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HIGH-VOLTAGE CONNECTOR FOR THREE-PHASE ELECTRICAL MACHINE

Abstract

An electrical connector may provide a threadless means for joining a junction box with a busbar without requiring tooling, which is desirable for ease-of-assembly when coupling and uncoupling the electrical connector. The junction box and the busbar may include side release buckle geometries which are configured for engagement. The junction box may include plugs with a base, prongs, and conductive lips which define a male portion of the side release buckle geometries. The busbar may include sockets with side portions, through holes, and a center portion which may define a female portion of the side release buckle geometries.

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Background/Summary

TECHNICAL FIELD

[0001] The present disclosure generally relates to electrical connections between conductive members, and, more particularly, to securing electrical connections.

BACKGROUND

[0002] High-voltage electrical connections are used in several three-phase electric machines. The high-voltage electrical connections in the three-phase electric machines typically use a threaded connection. The threaded connection ensures the connection is maintained when subject to vibrations. However, the threaded connection undesirably requires the use of tooling during assembly and disassembly. Therefore, it would be advantageous to provide a device, system, and method that cures the shortcomings described above.

SUMMARY

[0003] An electrical connector is described, in accordance with one or more embodiments of the present disclosure.

[0004] The electrical connector may include a junction box including a plurality of plugs including a base, a first prong, a second prong, a first conductive lip and a second conductive lip. The first prong and the second prong may extend from the base. The first conductive lip may extend from the first prong. The second conductive lip may extend from the second prong. The first prong and the second prong may be disposed between the first conductive lip and the second conductive lip. The electrical connector may include a busbar including a plurality of sockets including a center portion, a first side portion, and a second side portion. The center portion may be disposed between the first side portion and the second side portion. The first side portion and the center portion may define a first through hole. The second side portion and the center portion may define a second through hole. The plurality of plugs may be connected to the plurality of sockets. The first prong may be disposed in the first through hole and the second prong is disposed in the second through hole. The first conductive lip may abut the first side portion and the second conductive lip abuts the second side portion.

[0005] An electric motor is described, in accordance with one or more embodiments of the present disclosure. The electric motor may include an electrical connector. The electrical connector may include a junction box including a plurality of plugs including a base, a first prong, a second prong, a first conductive lip and a second conductive lip. The first prong and the second prong may extend from the base. The first conductive lip may extend from the first prong. The second conductive lip may extend from the second prong. The first prong and the second prong may be disposed between the first conductive lip and the second conductive lip. The electrical connector may include a busbar including a plurality of sockets including a center portion, a first side portion, and a second side portion. The center portion may be disposed between the first side portion and the second side portion. The first side portion and the center portion may define a first through hole. The second side portion and the center portion may define a second through hole. The plurality of plugs may be connected to the plurality of sockets. The first prong may be disposed in the first through hole and the second prong is disposed in the second through hole. The first conductive lip may abut the first side portion and the second conductive lip abuts the second side portion. The electric motor may include a stator including a stator core and a winding. The winding may be connected to the busbar. The electric motor may include a rotor.

[0006] A method is described, in accordance with one or more embodiments of the present disclosure. The method may include inserting a plurality of plugs of a junction box into a plurality of sockets of a busbar such that the plurality of plugs are connected to the plurality of sockets. The plurality of plugs may include a base, a first prong, a second prong, a first conductive lip and a second conductive lip. The first prong and the second prong may extend from the base. The first conductive lip may extend from the first prong. The second conductive lip may extend from the second prong. The first prong and the second prong may be disposed between the first conductive

lip and the second conductive lip. The electrical connector may include a busbar including a plurality of sockets including a center portion, a first side portion, and a second side portion. The center portion may be disposed between the first side portion and the second side portion. The first side portion and the center portion may define a first through hole. The second side portion and the center portion may define a second through hole. The first prong may be disposed in the first through hole and the second prong is disposed in the second through hole. The first conductive lip may abut the first side portion and the second conductive lip abuts the second side portion. The electric motor may include a stator including a stator core and a winding. The winding may be connected to the busbar. The electric motor may include a rotor.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The numerous advantages of the disclosure may be better understood by those skilled in the art by reference to the accompanying figures in which:

[0008] FIG. **1**A illustrates a perspective view of an electrical connection before plugs of a junction box are inserted into sockets of a busbar, in accordance with one or more embodiments of the present disclosure.

[0009] FIG. **1**B illustrates a partial perspective view of a junction box of an electrical connection, in accordance with one or more embodiments of the present disclosure.

[0010] FIG. **1**C illustrates a partial perspective view of a busbar of an electrical connection, in accordance with one or more embodiments of the present disclosure.

[0011] FIG. **1**D illustrates a partial perspective view of an electrical connection with plugs of a junction box inserted into sockets of a busbar such that the plugs and sockets are connected, in accordance with one or more embodiments of the present disclosure.

[0012] FIG. **1**E illustrates a partial perspective view of an electrical connection with a plug connected to a socket, in accordance with one or more embodiments of the present disclosure.

[0013] FIG. **2**A illustrates a perspective view of an electric motor, in accordance with one or more embodiments of the present disclosure.

[0014] FIG. **2**B illustrates a partial perspective view of an electric motor, in accordance with one or more embodiments of the present disclosure.

[0015] FIG. **3** depicts a flow diagram of a method of securing an electrical connection, in accordance with one or more embodiments of the present disclosure.

DETAILED DESCRIPTION OF THE INVENTION

[0016] Embodiments of the present disclosure are described herein. It is to be understood, however, that the disclosed embodiments are merely examples and other embodiments can take various and alternative forms. The figures are not necessarily to scale; some features could be exaggerated or minimized to show details of components. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a representative basis for teaching one skilled in the art to variously employ the embodiments. As those of ordinary skill in the art will understand, various features illustrated and described with reference to any one of the figures can be combined with features illustrated in one or more other figures to produce embodiments that are not explicitly illustrated or described. The combinations of features illustrated provide representative embodiments for typical applications. Various combinations and modifications of the features consistent with the teachings of this disclosure, however, could be desired for applications or implementations.

[0017] Embodiments of the present disclosure are directed to an electrical connector. The electrical connector may provide a threadless means for joining a junction box with a busbar without requiring tooling, which is desirable for ease-of-assembly when coupling and uncoupling the

electrical connector. The junction box and the busbar may include side release buckle geometries which are configured for engagement. The junction box may include plugs with a base, prongs, and conductive lips which define a male portion of the side release buckle geometries. The busbar may include sockets with side portions, through holes, and a center portion which may define a female portion of the side release buckle geometries.

[0018] FIGS. **1**A-**1**E illustrate an electrical connector **100**, in accordance with one or more embodiments of the present disclosure. The electrical connector **100** may be an electrical connector used in a three-phase electric motor. The electrical connector **100** may include a junction box **102** and/or a busbar **104**.

[0019] The junction box **102** may receive current from one or more external components. For example, the junction box **102** may receive current from an inverter, controller, or the like. The junction box **102** may receive one or more phases of current. In embodiments, the junction box **102** may receive three phases of current, including first-phase (u), second-phase (v), and third-phase (w). The first-phase (u), the second-phase (v), and the third-phase (w) are generally aligned 120-degrees out of phase. The junction box **102** may include plugs **106**, molding **108**, and/or bars **110**.

[0020] The bars **110** may be rigid elements for engagement with one or more external components. The plugs **106** may be rigid elements for engagement with the busbar **104**. The junction box **102** may include any number of the plugs **106** and/or bars **110**. In embodiments, the junction box **102** may include three of the plugs **106** and three of the bars **110**. For example, the junction box **102** may include a first-phase plug **106***u*, a second-phase plug **106***v*, a third-phase plug **106***w*, a first-phase bar **110***u*, a second-phase bar **110***v*, and/or a third-phase bar **110***w*. The plugs **106** and the bars **110** may each carry a respective phase of electricity. For example, the first-phase plug **106***u*, second-phase plug **106***v*, and third-phase plug **106***w* may carry a first-phase, a second-phase, and a third-phase of electricity, respectively. By way of another example, the first-phase bar **110***u*, second-phase bar **110***v*, and/or third-phase bar **110***w* may carry a first-phase, a second-phase, and a third-phase of electricity, respectively. The bars **110** may connect with a respective of the plugs **106** through one or more internal traces within the molding **108**.

[0021] The plugs **106** may include a base **122**, prongs **124**, and conductive lips **126**. For example, each of the first-phase plug **106***u*, second-phase plug **106***v*, and third-phase plug **106***w* may include the base **122**, prongs **124**, and conductive lips **126**. The plugs **106** may define a male buckle geometry. For example, the plugs **106** may define a male side-release buckle geometry. The base **122**, prongs **124**, and conductive lips **126** may collectively define the male side-release buckle geometry.

[0022] The base **122** may be a flat plate. The base **122** may include a cuboid shape. A thickness of the base **122** may be much less than a length and/or a width of the base **122**. The base **122** may extend from the molding **108**.

[0023] The prongs **124** may be a pair of the prongs **124**. For example, the plugs **106** may include a first prong **124***a* and a second prong **124***b*. The prongs **124** may extend from the base **122**. For example, the prongs **124** may extend from a top edge of the base **122**. For instance, the first prong **124***a* may extend from a first corner of the top edge of the base **122** and the second prong **124***b* may extend from a second corner of the top edge of the base **122**. The prongs **124** may be aligned in parallel. For example, the first prong **124***a* may be aligned in parallel with the second prong **124***b*. The prongs **124** may be in a rest position when the prongs **124** are aligned in parallel.

[0024] In embodiments, the prongs **124** may have a selected length. For example, the prongs **124** may each have the same length. Although the prongs **124** are described as having the same length, this is not intended as a limitation of the present disclosure. It is further contemplated that the prongs **124** may have differing lengths.

[0025] The base **122** and the prongs **124** may define a center notch **128**. The center notch **128** may be disposed between the first prong **124***a* and the second prong **124***b*. The center notch **128** may include a shape, such as, but not limited to, a square shape, a V-shape, a U-shape, or the like. It is

contemplated the base **122** and the prongs **124** may include various geometries such as rounded corner, squared corners, and the like to define the shape of the center notch **128**.

[0026] In embodiments, the prongs **124** may be a resilient member. In this regard, the prongs **124** may return to an original shape after being deformed. The prongs **124** may have a selected elastic modulus sufficient to allow the prongs **124** to deform and then recover to the original shape. The prongs **124** may be elastically deformed by prongs **124** together. The prongs **124** may be configured to elastically bend inwards from the rest position. For example, the prongs **124** may be pinched together thereby elastically bending the prongs **124** inwards. Bending inwards may refer to bending the prongs **124** towards each other within the center notch **128**. For example, the first prong **124***a* and the second prong **124***b* may be bent towards each other by a pinching action. The prongs **124** may also be configured to return to the rest position. The return of the prongs **124** may also be referred to as springing backwards. Once the external force is removed, the prongs **124** may expand away from each other due to internal stresses within the prongs **124**. Thus, the prongs **124** may be configured to elastically deform from and return to the rest position. The prongs **124** may include a selected elastic modulus to enable bending inwards from and returning to the rest position.

[0027] The conductive lips **126** may be wedges or the like. The conductive lips **126** may include a selected shape, such as, but not limited to, a triangular shape. The conductive lips **126** may be a pair of the conductive lips **126**. For example, the plugs **106** may include a first conductive lip **126***a* and a second conductive lip **126***b*. The conductive lips **126** may extend from the prongs **124**. For example, the first conductive lip **126***a* may extend from the first prong **124***a* and the second conductive lip **126***b* may extend from the second prong **124***b*. The first conductive lip **126***a* and the second conductive lip **126***b* may extend from opposing sides of the first prong **124***a* and the second prong **124***b*. The first prong **124***a* and the second prong **124***b* may be disposed between the first conductive lip **126***a* and the second conductive lip **126***b*. In this regard, the prongs **124** may be disposed between the conductive lips **126**. In embodiments, the conductive lips **126** may extend from top corners of the prongs **124**.

[0028] In embodiments, the base **122**, prongs **124**, and/or conductive lips **126** may be co-planar. For example, the base **122**, prongs **124**, and/or conductive lips **126** may be disposed in an upright plane. Although the base **122**, prongs **124**, and/or conductive lips **126** are described as being co-planar, this is not intended as a limitation of the present disclosure. It is further contemplated that the one or more of the base **122**, prongs **124**, and/or conductive lips **126** may be in offset planes.

[0029] In embodiments, each of the plugs **106** may be co-planar. For example, the first-phase plug **106***u*, the second-phase plug **106***v*, and/or the third-phase plug **106***w* may be co-planar. For example, the first-phase plug **106***u*, the second-phase plug **106***v*, and/or the third-phase plug **106***w* may be co-planar in the upright plane. The first-phase plug **106***u*, second-phase plug **106***v*, and third-phase plug **106***w* may be aligned in a row. The second-phase plug **106***v* may be disposed between the first-phase plug **106***u* and the third-phase plug **106***w*. The first-phase plug **106***u*, second-phase plug **106***v*, and third-phase plug **106***w* may each include a same length. Thus, the base **122**, prongs **124**, and/or conductive lips **126** of each of the first-phase plug **106***u*, the second-phase plug **106***v*, and/or the third-phase plug **106***w* may be co-planar. Although the plugs **106** are described as being co-planar, this is not intended as a limitation of the present disclosure. It is further contemplated that the one or more of the plugs **106** may be in offset planes.

[0030] The busbar **104** may receive current from the junction box **102**. For example, the busbar **104** may receive current from the plugs **106**. The busbar **104** may receive one or more phases of current. In embodiments, the busbar **104** may receive three phases of current, including first-phase (u), second-phase (v), and third-phase (w). The busbar **104** may include sockets **112**, bus pins **114**, neutral bus **116**, and/or molding **118**.

[0031] The sockets **112** may be rigid elements for engagement with the plugs **106**. The busbar **104** may include any number of the sockets **112**. In embodiments, the busbar **104** may include three of

the sockets **112**. For example, the busbar **104** may include a first-phase socket **112***u*, a second-phase socket **112***v*, and a third-phase socket **112***w*. The sockets **112** may each carry a respective phase of electricity. For example, the first-phase socket **112***u*, second-phase socket **112***v*, and third-phase socket **112***w* may carry the first-phase, the second-phase, and the third-phase of electricity, respectively.

[0032] The sockets **112** may include a center portion **120** and side portions **130**. The sockets **112** may define one or more through holes **132**. The through holes **132** may be disposed between the center portion **120** and the side portions **130**. Each of the first-phase socket **112***u*, second-phase socket **112***v*, and third-phase socket **112***w* may include the center portion **120**, the side portions **130**, and the through holes **132**.

[0033] The sockets **112** may define a female buckle geometry. For example, the sockets **112** may define a female side-release buckle geometry. The center portion **120**, the side portions **130**, and through holes **132** may collectively define the female side-release buckle geometry.

[0034] The side portions **130** may be a pair of the side portions **130** and a pair of through holes **132**. For example, the sockets **112** may include a first side portion **130***a* and a second side portion **130***b*. The center portion **120** may be disposed between the first side portion **130***a* and second side portion **130***b*.

[0035] The through holes **132** may be a pair of through holes. For example, the sockets **112** may define a first through hole **132***a* and a second through hole **132***b*. The first side portion **130***a* and center portion **120** may define the first through hole **132***a*. The second side portion **130***b* and center portion **120** may define the second through hole **132***b*. The first through hole **132***a* may be disposed between the first side portion **130***a* and center portion **120**. The second through hole **132***b* may be disposed between the second side portion **130***b* and the center portion **120**. The first side portion **130***a* may be adjacent to the second side portion **130***b*. Similarly, the first through hole **132***a* may be adjacent to the second through hole **132***b*.

[0036] In embodiments, the center portion **120**, the side portions **130**, and/or the through holes **132** may include a selected cross-section. For example, the center portion **120**, the side portions **130**, and/or the through holes **132** may include a rectangular cross-section. The rectangular cross-section may be along the length of the center portion **120**, the side portions **130**, and/or the through holes **132**. The rectangular cross-sections of the center portion **120**, the rectangular cross-section of the side portions **130**, and/or the rectangular cross-section of the through holes **132** may include different dimensions. The rectangular cross-sections may or may not be square cross-sections.

[0037] The junction box **102** may be connected to the busbar **104**. The plugs **106** may connect with the sockets **112** to establish the electrical connection. For example, the plugs **106** of the junction box **102** may be connected to the sockets **112** of the busbar **104**. For instance, the first-phase plug **106***u*, second-phase plug **106***v*, and third-phase plug **106***w* may be connected to the first-phase socket **112***u*, second-phase socket **112***v*, and third-phase socket **112***w*, respectively. The busbar **104** may receive the current from the plugs **106**. For example, the busbar **104** may receive the three phases of current from the junction box **102**. For instance, the first-phase socket **112***u*, second-phase socket **112***v*, and third-phase socket **112***w* may receive the first-phase from the first-phase plug **106***u*, the second-phase from the second-phase plugs **106***v*, and the third-phase from the third-phase plugs **106***w*, respectively. The electrical connector **100** may be a coupling device having the plugs **106** and the sockets **112** which may be adapted for repeated physical engagement or disengagement for establishing and breaking the electrical connection. In embodiments, the plugs **106** may be a threadless joining element. In this regard, the plugs **106** may not include a thread. In this regard, the junction box **102** may be joined to the busbar **104** without using a threaded connection.

[0038] The prongs **124** may be configured to join the junction box **102** and busbar **104**. The prongs **124** may join the plugs **106** of the junction box **102** to the sockets **112** of the busbar **104** when the plugs **106** are disposed in the sockets **112**. The prongs **124** may be disposed in the through holes

132 when the plugs **106** are engaged with the sockets **112**. For example, the first prong **124***a* may be disposed in the first through hole **132***a* and the second prong **124***b* may be disposed in the second through hole **132***b*. The prongs **124** may abut the side portions **130**. The prongs **124** may exert pressure on the plugs **106** and the sockets **112**. The pressure exerted by the prongs **124** may prevent separation of the plugs **106** from the sockets **112**. The abutment between the prongs **124** and the side portions **130** may also serve as an electrical contact area for conducting the electricity. The prongs **124** may be resilient and may exert an outwards force on the side portions **130**. The outward force may clamp the plugs **106** to the sockets **112**, thereby joining the junction box **102** to the busbar **104**. Thus, the busbar **104** may be prevented from sliding in any direction with respect to the junction box **102**. The side portions **130** may have a high enough resistance to deformation such that the outwards force from the prongs **124** induces contact between the prongs **124** and side portions **130**, without plastic deformation of the side portions **130**. The abutment between the prongs **124** and the side portions **130** may also serve as an electrical contact area for conducting the electricity. Thus, the prongs **124** may ensure electrical conductivity and prevent the plugs **106** from disconnecting from the sockets **112** during normal operation of the electrical connector **100**.

[0039] The conductive lips **126** may abut the side portions **130**. For example, the first conductive lip **126***a* may abut the first side portion **130***a* and the second conductive lip **126***b* may abut the second side portion **130***b*. The abutment between the conductive lips **126** and the side portions **130** may prevent the plugs **106** from disengaging with the sockets **112**. Thus, the conductive lips **126** may prevent the junction box **102** from translating relative to the busbar **104** when the plugs **106** are coupled to the sockets **112**. The abutment between the conductive lips **126** and the side portions **130** may also serve as an electrical contact area for conducting the electricity. The conductive lips **126** may also cause the prongs **124** to translate inwards as the prongs **124** are inserted into the through holes **132**.

[0040] The molding **118** may include molded lips **134**. For example, the molding **118** may include a pair of the molded lips **134**. For instance, the molding **118** may include a first molded lip **134***a* and a second molded lip **134***b*. The molding **118** may include the molded lips **134** for each of the sockets **112**. The molded lips **134** may be disposed above the side portions **130**. For example, the first molded lip **134***a* may be disposed above the first side portion **130***a* and the second molded lip **134***b* may be disposed above the second side portion **130***b*. The molded lips **134** may be a lock geometry for retaining the plugs **106**. For example, the conductive lips **126** may abut both the side portions **130** and the molded lips **134**. For instance, the first conductive lip **126***a* may abut the first side portion **130***a* and the first molded lip **134***a* and the second conductive lip **126***b* may abut the second side portion **130***b* and the second molded lip **134***b*. A first side of the conductive lips **126** may abut the conductive lips **126** and a second side of the conductive lips **126** opposed to the first side may abut the molded lips **134**. For example, a first side of the first conductive lip **126***a* and the second conductive lip **126***b* may abut the first conductive lip **126***a* and the second conductive lip **126***b*, respectively, and a second side of the first conductive lip **126***a* and the second conductive lip **126***b* opposed to the first side may abut the first molded lip **134***a* and the second molded lip **134***b*, respectively. Thus, the conductive lips **126** may be disposed between the side portions **130** and the molded lips **134**. For example, the first conductive lip **126***a* may be disposed between the first side portion **130***a* and the first molded lip **134***a* and the second conductive lip **126***b* may be disposed between the second side portion **130***b* and the second molded lip **134***b*. Thus, the plugs **106** may include a lock geometry that prevents the plugs **106** from sliding in the axial direction.

[0041] The molding **118** may include tabs **136**. For example, the molding **118** may include a pair of the tabs **136**. For instance, the molding **118** may include a first tab **136***a* and a second tab **136***b*. The molding **118** may include the tabs **136** for each of the sockets **112**. The tabs **136** may be disposed below the side portions **130**. For example, the first tab **136***a* may be disposed below the first side portion **130***a* and the second tab **136***b* may be disposed below the second side portion **130***b*. The tabs **136** may align the plugs **106** with the sockets **112** when inserting the plugs **106** in the sockets

112. The tabs **136** may also assist in maintain the connection between the plugs **106** and the sockets **112**. For example, the tabs **136** may abut the base **122**.

[0042] The center portion **120** may be disposed in the center notch **128**. For example, the center portion **120** may be disposed in the center notch **128** when the plugs **106** are engaged with the sockets **112**. Airgaps **138** may be defined between the prongs **124** and the center portion **120** when the junction box **102** is connected to the busbar **104**. For example, a first airgap **138***a* may be defined between the first prong **124***a* and the center portion **120** and a second airgap **138***b* may be defined between the second prong **124***b* and the center portion **120**. The airgaps **138** may permits pinching the prongs **124** together towards the center portion **120**. The prongs **124** may be pinched together towards the center portion **120** until the conductive lips **126** no longer abut the side portions **130** and the molded lips **134**. The prongs **124** may flex inwards causing the conductive lips **126** to be aligned with the through holes **132**. The plugs **106** may be free to translate axially relative to the sockets **112** when the conductive lips **126** no longer abut the side portions **130** and the molded lips **134**. Thus, the plugs **106** may be removed from the sockets **112** by pinching the prongs **124** inwards towards the center portion **120**. For example, the plugs **106** may be removed from the sockets **112** by pinching the first prong **124***a* and the second prong **124***b* together within the first airgap **138***a* and the second airgap **138***b*, respectively.

[0043] The bus pins **114** may be connected to the sockets **112**. For example, the bus pins **114** may be connected to the sockets **112** via one or more internal traces within the busbar **104**. The bus pins **114** may be connected to the sockets **112** such that each of the bus pins **114** is associated with a respective phase of electricity. For example, the bus pins **114** may include first-phase bus pins **114***u*, second-phase bus pins **114***v*, and third-phase bus pins **114***w*. The first-phase bus pins **114***u* may be connected to the first-phase sockets **112***u*, the second-phase bus pins **114***v* may be connected to the second-phase sockets **112***v*, and the third-phase bus pins **114***w* may be connected to the third-phase sockets **112***w*, respectively. The bus pins **114** may be rigid elements for engagement with one or more hairpin windings.

[0044] The plugs **106** and sockets **112** may be formed from an electrical conductor. For example, the plugs **106** and sockets **112** may be formed from copper, aluminum, or an alloy thereof. The plugs **106** and sockets **112** may form an electrical connection when the plugs **106** contacts the sockets **112**. The plugs **106** and sockets **112** may be formed using metal sheet forming, stamping, or the like. In embodiments, the plugs **106** and sockets **112** may include a flat metal plate. For example, the plugs **106** and sockets **112** may each have a thickness which may be much smaller than the width and length. The length of the sockets **112** may be orthogonal to the length of the plugs **106**.

[0045] The molding **108** and the molding **118** may be formed from an electrical insulator. For example, the molding **108** and the molding **118** may be formed from a plastic material.

[0046] The prongs **124** may be advantageous to provide ease-of-assembly when coupling and uncoupling the plugs **106** and sockets **112**. The plugs **106** may be coupled and/or uncoupled when external force is applied pinching the prongs **124** together. It is contemplated that the prongs **124** may maintain pressure between the plugs **106** and the sockets **112** with repeated assembly and disassembly of the electrical connector **100**. For example, the prongs **124** may maintain pressure between the plugs **106** and the sockets **112** with repeated assembly and disassembly for as long as the prongs **124** are not plastically deformed.

[0047] In embodiments, the junction box **102** and the busbar **104** may include an equal number of the plugs **106** and the sockets **112**. In this regard, each of the plugs **106** corresponds to a respective of the sockets **112**. The busbar **104** may include three of the sockets **112**. Similarly, the busbar **104** may include a first-phase socket **112***u*, a second-phase socket **112***v*, and a third-phase socket **112***w*. The first-phase socket **112***u*, second-phase socket **112***v*, and third-phase socket **112***w* may be aligned in a row. The second-phase socket **112***v* may be disposed between the first-phase socket **112***u* and the third-phase socket **112***w*. The first-phase socket **112***u*, second-phase socket **112***v*, and

third-phase socket **112***w* may receive the first-phase plug **106***u*, second-phase plug **106***v*, and third-phase plug **106***w*, respectively. Although the electrical connector **100** is described as including three of the plugs **106** and three of the sockets **112**, this is not intended as a limitation of the present disclosure. It is contemplated that the electrical connector **100** may include variations on the number of the plugs **106** and the sockets **112**. The benefits provided by the prongs **124** may apply to such variable numbers of the plugs **106** and the sockets **112**.

[0048] In embodiments, the electrical connector **100** may be a high-voltage electrical connector. For example, the electrical connector **100** may be rated to carry over 1,000 VAC. Although the electrical connector **100** is described as a high voltage electrical connector, this is not intended as a limitation of the present disclosure. In embodiments, the electrical connector **100** may be a low voltage electrical connector. The benefits provided by the electrical connector **100** may apply to both low-voltage and high-voltage connectors.

[0049] In embodiments, the electrical connector **100** is used for an electrical machine. The electrical machine may include any electrical machine known in the art. It is contemplated that the electrical connector **100** may be used in any electrical machine with the junction box **102** and busbar **104**. For example, the electrical machine may include an electric motor. The electric motor may be a three-phase electric motor. The electric motor may be used as a traction drive in a vehicle drive system. Thus, the electrical connector may be a high-voltage connector for a three-phase electrical machine.

[0050] FIGS. **2**A-**2**B illustrates an electric motor **200**, in accordance with one or more embodiments of the present disclosure. The electric motor **200** may be a three-phase electric motor. The three-phase electric motor may carry the respective phases received by the junction box **102**. The electric motor **200** may include the electrical connector **100**, a stator **202**, and/or a rotor **204**.

[0051] The bus pins **114** may engagement with the stator **202**. The busbar **104** may distribute the three phases of current to the stator **202**. For example, the bus pins **114** may be connected to the stator **202** for distributing the three phases of current. The stator **202** may receive the current from the busbar **104**. The stator **202** may induce a magnetic field in response to receiving the three phases of current from the busbar **104**.

[0052] The rotor **204** may be disposed within a central axis of the stator **202**. The rotor **204** may be supported by the stator **202** via one nor more bearings. The magnetic field induced by the stator **202** may cause the rotor **204** to rotate relative to the stator **202**. The rotor **204** may perform work on one or more external components via the rotation of the rotor **204**. Thus, the electric motor **200** may be a dynamo-electric machine which converts electrical energy to mechanical energy by electromagnetic means.

[0053] The stator **202** may include one or more of a stator carrier **206**, a stator core **208**, a winding **210**, and the like. The stator carrier **206** may be a housing for the components of the stator **202**. The stator carrier **206** may encapsulate the stator core **208**, the winding **210**, and the like. The stator core **208** may be made of stacks of one or more stacks of lamination. The stator core **208** may define one or more slots for the winding **210**. The winding **210** of the stator **202** may disposed in the slots of the stator core.

[0054] The winding **210** may be connected to the busbar **104**. The winding **210** may receive the current from the busbar **104** and induce the magnetic field. The winding **210** may include any suitable type of winding, such as, but not limited to, a hairpin winding (e.g., a hairpin lap winding) or the like. The winding **210** may be made of a plurality of hairpins. The hairpins may be joined together to form the winding **210**. For example, the hairpins may be joined together by a weld (e.g., a laser weld), cap, or the like to form the winding **210**. The hairpins may be flat bars which may be bent into a select shape. For example, the hairpins may include a “U-shape” or the like.

[0055] The winding **210** may be a three-phase winding including the first-phase (u), the second-phase (v), and the third-phase (w). The winding **210** may include poles which alternate in sequence between the first-phase (u), the second-phase (v), and the third-phase (w). The hairpins may carry a

respective of the phases to define the poles. For example, the hairpins may include first-phase hairpins, second-phase hairpins, and third-phase hairpins. The first-phase hairpins, second-phase hairpins, and third-phase hairpins may similarly be arranged in the alternating arrangement. The first-phase hairpins, second-phase hairpins, and third-phase hairpins may be connected to the first-phase bus pins **114***u*, the second-phase bus pins **114***v*, and the third-phase bus pins **114***w*, respectively. Thus, the hairpins of the winding **210** may connect to the bus pins **114** of the busbar **104**. The connection between the winding **210** and the bus pins **114** may be referred to as a pin/pin connection.

[0056] The winding **210** may be coupled to the neutral bus **116**. The first-phase hairpins, second-phase hairpins, and third-phase hairpins of the winding **210** may be connected to the neutral bus **116**. The connection between the winding **210** and the neutral bus **116** may be referred to as a pin/neutral connection.

[0057] Current distribution to the electric motor **200** may be achieved through the electrical connector **100**. Internally the junction box **102** connects and distributes the current for the stator **202** through the busbar **104**. The busbar **104** distributes the current at the stator **202** to generate the magnetic field and produce the rotor movement. The busbar **104** may distribute current for the winding **210**. For example, the busbar **104** may distribute each of the phases of current to the winding **210**. The winding **210** may be a "wye" transformer by being connected at a first end to the first-phase bus pins **114***u*, the second-phase bus pins **114***v*, and the third-phase bus pins **114***w*, respectively, and by being connected at a second end to the neutral bus **116**. The neutral bus **116** is a common neutral between each of the phases. The neutral bus **116** may or may not be connected to a ground.

[0058] FIG. **3** illustrates a flow diagram of a method **300** of securing a plug and socket of an electrical connector of an electrical machine, in accordance with one or more embodiments of the present disclosure. The method **300** provides a means for electrically coupling and uncoupling the electrical connector **100**. The embodiments and the enabling technology described previously herein in the context of the electrical connector **100** should be interpreted to extend to the method **300**. It is further recognized, however, that the method is not limited to the electrical connector **100**.

[0059] In a step **310**, plugs of a junction box may be inserted into sockets of a busbar such that the plugs are connected to the sockets. For examples, the plugs **106** may be inserted in the sockets **112** such that the plugs **106** are connected to the sockets **112**. For instance, the first-phase plug **106***u*, second-phase plug **106***v*, and the third-phase plug **106***w* may be inserted in the first-phase socket **112***u*, second-phase socket **112***v*, and third-phase socket **112***w*, respectively. Inserting may include translating the plugs **106** relative to the sockets **112**. For example, the busbar **104** may be fixed while inserting the plugs **106** of the junction box **102** into the sockets **112**.

[0060] In a step **320**, the prongs of the plugs may be pinched together. For example, the prongs **124** of the plugs **106** may be pinched together. For instance, the prongs **124** of the plugs **106** may be pinched together within the airgap **138** defined between the prongs **124** and the center portion **120**. The first prong **124***a* and the second prong **124***b* may be pinched together. For example, the first prong **124***a* and the second prong **124***b* may be pinched together within the first airgap **138***a* and the second airgap **138***b*, respectively. The prongs **124** of the plugs **106** may be pinched together such that the conductive lips **126** do not abut the side portions **130** and are aligned with the through holes **132**. For instance, the first prong **124***a* and the second prong **124***b* may be pinched together the first conductive lip **126***a* does not abut the first side portion **130***a* and is aligned with the first through hole **132***a* and such that the second conductive lip **126***b* does not abut the second side portion **130***b* and is aligned with the second through hole **132***b*.

[0061] In a step **330**, the plugs of the electrical connector may be removed from the sockets of the electrical connector. For example, the plugs **106** may be removed from the sockets **112** such that the plugs **106** and the sockets **112** are not in electrical contact. The plugs **106** may be removed by translating the plugs **106** relative to the sockets **112**. For example, the prongs **124** may be removed

from the through holes **132**. The first-phase plug **106***u*, second-phase plug **106***v*, and the third-phase plug **106***w* may be removed from the first-phase socket **112***u*, second-phase socket **112***v*, and third-phase socket **112***w*, respectively.

[0062] Referring generally again to the figures. Although much of the present disclosure has described the junction box **102** as including the plugs **106** and the busbar **104** as including the sockets **112**, this is not intended as a limitation of the present disclosure. It is contemplated that the junction box **102** may include the sockets **112** and the busbar **104** may include the plugs **106**. However, the junction box **102** including the plugs **106** may be desirable to improve ease-of-assembly of the electrical connector **100**.

[0063] One skilled in the art will recognize that the herein described components operations, devices, objects, and the discussion accompanying them are used as examples for the sake of conceptual clarity and that various configuration modifications are contemplated. Consequently, as used herein, the specific exemplars set forth and the accompanying discussion are intended to be representative of their more general classes. In general, use of any specific exemplar is intended to be representative of its class, and the non-inclusion of specific components, operations, devices, and objects should not be taken as limiting.

[0064] As used herein, directional terms such as “top,” “bottom,” “over,” “under,” “upper,” “upward,” “lower,” “down,” and “downward” are intended to provide relative positions for purposes of description, and are not intended to designate an absolute frame of reference. Various modifications to the described embodiments will be apparent to those with skill in the art, and the general principles defined herein may be applied to other embodiments

[0065] With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations are not expressly set forth herein for sake of clarity.

[0066] While exemplary embodiments are described above, it is not intended that these embodiments describe all possible forms encompassed by the claims. The words used in the specification are words of description rather than limitation, and it is understood that various changes can be made without departing from the spirit and scope of the disclosure. As previously described, the features of various embodiments can be combined to form further embodiments of the disclosure that may not be explicitly described or illustrated. While various embodiments could have been described as providing advantages or being preferred over other embodiments or prior art implementations with respect to one or more desired characteristics, those of ordinary skill in the art recognize that one or more features or characteristics can be compromised to achieve desired overall system attributes, which depend on the specific application and implementation. As such, to the extent any embodiments are described as less desirable than other embodiments or prior art implementations with respect to one or more characteristics, these embodiments are not outside the scope of the disclosure and can be desirable for applications.

LIST OF REFERENCE NUMBERS

[0067] **100** electrical connector [0068] **102** junction box [0069] **104** busbar [0070] **106** plugs [0071] **106***u* first-phase plug [0072] **106***v* second-phase plug [0073] **106***w* third-phase plug [0074] **108** molding [0075] **110** bars [0076] **110***u* first-phase bar [0077] **110***v* second-phase bar [0078] **110***w* third-phase bar [0079] **112** sockets [0080] **112***u* first-phase socket [0081] **112***v* second-phase socket [0082] **112***w* third-phase socket [0083] **114** bus pins [0084] **114***u* first-phase bus pins [0085] **114***v* second-phase bus pins [0086] **114***w* third-phase bus pins [0087] **116** neutral bus [0088] **118** molding [0089] **120** center portion [0090] **122** base [0091] **124** prongs [0092] **124***a* first prong [0093] **124***b* second prong [0094] **126** conductive lips [0095] **126***a* first conductive lip [0096] **126***b* second conductive lip [0097] **128** center notch [0098] **130** side portions [0099] **130***a* first side portion [0100] **130***b* second side portion [0101] **132** through holes [0102] **132***a* first through hole [0103] **132***b* second through hole [0104] **134** molded lips [0105] **134***a* first molded lip [0106] **134***b*

second molded lip [0107] **136** tabs [0108] **136***a* first tab [0109] **136***b* second tab [0110] **138** airgaps [0111] **138***a* first airgap [0112] **138***b* second airgap [0113] **200** electric motor [0114] **202** stator [0115] **204** rotor [0116] **206** stator carrier [0117] **208** stator core [0118] **210** winding

Claims

1. An electrical connector comprising: a junction box comprising a plurality of plugs comprising a base, a first prong, a second prong, a first conductive lip and a second conductive lip, wherein the first prong and the second prong extend from the base, wherein the first conductive lip extends from the first prong, wherein the second conductive lip extends from the second prong, wherein the first prong and the second prong are disposed between the first conductive lip and the second conductive lip; and a busbar comprising a plurality of sockets comprising a center portion, a first side portion, and a second side portion, wherein the center portion is disposed between the first side portion and the second side portion, wherein the first side portion and the center portion define a first through hole, wherein the second side portion and the center portion define a second through hole; wherein the plurality of plugs are connected to the plurality of sockets, wherein the first prong is disposed in the first through hole and the second prong is disposed in the second through hole, wherein the first conductive lip abuts the first side portion and the second conductive lip abuts the second side portion.
2. The electrical connector of claim 1, wherein the plurality of plugs are a first-phase plug, a second-phase plug, and a third-phase plug, wherein the plurality of sockets are a first-phase socket, a second-phase socket, and a third-phase socket, wherein the first-phase plug, the second-phase plug, and the third-phase plug are connected to the first-phase socket, the second-phase socket, and the third-phase socket, respectively.
3. The electrical connector of claim 1, wherein the first prong abuts the first side portion, wherein the second prong abuts the second side portion.
4. The electrical connector of claim 3, wherein the base, the first prong, and the second prong define a center notch, wherein the center notch is disposed between the first prong and the second prong, wherein the center portion is disposed in the center notch.
5. The electrical connector of claim 4, wherein a first airgap is defined between the first prong and the center portion and a second airgap is defined between the second prong and the center portion.
6. The electrical connector of claim 5, wherein the plurality of plugs are configured to be removed from the plurality of sockets by pinching the first prong and the second prong together within the first airgap and the second airgap, respectively.
7. The electrical connector of claim 1, wherein the base, the first prong, the second prong, the first conductive lip, and the second conductive lip are co-planar.
8. The electrical connector of claim 7, wherein each of the plurality of plugs are co-planar.
9. The electrical connector of claim 1, wherein the center portion, the first side portion, the second side portion, the first through hole, and the second through hole comprise a rectangular cross-section.
10. The electrical connector of claim 1, the busbar comprising a molding comprising a first molded lip and a second molded lip for each of the plurality of sockets, wherein the first conductive lip abuts the first molded lip and the second conductive lip abuts the second molded lip.
11. The electrical connector of claim 10, wherein the first conductive lip is disposed between the first side portion and the first molded lip and the second conductive lip is disposed between the second side portion and the second molded lip.
12. The electrical connector of claim 1, the busbar comprising a molding comprising a first tab and a second tab for each of the plurality of sockets, wherein the first tab is disposed below the first side portion and the second tab is disposed below the second side portion.
13. The electrical connector of claim 12, wherein the first tab and the second tab abut the base.

14. The electrical connector of claim 1, the busbar comprising a plurality of bus pins connected to the plurality of sockets.

15. An electric motor comprising: an electrical connection comprising: a junction box comprising a plurality of plugs comprising a base, a first prong, a second prong, a first conductive lip and a second conductive lip, wherein the first prong and the second prong extend from the base, wherein the first conductive lip extends from the first prong, wherein the second conductive lip extends from the second prong, wherein the first prong and the second prong are disposed between the first conductive lip and the second conductive lip; and a busbar comprising a plurality of sockets comprising a center portion, a first side portion, and a second side portion, wherein the center portion is disposed between the first side portion and the second side portion, wherein the first side portion and the center portion define a first through hole, wherein the second side portion and the center portion define a second through hole; wherein the plurality of plugs are connected to the plurality of sockets, wherein the first prong is disposed in the first through hole and the second prong is disposed in the second through hole, wherein the first conductive lip abuts the first side portion and the second conductive lip abuts the second side portion; a stator comprising a stator core and a winding; wherein the winding is connected to the busbar; and a rotor.

16. The electric motor of claim 15, wherein the electric motor is a three-phase electric motor, wherein the plurality of plugs are a first-phase plug, a second-phase plug, and a third-phase plug, wherein the plurality of sockets are a first-phase socket, a second-phase socket, and a third-phase socket, wherein the first-phase plug, the second-phase plug, and the third-phase plug are connected to the first-phase socket, the second-phase socket, and the third-phase socket, respectively.

17. The electric motor of claim 16, the busbar comprising a plurality of bus pins and a neutral bus, wherein the plurality of bus pins are connected to the plurality of sockets, wherein the winding is connected to the plurality of bus pins and the neutral bus, wherein the plurality of bus pins comprise one or more first-phase bus pins, one or more second-phase bus pins, and one or more third-phase bus pins.

18. The electric motor of claim 17, wherein the winding is a hairpin winding.

19. A method comprising: inserting a plurality of plugs of a junction box into a plurality of sockets of a busbar such that the plurality of plugs are connected to the plurality of sockets, wherein the plurality of plugs comprise a base, a first prong, a second prong, a first conductive lip and a second conductive lip, wherein the first prong and the second prong extend from the base, wherein the first conductive lip extends from the first prong, wherein the second conductive lip extends from the second prong, wherein the first prong and the second prong are disposed between the first conductive lip and the second conductive lip, wherein the plurality of sockets comprise a center portion, a first side portion, and a second side portion, wherein the center portion is disposed between the first side portion and the second side portion, wherein the first side portion and the center portion define a first through hole, wherein the second side portion and the center portion define a second through hole, wherein the first prong is disposed in the first through hole and the second prong is disposed in the second through hole, wherein the first conductive lip abuts the first side portion and the second conductive lip abuts the second side portion.

20. The method of claim 19, comprising: pinching together the first prong and the second prong such that the first conductive lip does not abut the first side portion and is aligned with the first through hole and such that the second conductive lip does not abut the second side portion and is aligned with the second through hole; and removing the plurality of plugs from the plurality of sockets.