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Hoyack et al.

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(54) **CONTACT MEMBER FOR ELECTRICAL CONNECTOR**

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H01R 24/40 (2011.01)
H01R 4/2495 (2018.01)
H01R 9/05 (2006.01)

(52) **U.S. Cl.**
CPC ***H01R 24/40*** (2013.01); ***H01R 4/2495*** (2013.01); ***H01R 9/0509*** (2013.01)

(58) **Field of Classification Search**
CPC H01R 24/40; H01R 4/2495; H01R 9/0509
See application file for complete search history.

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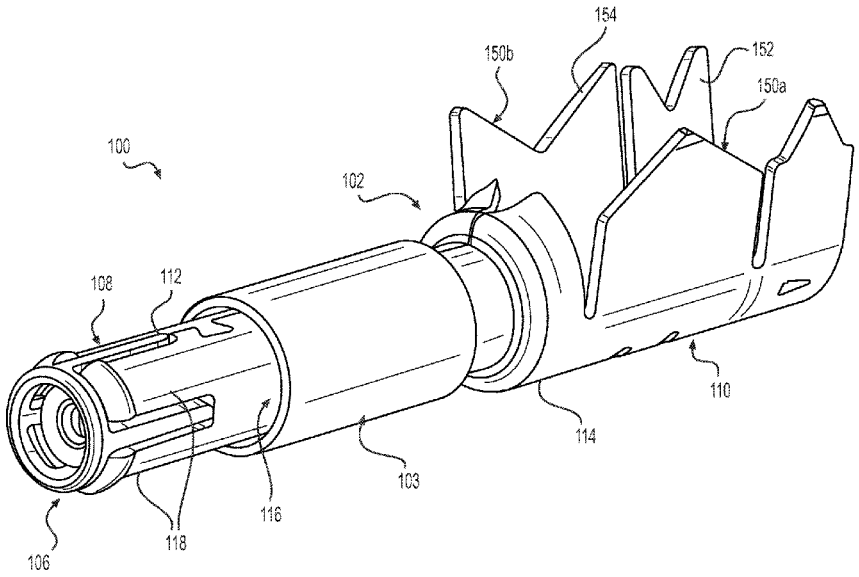
(57) **ABSTRACT**

A contact member includes, an outer conductor including a mating interface section that includes a front end of the outer conductor, a termination section including a rear end of the outer conductor, and a middle section therebetween joining the mating interface and termination sections; an inner conductor received in the mating interface section; and a protective insulator including a main portion received in the mating interface section of the outer conductor and supporting the inner conductor and including an end portion configured for closed entry mating. The end portion has an end face extending outside of the front end of the outer conductor.

15 Claims, 12 Drawing Sheets



Related U.S. Application Data

continuation of application No. 16/712,110, filed on Dec. 12, 2019, now Pat. No. 10,992,087.

(60) Provisional application No. 62/779,030, filed on Dec. 13, 2018.

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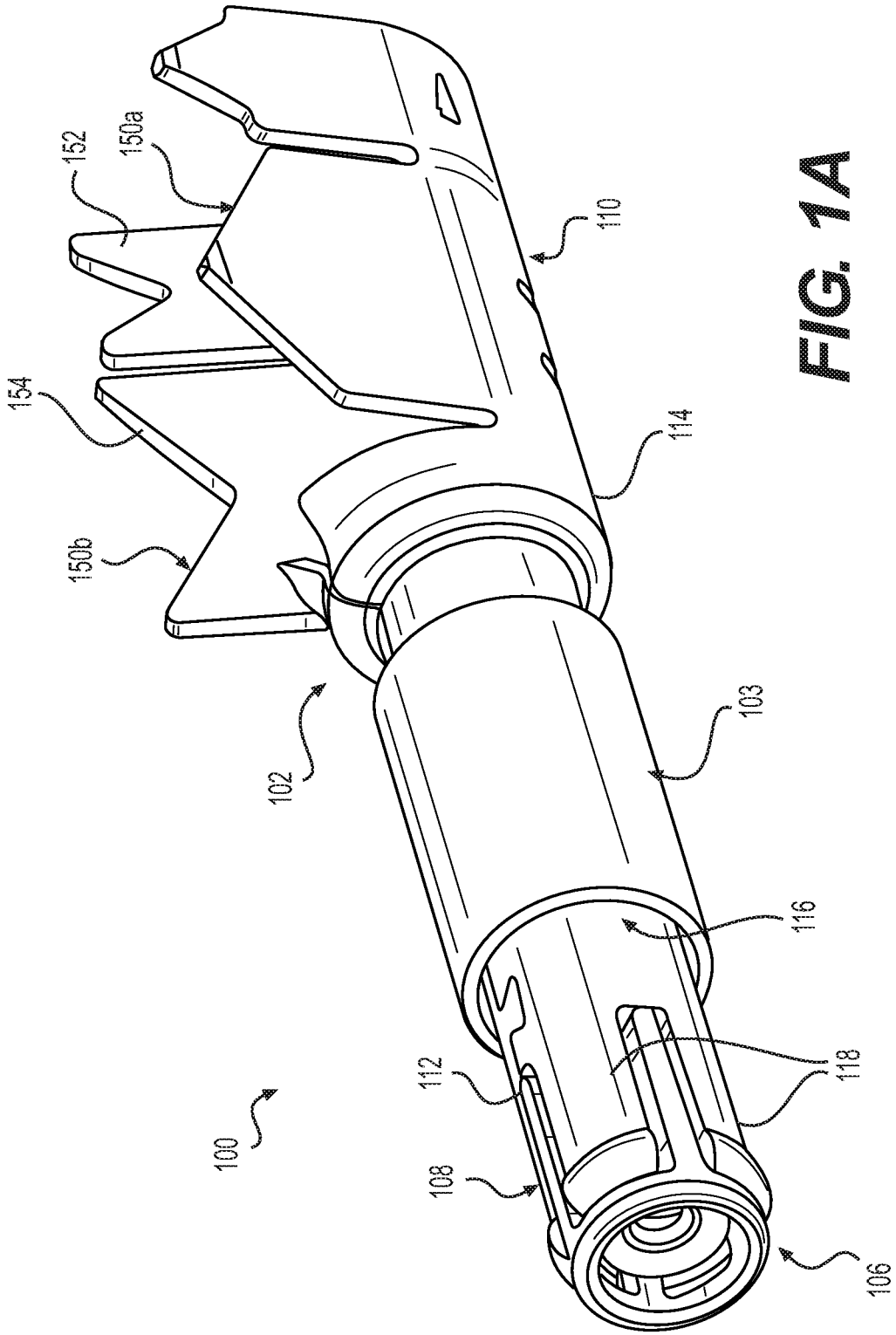
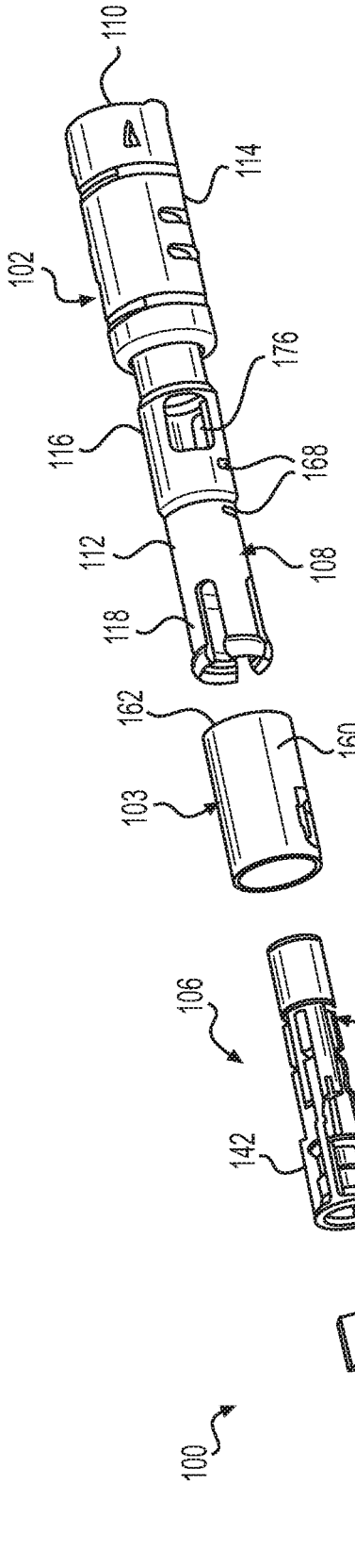


FIG. 1A


110
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105

FIG. 1B

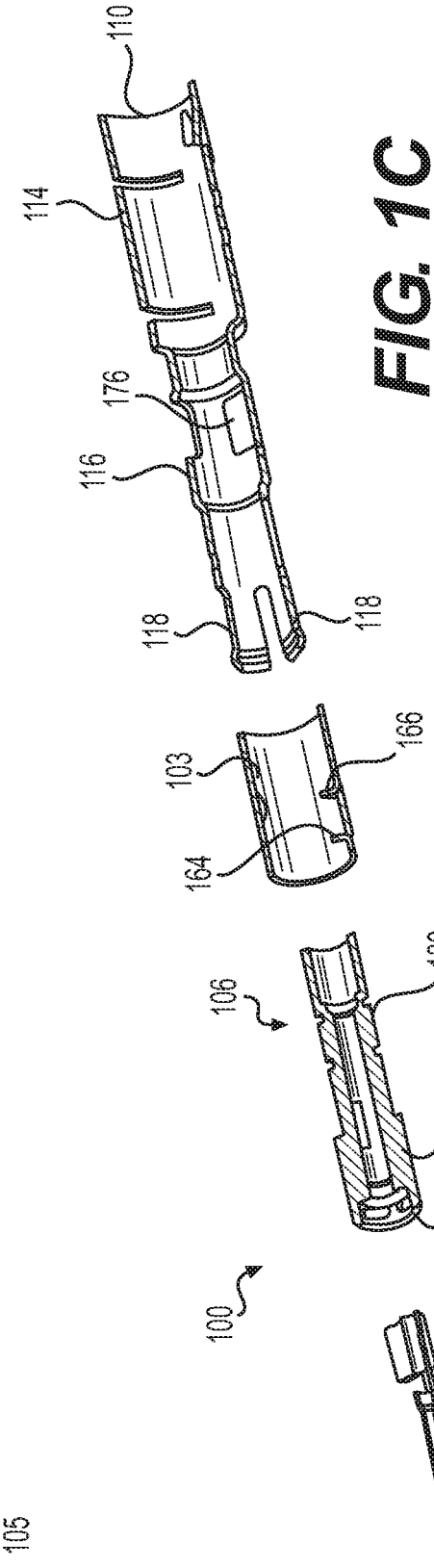
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FIG. 1C

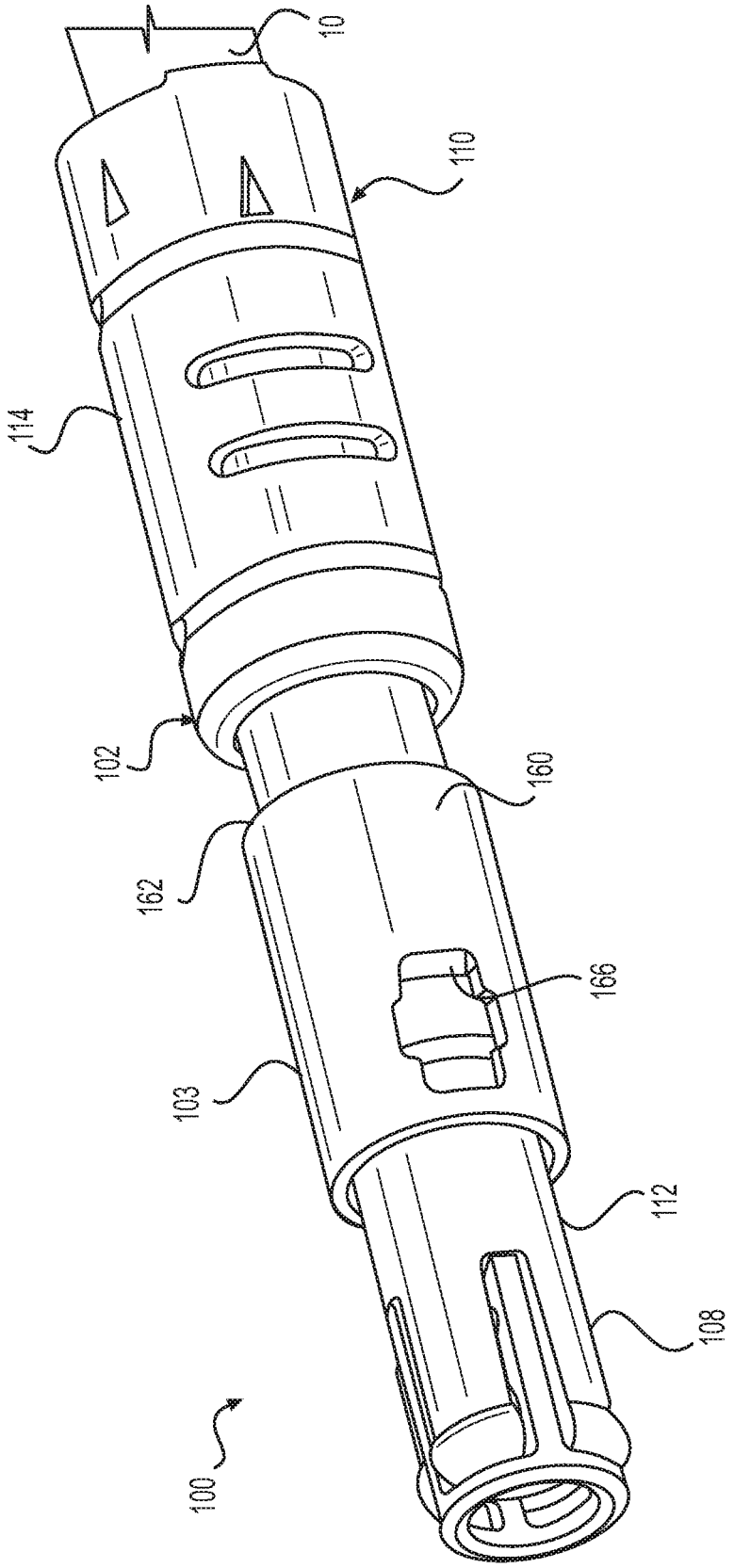

FIG. 1D

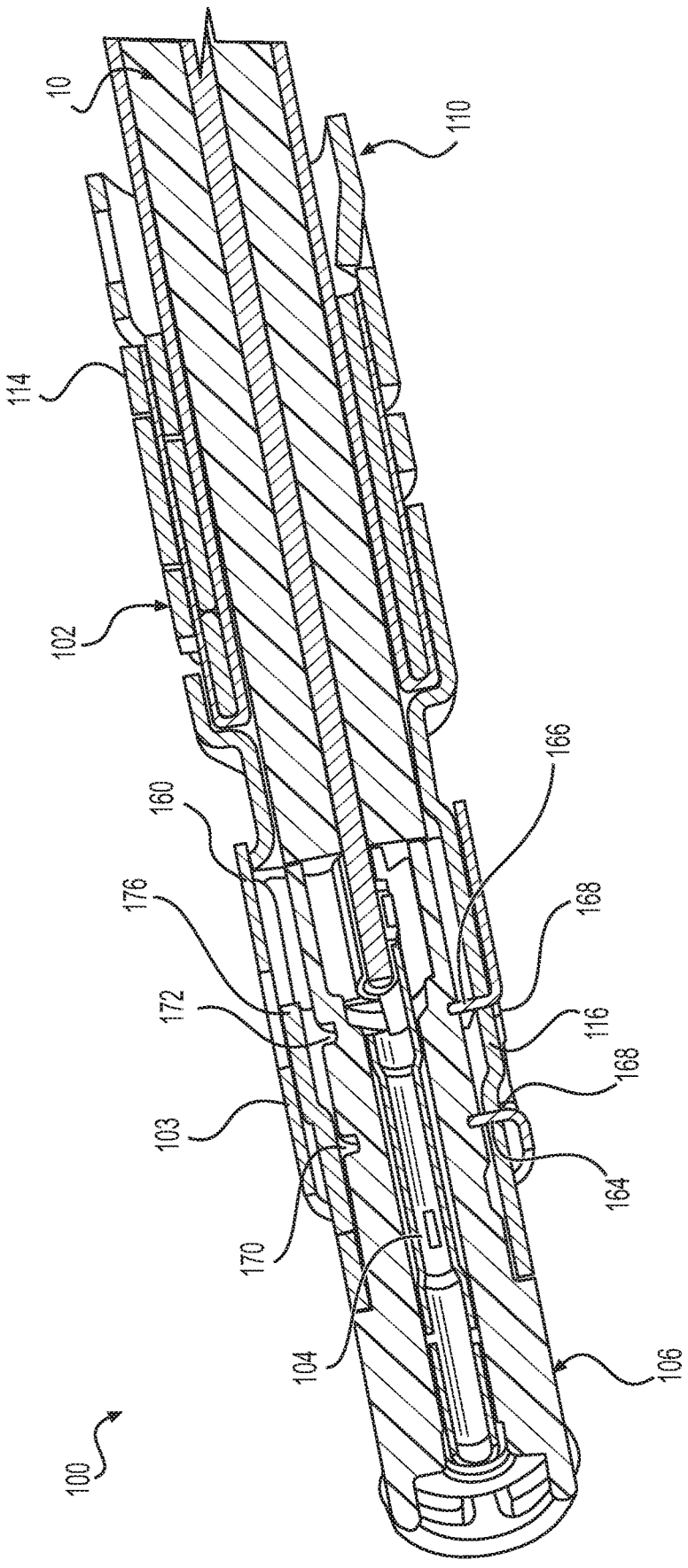
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FIG. 1E

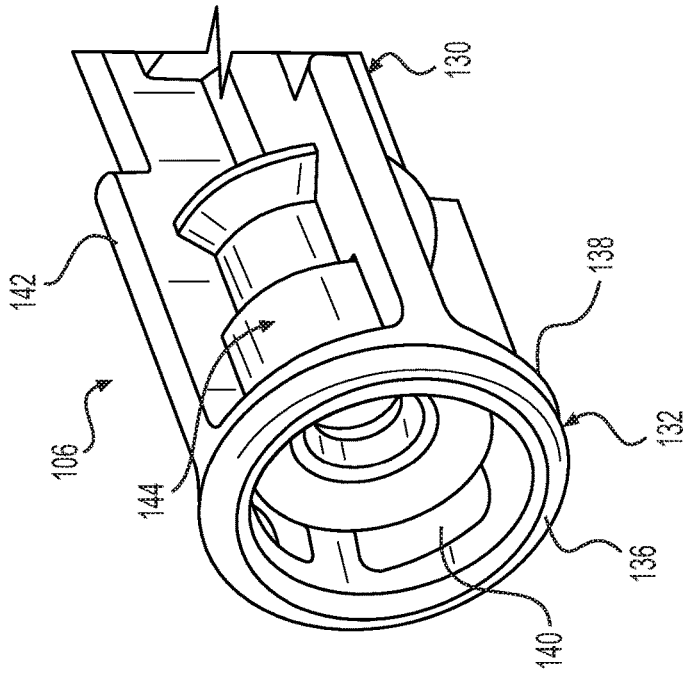


FIG. 2B

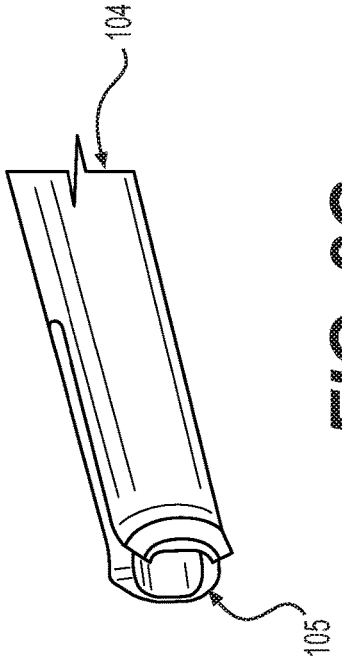


FIG. 2C

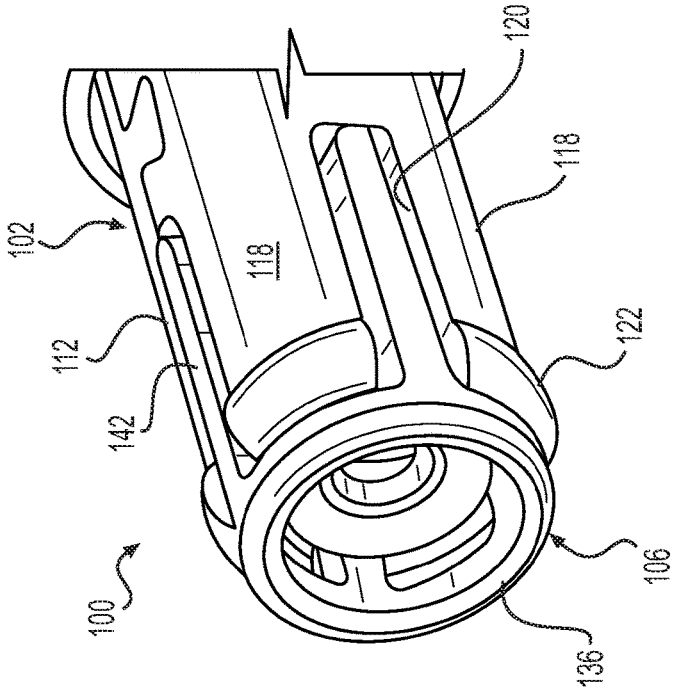
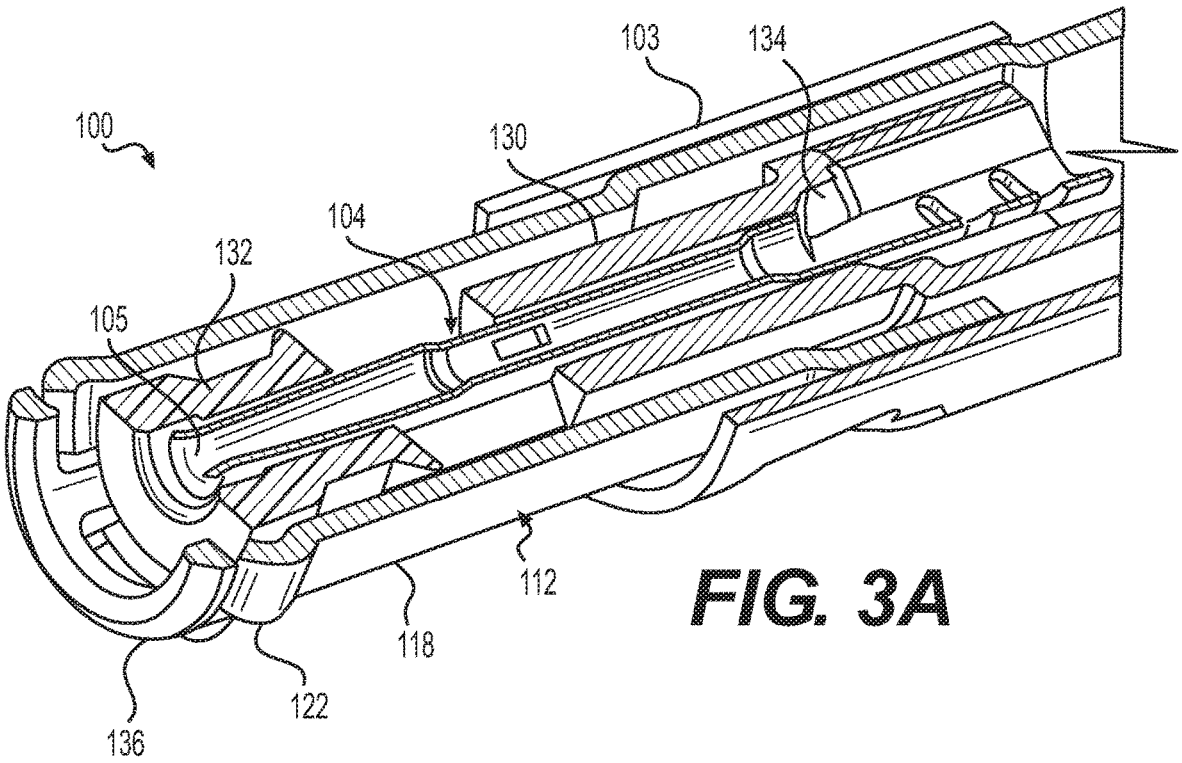


FIG. 2A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136

FIG. 3A

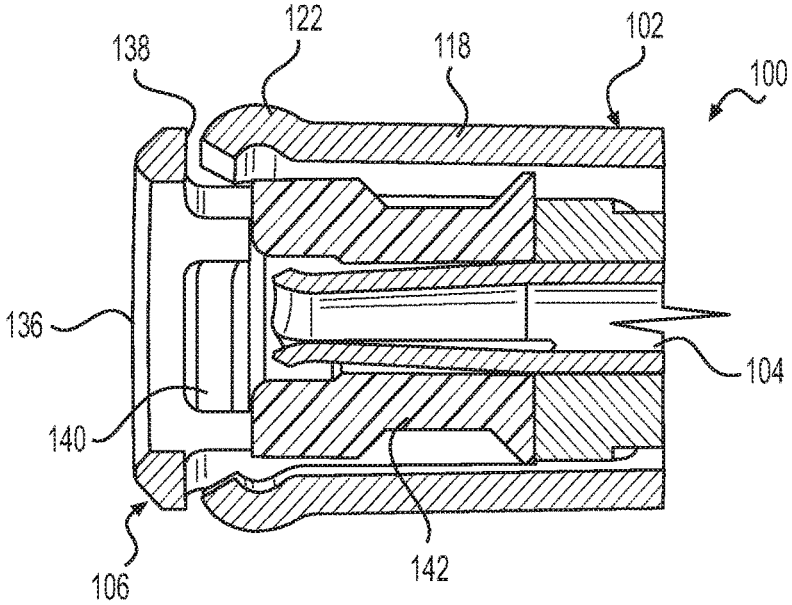
138
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FIG. 3B

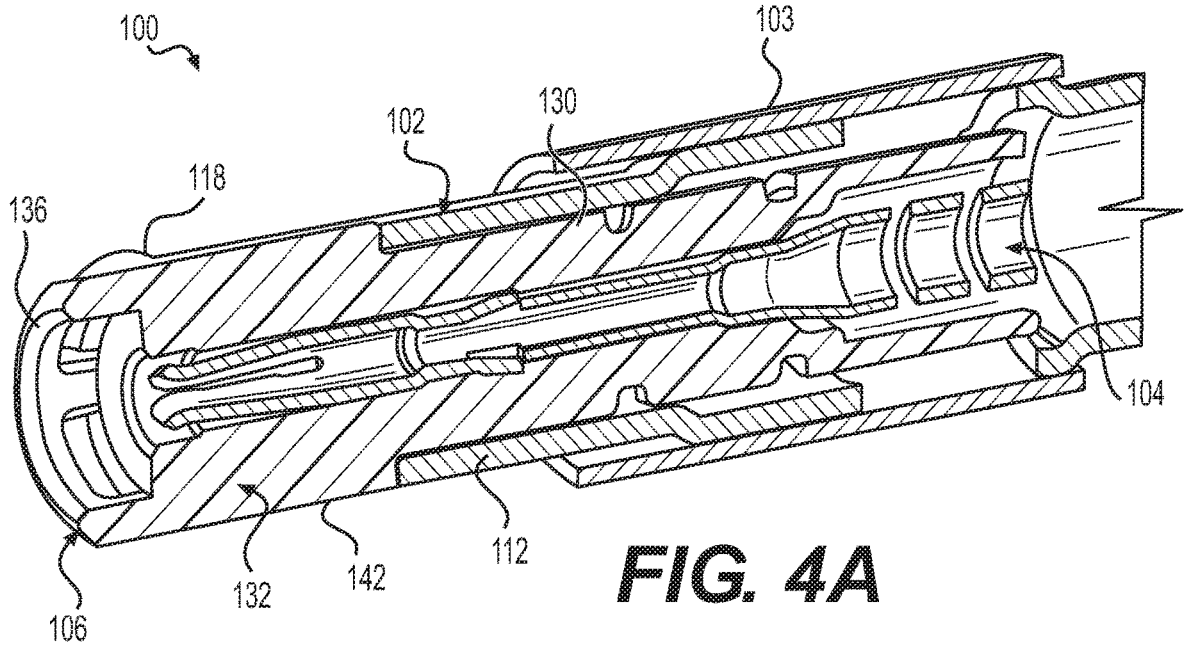
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FIG. 4A

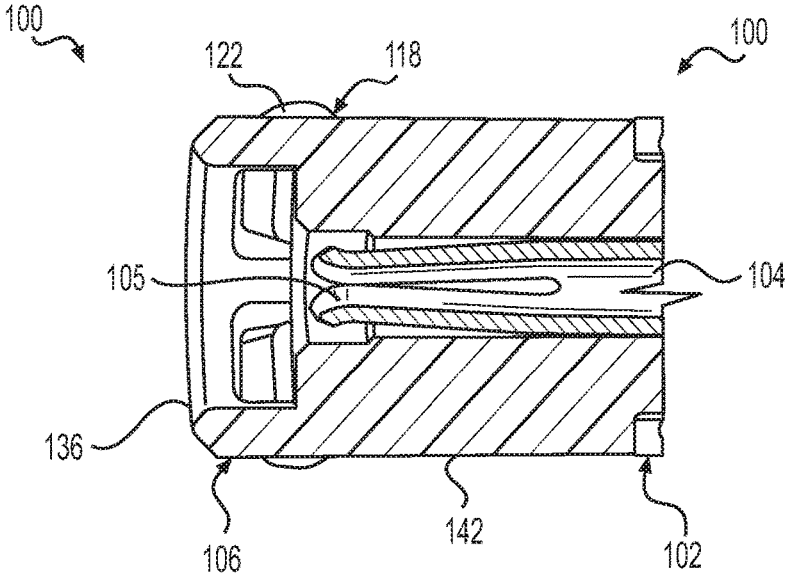
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FIG. 4B

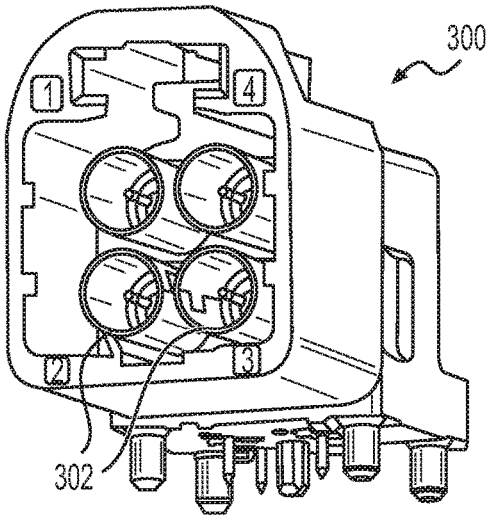


FIG. 5A

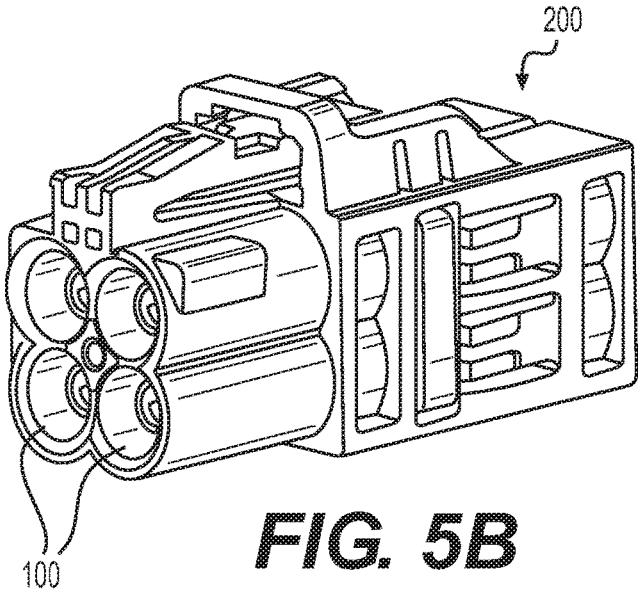


FIG. 5B

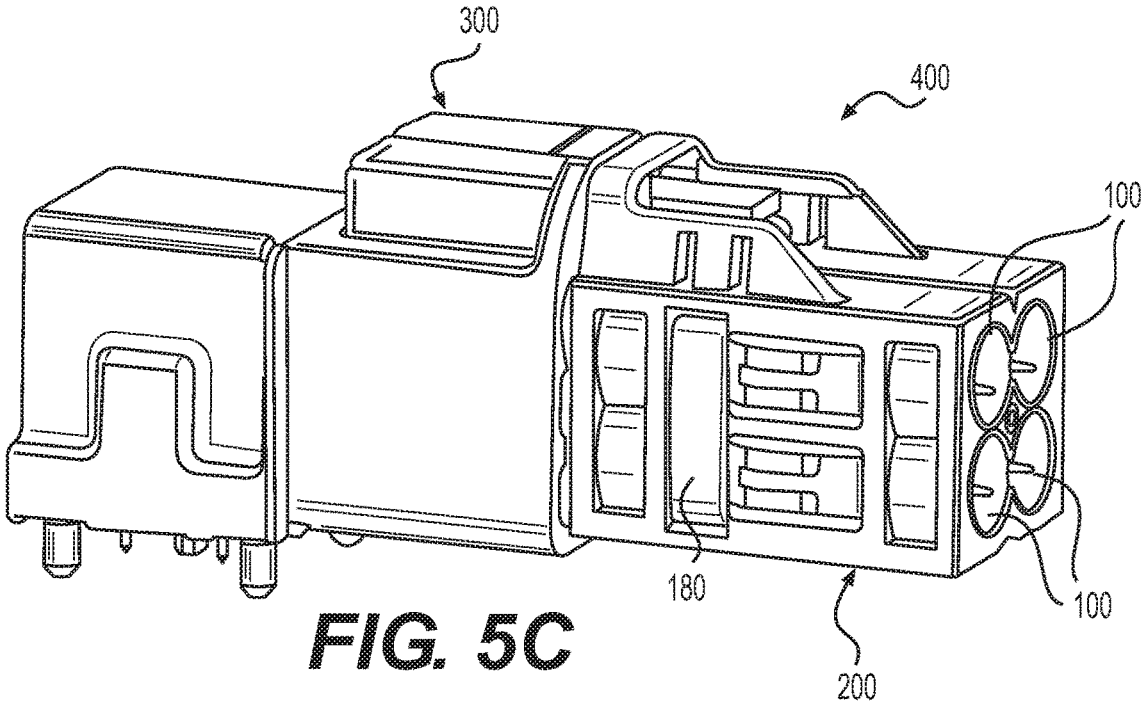
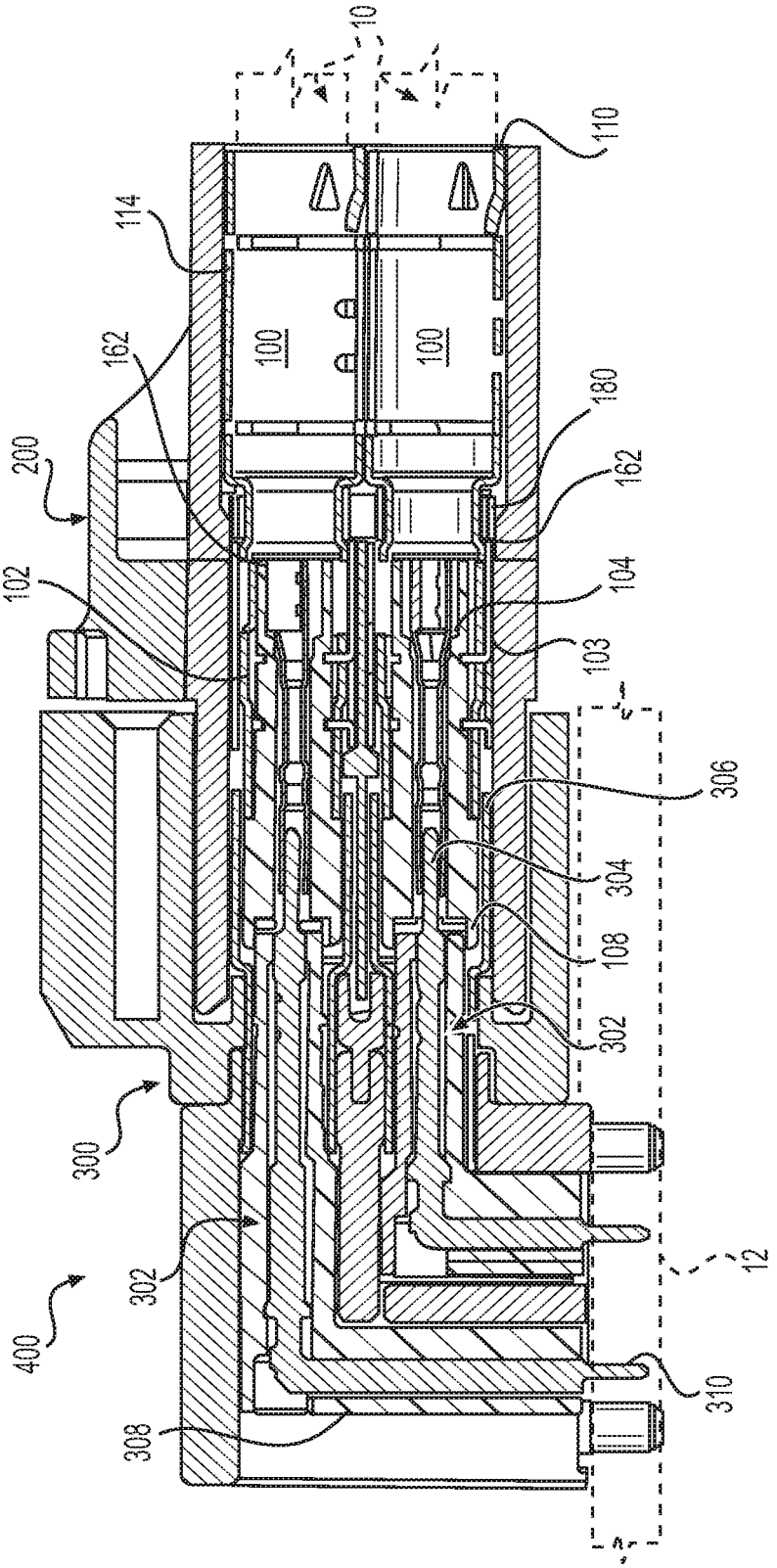


FIG. 5C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310
308

FIG. 6A

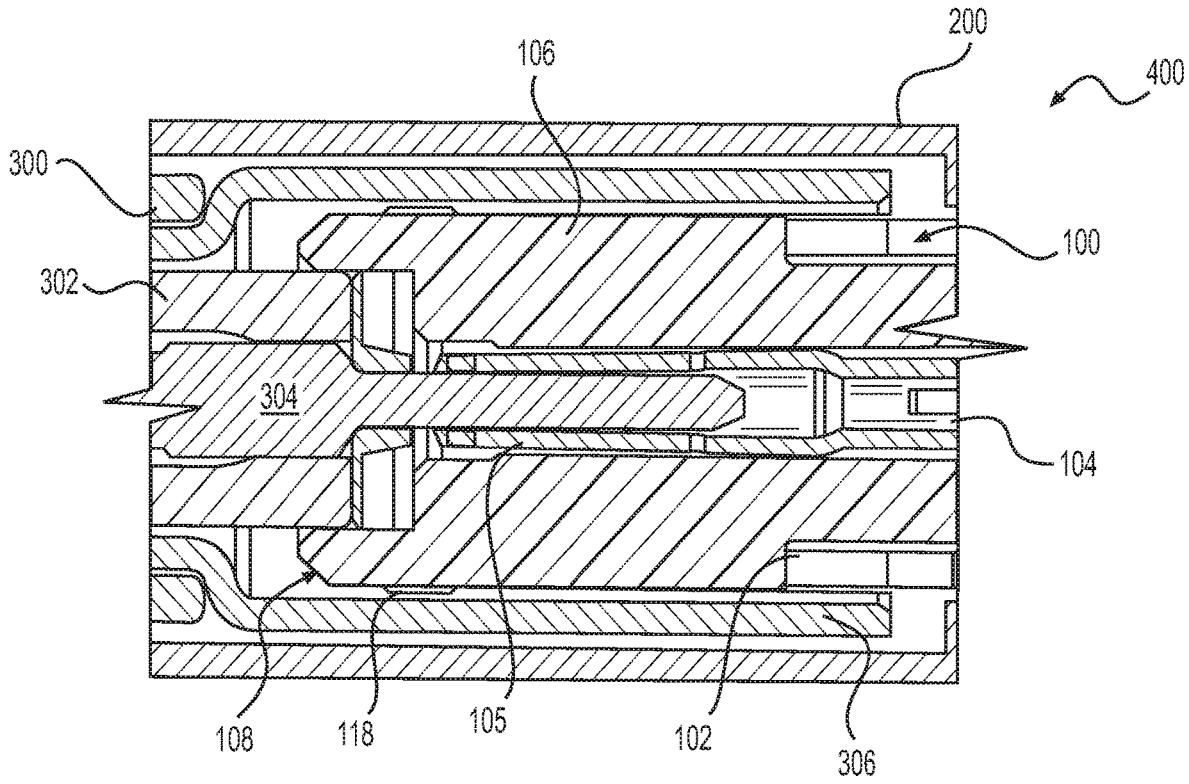

FIG. 6B

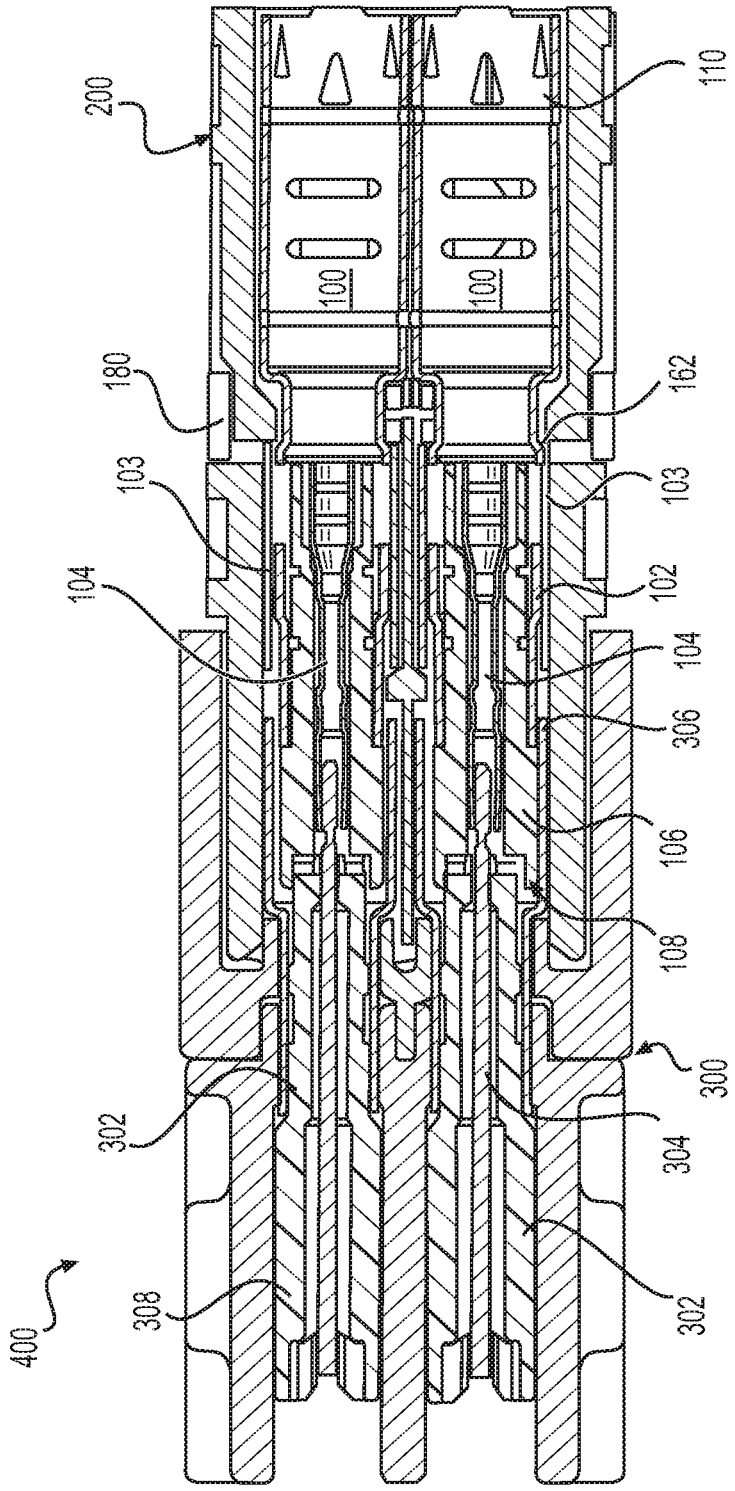
200
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FIG. 7A

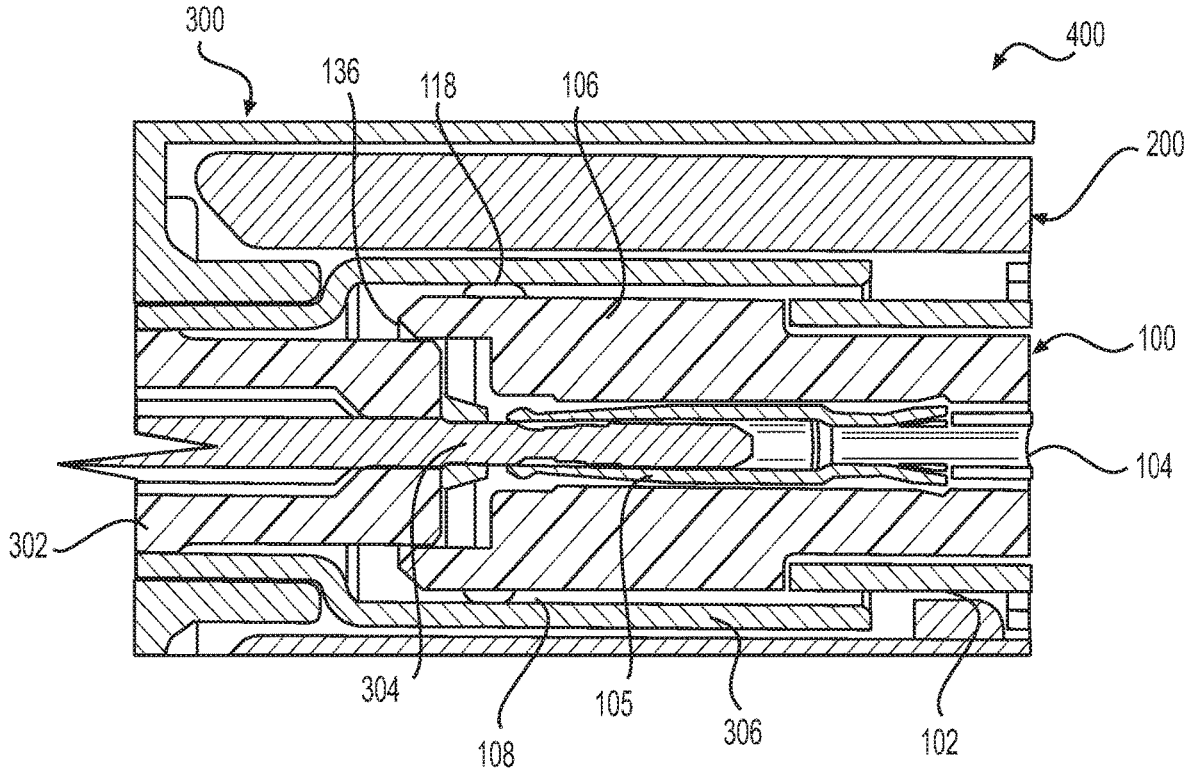

FIG. 7B

CONTACT MEMBER FOR ELECTRICAL CONNECTOR

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation application of U.S. application Ser. No. 17/170,202 filed on Feb. 8, 2021 and entitled "Contact Member for Electrical Connector," which is a continuation application of U.S. application Ser. No. 16/712,110 filed on Dec. 12, 2019 and entitled "Contact Member for Electrical Connector," which claims the benefit of priority of U.S. Provisional Application Ser. No. 62/779,030 filed on Dec. 13, 2018 and entitled "Contact Member for Electrical Connector," the contents of which are relied upon and incorporated herein by reference in its entirety.

BACKGROUND

The disclosure relates to a contact member for an electrical connector and more particularly to a contact member being configured for both high density and high frequency capabilities for the connector.

Next generation radio frequency (RF) interconnect systems require increased channels and higher data bandwidth, which in turn require smaller, higher density and higher frequency RF connectors. Automobiles, for example, have an increasing need for RF interconnect to support new technologies, such as autonomous driving, 5G wireless networks, and V2X communications. The current automobile industry interface standard "FAKRA" is limiting based on size and frequency range. Also, this standard does not include a multi-channel version for higher density packaging.

SUMMARY

An aspect of this disclosure is a contact member for an electrical connector. The contact member includes an outer conductor including a mating interface section including a front end of the outer conductor, a termination section including a rear end of the outer conductor, and a middle section therebetween joining the mating interface and termination sections; an inner conductor received in the mating interface section; and a protective insulator including a main portion received in the mating interface section of the outer conductor and supporting the inner conductor and including an end portion configured for closed entry mating. The end portion has an end face extending outside of the front end of the outer conductor.

In certain examples, the front end of the outer conductor includes a plurality of spring fingers extending over at least part of the end portion of the protective insulator.

In some examples, the end portion of the protective insulator includes longitudinal spokes each extending between the spring fingers.

In other examples, the end face of the end portion of the protective insulator is an outer ring from which the spokes extend.

In another example, distal ends of the spring fingers rest behind a rear wall of the outer ring for the closed entry mating.

In certain examples, one or more openings are provided behind the rear wall of the outer ring allowing for free movement of the distal ends of the spring fingers.

In some examples, the outer conductor is formed as one-piece.

In other examples, a sleeve is disposed around the middle section of the outer conductor.

In another example, the middle section includes at least one window that is covered by the sleeve.

In certain examples, the termination section is deformable.

In some examples, the termination section includes one or more extensions shaped to fit together when the termination section is deformed.

Another aspect of this disclosure is an electrical connector. The electrical connector includes one or more contact members. Each contact member includes an outer conductor including a mating interface section including a front end of the outer conductor, a termination section including a rear end of the outer conductor, and a middle section therebetween joining the mating interface and termination sections; an inner conductor received in the mating interface section; and a protective insulator including a main portion received in the mating interface section and supporting the inner conductor and an end portion configured for closed entry mating. The end portion has an end face extending outside of the front end of the outer conductor.

In certain examples, the front end of the outer conductor includes a plurality of spring fingers extending over at least part of the end portion of the protective insulator.

In some examples, the end portion of the protective insulator includes longitudinal spokes each extending between the spring fingers.

In other examples, the end face of the end portion of the protective insulator is an outer ring.

In another example, one or more openings are provided behind a rear wall of the outer ring allowing for free movement of distal ends of the spring fingers.

In certain examples, the outer conductor is formed as one-piece.

In some examples, a sleeve is disposed around the middle section of the outer conductor and the middle section has an outer diameter that is smaller than an outer diameter of the termination section.

In other examples, the middle section includes at least one window that is covered by the sleeve.

Yet another aspect of this disclosure is an electrical connector. The electrical connector includes one or more contact members. Each contact member includes an outer conductor including a mating interface section including a front end of the outer conductor, a termination section including a rear end of the outer conductor, and a middle section therebetween joining the mating interface and termination sections, where the middle section has at least one slot; an inner conductor received in the mating interface section; a protective insulator including a main portion received in the mating interface section and supporting the inner conductor and an end portion configured for closed entry mating, where the main portion has at least one outer notch or annular groove; and a sleeve disposed around the middle section of the outer conductor. The sleeve has at least one inwardly extending tab received in the at least one slot of the middle section of the outer conductor and the at least outer notch or annular groove of the protective insulator.

In certain examples, the sleeve has an end shoulder configured to abut an inner portion of a housing of the electrical connector, thereby retaining the respective contact member in the housing.

In some examples, the middle section has an outer diameter that is less than an outer diameter of the termination section and the sleeve is disposed around the outer diameter of the middle section.

In other examples, the end portion of the protective insulator has an end face extending outside of the front end of the outer conductor.

In another example, the front end of the outer conductor includes a plurality of spring fingers extending over at least part of the end portion of the protective insulator and between spokes of the end portion.

This summary is not intended to identify all essential features of the claimed subject matter, nor is it intended for use in determining the scope of the claimed subject matter. It is to be understood that both the foregoing general description and the following detailed description are exemplary and are intended to provide an overview or framework to understand the nature and character of the disclosure.

BRIEF DESCRIPTION OF THE FIGURES

The accompanying drawings are incorporated in and constitute a part of this specification. It is to be understood that the drawings illustrate only some examples of the disclosure and other examples or combinations of various examples that are not specifically illustrated in the figures may still fall within the scope of this disclosure. Examples will now be described with additional detail through the use of the drawings, in which:

FIG. **1**A is a perspective view of a contact member according to one example;

FIG. **1**B is an exploded perspective view of the contact member illustrated in FIG. **1**A;

FIG. **1**C is an exploded cross-sectional view of the contact member illustrated in FIG. **1**B;

FIG. **1**D is a perspective view of the contact member illustrated in FIG. **1**A, showing a cable terminated to the contact member;

FIG. **1**E is a cross-sectional view of the contact member illustrated in FIG. **1**D;

FIG. **2**A is an enlarged partial end perspective view of the contact member illustrated in FIG. **1**A;

FIG. **2**B is an enlarged perspective view of a protective insulator of the contact member illustrated in FIGS. **1**A and **2**A;

FIG. **2**C is an enlarged partial perspective end view of an inner conductor of the contact member illustrated in FIG. **1**A;

FIG. **3**A is a partial cross-sectional perspective view of the contact member illustrated in FIG. **1**A;

FIG. **3**B is a partial cross-sectional elevational view of the contact member illustrated in FIG. **3**A;

FIG. **4**A is another partial cross-sectional perspective view of the contact member illustrated in FIG. **1**A;

FIG. **4**B is a partial cross-sectional elevational view of the contact member illustrated in FIG. **4**A;

FIGS. **5**A-**5**C are various perspective views of RF connectors components and the assembly of the same according to an example;

FIG. **6**A is a side elevational cross-sectional view of the assembly illustrated in FIG. **5**C, showing a right hand configuration;

FIG. **6**B is an enlarged partial cross-sectional view of the assembly illustrated in FIG. **6**A;

FIG. **7**A is a side elevational cross-sectional view of the assembly similar to FIG. **6**A, showing a straight configuration; and

FIG. **7**B is an enlarged partial cross-sectional view of the assembly illustrated in FIG. **7**A.

DETAILED DESCRIPTION

FIG. **1**A is a perspective view of a contact member **100** according to one example; FIG. **1**B is an exploded perspective view of the contact member illustrated in FIG. **1**A; FIG. **1**C is an exploded cross-sectional view of the contact member illustrated in FIG. **1**B; FIG. **1**D is a perspective view of the contact member illustrated in FIG. **1**A, showing a cable terminated to the contact member; and FIG. **1**E is a cross-sectional view of the contact member illustrated in FIG. **1**D. Referring to FIGS. **1**A to **1**E, the present disclosure provides a contact member **100** that may be used in electrical connectors, such as RF connectors, that may be used in automobiles, for example. The design of contact member **100** is compact for a higher density connector **200** (see, e.g., FIG. **5**B) and also provides electrical loss and mechanical protection to the conductors/contacts of the connector **200**, thereby providing the connector **200** with improved performance and higher frequency capability. Contact member **100** incorporates a robust closed entry mating; a low mating force contact configuration for improved ergonomics; and/or a geometry configuration that provides good impedance matching for high frequency operation with the standard mating interface.

Contact member **100** generally includes an outer conductor **102**, an inner conductor **104** received in outer conductor **102**, and a protective insulator **106** that is at least partially received in outer conductor **102** and supports the inner conductor **104**, as seen in FIGS. **1**A-**1**E. A sleeve **103** may also be provided that wraps around the outer conductor **102**. The sleeve **103** may be formed of a conductive material.

Outer conductor **102** may include a front end **108** for engaging a mating connector **300** (FIG. **5**A) and a rear end **110** for electrically connecting to cable **10** (FIGS. **1**D and **1**E), wires, and the like. Outer conductor **102** may comprise a mating interface section **112** that includes the front end **108** of the outer conductor **102**, a termination section **114** that includes the rear end **110** of the outer conductor **102**, and a middle section **116** therebetween joining the mating interface and termination sections **112** and **114**, as seen in FIG. **1**. The mating interface section **112** is designed to mate with a corresponding interface of a contact **302** of the mating connector **300** and the termination section **114** is designed to terminate and fasten to a prepared end of the cable **10**, such as by crimping. The sleeve **103** may be disposed on the middle section **116**. In an example, the outer conductor **102** is formed as one-piece.

At the front end **108** of outer conductor **102** there may be one or more grounding spring fingers or tines **118** that define slots **120** therebetween. The distal end **122** of each spring finger **118** can be designed for electrical contact and connection with the mating connector **300**. Each distal end **122** of the spring fingers **118** may have a generally convex shape that projects outwardly, as best seen in FIGS. **2**A and **3**B, to facilitate the electrical contact with the mating connector **300**.

Protective insulator **106** may comprise a main portion **130** and an end portion **132**, as seen in FIGS. **1**B and **1**C. Main portion **130** is configured to support the inner conductor **104** and may be elongated, as seen in FIGS. **3**A and **4**A. End portion **132** is configured for closed entry mating to protect both the mating end **105** (FIG. **2**C) of the inner contact **104**, which may be a socket, for example, and the spring fingers **118** of the outer conductor **102**, when mating contact member **100** with corresponding contact member **302** of the mating connector **300**. Main portion **130** has an inner bore **134** sized and shaped to accommodate inner conductor **104** and to fit within the body of the outer conductor **102**.

End portion **132** of insulator **106** may have an end face **136** that extends outside of the front end **108** of the outer conductor **102** past the spring fingers **118**, as seen in FIG.

2A. In an example, the end face **136** forms a protective outer ring, as seen in FIG. **2**B. A rear wall **138** of the end face **136** provides a barrier for the distal ends **122** of springs fingers **118**, as best seen in FIG. **3**B, thereby protecting the distal ends **122** from being damaged, stubbed or bent during mating of the connectors **200** and **300**. End portion **132** may include one or more openings **140** behind the rear wall **138**. Openings **140** may be located and configured to give the distal ends **122** of the spring fingers **118** free movement without interference from the insulator's end portion **132**, as best seen in FIGS. **2**B and **3**B. Openings **140** can be arranged on end portion **132** to correspond to the location of the distal ends **122** of the fingers **118**.

Longitudinal spokes **142** may also be provided on the end portion **132** of insulator **106** which extend back from the end face's rear wall **138**. Spokes **142** are designed to provide structural support to strengthen the outer ring **136** and further protect fingers **118**. In an example, each spoke **142** may be received in one of the slots **120** between spring fingers **118**, as seen in FIG. **2**A. Spokes **142** may be positioned around the end portion **132** such that the spaces **144** between spokes **142** are sized to receive one of the fingers **118**, as seen in FIGS. **2**A and **2**B. In an example, the spokes **142** are uniformly spaced on end portion **132**.

The termination section **114** of outer conductor **102** may be deformable for terminating to cable **10**, wire, or the like. In an example, termination section **114** may be crimped to the cable **10**, wire, or the like. Rear end **110** of outer conductor **102** is initially open for receiving the cable **10** such that one more extensions **150***a* and **150***b* of termination section **114** extend outwardly, as best seen in FIG. **1**A. Extensions **150***a* and **150***b* are located opposite one another on section **114** and are configured to fit together when termination section **114** is deformed, such as by crimping. For example, one extension **150***a* may have a tail **152** that fits into a corresponding cut-out **154** of another extension **150***b*. As such, when termination section **114** is crimped, the extensions **150***a* and **150***b* fit together to close or nearly close the rear end **110**.

Sleeve **103** may comprise a generally cylindrical shaped body **160**, as seen in FIG. **1**B, that fits over the middle section **116** of outer conductor **102**, to provide added strength to contact member **100** and improved mechanical performance. The sleeve's body **160** may have one or more end shoulders **162** configured to assist with retaining contact member **100** within the housing of connector **200**. Sleeve **103** may have one or more engagement features, such as tabs **164** and **166**, for engaging outer conductor **102** and insulator **106**. As seen in FIGS. **1**C and **1**E, the tabs **164** and **166** may extend inwardly from the sleeve's body **160**. The tabs **164** and **166** can be positioned and spaced on the sleeve's body **160** to engage corresponding engagement features disposed in the middle section **116** of outer conductor **102** and in the main portion **130** of insulator **106**. For example, the engagement features of the outer conductor's middle section **116** may be one or more slots **168** (FIG. **1**B) and the engagement features of the insulator's main portion **130** may be one or more outer notches or annular grooves **170** and **172** (FIG. **1**E). When contact member **100** is assembled, as seen in FIG. **1**D, tabs **164** and **166** extend through slots **168** of the middle section **116** of outer conductor **120** and into outer notches or annular grooves **170** and **172**, respectively, of the main portion of insulator **106**, as seen in FIG. **1**E. Other known engagement features may also to be used to engage the sleeve **103** with the middle section **116** of the outer conductor **102** and the main portion **130** of the insulator **106**.

In an example, the middle section **116** of outer conductor **102** has an outer diameter that is smaller than the outer diameter of the termination section **114**, thereby making contact member **100** more compact in size. Sleeve **103** may be disposed around the smaller outer diameter of the middle section **116**. One or more windows **176** may be provided in the middle section **116** of outer conductor **102**, as seen in FIGS. **1**B and **1**C. Windows **176** are positioned and configured to improve electrical performance by adding air inside outer conductor **102** and around insulator **106** and inner conductor **104** for impedance matching, as seen in FIG. **1**E. Sleeve **103** can be positioned to cover the windows **176** to prevent signal leakage therethrough.

FIGS. **5**A-**5**C illustrate an exemplary connector **200** having one or more of the contact members **100** of the present disclosure, an exemplary mating connector **300**, and the assembly **400** of the connectors **200** and **300**. Connector **200** may be, for example, a four (**4**) position cable plug and mating connector **300** may be, for example, a four (**4**) line printed-circuit-board (PCB) jack.

FIG. **6**A shows a cross-section of the assembly **400** of connectors **200** and **300** and FIG. **6**B shows an enlarged view of the mating interface between connectors **200** and **300**. In the assembly, each contact member **100** may be mated with a corresponding contact member **302** of the mating connector **300** by inserting the front end **108** of each contact member **100** into an interface end **306** of each mating contact member **302**. The inner conductor **104** (e.g. socket) of each contact member **100** engages (electrically and mechanically) a corresponding inner conductor **304** (e.g. pin) of mating connector **300** at one end and engages (electrically and mechanically) with cable **10**, wires or the like at its other end. The end shoulder **162** of sleeve **103** of each contact member **100** may abut with the inside of the housing of connector **200** and/or with a captivation ring **180** disposed around the contact members **100**. The captivation ring **180** may alternatively be disposed around the housing of connector **200**, as seen in FIG. **7**A. A tail end **308** of each mating contact member **302** may have a right hand configuration, as seen in FIG. **6**A or a straight configuration, as seen in FIG. **7**A. The inner conductors **304** may have tail ends **310** corresponding to the tail ends **308** of the contact members **302** that are configured to engage (electrically and mechanically) a printed circuit board **12**.

As best seen in FIGS. **6**B and **7**B, when mated, end portion **132** of protective insulator **106** provides a closed entry and barrier to protect the front end **108** of outer conductor **102** and particularly its fingers **118**. The mating end **105** of inner conductor **104** (e.g. socket) may be set-back from the front end **108** for closed entry mating with the corresponding inner conductor **304** (e.g. pin) of mating connector **300**. And the end face **136** of protective insulator **106** can be configured to prevent the contact member **302** of mating connector **300**, and particularly its inner pin **304**, from being inserted too far into the mating end **105** of socket **104** of connector **200**.

It will be apparent to those skilled in the art having the benefit of the teachings presented in the foregoing descriptions and the associated drawings that modifications, combinations, sub-combinations, and variations can be made without departing from the spirit or scope of this disclosure. Likewise, the various examples described may be used individually or in combination with other examples. Those skilled in the art will appreciate various combinations of examples not specifically described or illustrated herein that are still within the scope of this disclosure. In this respect, it is to be understood that the disclosure is not limited to the

specific examples set forth and the examples of the disclosure are intended to be illustrative, not limiting.

As used in this specification and the appended claims, the singular forms "a", "an" and "the" include plural referents, unless the context clearly dictates otherwise. Similarly, the adjective "another," when used to introduce an element, is intended to mean one or more elements. The terms "comprising," "including," "having" and similar terms are intended to be inclusive such that there may be additional elements other than the listed elements.

Additionally, where a method described above or a method claim below does not explicitly require an order to be followed by its steps or an order is otherwise not required based on the description or claim language, it is not intended that any particular order be inferred. Likewise, where a method claim below does not explicitly recite a step mentioned in the description above, it should not be assumed that the step is required by the claim.

It is noted that the description and claims may use geometric or relational terms, such as front, rear, right, elongated. These terms are not intended to limit the disclosure and, in general, are used for convenience to facilitate the description based on the examples shown in the figures. In addition, the geometric or relational terms may not be exact. For instance, walls may not be exactly perpendicular or parallel to one another because of, for example, roughness of surfaces, tolerances allowed in manufacturing, etc., but may still be considered to be perpendicular or parallel.

What is claimed is:

1. A contact member for an electrical connector, comprising:

an outer conductor including a mating interface section, a termination section, and a middle section between the mating interface section and the termination section, wherein the mating interface section includes a front end of the outer conductor, and the termination section includes a rear end of the outer conductor;

an inner conductor received in the mating interface section; and

a protective insulator including a main portion and an end portion, wherein the main portion is received in the mating interface section of the outer conductor and supports the inner conductor, and wherein the end portion is configured for closed entry mating, the end portion having an end face extending outside of the front end of the outer conductor,

wherein a sleeve is disposed around the middle section of the outer conductor and wherein the middle section includes at least one window that is covered by the sleeve.

2. The contact member of claim **1**, wherein the front end of the outer conductor includes a plurality of spring fingers extending over at least part of the end portion of the protective insulator.

3. The contact member of claim **2**, wherein the end portion of the protective insulator includes longitudinal spokes each extending between the spring fingers.

4. The contact member of claim **3**, wherein the end face of the end portion of the protective insulator is an outer ring from which the spokes extend.

5. The contact member of claim **4**, wherein distal ends of the spring fingers rest behind a rear wall of the outer ring for the closed entry mating.

6. The contact member of claim **5**, wherein one or more openings are provided behind the rear wall of the outer ring allowing for free movement of the distal ends of the spring fingers.

7. The contact member of claim **1**, wherein the outer conductor is formed as one-piece.

8. The contact member of claim **1**, wherein the termination section is deformable.

9. The contact member of claim **8**, wherein the termination section includes one or more extensions shaped to fit together when the termination section is deformed.

10. An electrical connector, comprising:

one or more contact members, each contact member including,

an outer conductor including a mating interface section, a termination section, and a middle section between the mating interface section and the termination section, wherein the mating interface section includes a front end of the outer conductor, and the termination section includes a rear end of the outer conductor;

an inner conductor received in the mating interface section; and

a protective insulator including a main portion and an end portion, wherein the main portion is received in the mating interface section of the outer conductor and supports the inner conductor, and wherein the end portion is configured for closed entry mating, the end portion having an end face extending outside of the front end of the outer conductor,

wherein a sleeve is disposed around the middle section of the outer conductor and the middle section has an outer diameter that is smaller than an outer diameter of the termination section and wherein the middle section includes at least one window that is covered by the sleeve.

11. The electrical connector of claim **10**, wherein the front end of the outer conductor includes a plurality of spring fingers extending over at least part of the end portion of the protective insulator.

12. The electrical connector of claim **11**, wherein the end portion of the protective insulator includes longitudinal spokes each extending between the spring fingers.

13. The electrical connector of claim **11**, wherein the end face of the end portion of the protective insulator is an outer ring.

14. The electrical connector of claim **13**, wherein one or more openings are provided behind a rear wall of the outer ring allowing for free movement of distal ends of the spring fingers.

15. The electrical connector of claim **10**, wherein the outer conductor is formed as one-piece.

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