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(54) **SPLIT MODULE FOR MODULAR CONNECTOR ASSEMBLY**

(57) A split module for a modular connector assembly, comprising: a module casing; and at least one terminal cavity that is adapted to accommodate an electrical terminal and is formed along a longitudinal axis of the module casing; wherein the module casing comprises a fastening element for fastening the module casing to a second module casing of a second split module. A mixed module comprising at least two such split modules, wherein the split modules are connected to each other by means of their fastening element. A modular connector assembly for automotive applications comprising: a connector housing with at least one module slot; wherein the at least one module slot accommodates such a mixed module. A method for manufacturing such a modular connector assembly.

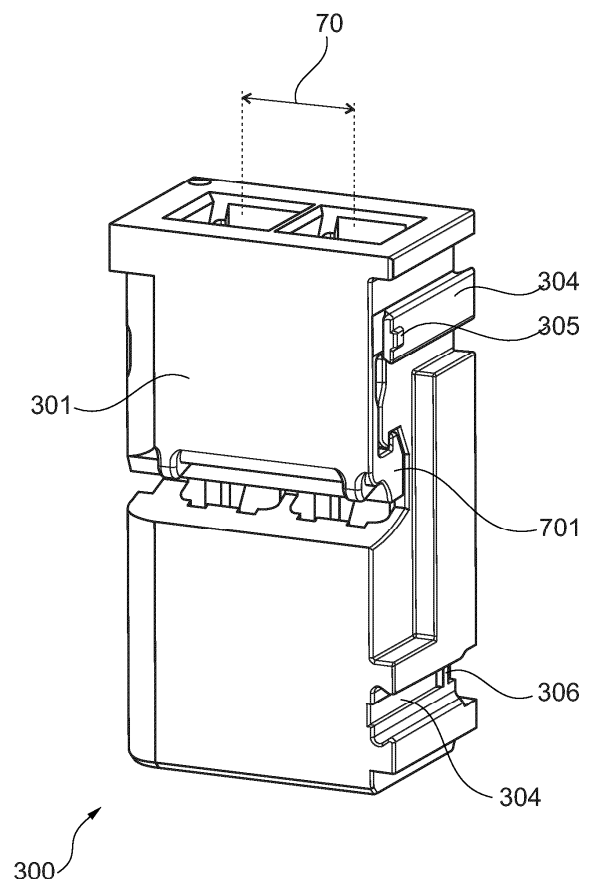


Fig. 4

Description

FIELD OF THE DISCLOSURE

[0001] The present disclosure relates to a system and method for modular connector assemblies used in automotive applications. Specifically, the present disclosure relates to split modules that can be connected to form mixed modules, which can then be inserted into a connector housing to create a modular connector assembly. The disclosure also relates to a method for manufacturing a modular connector assembly.

BACKGROUND OF THE INVENTION

[0002] In the field of automotive electrical systems, it is common to use modular connector assemblies to facilitate the connection of various electrical components. These connectors are essential for ensuring reliable communication and power distribution throughout the vehicle. Known systems typically involve connector housings with multiple slots to accommodate different (monoblock) modules, each containing several terminal cavities for electrical terminals. However, these systems often face challenges related to flexibility and adaptability. For instance, the need to accommodate a wide range of terminal configurations and sizes can lead to increased complexity in the design and manufacturing process. Additionally, ensuring a secure and stable connection between modules within the connector housing can be problematic, especially when dealing with vibrations and other environmental factors common in automotive applications.

[0003] One of the general problems in automotive connection systems is the need for high-density connections in limited spaces. As vehicles become more technologically advanced, the number of electronic components and sensors increases, necessitating more connections within the same or even smaller spaces. This demand for miniaturization without compromising the reliability and performance of the connections poses significant design and engineering challenges. Moreover, the connectors must be robust enough to withstand harsh automotive environments, including extreme temperatures, moisture, and mechanical stress, which can affect the integrity and performance of the electrical connections over time.

[0004] Despite the substantial advances in the field of modular connector assemblies, there remains a need for improved systems that offer greater flexibility, ease of assembly, and reliability. Current solutions often lack the ability to easily customize and reconfigure the modules to meet specific application requirements. This limitation can result in increased production costs and longer development times, as manufacturers may need to design and produce multiple connector variants to accommodate different terminal configurations. Furthermore, ensuring a secure and stable connection between modules,

while allowing for easy assembly and disassembly, remains a critical challenge that has not been fully addressed by existing technologies.

[0005] It is therefore a technical problem underlying the present invention to provide a modular connector assembly that at least partially overcomes the disadvantages of known systems.

SUMMARY OF THE DISCLOSURE

[0006] It is an object of this invention to provide a split module for a modular connector assembly, a mixed module for a modular connector assembly and a modular connector assembly that overcome one or more of the disadvantages of known systems.

[0007] A first aspect of the invention provides a split module for a modular connector assembly, comprising: a module casing; and at least one terminal cavity that is adapted to accommodate an electrical terminal and is formed along a longitudinal axis of the module casing; wherein the module casing comprises a fastening element for fastening the module casing to a second module casing of a second split module.

[0008] The subject matter of the first aspect hence describes a split module designed for a modular connector assembly. This split module includes a module casing and at least one terminal cavity. The terminal cavity is specifically adapted to accommodate an electrical terminal and is formed along the longitudinal axis of the module casing. The module casing also features a fastening element, which can be used to secure the module casing to another module casing of another split module.

[0009] In this context, a split module refers to a component that can be combined with another similar component, i.e., another split module, to form a mixed module. The modular connector assembly is a system that allows for the combination of different modules to create a customized connector solution. The module casing is the outer structure that houses the internal components, including the terminal cavity. The terminal cavity is a space within the casing designed to hold an electrical terminal, which is a conductive element used to connect electrical circuits. The terminal cavity may have a circular or rectangular cross-section. The longitudinal axis is an imaginary line that runs lengthwise through the module casing, along which the terminal cavity is aligned. The fastening element is a feature that enables the secure attachment of one module casing to another, facilitating the creation of mixed modules.

[0010] The advantages of this design include increased flexibility and scalability in creating modular connector assemblies. By allowing split modules to be combined, it is possible to create a wide variety of configurations without the need for new tools or designs for each new combination. This reduces the investment in tooling and allows for more efficient use of space within the connector assembly, as there are fewer unused

cavities. Additionally, the ability to assemble split modules from different harness makers enhances the adaptability of the system to meet diverse requirements.

[0011] In a first implementation of the split module according to the first aspect, the fastening element may be a slide or a rail that extends along a guiding axis and is preferably of a dovetail, L-shape, or T-shape type.

[0012] The implementation introduces a specific mechanism for the fastening element of the split module. The implementation refines the split module according to the first aspect by specifying that the fastening element is a slide or a rail extending along a guiding axis, with a preference for a dovetail slide or dovetail rail. This specification of the fastening element as a slide or rail introduces a precise mechanism for the communication between the module casing and the second module casing of another split module. The guiding axis provides a directional path along which the slide or rail operates, ensuring a more controlled and stable connection between the two module casings. The preference for a dovetail slide or dovetail rail enhances this connection by utilizing a design known for its interlocking capability, which offers increased mechanical strength and alignment precision. The dovetail design is characterized by its trapezoidal shape, which allows for a tight fit and prevents lateral movement, thereby improving the stability and reliability of the connection. This feature is particularly beneficial in applications where the modular connector assembly may be subject to vibrations or mechanical stress, as it ensures that the connection remains secure. By specifying the nature of the fastening element, the implementation not only enhances the functionality of the split module but also provides a clear and tangible improvement over the more generic fastening element described in the first aspect. This specificity in the design of the fastening element facilitates easier assembly and disassembly of the modular connector assembly, offering practical advantages in terms of maintenance and re-configuration. Furthermore, the use of a dovetail slide or rail can contribute to the overall compactness and efficiency of the modular connector assembly, as it allows for a seamless integration of the split modules without the need for additional fastening components. This refinement in the design of the fastening element thus represents a significant advancement in the modular connector assembly's capability to provide a robust and adaptable electrical connection solution.

[0013] The slide and the rail may also be of an L-shape or T-shape type. These shapes help ensure proper alignment during assembling, reducing the risk of misalignment and potential damage to the split modules. L-shaped and T-shaped guidings provide additional mechanical stability, which can help maintain a secure connection even in environments subject to vibrations or movement. These guidings can further act as a physical barrier to prevent connectors from being inserted in the wrong orientation, thereby protecting the integrity of the connection and improving the assembling process.

Furthermore, the distinct shapes of L-shaped and T-shaped guidings can facilitate faster and more accurate alignment of the split modules during an automatic assembly process, reducing the time required for each connection.

[0014] In a further implementation of the split module according to the first aspect, the guiding axis may be perpendicular or parallel to the longitudinal axis of the module casing.

[0015] The implementation introduces a specific orientation for the guiding axis, stating that it is perpendicular or parallel to the longitudinal axis of the module casing. This feature brings a significant improvement in the mechanical stability and reliability of the split module assembly. By ensuring that the guiding axis is perpendicular to the longitudinal axis, the design facilitates a more secure and precise alignment of the split modules during assembly. This perpendicular arrangement means that when two split modules are connected to each other, the direction of fitting the electrical terminals is distinct from the direction of connecting the modules themselves. This separation of movements reduces the likelihood of accidental disconnection, as the forces applied during the insertion of electrical terminals do not directly impact the connection between the split modules. This is particularly advantageous in automated processes where precision and reliability are critical. The perpendicular guiding axis ensures that any mechanical stress or movement during terminal fitting does not compromise the integrity of the module connection. This feature enhances the overall robustness of the modular connector assembly, making it more suitable for applications where secure and stable electrical connections are essential. Additionally, this orientation can simplify the assembly process, as it provides a clear and distinct pathway for each action, reducing the potential for errors and improving the efficiency of the assembly process.

[0016] A guiding axis that is parallel to the longitudinal axis of the module casing may increase the speed of the assembly process because the axes of mating the terminal cavities with electrical terminals and fastening the two split modules are the same.

[0017] In a further implementation of the split module according to the first aspect, the fastening element may comprise a snap hook and/or a locking shoulder.

[0018] In the context of the implementation, the split module is enhanced by the inclusion of a fastening element that comprises a snap hook and/or a locking shoulder. A snap hook is a type of fastening mechanism that typically involves a hook-like structure that can latch onto a corresponding feature, providing a secure and quick connection. The locking shoulder, on the other hand, is a structural feature that can engage with a corresponding element, such as a snap hook, to lock two components together. The interaction between a snap hook on a first split module and a locking shoulder on a second split module facilitates a secure connection between the two modules. This interaction ensures that

the modules are held together firmly, preventing unintentional disconnection and maintaining the integrity of the modular connector assembly. The feature introduced by this implementation is the specific configuration of the fastening element, which can include either or both a snap hook and a locking shoulder. This configuration provides versatility in the design of the split module, allowing for different combinations of fastening elements to be used depending on the specific requirements of the application. For instance, a split module may comprise a first fastening element with a snap hook and a second fastening element with a locking shoulder, enabling it to connect securely with another module that has complementary fastening elements. This feature enhances the adaptability and reliability of the modular connector assembly, as it allows for a more customizable and robust connection between modules. By incorporating these specific fastening elements, the split module can achieve a more secure and stable connection, which is particularly beneficial in applications where the modular connector assembly may be subjected to mechanical stresses or vibrations.

[0019] In a further implementation of the split module according to the first aspect, the split module may comprise between 1 to 20 terminal cavities, preferably a total number of 1, 2, 3, 6, 8, or 12 terminal cavities.

[0020] The implementation introduces a specific range and preferred quantities for the terminal cavities within the split module. The split module comprises between one to twenty terminal cavities, with a preference for having a total number of one, two, three, six, eight, or twelve terminal cavities. This feature brings flexibility and adaptability to the split module, allowing it to accommodate different numbers of electrical terminals based on the specific requirements of the modular connector assembly. The ability to have a varying number of terminal cavities enhances the versatility of the split module, making it suitable for a wide range of applications. By specifying preferred quantities, the implementation also highlights common configurations that may be particularly useful or efficient in certain contexts. For example, a 1-way split module with a single terminal cavity might be used for simple connections, while a 12-way split module with twelve terminal cavities could be employed in more complex assemblies requiring multiple connections. This range and preference for specific quantities of terminal cavities provide a clear framework for designing and manufacturing split modules that can meet diverse electrical and mechanical needs. The inclusion of these details in the implementation adds a layer of specificity that can guide the development and implementation of the split module in various modular connector assemblies.

[0021] The terminal cavities of a split module may be arranged in one or two rows.

[0022] In a further implementation of the split module according to the first aspect, a pitch distance between two terminal cavities may be between 0.1mm to 5mm, preferably 0.5mm, 0.63mm, 1.2mm, 2.8mm, or 4.8mm.

[0023] The implementation introduces a specific feature related to the pitch distance between two terminal cavities within the split module. This pitch distance is defined to be within a range of 0.1mm to 5mm, with preferred values specified as 0.5mm, 0.63mm, 1.2mm, 2.8mm, or 4.8mm. The pitch distance is a critical parameter that influences the module's ability to accommodate electrical terminals and affects the overall density and compactness of the modular connector assembly. By specifying a range for the pitch distance, the implementation provides flexibility in the design and manufacturing of the split module, allowing it to be tailored to different application requirements and standards. The preferred values offer specific options that may align with industry norms or particular use cases, enhancing the module's adaptability and functionality. This feature brings several advantages to the split module design. Firstly, it allows for precise control over the spacing of electrical terminals, which can be crucial for ensuring reliable electrical connections and minimizing interference between adjacent terminals. A smaller pitch distance can lead to a more compact design, which is beneficial in applications where space is limited. Conversely, a larger pitch distance may be preferred in scenarios where ease of handling and installation are prioritized, or where there is a need to accommodate larger terminals. Additionally, the specified pitch distances can facilitate compatibility with existing systems and components, making the split module a versatile option for various modular connector assemblies. The inclusion of preferred values provides guidance for optimal configurations, potentially simplifying the design process and reducing the need for extensive customization.

[0024] The pitch distance may also be so that the split module complies with known connector designs such as High-Speed Cable Assembly (HSCA), High-Speed Data (HSD), High-Frequency Miniature (HFM), or High-Speed Modular Twisted-Pair Data (HMTD).

[0025] A second aspect of the invention provides a mixed module comprising at least a first split module and a second split module according to the first aspect; wherein the first and second split modules are connected to each other by means of their fastening element.

[0026] The subject matter described involves a mixed module that includes at least a first split module and a second split module. These split modules are connected to each other using their fastening elements.

[0027] In this context, a mixed module refers to a modular component that can combine different or equal types of split modules. Split modules are individual segments of the mixed module and may be implemented as described above. The fastening elements are the parts of the split modules that allow them to be securely attached to one another.

[0028] The advantage of this configuration is that it allows for greater flexibility and customization in creating modular connectors. By using split modules, different combinations can be achieved without the need for

new tools or designs each time a new configuration is required. This reduces the overall investment in tooling and allows for easier assembly from different harness makers. Additionally, it minimizes unused cavity space and can reduce the overall size of the connector, making it more efficient and adaptable to various applications.

[0029] In a first implementation of the mixed module according to the second aspect, the fastening elements may prevent a relative movement of the split modules to each other along the longitudinal axis by means of a form fit.

[0030] The implementation introduces a specific feature concerning the fastening elements of the split modules that form the mixed module. The fastening elements are designed to prevent relative movement of the split modules along the longitudinal axis through a form fit. This feature adds a significant advantage to the mixed module's structural integrity and operational reliability. The form fit may be established by interaction between a rail and a slide, in particular a dovetail rail and a dovetail slide. The form fit ensures that once the split modules are connected, they remain securely in place without the risk of shifting or loosening along the longitudinal axis. This is particularly beneficial in applications where the modules may be subject to vibrations, external forces, or any conditions that could otherwise cause movement. The prevention of relative movement along the longitudinal axis is crucial in maintaining the alignment and connection integrity of the modules, especially when they are fitted with electrical terminals. In automated processes, where precision and reliability are paramount, the form fit feature ensures that the modules are correctly aligned and remain in position during operation. This reduces the risk of accidental disconnection or misalignment, which could lead to operational failures or the need for frequent maintenance. Additionally, the form fit provides a mechanical interlock that enhances the overall stability of the mixed module assembly. By preventing movement along the longitudinal axis, the form fit contributes to the durability and longevity of the mixed module, as it minimizes wear and tear that could result from relative movement between the split modules. This feature is particularly advantageous in environments where the mixed module may be exposed to dynamic loads or where precise positioning is critical for the module's function. Overall, the form fit of the fastening elements enhances the mixed module's performance by ensuring a secure and stable connection between the split modules, thereby improving the reliability and efficiency of the system in which the mixed module is utilized.

[0031] In a further implementation of the mixed module according to the second aspect, the split modules together may comprise a total number of terminal cavities between 2 to 40.

[0032] The implementation specifies that the combined total number of terminal cavities within the split modules ranges from 2 to 40, with a preference for specific numbers such as 2, 3, 4, 5, 14, 18, or 26. This

feature introduces a degree of flexibility and customization to the mixed module, allowing it to be tailored to specific applications or requirements by varying the number of terminal cavities. The specification of a range and preferred numbers for the terminal cavities implies that the mixed module can accommodate different configurations and functionalities, depending on the needs of the user or the application. This flexibility is significant because it allows for the creation of a mixed module that can be used in various contexts, potentially reducing the need for multiple different modules and thereby streamlining inventory and production processes. By specifying a range and preferred numbers, the implementation ensures that the mixed module can meet a wide array of requirements while still maintaining a level of standardization that facilitates ease of use and integration. This feature enhances the versatility and adaptability of the mixed module, making it a more attractive option for users who need a reliable and customizable solution for their specific needs.

[0033] In a further implementation of the mixed module according to the second aspect, the total number of terminal cavities of the first split module may be same or different than the total number of terminal cavities of the second split module.

[0034] The implementation introduces a specific feature concerning the total number of terminal cavities in the first and second split modules. Specifically, the total number of terminal cavities in the first split module may be different from the total number of terminal cavities in the second split module. This feature brings a new dimension to the mixed module by allowing for a variation in the number of terminal cavities between the two split modules. This variation can provide flexibility in the design and functionality of the mixed module, enabling it to accommodate different types of connections or electrical components that may require a different number of terminal cavities. This differentiation in the number of terminal cavities can also facilitate the customization of the mixed module for specific applications, where the requirements for terminal connections may vary. Additionally, this feature can enhance the modularity of the mixed module, making it easier to adapt and reconfigure the module for different uses without the need for significant modifications. The ability to have split modules with different numbers of terminal cavities can also improve the efficiency of the mixed module by optimizing the use of space and resources, ensuring that each split module is tailored to its specific function within the overall system. This can lead to improved performance and reliability of the mixed module, as each split module can be designed to meet the exact requirements of its intended application.

[0035] The total number of terminal cavities in the first split module may also be same to the total number of terminal cavities in the second split module. This way, a known connector may be split in two equal split modules which may simplify the assembly process.

[0036] A third aspect of the invention provides a modular connector assembly for automotive applications comprising: a connector housing with at least one module slot; wherein the at least one module slot accommodates a mixed module according to the second aspect.

[0037] The modular connector assembly is designed for automotive applications and includes a connector housing that features at least one module slot. This module slot is specifically designed to accommodate a mixed module that is constructed according to the second aspect, which involves the combination of split modules according to the first aspect.

[0038] A modular connector assembly is a system that allows for the connection of various electrical components within a vehicle. The connector housing serves as the protective outer shell that holds the internal components securely. The module slot is a designated space within the connector housing that is intended to hold a module, which is a unit containing electrical terminals within terminal cavities.

[0039] The advantage of using split modules in a modular connector assembly is the increased flexibility and scalability it offers. It allows for easier customization and adaptation to different configurations without the need for new tools or designs. For example, it enables the combination of different types of connections, such as power and signal terminals, within a single (mixed) module.

[0040] This can lead to reduced connector size, less unused space, and lower investment in tooling. Additionally, it supports the next level of automation for harness makers, enabling more efficient and versatile electrical systems in vehicles.

[0041] In a first implementation of the modular connector assembly according to the third aspect, the connector housing may comprise multiple module slots, preferably four module slots.

[0042] The implementation introduces a modular connector assembly for automotive applications that expands upon the aspect by specifying the presence of multiple module slots, with a preference for four module slots. This enhancement allows for greater versatility and scalability in the design and application of the connector assembly. By incorporating multiple module slots, the assembly can support a variety of standard (monoblock) and mixed modules, thereby increasing the potential for customization and adaptability to different automotive systems and requirements. The feature of having multiple module slots, particularly the preference for four, brings several advantages. It allows for the integration of multiple mixed modules within a single connector housing, which can enhance the functionality and performance of the automotive system. This configuration can support complex electrical and electronic systems by facilitating the connection and communication of various components through the mixed modules. Additionally, the presence of multiple module slots can improve the ease of maintenance and upgradeability of the system. By having multiple slots, individual modules can be re-

placed or upgraded without the need to replace the entire connector assembly, thus reducing downtime and maintenance costs. The preference for four module slots suggests an optimal balance between size, functionality, and cost, providing sufficient capacity for most automotive applications while maintaining a compact and efficient design. This feature also aligns with allowing manufacturers to tailor the connector assembly to specific applications and customer needs.

[0043] In a further implementation of the modular connector assembly according to the third aspect, the at least one module slot may have a length of between 20mm to 30mm and a height of between 5mm to 10mm.

[0044] The implementation introduces specific dimensional characteristics to the modular connector assembly's module slot. The implementation further refines this by specifying that the module slot has a length ranging from 20mm to 30mm and a height ranging from 5mm to 10mm, with a preference for a length of 25.3mm and a height of 8.3mm. This refinement introduces precise dimensional constraints that are crucial for ensuring compatibility and proper fit with the mixed module that the slot is designed to accommodate. The specific dimensions facilitate the design and manufacturing process by providing clear guidelines for the size of the module slot, which can help in maintaining consistency across different units of the modular connector assembly. The communication mechanism between the module slot and the mixed module is inherently mechanical, as the dimensions of the slot dictate the physical space available for the module to be inserted and secured. By defining the dimensions, the implementation ensures that the module slot can reliably house the mixed module without issues related to improper fit or mechanical instability. The introduction of these dimensions also potentially impacts the thermal and electrical performance of the connector assembly, as the size of the slot may influence the heat dissipation characteristics and the spatial arrangement of electrical contacts within the housing. Furthermore, specifying preferred dimensions allows for optimization of the connector assembly's performance in specific automotive applications, where space constraints and precise alignment are often critical. The dimensional constraints may ensure compliance with industry standards or regulations that govern the design and use of automotive connectors.

[0045] In a further implementation of the modular connector assembly according to the third aspect, the modular connector assembly may comprise a plurality of mixed modules, each accommodated in a module slot of the connector housing, and each comprising a different total number of terminal cavities.

[0046] The introduction of multiple mixed modules, each with a distinct number of terminal cavities, brings several new features and advantages to the modular connector assembly. Firstly, it enhances the flexibility of the connector assembly by allowing for customization based on specific application requirements. Different

automotive systems may require varying numbers of terminal connections, and the ability to accommodate mixed modules with different terminal cavity counts enables the assembly to be tailored to meet these diverse needs. This feature is particularly beneficial in complex automotive systems where different components may have varying connectivity requirements. Additionally, the use of multiple mixed modules with different terminal cavity configurations can improve the scalability of the connector assembly. As automotive systems evolve and expand, the connector assembly can be easily adapted to accommodate additional connections by simply introducing mixed modules with different/more terminal cavities. This scalability is crucial in modern automotive applications where technological advancements and increased system complexity demand more sophisticated connectivity solutions. Furthermore, the modular nature of the assembly allows for easier maintenance and replacement of individual modules without the need to replace the entire connector assembly. This can lead to cost savings and reduced downtime in automotive systems, as faulty or outdated modules can be swapped out with minimal disruption.

[0047] A fourth aspect of the invention provides a method for manufacturing the modular connector assembly according to the third aspect, the method comprising the steps: forming a mixed module according to the second aspect by connecting a first split module and a second split module each according to the first aspect; and inserting the mixed module into a module slot of the connector housing along the longitudinal axis of the split modules of the mixed module.

[0048] The subject matter describes a method for manufacturing a modular connector assembly. This method involves forming a mixed module by connecting a first split module and a second split module. The mixed module is then inserted into a module slot of the connector housing along the longitudinal axis of the split modules.

[0049] The advantages of this method include increased flexibility and scalability for harness makers, reduced connector size due to less unused cavity, the ability to assemble split modules from different harness makers, and low tool investment as no new tools are required for different hybrid connector configurations. This method allows for the creation of various module combinations using a standard connector shell, thereby supporting future applications with intelligently designed modular connections.

SHORT DESCRIPTION OF THE FIGURES

[0050]

Figure 1: shows a prior art connector assembly.
 Figure 2: illustrates the combination of split modules to form mixed modules.
 Figure 3: shows a mixed module formed by connect-

ing a first split module and a second split module.

Figure 4: shows an embodiment of a split module.
 Figure 5: shows an embodiment of a modular connector assembly.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0051] Figure 1 illustrates a connector assembly 1, which is representative of prior art in the field of electrical connectors. This assembly houses a module with a monoblock structure, meaning it is constructed as a single, unified piece rather than comprising multiple detachable components. The assembly integrates terminal cavities 2 of various types, allowing for the accommodation of different electrical terminals within a singular housing 3.

[0052] The modular connector assembly 1 is depicted with a housing 3 that encapsulates the terminal cavities 2. The housing 3 serves as the structural framework that holds the terminal cavities 2 in place and provides protection against environmental factors such as dust and moisture. The housing is typically made from a durable material, often a type of plastic or composite, which ensures the integrity and longevity of the connector assembly in various applications, including automotive and industrial environments.

[0053] The terminal cavities 2 within the housing 3 are arranged in a grid-like pattern, allowing for the efficient organization and connection of multiple electrical terminals. These cavities are designed to securely hold the terminals in place, ensuring reliable electrical connections. The configuration of the terminal cavities can vary, accommodating different sizes and types of terminals, which is essential for the versatility of the modular connector assembly in interfacing with various electrical systems.

[0054] The module's monoblock structure may limit the flexibility of the connector assembly 1 in terms of customization and scalability, as the entire module must be replaced or modified if changes to the connector assembly 1 configuration are required.

[0055] Figure 2 illustrates the possible replacement of prior art modules 10 and 20 with split modules 100, 200, 300, 400 that can be combined to form mixed modules. The figure shows two examples of this replacement.

[0056] In the first example, module 10, which is a known module from the prior art, is depicted on the left side of the figure. Module 10 comprises a module casing 11 and terminal cavities 12 that are arranged in two rows. This module 10 can be replaced by combining two split modules, specifically split module 100 and split module 200. Split module 100 comprises a module casing 101 and terminal cavities 102 that are arranged in two rows. It also includes a fastening element 104 for connecting to another split module. Split module 200 comprises a module casing 201, terminal cavities 202 that are ar-

ranged in one row, and a fastening element 204. When split module 100 and split module 200 are connected via their respective fastening elements 104 and 204, they form a mixed module that can replace the prior art module 10.

[0057] In the second example, module 20, another known module from the prior art, is depicted on the left side of the figure. Module 20 comprises a module casing 21 and terminal cavities 22. This module 20 can be replaced by combining two split modules, specifically split module 300 and split module 400. Split module 300 comprises a module casing 301 and terminal cavities 302. It also includes a fastening element 304 for connecting to another split module. Split module 400 comprises a module casing 401, terminal cavities 402, and a fastening element 404. When split module 300 and split module 400 are connected via their respective fastening elements 304 and 404, they form a mixed module that can replace the prior art module 20.

[0058] The figure demonstrates the modularity and flexibility of the split modules, allowing for the creation of mixed modules that can replace existing standard modules in a modular connector assembly. This approach provides the advantage of customizable configurations, enabling the assembly to accommodate various electrical terminal requirements by combining different split modules. The fastening elements ensure a secure connection between the split modules, maintaining the structural integrity and functionality of the mixed module.

[0059] Figure 3 illustrates the assembly process of a mixed module 500, which comprises a first split module 100 and a second split module 400. The figure provides a visual representation of the components and their interaction during the assembly process.

[0060] The terminal cavities 102 are designed to accommodate electrical terminals and are aligned along the longitudinal axis 40 of the module casing 101. The module casing 101 is equipped with a fastening element 104, which is integral to the process of connecting the first split module 100 to the second split module 400.

[0061] The second split module 400 is similarly structured. This module also includes a fastening element 404, which is designed to engage with the fastening element 104 of the first split module 100. The fastening elements 104 and 404 are crucial for the secure attachment of the two modules, ensuring a stable and reliable connection. Fastening element 104 is a dovetail rail, while fastening element 404 is a dovetail slide.

[0062] The assembly process is depicted in a sequence of steps. Initially, the first split module 100 and the second split module 400 are positioned such that their respective fastening elements 104 and 404 are aligned. The guiding axis 30, which is perpendicular to the longitudinal axis 40, facilitates the alignment and connection of the modules. The modules are then brought together along the guiding axis 30, as indicated by the directional arrows in the figure.

[0063] Upon successful alignment and engagement of

the fastening elements 104 and 404, the modules are securely connected, forming the mixed module 500. The figure indicates this successful connection with a "click" sound effect, symbolizing the completion of the assembly process. The mixed module 500 then comprises the combined terminal cavities 102 and 402, allowing for a versatile configuration of electrical terminals.

[0064] The design of the fastening elements 104 and 404 is such that they prevent relative movement of the split modules 100 and 400 along the longitudinal axis 40, ensuring a form fit. This secure connection is essential for maintaining the integrity and functionality of the mixed module 500 in various applications.

[0065] Figure 4 illustrates an embodiment of a split module 300 for a modular connector assembly. The split module 300 comprises a module casing 301 and terminal cavities 302 formed along a longitudinal axis 40 of the module casing 301. The module casing 301 includes fastening elements 304 at the top and at the bottom that are designed to fasten the module casing 301 to a second module casing of a second split module.

[0066] The fastening elements 304 in this embodiment are shown as a dovetail rail (at the top) and a dovetail slide (at the bottom) that extend along the guiding axis 30. The guiding axis 30 is perpendicular to the longitudinal axis 40 of the module casing 301, as depicted in Figure 3. The fastening element 304 at the top further includes a snap hook 305 and the fastening element 304 at the bottom a locking shoulder 306, which facilitate the secure attachment of the module casing 301 to the second module casing.

[0067] The split module 300 also features a terminal position assurance (TPA) 701, which ensures the proper positioning of the electrical terminals within the terminal cavities 302. The TPA 701 is an essential component for maintaining the reliability and integrity of the electrical connections within the split module 300.

[0068] The terminal cavities 302 are arranged with a specific pitch distance 70 between them, which can range from 0.1mm to 5mm. This pitch distance is crucial for accommodating various electrical terminals and ensuring proper alignment and spacing within the module casing 301.

[0069] The embodiment depicted in Figure 4 shows a split module 300 that can be easily connected to another split module using the fastening elements 304, snap hook 305, and locking shoulder 306. This modular design allows for flexibility in configuring the connector assembly to meet specific requirements, such as the number of terminal cavities and the pitch distance between them.

[0070] Figure 5 illustrates a modular connector assembly 600, which is designed for automotive applications. The assembly comprises a connector housing 602 and is shown with a mixed module 500 being inserted into one of the module slots 601. The connector housing 602 is structured to accommodate multiple module slots, with the depicted embodiment featuring four module slots

601. These module slots are configured to house both mixed modules 500, as described in the invention, and standard monoblock modules 603, demonstrating the assembly's versatility in accommodating different module types.

[0071] The mixed module 500, which is composed of split modules, is inserted along the longitudinal axis 40 of the module slots 601. The design ensures that once fully inserted, the split modules forming the mixed module 500 are securely held in place. This is achieved because the connector housing 602 prevents any relative movement of the split modules along the guiding axis 30, thereby ensuring a stable connection.

[0072] The split modules forming the mixed module 500 have a different number of terminal cavities, highlighting the modularity of the modular connector assembly 600.

[0073] The figure also highlights the presence of a standard monoblock module 603 within the assembly, indicating that the modular connector assembly 600 is capable of housing both the inventive mixed modules and conventional monoblock modules simultaneously. This capability underscores the flexibility and adaptability of the assembly in various applications, allowing for a combination of different module types to meet specific electrical or mechanical requirements.

[0074] The assembly is equipped with a mate assist lever 604, which interacts with mate assist means 605. This interaction facilitates an easier connection of the modular connector assembly 600 to counterpart connections, enhancing the user experience by simplifying the process of establishing a secure connection. The mate assist lever 604 is strategically positioned to provide leverage, thereby reducing the effort required during the mating process.

[0075] Additionally, the module slots 601 feature a coding groove 606. This groove is designed to interact with a coding rib on a module casing, ensuring the correct insertion of the module into the slot. The coding groove 606 serves as a guide, preventing incorrect orientation and insertion of the modules, which could otherwise lead to connection errors or damage to the assembly. In the depicted example, the mixed module 500 does not provide a coding rib for interaction with the coding groove, however, this in another embodiment one of the split modules forming the mixed module 500 may comprise a coding rib on the module casing.

[0076] Figures 3 and 5 together show a method of manufacturing the modular connector assembly 600. According to figure 3, two split modules 100 and 400 are connected to form a mixed module 500. According to figure 5, the mixed module 500 then is inserted into the module slot 601 of the connector housing 602 along the longitudinal axis 40. The longitudinal axis 40 in figure 5 is the same as the longitudinal axis 40 in figure 3, i.e., the longitudinal axis 40 of the split modules 100 and 400 of the split module 500.

Claims

1. A split module (100, 300) for a modular connector assembly (600), comprising:
 - a module casing (101, 301); and
 - at least one terminal cavity (102, 302) that is adapted to accommodate an electrical terminal and is formed along a longitudinal axis (40) of the module casing (101, 301);
 - wherein the module casing (101, 301) comprises a fastening element (104, 304) for fastening the module casing (101, 301) to a second module casing (201, 401) of a second split module (200, 400).
2. The split module (100, 300) of claim 1, wherein the fastening element (104) is a slide or a rail that extends along a guiding axis (30) and is preferably of a dovetail, L-shape, or T-shape type.
3. The split module (100) of claim 2, wherein the guiding axis (30) is perpendicular or parallel to the longitudinal axis (40) of the module casing (101, 301).
4. The split module (100, 300) of any one of claims 1 to 3, wherein the fastening element (104, 304) comprises a snap hook (305) and/or a locking shoulder (306).
5. The split module (100) of any one of claims 1 to 4, wherein the split module (100) comprises between 1 to 20 terminal cavities (102, 302), preferably a total number of 1, 2, 3, 6, 8, or 12 terminal cavities (102, 302).
6. The split module (100) of any one of claims 1 to 5, wherein a pitch distance (70) between two terminal cavities is between 0.1mm to 18mm, preferably 0.5mm, 0.63mm, 1.2mm, 2.8mm, or 4.8mm.
7. A mixed module (500) comprising
 - at least a first split module (100, 300) and a second split module (200, 400) according to any one of claims 1 to 6;
 - wherein the first and second split modules (100, 200, 300, 400) are connected to each other by means of their fastening element (104, 204, 304, 404).
8. The mixed module (500) of claim 7, wherein the fastening elements (104, 204, 304, 404) prevent a relative movement of the split modules (100, 200, 300, 400) to each other along the longitudinal axis (40) by means of a form fit.

9. The mixed module (500) of any one of claims 7 or 8, wherein the split modules (100, 200, 300, 400) together comprise a total number of terminal cavities (102, 202, 302, 402) between 2 to 40, preferably 2, 3, 4, 5, 14, 18, or 26. 5
10. The mixed module (500) of any one of claims 7 to 9, wherein the total number of terminal cavities (102, 302) of the first split module (100, 300) is same or different than the total number of terminal cavities (202, 402) of the second split module (200, 400). 10
11. A modular connector assembly (600) for automotive applications comprising: 15
- a connector housing (602) with at least one module slot (601); wherein the at least one module slot (601) accommodates a mixed module (500) according to any one of claims 7 to 9. 20
12. The modular connector assembly (600) of claim 11, wherein the connector housing (602) comprises multiple module slots (601), preferably four module slots (601). 25
13. The modular connector assembly (600) of any one of claims 11 or 12, wherein the at least one module slot (601) has a length of between 20mm to 30mm and a height of between 5mm to 10mm, preferably a length of 25.3mm and a height of 8.3mm. 30
14. The modular connector assembly (600) of any one of claims 11 to 13, further comprising: 35
- a plurality of mixed modules (400), each accommodated in a module slot (601) of the connector housing (601), and each comprising a different total number of terminal cavities (102, 202, 302, 402). 40
15. A method for manufacturing the modular connector assembly (600) of any one of claims 11 to 14, the method comprising the steps: 45
- forming a mixed module (500) according to any one of claims 7 to 9 by connecting a first split module (100, 300) and a second split module (200, 400) according to any one of claims 1 to 6; and 50
- inserting the mixed module (500) into a module slot (601) of the connector housing (601) along the longitudinal axis (40) of the split modules (100, 200, 300, 400) of the mixed module (500). 55

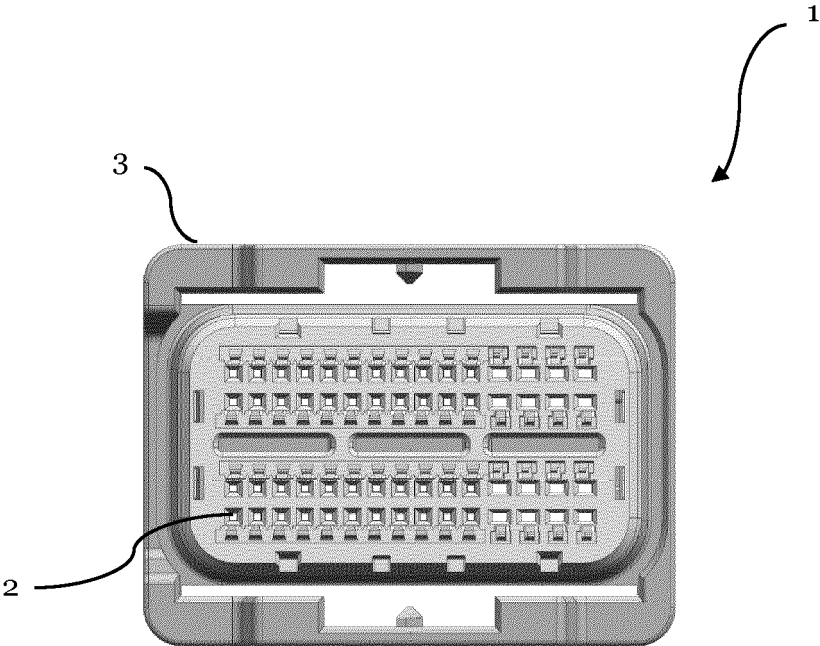


FIG. 1

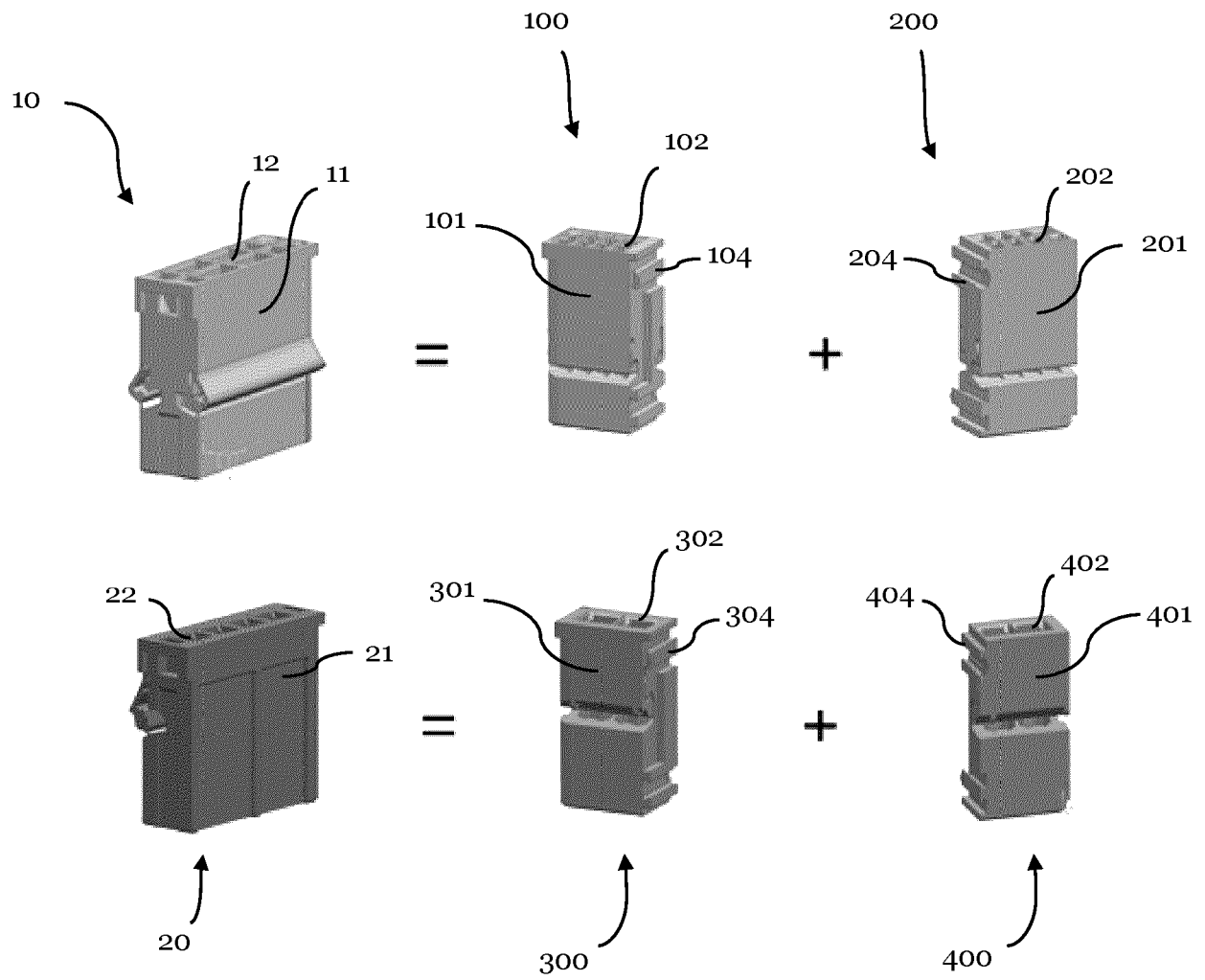


FIG. 2

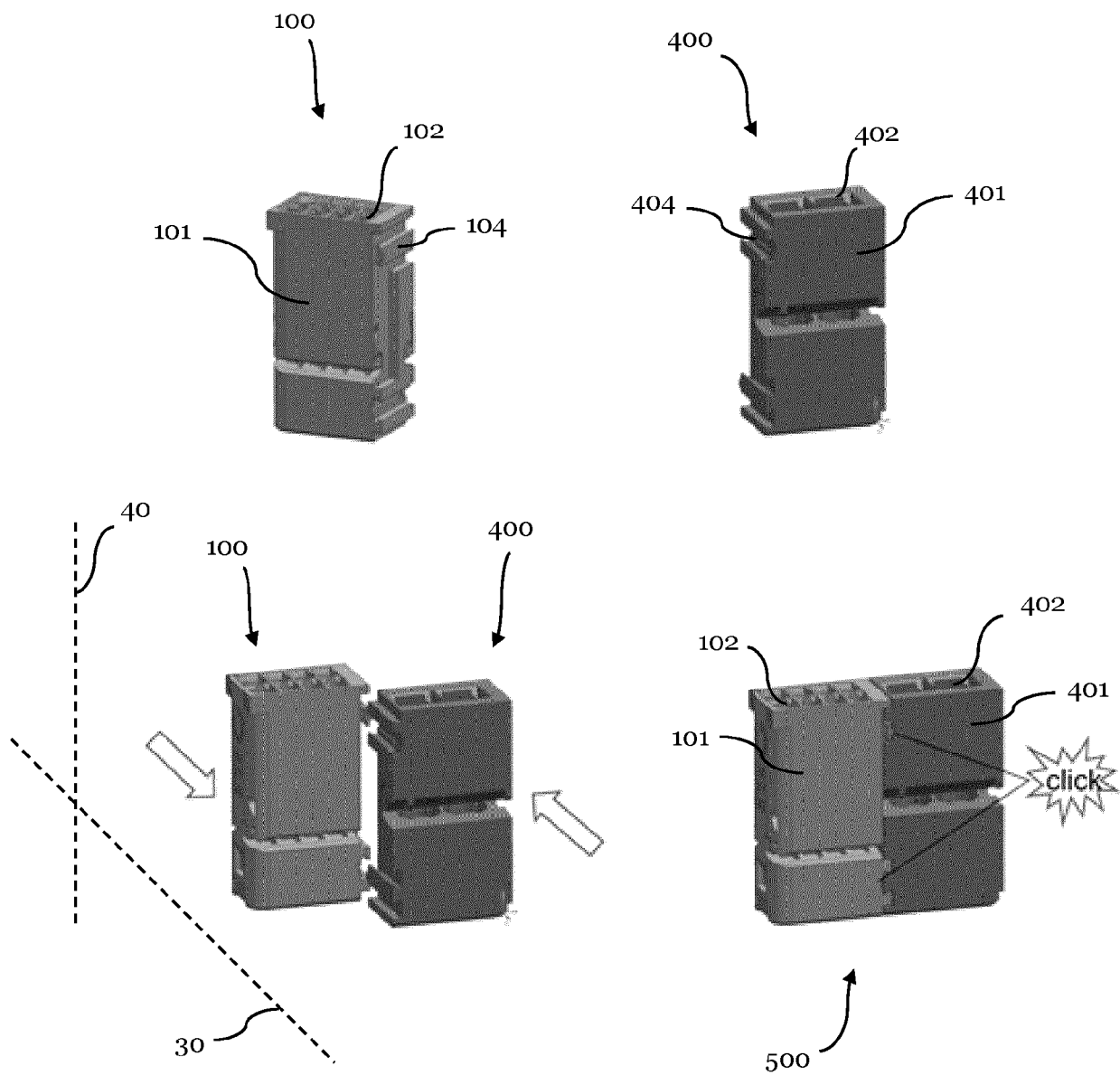


FIG. 3

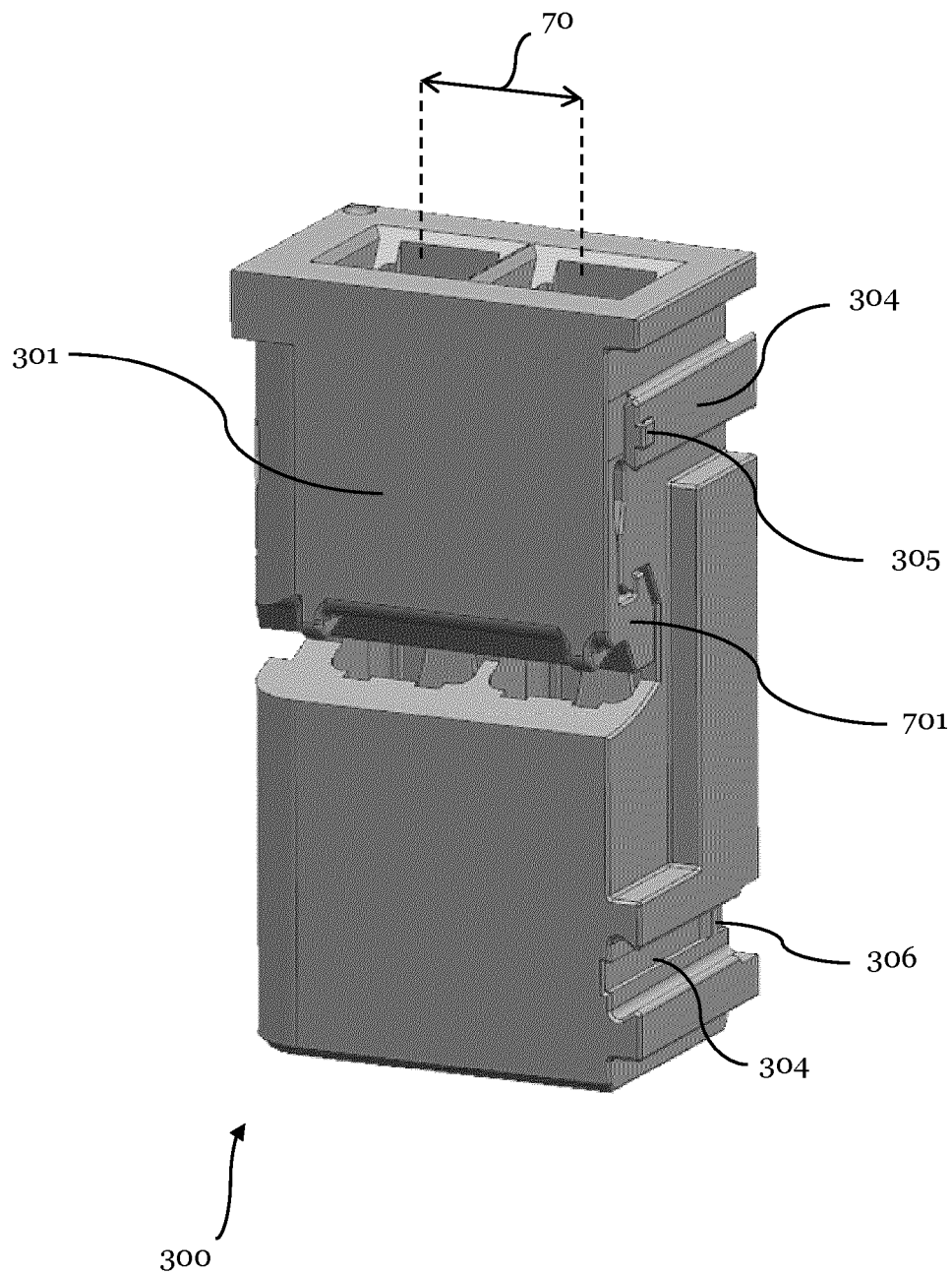


FIG. 4

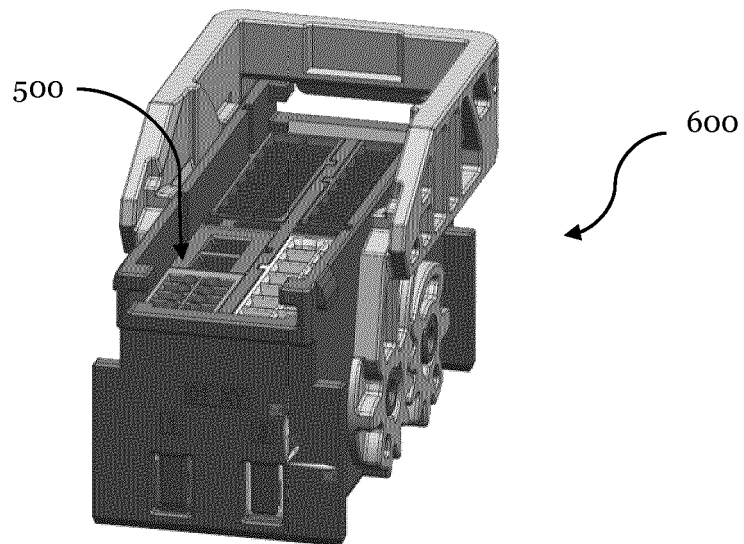
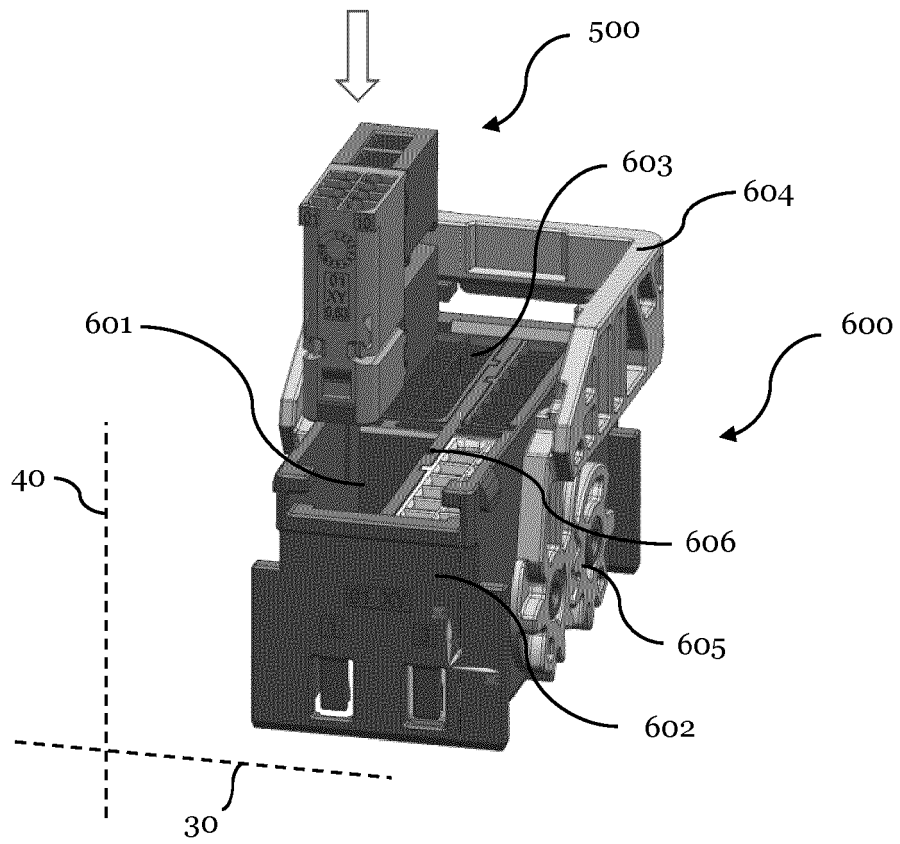


FIG. 5



EUROPEAN SEARCH REPORT

Application Number

EP 25 16 8574

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	EP 1 746 689 A1 (SUMITOMO WIRING SYSTEMS [JP]) 24 January 2007 (2007-01-24) * paragraphs [0040] - [0046]; figures 7-13 *	1-15	INV. H01R13/506 H01R13/514 H01R13/518
X	US 2018/175571 A1 (CHOO SUNG KWAN [KR] ET AL) 21 June 2018 (2018-06-21) * paragraphs [0038] - [0054]; figures 1, 2a, 2b, 7-9 *	1-14	
X	EP 1 816 709 B1 (SUMITOMO WIRING SYSTEMS [JP]) 15 December 2010 (2010-12-15) * paragraphs [0032] - [0045]; figures 1-9 *	1-10 11-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			H01R
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		26 August 2025	López García, Raquel
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 25 16 8574

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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26-08-2025

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1746689	A1	24-01-2007	CN 1901290 A
			24-01-2007
			EP 1746689 A1
			24-01-2007
			JP 4613725 B2
			19-01-2011
			JP 2007026948 A
			01-02-2007
			US 2007020979 A1
			25-01-2007

US 2018175571	A1	21-06-2018	CN 108206364 A
			26-06-2018
			KR 20180071660 A
			28-06-2018
			US 2018175571 A1
			21-06-2018

EP 1816709	B1	15-12-2010	CN 101034774 A
			12-09-2007
			EP 1816709 A1
			08-08-2007
			JP 4770491 B2
			14-09-2011
			JP 2007207565 A
			16-08-2007
			US 2007178765 A1
			02-08-2007
