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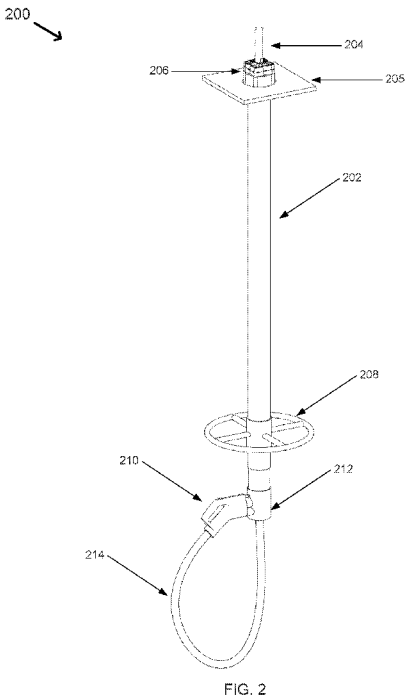

FIG. 2

(57) Abstract: Technologies are described for providing a electric vehicle charging assembly with a mechanical arrangement that includes a vertical pipe coupled through a fixed bearing to a ceiling and containing power cable. A loose and relatively short piece of charging cable may be connected to the power cable at a bottom end of the vertical pipe. The fixed bearing at the top may be loaded with a spring to allow the pipe to be released from the fixed bearing and to be tilted around allowing an extended range of movement.

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ELECTRIC VEHICLE CHARGING ASSEMBLY

BACKGROUND

[0001] Unless otherwise indicated herein, the materials described in this section are not prior art to the claims in this application and are not admitted as prior art by inclusion in this section.

[0002] Electrical and hybrid vehicles are increasing in their percentage among all vehicles in use. Such vehicles, similar to gas stations for fossil fuel powered vehicles, require charging stations, where vehicle batteries are recharged through an electrical cable coupled to the electrical grid. Charging systems are subject to various requirements including, but not limited to, performance, environmental, regulatory, etc. For example, bigger vehicles such as trucks, buses, and vans are often charged by cables hanging from the ceiling. Thus, storage of cable and charging connector are design concerns. As the charging cables for large vehicles (i.e., large batteries) tend to be larger and heavier due to current capacity requirements, safe handling of cables during storage and use are also part of the design concerns. Furthermore, water and dust protection when the charging connector is in unmated condition need to be addressed as well.

SUMMARY

[0003] The present disclosure generally describes various structures to provide cable handling systems for electric and hybrid vehicle charging cables.

[0004] According to some examples, an electric vehicle charging assembly may include an overhead fixture; a first cable to provide charging power configured to extend from the overhead fixture downward; and a vertical pipe to contain the first cable. The vertical pipe may be mechanically affixed to the overhead fixture through a ball joint, configured to be in a stationary position in a storage mode, and configured to be tiltable and rotatable in an in-use mode. The electric vehicle charging assembly may also include a second cable coupled at a first end to the first cable at a bottom end of the vertical pipe, the second cable configured to hang without touching a floor; and a charging gun coupled to a second end of the second cable and configured to contain a charging connector to mate with a charging port of a vehicle.

[0005] According to other examples, a ceiling-connected electric vehicle charging assembly may include a fixed bearing integrated into a ceiling; a first cable to provide charging power, the first cable configured to extend from the ceiling downward through the fixed bearing; and a vertical pipe to contain the first cable. The vertical pipe may be mechanically affixed to the ceiling through the fixed bearing and a spring-loaded mechanism within the vertical pipe, configured to be in a stationary position in a storage mode, and configured to be tiltable and rotatable in an in-use mode. The system may also include a second cable with a first end of the second cable coupled to the first cable at a bottom end of the vertical pipe, and the second cable configured to hang without touching a floor; and a charging gun coupled to a second end of the second cable and configured to contain a charging connector to mate with a charging port of a vehicle.

[0006] According to further examples, methods to charge an electric vehicle through a charging assembly may include releasing a vertical pipe from a cap portion of an overhead fixture upon detecting a bottom portion of the vertical pipe being pulled downward by a user, where the vertical pipe is mechanically affixed to the overhead fixture through fixed bearing comprising a ball joint and the cap portion, is in a stationary position when pulled into the cap portion in a storage mode, and is tiltable and rotatable when released from the cap portion in an in-use mode. Example methods may also include detecting removal of a charging gun coupled to a second cable from a connector holder at the bottom end of the vertical pipe, where the second cable is electrically coupled to a first cable contained within the vertical pipe and is configured to hang without touching a floor, and the charging gun includes a charging connector to mate with a charging port of a vehicle. Method may further include providing power to the charging connector; upon detecting removal of the charging connector from the charging port of the vehicle, disconnecting power; and upon detecting release of the bottom portion of the vertical pipe, pulling the top portion of the vertical pipe into the cap portion for storage mode through a spring-loaded mechanism.

[0007] The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The foregoing and other features of this disclosure will become more fully apparent from the following description and appended claims, taken in conjunction with the accompanying drawings. Understanding that these drawings depict only several embodiments in accordance with the disclosure and are, therefore, not to be considered limiting of its scope, the disclosure will be described with additional specificity and detail through use of the accompanying drawings, in which:

FIG. 1 illustrates example charging stations for different types of vehicles;

FIG. 2 illustrates an electric vehicle charging assembly;

FIG. 3 illustrates various positions of the electric vehicle charging assembly of FIG. 2;

FIG. 4 illustrates cross-sectional views of the spring-loaded fixed bearing of the electric vehicle charging assembly;

FIG. 5 illustrates various assembly views of the electric vehicle charging assembly; and

FIG. 6A and 6B illustrate two example connection methods for the charging gun to the electric vehicle charging assembly,

arranged in accordance with at least some embodiments described herein.

DETAILED DESCRIPTION

[0009] In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. In the drawings, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative embodiments described in the detailed description, drawings, and claims are not meant to be limiting. Other embodiments may be utilized, and other changes may be made, without departing from the spirit or scope of the subject matter presented herein. The aspects of the present disclosure, as generally described herein, and illustrated in the Figures, can be arranged, substituted, combined, separated, and designed in a wide variety of different configurations, all of which are explicitly contemplated herein.

[0010] This disclosure is generally drawn, *inter alia*, to methods, apparatus, systems and/or devices related to providing various structures to provide cable handling systems for electric and hybrid vehicle charging cables.

[0011] FIG. 1 illustrates example charging stations for different types of vehicles, arranged in accordance with at least some embodiments described herein.

[0012] Diagram 100 shows two example charging stations. In one example, a truck charging station is shown with an electric truck 102, a ceiling power line 110, charging cable 106, charging gun 108, which includes a charging connector to mate with the truck's charging port 104. In the other example, a multi-vehicle charging station is shown with a bus 112 and a car 114. Charging cables 118, 119 are coupled to the ceiling power line 120 and include charging guns 116, 117 for coupling to respective vehicle charging ports.

[0013] Electric vehicle (EV) chargers may be classified into three categories: Level 1, Level 2, and direct current (DC) fast charging. Level 1 chargers may use 110/120 Volts with a current rating of 12-16 Amperes. Level 2 chargers may use 208/240 Volts with a current rating of 16-40 Amperes, and DC fast chargers may use between 200 and 600 Volts with current ratings exceeding 100+ Amperes. Thus, the charging cables, especially those for larger vehicles may carry high currents and voltages, and are, therefore, subject to strict regulatory and industrial requirements. To provide safety and reliability such cables may include relatively thick insulators and, as a result, be heavy. The robust construction of such cables presents challenges for flexible connectivity and storage.

[0014] Some conventional approaches include motorized or spring-loaded spools (at the ceiling), but the weight of the cable may negatively impact reliability of the overall system and increase cost. Furthermore, free-hanging cables (considering the weight) may cause accidents when swinging.

[0015] An electric vehicle charging assembly according to examples provides a mechanical arrangement that includes a vertical pipe coupled through a fixed bearing to a ceiling and containing power cable. A loose and relatively short piece of charging cable may be connected to the power cable at a bottom end of the vertical pipe. The fixed bearing at the top may be loaded with a spring to allow the pipe to be released from the fixed bearing and to be tilted around allowing an extended range of movement.

[0016] While example assemblies are shown or described as providing charging power from a ceiling throughout this description, embodiments are not limited to ceiling-connected systems. Charging power may be provided from any overhead fixture. Such an overhead fixture may be integrated into a ceiling or be free-standing.

[0017] Technical advantages of example embodiments may include, but are not limited to, protection of the charging connector against water and dust, lack of need for any accessories or contacts on the floor, safe storage of cable without a need for a motorized system or excess cable, lack of need for any remote control to release the charging connector, ease of maintenance and/or replacement of individual parts, and lack of need for additional power to activate any motorized accessories.

[0018] FIG. 2 illustrates an electric vehicle charging assembly, arranged in accordance with at least some embodiments described herein.

[0019] Diagram 200 shows a vertical pipe 202 with a fixed bearing 206 at the top end guiding the main part of the cable 204. The fixed bearing 206 coupling the vertical pipe 202 and the ceiling 205 is arranged to prevent movement of the pipe and cable in stored condition. That causes a stiff hanging pipe/cable. A charging connector at the charging gun 210 may be plugged into a corresponding receptacle 212 at the bottom end of the vertical pipe 202 for storage. The charging gun 210 may be electrically coupled to the main cable 204 through a charging cable 214. A connector at the bottom end of the vertical pipe 202 may provide this connection. Also at the bottom end of the vertical pipe 202 is a handle 208. A user may pull the handle 208 downwards to release the vertical pipe 202 from the fixed bearing 206 and tilt in any direction. The handle 208 is shown as a ring style handle, but embodiments are not limited to the illustrated style or size. Any shape or form of handle may be fitted toward the bottom end of the vertical pipe 202 to control the vertical pipe's position and movement. In some examples, a single cable may be used instead of two separate, electrically-coupled cables (204 and 214). Thus, no connector may be needed inside the connector holder to couple the main cable 204 and charging cable 214.

[0020] FIG. 3 illustrates various positions of the electric vehicle charging assembly of FIG. 2, arranged in accordance with at least some embodiments described herein.

[0021] Diagram 300 shows various example storage and in-use positions of the charging system. In storage positions 302 and 304, the vertical pipe is affixed to the ceiling through the fixed bearing and does not move due to wind or similar. Thus, any accidents due to unintentional swinging of the relatively heavy cable can be prevented. As the only needed flexible portion of the cable is the lower portion, which can be relatively short, a spool-based or similar cable storage mechanism is not needed. The two storage positions 302 and 304 show the charging gun

in opposite directions. By designing the connector at the bottom end of the vertical pipe and/or the fixed bearing at the top end to be rotatable, the charging gun can be rotated in any direction on a horizontal plane at the bottom of the vertical pipe.

[0022] In-use positions 306 and 308 show the vertical pipe tilted at an angle for easier access of the charging gun depending on the vehicle position and type. As discussed above, the vertical pipe may be released from the fixed bearing through a downward pull action (e.g., user holding and pulling down the ring-style handle at the bottom of the vertical pipe). The released vertical pipe may be tilted within a predefined angle range (based on the design of the fixed bearing) and rotated to any position along a 360-degree movement range. In-use position 310 is intended to show the vertical pipe tilted toward or from the plane of the page.

[0023] FIG. 4 illustrates cross-sectional views of the spring-loaded fixed bearing of the electric vehicle charging assembly, arranged in accordance with at least some embodiments described herein.

[0024] Diagram 400 shows the pipe-based, ceiling connected charging system in storage and use modes. In the storage mode, a stiff cable 412 providing charging current from the supply system to the charging gun is secured through a movable portion 402 of a ball joint. The non-movable portion 404 of the ball joint is affixed to the ceiling 406. The vertical pipe 414, which contains the stiff cable 412 is partially inside a cap portion 410 stopped the movable portion 402 of the ball joint. This allows the vertical pipe 414 to be stable and vertical in the storage mode and prevents swinging of the cable (and the pipe) due to wind, etc. A spring 408 inside the vertical pipe 414 around the stiff cable 412 pushes the vertical pipe upward ensuring the partial placement inside the cap portion 410.

[0025] As mentioned above, a handle at a bottom portion of the vertical pipe 414 (not shown) may be used to pull the pipe down and remove its top portion from the cap portion 410 in a use mode. At that point, the vertical pipe becomes tiltable (and rotatable) through the ball joint and cam be moved (420) within a predefined angle range. The range of the tilt angle may be defined by the size of the ball joint as well as the size of the cap portion 410. When the vertical pipe 414 is pulled downward, the spring 408 is compressed, thus ready to pull the vertical pipe upward into the cap portion and into storage mode. This allows the charging assembly to be automatically brought back to storage mode when a user releases the assembly.

[0026] FIG. 5 illustrates various assembly views of the electric vehicle charging assembly, arranged in accordance with at least some embodiments described herein.

[0027] Diagram 500 shows an example spring loading approach for the electric vehicle charging assembly. The spring loading assembly, as shown in diagram 500A, may include an inside pipe 502, spring 504, inside pipe cap 506, stiff cable 508, and movable portion 510 of the ball joint. When assembled, as shown in diagram 500B, the spring 504 is secured between one end (a circular protrusion at the end) of the inside pipe 502 and the inside pipe cap 506. The stiff cable 508 is fitted through the inside pipe 502 and the movable portion 510 of the ball joint. The inside pipe cap 506 may fit around the inside pipe 502 loosely such that it can be moved along the inside pipe 502 and result in compression and release of the spring 504.

[0028] As shown in diagram 500C, the vertical pipe 512 may be fitted loosely around the inside pipe 502 and the spring 504. The inside pipe cap 506 may be secured to the top end of the vertical pipe 512 through a threaded mechanism, a click-on mechanism, or similar approaches. Thus, when the vertical pipe is pulled down, the inside pipe cap 506 is also pulled down compressing the spring 504 and moving the pipe away from the ball joint. This, in turn, moves the top portion of the vertical pipe out of a cap portion as discussed in conjunction with FIG. 4 and allows the vertical pipe (and the cable inside) to be tilted in any direction. The compressed spring in the use mode provides for automatic return to storage mode by pushing the inside pipe cap and the vertical pipe upward toward the ball joint (and into the cap portion) when the user releases the charging system.

[0029] FIG. 6A and 6B illustrate two example connection methods for the charging gun to the electric vehicle charging assembly, arranged in accordance with at least some embodiments described herein.

[0030] Diagram 600A shows bottom portion of the vertical pipe 602 with ring-style handle 604 and connector 606 (only outer edge shown). Connector 606 is arranged to mate with connector 608, which is coupled to the flexible portion of the charging cable 616 with the charging gun 614 at the end. The charging gun includes the charging connector to couple to a charging port of an electric vehicle and is coupled to a connector holder 610 in storage mode. The coupling of the charging gun to the connector holder 610 prevents damage due to water or dust when the charging gun is not being used. Pin numbers, configuration, and other parameters

of the connectors and the charging gun may be designed according to regulatory and/or industrial standard requirements.

[0031] In the example configuration of diagram 600A, the connector holder 610 (along with the connector 608) may be secured to the connector 606 (and thereby to the vertical pipe 602) through a number of vertical screws 612. In some examples, the connector 606 may be integrated with the handle 604. In other examples, the handle 604 may loosely fit over the connector 606 allowing the vertical pipe to be pulled down, but also connector 606 (and along with that the charging gun and cable) to be rotated 306 degrees.

[0032] Diagram 600B shows similar components numbered the same way as in diagram 600A with the difference of the connector holder 610 / connector 606 coupling. In this example configuration, connector holder 610 and connector 606 may be mechanically coupled through a pair of matching threads 622. In other examples, the connectors (thus, the charging gun / cable) may be mechanically coupled through other means such as a click-on mechanism, horizontal screws, etc. In some examples, the main cable and the charging cable may be designed as a single cable, thus allowing connector 608 to be removed from the structure (the single cable may pass through the connector holder 610 into the vertical pipe.

[0033] In further examples, an additional ball joint may be provided at the bottom end of the vertical pipe to afford additional freedom of movement. The bottom portion of the charging cable 616 may be connected to the charging gun 614 and connector holder 610 through standardized connections for ease of replacement of the cable. For example, an additional connector (beside connector 608) may be provided inside connector holder 610 for easy replacement by screws. Furthermore, lights / LEDs or similar indicators may be provided at the bottom portion of the vertical pipe to display information associated with charging status, traffic guidance, etc.

[0034] In yet other examples, the vertical pipe may be arranged with free movement but without a bearing (not locked in stored condition). An additional damping system may be employed to prevent unsafe movement or swinging. Vertical pipe may also be configured to be always fixed without ability to release for tilting or turning. Thus, the range of the charging cable (214) can be used to provide access for different vehicle port locations. A defined breaking point in the bearing or a kinking area in the pipe may be used in case of collision with cars or trucks providing advantage over conventional floor installed charging points. Vertical locking

movement may also be controlled by an electrical or pneumatic system with an additional control unit.

[0035] Various components of the electric vehicle charging assembly may be made from various synthetic materials such as PVC, polypropylene, ceramic, or metals such as aluminum, stainless steel, and other materials. Various surfaces may be treated. Different color and/or surface texture schemes may be used.

[0036] According to some examples, an electric vehicle charging assembly may include an overhead fixture; a first cable to provide charging power configured to extend from the overhead fixture downward; and a vertical pipe to contain the first cable. The vertical pipe may be mechanically affixed to the overhead fixture through a ball joint, configured to be in a stationary position in a storage mode, and configured to be tiltable and rotatable in an in-use mode. The electric vehicle charging assembly may also include a second cable coupled at a first end to the first cable at a bottom end of the vertical pipe, the second cable configured to hang without touching a floor; and a charging gun coupled to a second end of the second cable and configured to contain a charging connector to mate with a charging port of a vehicle.

[0037] According to other examples, the electric vehicle charging assembly may further include a connector holder mechanically coupled to the bottom end of the vertical pipe, where the connector holder contains an electrical coupling between the first cable and the second cable, is rotatable around a longitudinal axis of the vertical pipe, and includes a mating connector for the charging gun to be affixed to in a storage mode. The electric vehicle charging assembly may also include a spring loading mechanism at a top portion of the vertical pipe, where the spring loading mechanism includes a spring that is compressed when the vertical pipe is pulled downward and releases the vertical pipe from the stationary position. The stationary position may be achieved by the vertical pipe being pushed into a cap portion affixed to the overhead fixture by the spring in the storage mode.

[0038] According to further examples, the electric vehicle charging assembly may further include a handle at a bottom portion of the vertical pipe, the handle configured to be pulled by a user to release the vertical pipe from the cap portion and transition to the in-use mode. A range of tilt angle for the vertical pipe may be determined based on one or more of a size of the ball joint or a size of the cap portion. The spring loading mechanism may be configured to pull back the vertical pipe into the stationary position when the vertical pipe is released by a user. The

electric vehicle charging assembly may also include a first connector to couple the second cable to the charging connector inside the charging gun; and a second connector to couple the second cable to the first cable inside the connector holder. The overhead fixture may be integrated into a ceiling.

[0039] According to other examples, a ceiling-connected electric vehicle charging assembly may include a fixed bearing integrated into a ceiling; a first cable to provide charging power, the first cable configured to extend from the ceiling downward through the fixed bearing; and a vertical pipe to contain the first cable. The vertical pipe may be mechanically affixed to the ceiling through the fixed bearing and a spring-loaded mechanism within the vertical pipe, configured to be in a stationary position in a storage mode, and configured to be tiltable and rotatable in an in-use mode. The system may also include a second cable with a first end of the second cable coupled to the first cable at a bottom end of the vertical pipe, and the second cable configured to hang without touching a floor; and a charging gun coupled to a second end of the second cable and configured to contain a charging connector to mate with a charging port of a vehicle.

[0040] According to some examples, the ceiling-connected electric vehicle charging assembly may further include a connector holder mechanically coupled to the bottom end of the vertical pipe, wherein the connector holder contains an electrical coupling between the first cable and the second cable, is rotatable around a longitudinal axis of the vertical pipe, and includes a mating connector for the charging gun to be affixed to in a storage mode. The connector holder may be mechanically coupled to the vertical pipe through one or more of a plurality of screws, a pair of threads, or a click-on mechanism. The ceiling-connected electric vehicle charging assembly may also include a ball joint fitted between the vertical pipe and the connector holder to afford additional freedom of movement. The ceiling-connected electric vehicle charging assembly may further include an indicator affixed to one of a bottom portion of the vertical pipe or the connector holder. The indicator may include one or more light or light emitting diode (LED) based indicators or a display to provide information to the user.

[0041] According to other examples, the spring-loaded mechanism may include an inside pipe positioned inside a top portion of the vertical pipe and having a circular protrusion at a bottom end, a spring fitted between the inside pipe and the vertical pipe, and an inside pipe cap configured to fit on a top end of the inside pipe and affixed to the top end of the vertical pipe.

The ceiling-connected electric vehicle charging assembly may further include a handle at a bottom portion of the vertical pipe, where when the handle is pulled by a user, the vertical pipe is released from a cap portion of the fixed bearing and the spring is compressed by the inside pipe cap. The vertical pipe may be configured to be pushed back into the cap portion of the fixed bearing upon the handle being released by the user through decompression of the spring and transition into the storage mode. The fixed bearing may include a ball joint and a cap portion, and a range of tilt angle for the vertical pipe may be determined based on one or more of a size of the ball joint or a size of the cap portion. The charging gun may be configured to mate with the charging port of an electric truck, an electric bus, or an electric van.

[0042] According to further examples, methods to charge an electric vehicle through a charging assembly may include releasing a vertical pipe from a cap portion of an overhead fixture upon detecting a bottom portion of the vertical pipe being pulled downward by a user, where the vertical pipe is mechanically affixed to the overhead fixture through fixed bearing comprising a ball joint and the cap portion, is in a stationary position when pulled into the cap portion in a storage mode, and is tiltable and rotatable when released from the cap portion in an in-use mode. Example methods may also include detecting removal of a charging gun coupled to a second cable from a connector holder at the bottom end of the vertical pipe, where the second cable is electrically coupled to a first cable contained within the vertical pipe and is configured to hang without touching a floor, and the charging gun includes a charging connector to mate with a charging port of a vehicle. Method may further include providing power to the charging connector; upon detecting removal of the charging connector from the charging port of the vehicle, disconnecting power; and upon detecting release of the bottom portion of the vertical pipe, pulling the top portion of the vertical pipe into the cap portion for storage mode through a spring-loaded mechanism.

[0043] According to yet other examples, detecting a bottom portion of the vertical pipe being pulled downward may include detecting a handle affixed to the bottom portion of the vertical pipe being pulled down. Pulling the top portion of the vertical pipe into the cap portion for storage mode through a spring-loaded mechanism may include decompressing a spring fitted inside the top portion of the vertical pipe by letting the top portion of the vertical pipe to be reinserted into the cap portion, where the spring is compressed when the vertical pipe is pulled

downward. A range of tilt angle for the vertical pipe may be determined based on one or more of a size of the ball joint or a size of the cap portion.

[0044] The present disclosure is not to be limited in terms of the particular embodiments described in this application, which are intended as illustrations of various aspects. Many modifications and variations can be made without departing from its spirit and scope. Functionally equivalent methods and apparatuses within the scope of the disclosure, in addition to those enumerated herein, are possible from the foregoing descriptions. Such modifications and variations are intended to fall within the scope of the appended claims. The present disclosure is to be limited only by the terms of the appended claims, along with the full scope of equivalents to which such claims are entitled. The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting.

[0045] The herein described subject matter sometimes illustrates different components contained within, or connected with, different other components. Such depicted architectures are merely examples, and in fact, many other architectures may be implemented which achieve the same functionality. In a conceptual sense, any arrangement of components to achieve the same functionality is effectively "associated" such that the desired functionality is achieved. Hence, any two components herein combined to achieve a particular functionality may be seen as "associated with" each other such that the desired functionality is achieved, irrespective of architectures or intermediate components. Likewise, any two components so associated may also be viewed as being "operably connected", or "operably coupled", to each other to achieve the desired functionality, and any two components capable of being so associated may also be viewed as being "operably couplable", to each other to achieve the desired functionality. Specific examples of operably couplable include but are not limited to physically connectable and/or physically interacting components and/or wirelessly interactable and/or wirelessly interacting components and/or logically interacting and/or logically interactable components.

[0046] 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 may be expressly set forth herein for sake of clarity.

[0047] In general, terms used herein, and especially in the appended claims (e.g., bodies of the appended claims) are generally intended as “open” terms (e.g., the term “including” should

be interpreted as “including but not limited to,” the term “having” should be interpreted as “having at least,” the term “includes” should be interpreted as “includes but is not limited to,” etc.). It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation, no such intent is present. For example, as an aid to understanding, the following appended claims may contain usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim recitation to embodiments containing only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (e.g., “a” and/or “an” should be interpreted to mean “at least one” or “one or more”); the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such recitation should be interpreted to mean at least the recited number (e.g., the bare recitation of "two recitations," without other modifiers, means at least two recitations, or two or more recitations).

[0048] Furthermore, in those instances where a convention analogous to “at least one of A, B, and C, etc.” is used, in general, such a construction is intended in the sense one having skill in the art would understand the convention (e.g., “a system having at least one of A, B, and C” would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). It will be further understood by those within the art that virtually any disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For example, the phrase “A or B” will be understood to include the possibilities of “A” or “B” or “A and B.”

[0049] For any and all purposes, such as in terms of providing a written description, all ranges disclosed herein also encompass any and all possible subranges and combinations of subranges thereof. Any listed range can be easily recognized as sufficiently describing and enabling the same range being broken down into at least equal halves, thirds, quarters, fifths,

tenths, etc. As a non-limiting example, each range discussed herein can be readily broken down into a lower third, middle third and upper third, etc. As will also be understood by one skilled in the art all language such as "up to," "at least," "greater than," "less than," and the like include the number recited and refer to ranges which can be subsequently broken down into subranges as discussed above. Finally, a range includes each individual member. Thus, for example, a group having 1-3 cells refers to groups having 1, 2, or 3 cells. Similarly, a group having 1-5 cells refers to groups having 1, 2, 3, 4, or 5 cells, and so forth.

[0050] While various aspects and embodiments have been disclosed herein, other aspects and embodiments are possible. The various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

CLAIMS

I/WE Claim:

1. An electric vehicle charging assembly comprising:

an overhead fixture;

a first cable to provide charging power, the first cable configured to extend from the overhead fixture downward;

a vertical pipe to contain the first cable, wherein the vertical pipe is

mechanically affixed to the overhead fixture through a ball joint,

configured to be in a stationary position in a storage mode, and

configured to be tiltable and rotatable in an in-use mode;

a second cable coupled at a first end to the first cable at a bottom end of the vertical pipe, wherein the second cable is configured to hang without touching a floor; and

a charging gun coupled to a second end of the second cable and configured to contain a charging connector to mate with a charging port of a vehicle.

2. The electric vehicle charging assembly of claim 1, further comprising:

a connector holder mechanically coupled to the bottom end of the vertical pipe, wherein the connector holder

contains an electrical coupling between the first cable and the second cable,

is rotatable around a longitudinal axis of the vertical pipe, and

includes a mating connector for the charging gun to be affixed to in a storage mode.

3. The electric vehicle charging assembly of claim 1, further comprising:

a spring loading mechanism at a top portion of the vertical pipe, wherein the spring loading mechanism includes a spring that is compressed when the vertical pipe is pulled downward and releases the vertical pipe from the stationary position.

4. The electric vehicle charging assembly of claim 3, wherein the stationary position is achieved by the vertical pipe being pushed into a cap portion affixed to the overhead fixture by the spring in the storage mode.

5. The electric vehicle charging assembly of claim 4, further comprising:

a handle at a bottom portion of the vertical pipe, the handle configured to be pulled by a user to release the vertical pipe from the cap portion and transition to the in-use mode.

6. The electric vehicle charging assembly of claim 4, wherein a range of tilt angle for the vertical pipe is determined based on one or more of a size of the ball joint or a size of the cap portion.

7. The electric vehicle charging assembly of claim 3, wherein the spring loading mechanism is configured to pull back the vertical pipe into the stationary position when the vertical pipe is released by a user.

8. The electric vehicle charging assembly of claim 1, further comprising:

a first connector to couple the second cable to the charging connector inside the charging gun; and

a second connector to couple the second cable to the first cable inside the connector holder.

9. The electric vehicle charging assembly of claim 1, wherein the overhead fixture is integrated into a ceiling.

10. A ceiling-connected electric vehicle charging assembly comprising:

a fixed bearing integrated into a ceiling;

a first cable to provide charging power, the first cable configured to extend from the ceiling downward through the fixed bearing;

a vertical pipe to contain the first cable, wherein the vertical pipe is

mechanically affixed to the ceiling through the fixed bearing and a spring-loaded mechanism within the vertical pipe,

configured to be in a stationary position in a storage mode, and

configured to be tiltable and rotatable in an in-use mode;

a second cable, wherein a first end of the second cable is coupled to the first cable at a bottom end of the vertical pipe, and the second cable is configured to hang without touching a floor; and

a charging gun coupled to a second end of the second cable and configured to contain a charging connector to mate with a charging port of a vehicle.

11. The ceiling-connected electric vehicle charging assembly of claim 10, further comprising:

a connector holder mechanically coupled to the bottom end of the vertical pipe, wherein the connector holder

contains an electrical coupling between the first cable and the second cable,

is rotatable around a longitudinal axis of the vertical pipe, and

includes a mating connector for the charging gun to be affixed to in a storage mode.

12. The ceiling-connected electric vehicle charging assembly of claim 11, wherein the connector holder is mechanically coupled to the vertical pipe through one or more of a plurality of screws, a pair of threads, or a click-on mechanism.

13. The ceiling-connected electric vehicle charging assembly of claim 10, further comprising a ball joint fitted between the vertical pipe and the connector holder to afford additional freedom of movement.

14. The ceiling-connected electric vehicle charging assembly of claim 10, further comprising an indicator affixed to one of a bottom portion of the vertical pipe or the connector holder.

15. The ceiling-connected electric vehicle charging assembly of claim 14, wherein the indicator comprises one or more light or light emitting diode (LED) based indicators or a display to provide information to the user.

16. The ceiling-connected electric vehicle charging assembly of claim 10, wherein the spring-loaded mechanism comprises:

an inside pipe positioned inside a top portion of the vertical pipe and having a circular protrusion at a bottom end,

a spring fitted between the inside pipe and the vertical pipe, and

an inside pipe cap configured to fit on a top end of the inside pipe and affixed to the top end of the vertical pipe.

17. The ceiling-connected electric vehicle charging assembly of claim 16, further comprising:

a handle at a bottom portion of the vertical pipe, wherein when the handle is pulled by a user, the vertical pipe is released from a cap portion of the fixed bearing and the spring is compressed by the inside pipe cap.

18. The ceiling-connected electric vehicle charging assembly of claim 16, wherein the vertical pipe is configured to be pushed back into the cap portion of the fixed bearing upon the handle being released by the user through decompression of the spring and transition into the storage mode.

19. The ceiling-connected electric vehicle charging assembly of claim 10, wherein the fixed bearing comprises a ball joint and a cap portion, and a range of tilt angle for the vertical pipe is determined based on one or more of a size of the ball joint or a size of the cap portion.

20. The ceiling-connected electric vehicle charging assembly of claim 10, wherein the charging gun is configured to mate with the charging port of an electric truck, an electric bus, or an electric van.

21. A method to charge an electric vehicle through a charging assembly, the method comprising:

releasing a vertical pipe from a cap portion of an overhead fixture upon detecting a bottom portion of the vertical pipe being pulled downward by a user, wherein the vertical pipe is

mechanically affixed to the overhead fixture through fixed bearing comprising a ball joint and the cap portion,

in a stationary position when pulled into the cap portion in a storage mode, and

tiltable and rotatable when released from the cap portion in an in-use mode;

detecting removal of a charging gun coupled to a second cable from a connector holder at the bottom end of the vertical pipe, wherein

the second cable is electrically coupled to a first cable contained within the vertical pipe and is configured to hang without touching a floor, and

the charging gun includes a charging connector to mate with a charging port of a vehicle;

providing power to the charging connector;

upon detecting removal of the charging connector from the charging port of the vehicle, disconnecting power; and

upon detecting release of the bottom portion of the vertical pipe, pulling the top portion of the vertical pipe into the cap portion for storage mode through a spring-loaded mechanism.

22. The method of claim 21, wherein detecting a bottom portion of the vertical pipe being pulled downward comprises:

detecting a handle affixed to the bottom portion of the vertical pipe being pulled down.

23. The method of claim 21, wherein pulling the top portion of the vertical pipe into the cap portion for storage mode through a spring-loaded mechanism comprises:

decompressing a spring fitted inside the top portion of the vertical pipe by letting the top portion of the vertical pipe to be reinserted into the cap portion, wherein the spring is compressed when the vertical pipe is pulled downward.

24. The method of claim 21, wherein a range of tilt angle for the vertical pipe is determined based on one or more of a size of the ball joint or a size of the cap portion.

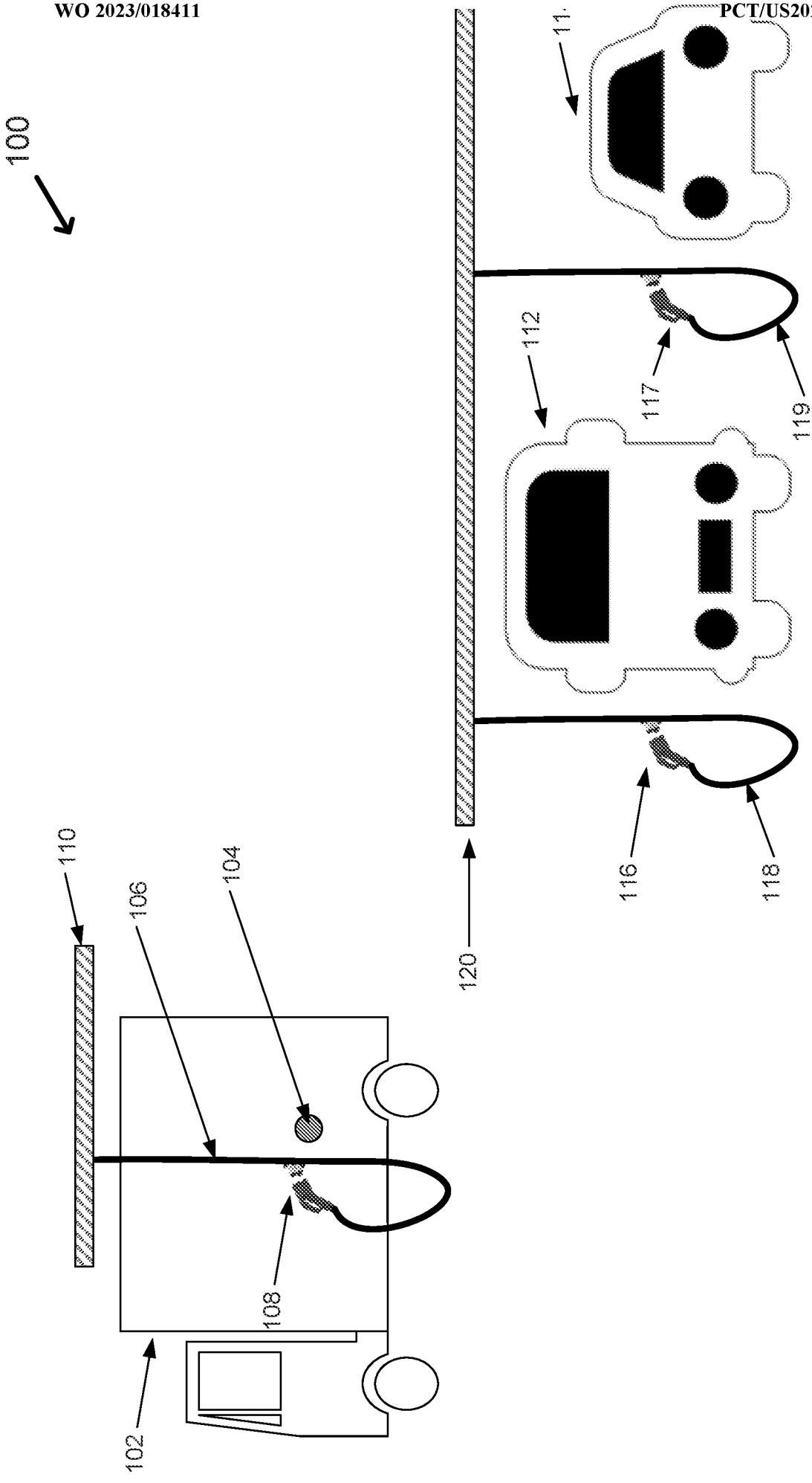


FIG. 1

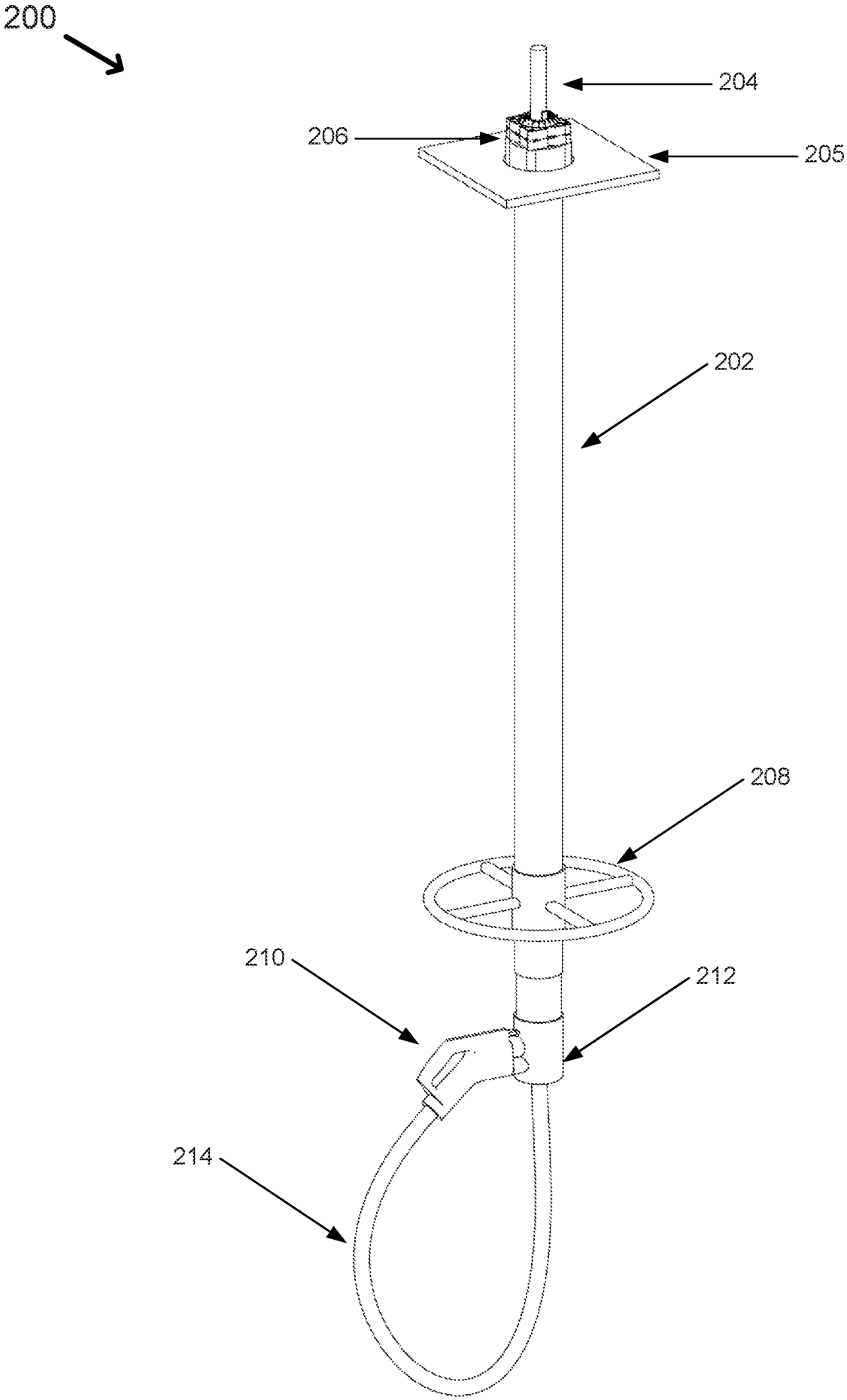


FIG. 2

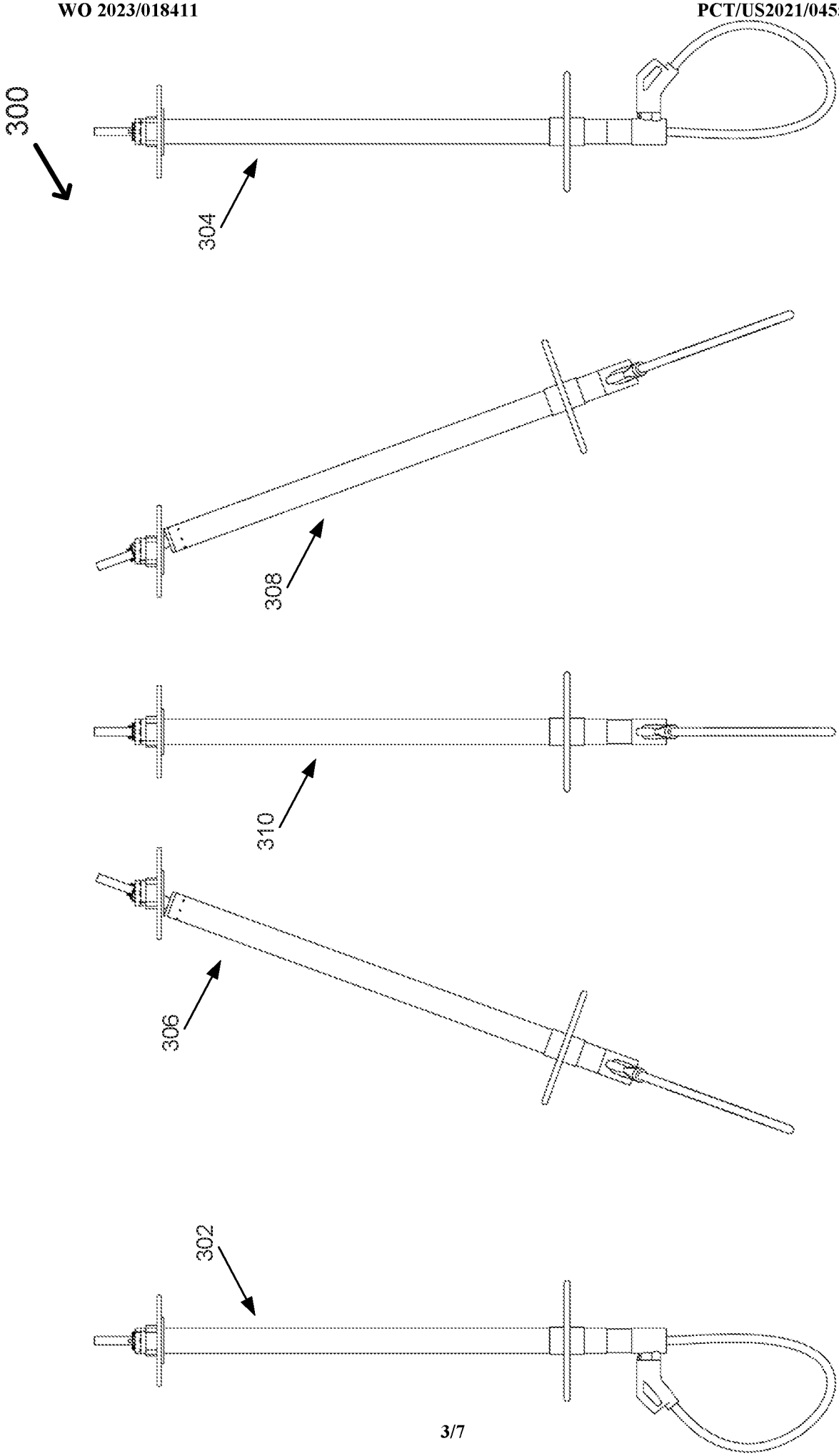


FIG. 3

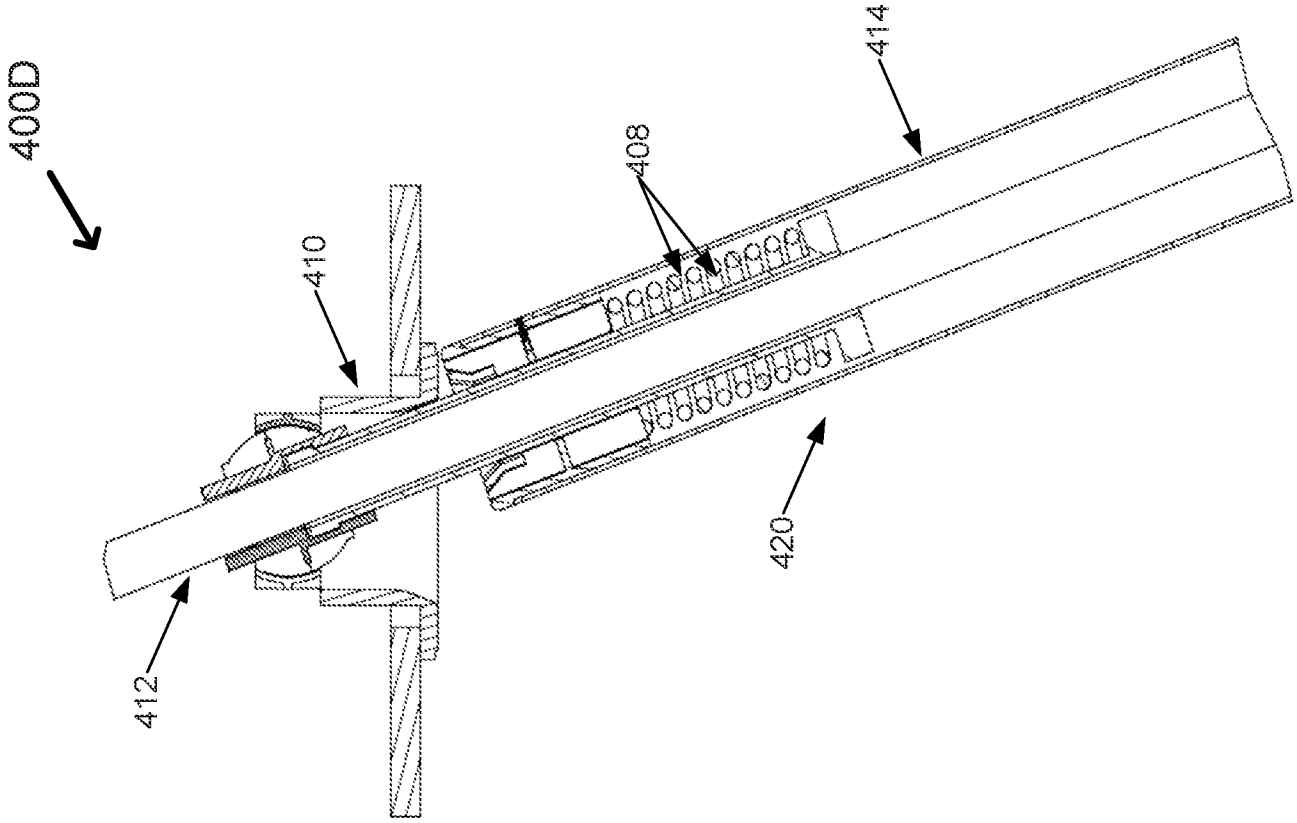
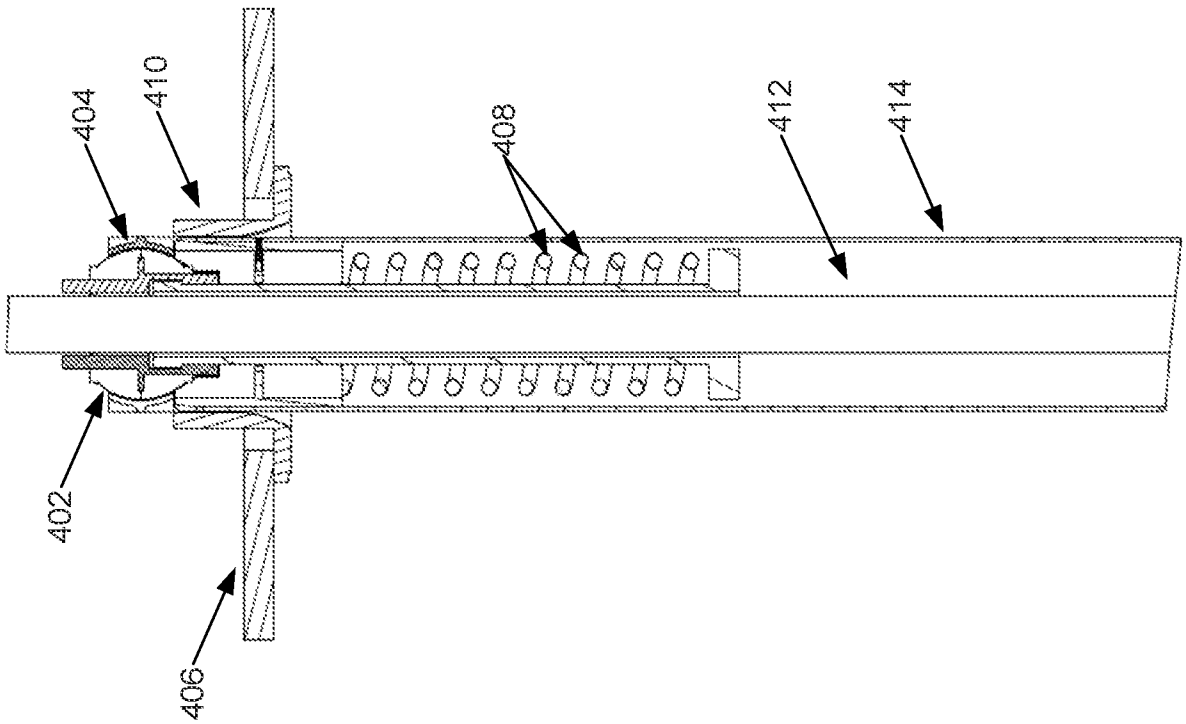


FIG. 4



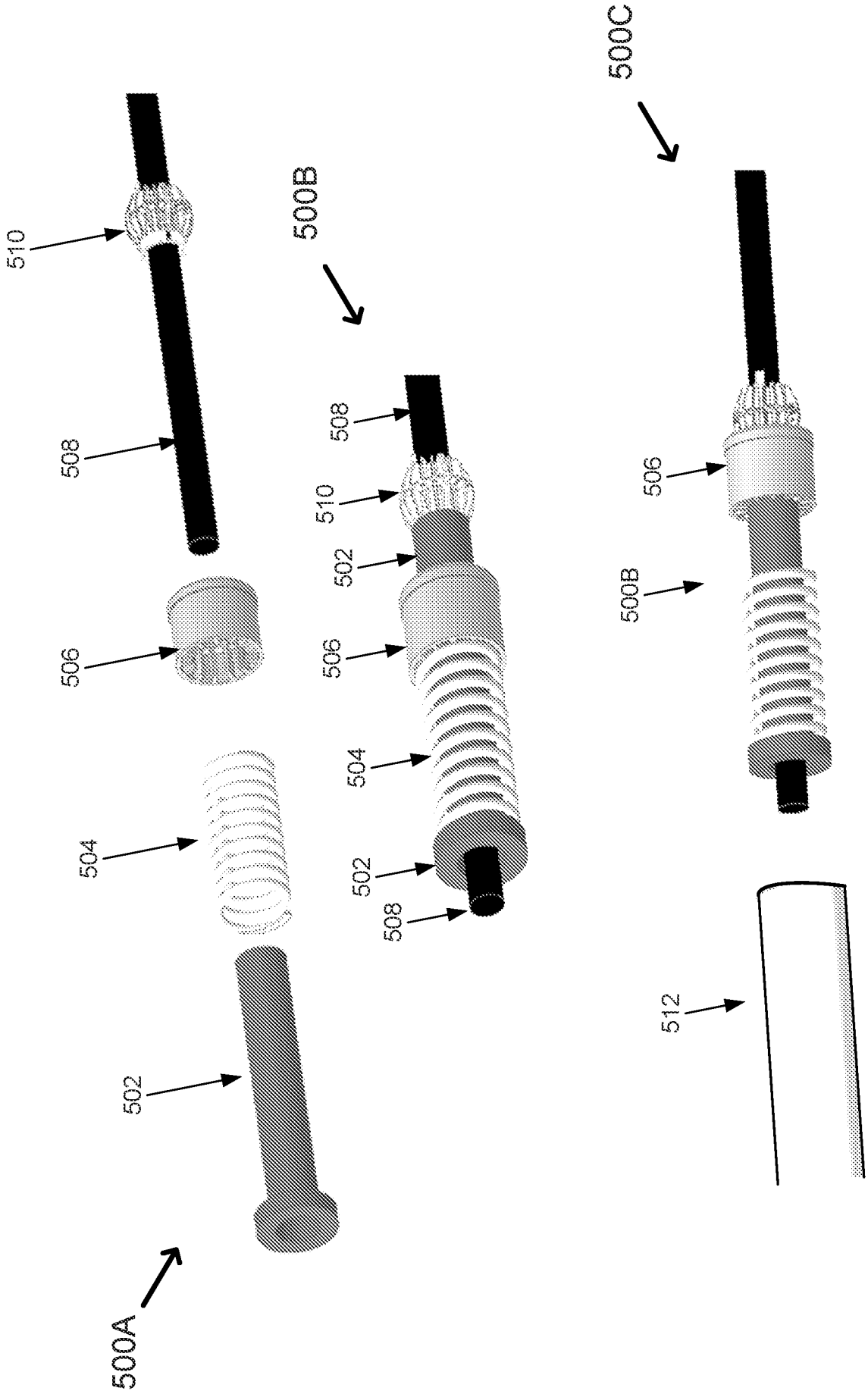

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FIG. 5

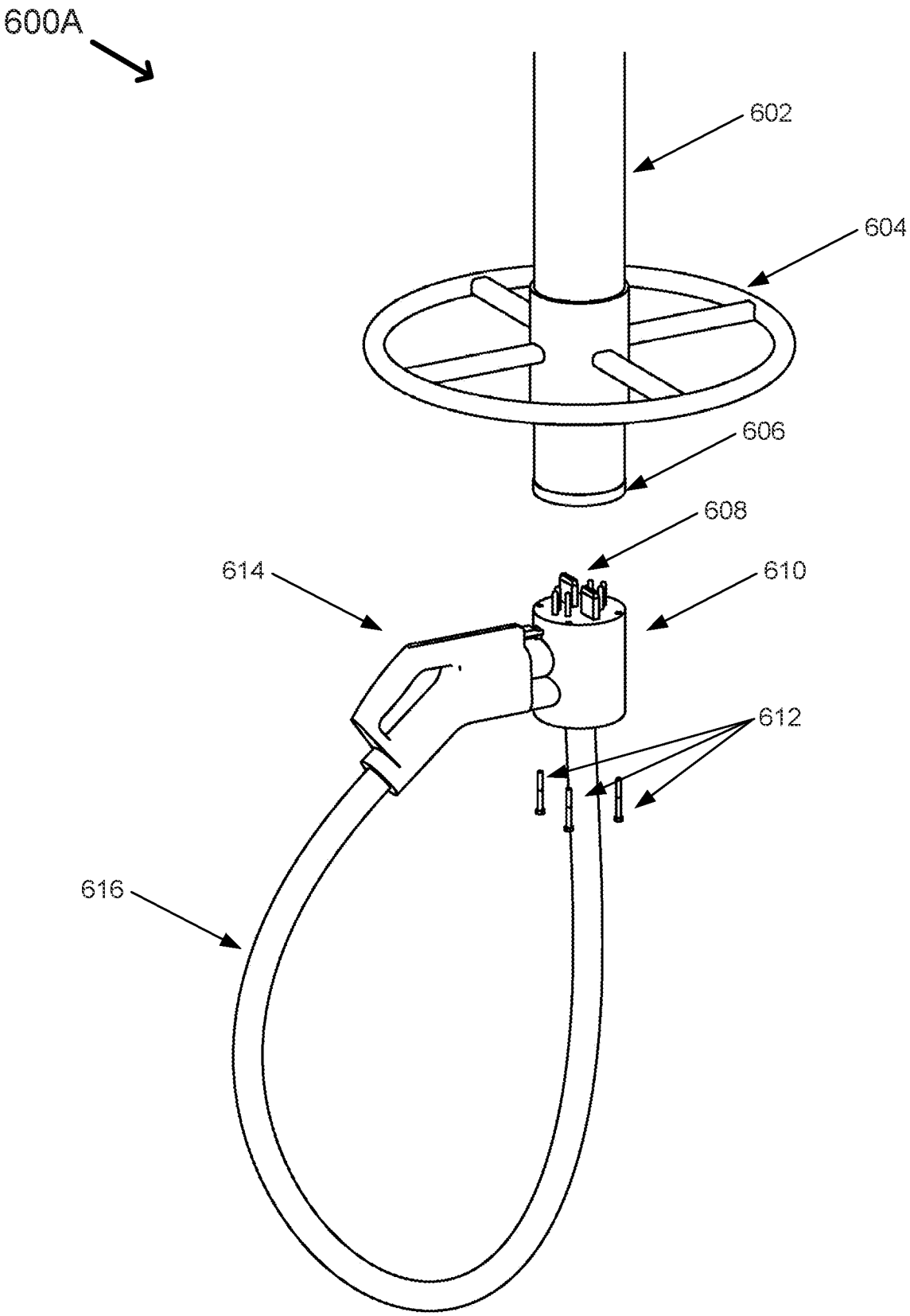

FIG. 6A

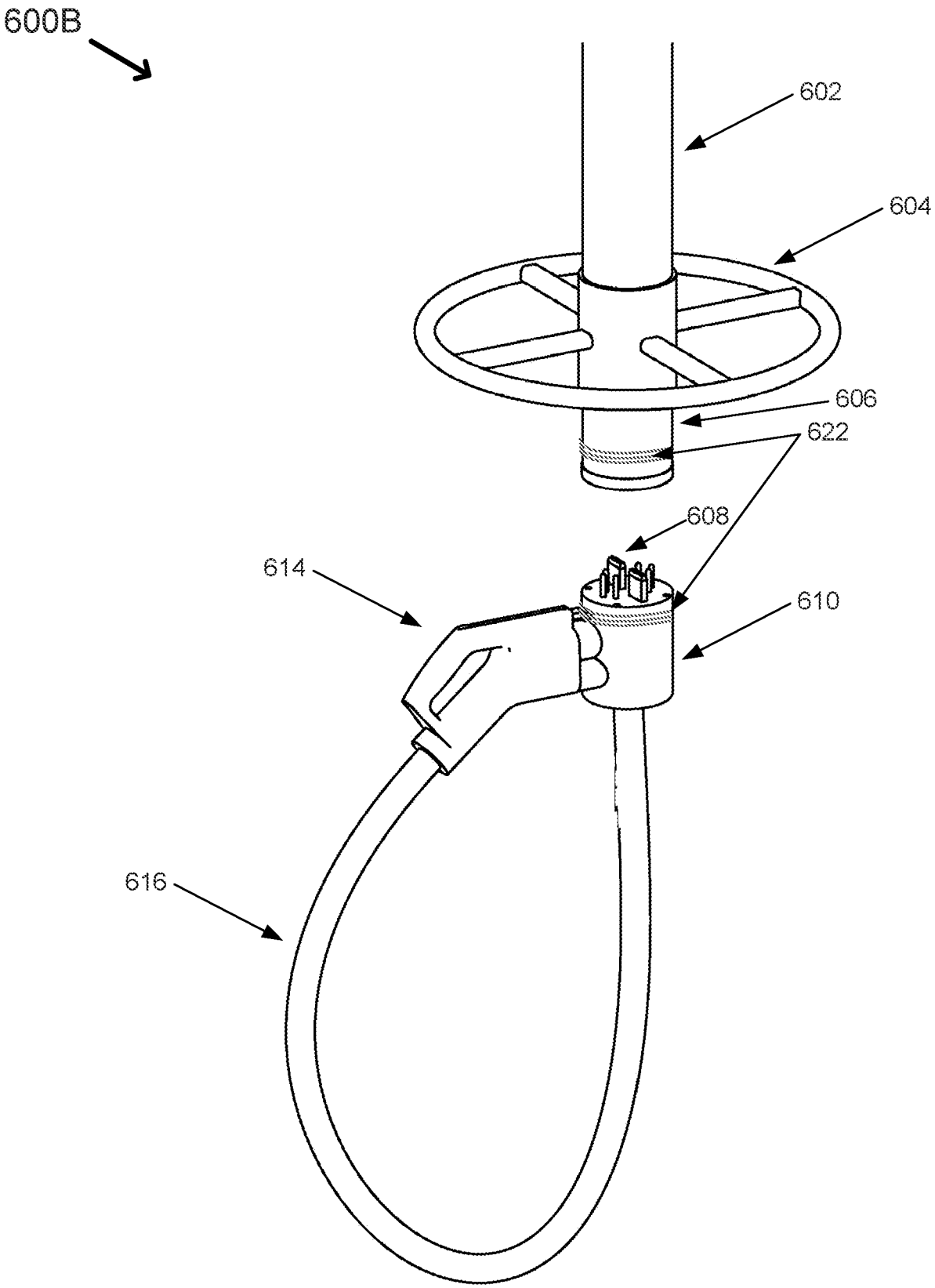

FIG. 6B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US21/45543

A. CLASSIFICATION OF SUBJECT MATTER

IPC - B60L 53/18; B60L 53/16; B60W 10/26 (2021.01)

CPC - B60L 53/16; Y02T 90/14; B60L 53/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	NL 8001084 A (DRAEGERWERK AG) 30 September 1980; see machine translation	1-24
A	JP 6876963 B2 (PANASONIC IP MANAGEMENT CO LTD) 26 May 2021; see machine translation	1-24
A	US 2020/0369167 A1 (ABB SCHWEIZ AG) 26 November 2020; Figure 1, 4; Paragraph [0024-0025], [0032], [0045]	1-24

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"P" document published prior to the international filing date but later than the priority date claimed
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 October 2021 (12.10.2021)	NOV 24 2021
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas Telephone No. PCT Helpdesk: 571-272-4300