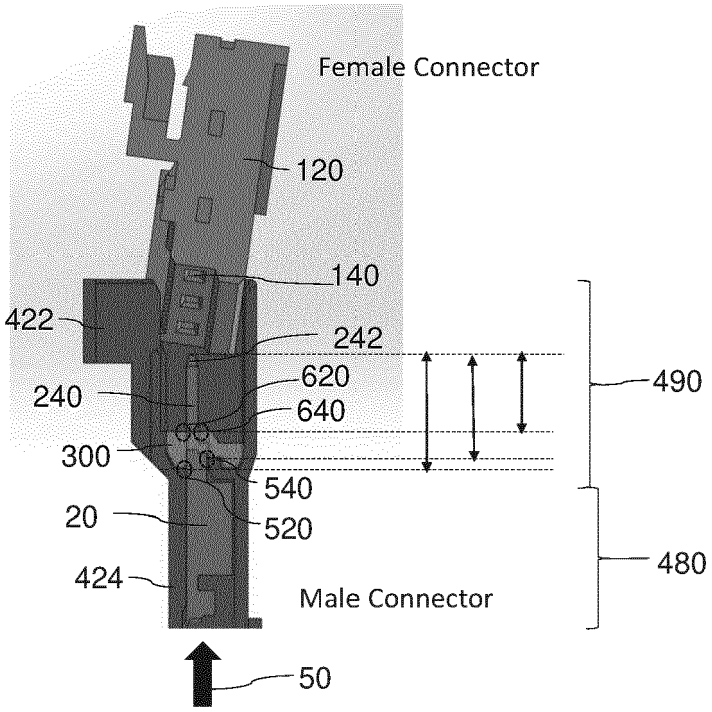

Female Connector
120
140
422
242
620
240
640
300
540
20
520
424
Male Connector
50
490
480

FIG. 10

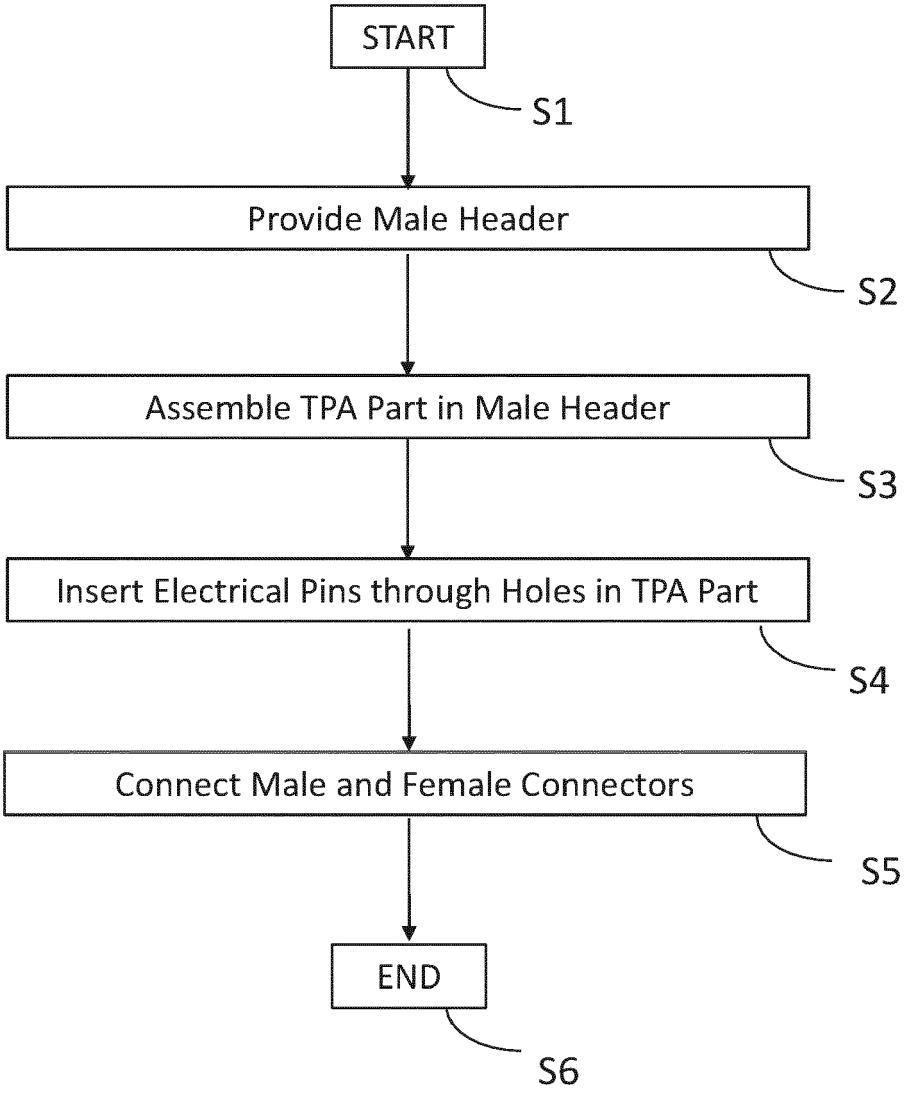

START
S1
Provide Male Header
S2
Assemble TPA Part in Male Header
S3
Insert Electrical Pins through Holes in TPA Part
S4
Connect Male and Female Connectors
S5
END
S6

FIG. 11

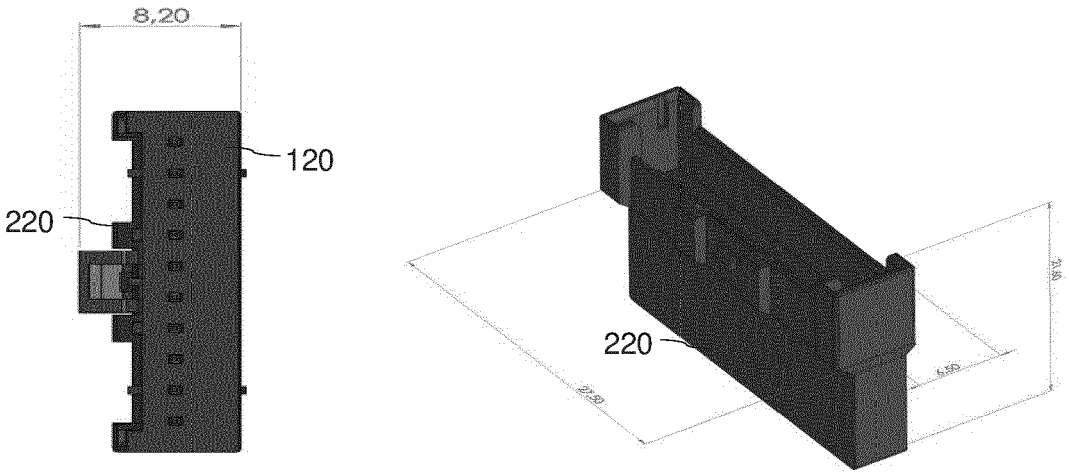


FIG. 12

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 21 20 0349

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2015/004830 A1 (GOMEZ DANIEL [MX] ET AL) 1 January 2015 (2015-01-01) * paragraph [0002] - paragraph [0026]; figures 1,2,6,7 * -----	1-15	INV. H01R13/436

TECHNICAL FIELDS SEARCHED (IPC)

H01R

2 The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	7 March 2022	Mateo Segura, C

CATEGORY OF CITED DOCUMENTS

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07-03-2022

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82