

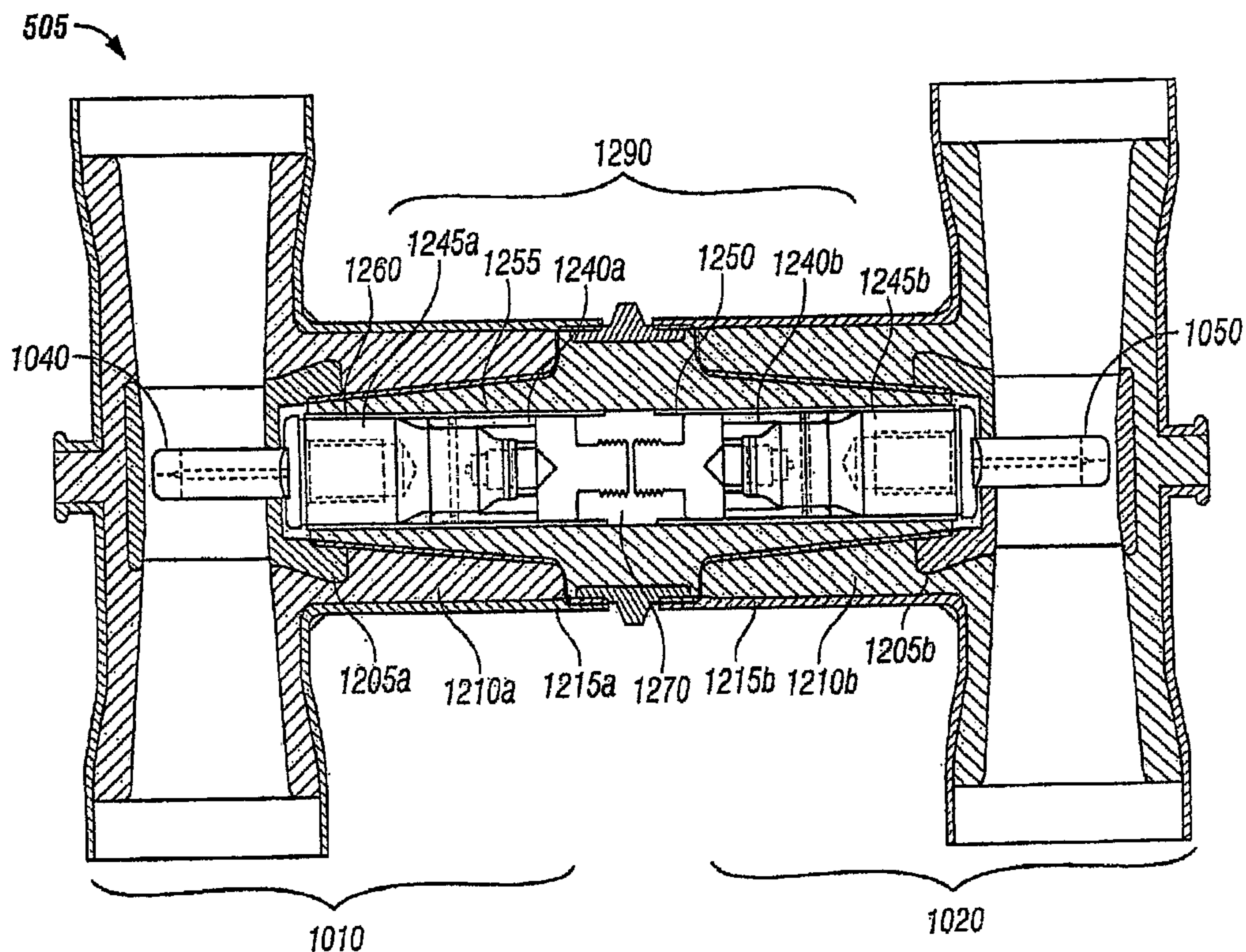


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(54) Titre : PROCÉDE DE FABRICATION ET REPARATION D'UN SYSTEME DE BARRE OMNIBUS A POUSSER  
MODULAIRE

(54) Title: METHOD OF MAKING AND REPAIRING A MODULAR PUSH-ON BUSBAR SYSTEM



**FIG. 12**

(57) Abrégé/Abstract:

An improved method of manufacturing, modifying and repairing a switchgear is disclosed that includes a busbar system and active switching elements that can be assembled from modular parts.



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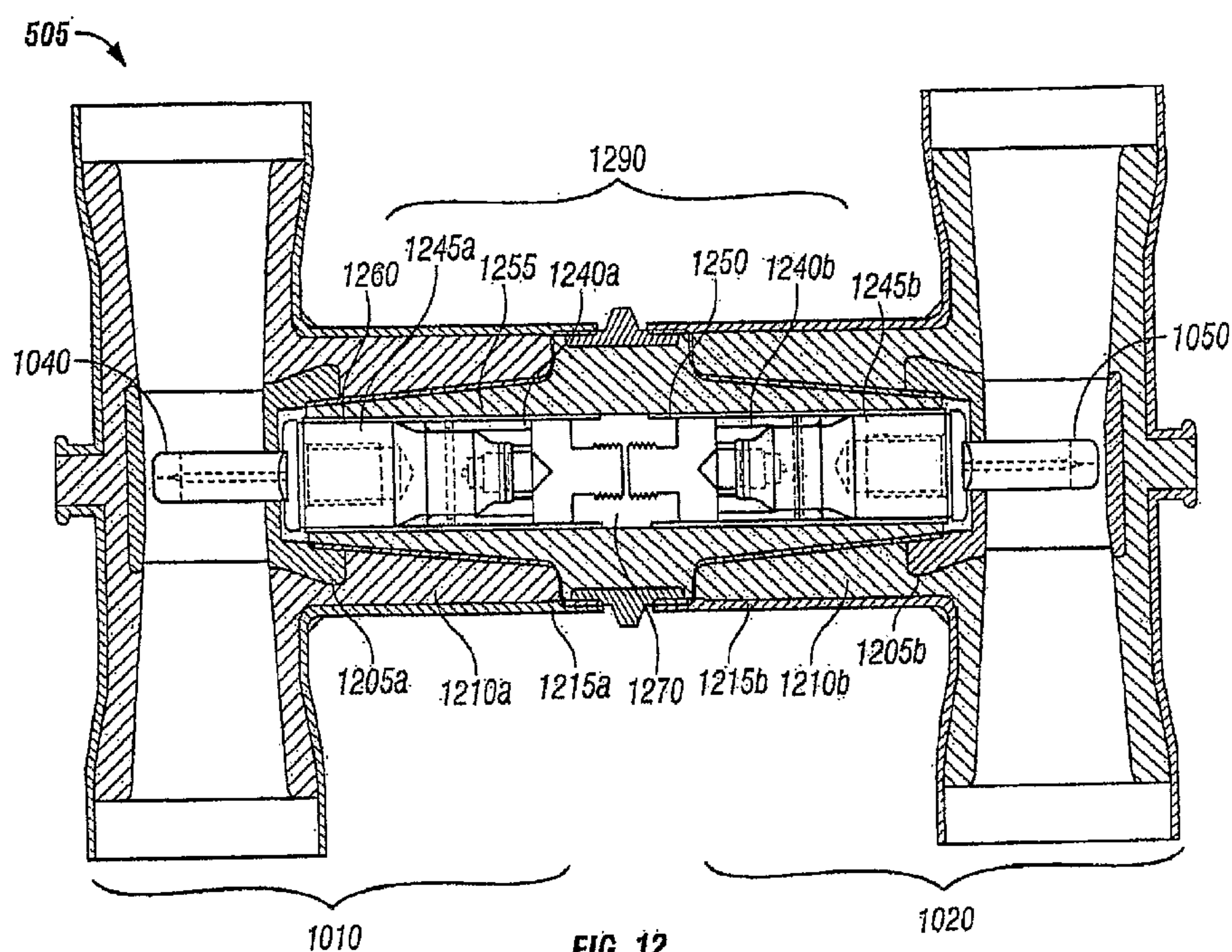


FIG. 12

(57) Abstract: An improved method of manufacturing, modifying and repairing a switchgear is disclosed that includes a busbar system and active switching elements that can be assembled from modular parts.

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# **METHOD OF MAKING AND REPAIRING A MODULAR PUSH-ON BUSBAR SYSTEM**

## **BACKGROUND**

[0001] This current invention is directed to a pad or vault mounted switchgear, and more particularly to a busbar and insulation system inside the switchgear.

## **BRIEF DESCRIPTION OF THE DRAWINGS**

[0002] Figs. 1 and 2 are perspective views of switchgear with open doors.

[0003] Fig. 3 is a cross-sectional view of internal parts of the switchgear of Figs. 1 and 2.

[0004] Fig. 4 is a plan view of the busbar system of the switchgear of Figs. 1-3.

[0005] Fig. 5 is a perspective view of a busbar system in accordance with one exemplary embodiment of the present invention.

[0006] Fig. 6 is a cross-sectional view of a connector in the busbar system of Fig. 5 in accordance with one exemplary embodiment of the present invention.

[0007] Fig. 7 is a cross-sectional view of a busbar in the exemplary busbar system of Fig. 5 in accordance with one exemplary embodiment of the present invention.

[0008] Figs. 8 and 9 are perspective views of exemplary components of the busbar of Fig. 7 in accordance with one exemplary embodiment of the present invention.

[0009] Fig. 10 is a perspective view of an alternative busbar in the busbar system of Fig. 5 in accordance with one exemplary embodiment of the present invention.

**[0010]** Fig. 11 is a perspective view of an exemplary component of the busbar of Fig. 10 in accordance with one exemplary embodiment of the present invention.

**[0011]** Fig. 12 is a cross-sectional view of the exemplary busbar of Fig. 10 in accordance with one exemplary embodiment of the present invention.

**[0012]** Fig. 13 is a perspective view of an alternative busbar system in accordance with one exemplary embodiment of the present invention.

**[0013]** Fig. 14 is a logical flowchart diagram illustrating an exemplary method for repairing a switching element in a switchgear having modular components in accordance with one exemplary embodiment of the present invention.

**[0014]** Fig. 15 is a logical flowchart diagram illustrating an exemplary method for modifying the organization or arrangement of components in a switchgear having modular components according to one exemplary embodiment of the present invention.

**[0015]** Fig. 16 is a logical flowchart diagram illustrating an exemplary method for making a switchgear having modular components in accordance with one exemplary embodiment of the present invention.

**[0016]** Fig. 17 is a logical flowchart diagram illustrating an exemplary method for reconfiguring the organization or arrangement of components in a switchgear having modular components in accordance with one exemplary embodiment of the present invention.

**[0017]** Like reference symbols in the various drawings indicate like elements.

## **DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS**

**[0018]** Utility companies distribute power to customers using a network of cables, switching stations and switchgear. Switchgear is high voltage (e.g. 5 kV-38 kV) equipment, typically subsurface, vault, or pad mounted and used to

distribute and control power distribution in relatively small areas. Historically, switchgear is a box or container that includes bushings, insulation, a busbar system and a collection of active switching elements. An active switching element is a device with an internal active component, such as a fuse, a switch, or an interrupter, and external points of connection. In some active switching elements, these external points of connection are bushings. Active switching elements are used to automatically, manually, or remotely open and/or close a circuit. It should be noted that active switching elements that include switches or interrupters often include contacts in a vacuum, air, insulating oil, or dielectric gas. Distribution cables are coupled to the bushings of the switchgear and have the capacity to transmit power at high voltages. The bushings in turn are coupled to, or form an integral part of, the active switching elements inside the switchgear. The active switching elements are coupled by a busbar system to create the switchgear.

**[0019]** FIG. 1 shows a common switchgear configuration 100 with source side door 110 in an open position. Latch(es) 111a and/or 111b are used to lock source side door 110 in a closed position. Inside door 110 is a front-plate 130 that forms one side of the container. In FIG. 1, the front-plate 130 is a vertical surface of the container. Coming up from the bottom of switchgear 100 are cables 112a-112f that each typically carry power in three phases from two different sources. More specifically, cables 112a-112c carry, respectively, the A, B and C phases of power from source 1, and cables 112d-112f carry, respectively, the C, B and A phases of power from source 2

**[0020]** Cables 112a-112f are coupled to front-plate 130 and switchgear 100 through connectors 114a-114f. A connector or connector body is a component for connecting a power cable or busbar to a bushing. Connectors can be straight or bent, live-break or dead-break, load-break, bolted, or probe and contact. Connectors 114a-114f are coupled to bushings extending through the front-plate 130. These bushings are coupled to active switching elements inside switchgear 100. The bushings represented in FIG. 1 are in a single plane that is horizontal to the pad. An exemplary connector is the "PUSH-OP.TM. Dead break Connector Catalog No. 600-13" manufactured by Cooper Power Systems, the specification of which is incorporated by reference. An exemplary bushing is

Cooper Power System's "600 A 15 and 25 KV Class Deadbreak PUSH-OP.TM. Apparatus Bushing" (Electrical Apparatus Catalog No. 800-46), the specification of which is incorporated by reference.

**[0021]** Additional features may include switch handles 116a and 116b that operate switches (the active elements) inside switchgear 100 to disconnect and connect the bushings extending through front-plate 130 from the internal busbar system. The cables 112a-112c may be disconnected from internal busbar system by manipulating handle 116a. Similarly, cables 112d-112f may be disconnected from the internal busbar system by manipulating handle 116b. Handles 116a and 116b are mounted onto front-plate or working surface 130 as shown in FIG. 1. It should be noted that alternative switchgear may use alternative active switching elements such as fault interrupters and fuses. It should also be noted that the front-plate or working surface 130 is a plane on the switchgear 100.

**[0022]** One use of switchgear is to segregate a network of power distribution cables into sections. That is, by manually opening or closing a switch (either locally or remotely), such as the switch coupled to handle 116a, the power supplied from one source to the switchgear is prevented from being conducted to the other side of the switchgear and/or to the bus. Similarly, when switch 116b is opened, power on one side of the switchgear is prevented from being conducted to the other side of the switchgear and to the bus and the taps. In this manner, a utility company is able to segregate a portion of the network for maintenance, either by choice, through the opening of a switch, or automatically for safety, through the use of a fuse or fault interrupter, depending on the type of active switching elements included in the switchgear.

**[0023]** FIG. 2 shows switchgear 100 with tap side door 220 open. Latch(es) 211a and/or 211b are used to lock tap side door 220 in the closed position. Inside door 220 is a front-plate or working surface 240, which is also one vertical side of the container. Coming up from the bottom of switchgear 100 are typically six cables 212a-212f that each typically carry one phase of power away from switchgear 100. In particular, cable 212a carries A phase power, cable 212b carries B phase power and cable 212c carries C phase power. Similarly, cable 212d carries C phase power, cable 212e carries B phase power and cable 212f

carries A phase power. Connectors 214a-214f connect cables 212a-212f to switchgear 100 through bushings (not visible in this figure). Exemplary connectors and bushings can be the same as those described in conjunction with FIG. 1. It should be noted that the exemplary switchgear in FIGS. 1 and 2 shows one type of phase configuration. The phase configuration shown in FIGS. 1 and 2 is ABC CBA. Other phase configurations include AA BB CC. Still other configurations have one or more sources and taps on the same front plate or each on its own front plate or on the sides of the switchgear on one or more additional front plates. It should also be noted that each phase may be designated by a number, such as 1, 2 and 3, and that the switchgear may accommodate more than three phases of power. Thus, a switchgear may have a configuration of 123456 654321.

**[0024]** It should also be noted that there are other places at which to locate the bushings on the switchgear. The orientation of the bushings, whether mounted onto the front, side, top or back of a frame, and thereby protruding toward an exterior working space of the switchgear, is called the bushing plane. For the switchgear shown in FIGS. 1 and 2, the front plates 130 and 240 are two bushing planes for the switchgear 100.

**[0025]** One structure not shown in FIGS. 1 and 2 is a frame. A frame is internal to the switchgear and provides support for the active switching elements as well as the busbar system. In other words, the frame holds the active switching elements and busbar system in place once they are coupled to the frame. The frame is oriented to allow portions of the active switching elements, typically bushings, to protrude as a bushing plane so that connections to cables can be made.

**[0026]** A way is a three-phase or single-phase circuit connection to a bus, which contains combinations of switches and/or protective devices. A way may carry power in either a single-phase system or a multi-phase system. The circuit connection may or may not include active switching elements. The switchgear shown in FIGS. 1 and 2 is four-way or 4W. That is, the switchgear has connections for two sources and two protected taps.

**[0027]** Handle 216a operates switches inside switchgear 100 to disconnect cables 212a, 212b and 212c from the internal busbar system. Similarly, handles 216b-216d each operate a switch inside switchgear 100 to disconnect and connect, respectively, one of individual cables 212d-212f from the internal busbar system. Alternate switchgear can use other active switching elements such as fuses and fault interrupters.

**[0028]** If fuses were implemented instead of switches, the switch handles shown in FIG. 1 would be replaced by hot stick operable to access removable fuse wells that extend through front-plate 240 to allow a technician to access and/or replace the fuse.

**[0029]** A cut-away side view of switchgear 100 is shown in FIG. 3. As previously described, switchgear 100 in this example includes switching and/or protective devices 305 and 310 and a busbar system 315. Devices 305 and 310 include bushings 305a and 310a for coupling to connectors 114a and 214f. Devices 305 and 310 also include bushings 305b and 310b for coupling to busbar system 315. It should be noted that bushings 305a, 305b, 310a and 310b may be integral to or separate from switching and/or protective devices 305 and 310 and they may include mechanical or push-on connectors. A mechanical connector connects two or more metallic elements by using threaded, crimp, or wedge connections. Typical mechanical bus connections consist of two or more conductors made from bars or braids which are secured together with a threaded bolt extending through holes in a flattened portion and secured by a bolt and a conductive member with internal threads. A typical mechanical connector to a flat bus conductor surface is accomplished by threading a conductive member with internal threads onto a threaded stud or a bolt. Push-on connectors consist of two or more metallic bus conductors that can be axially joined. The components consist of a matching set of probes, rods, or 'male' conductors that mate with finger-contacts, bores, or 'female' conductors or contacts.

**[0030]** FIG. 4 shows a cross sectional front view of a conventional busbar system 315. Conventional busbar system 315 includes three copper, aluminum or other electrically conductive metal bars 415a, 415b and 415c. As shown in FIG. 4, metal bar 415a is formed or bent around metal bar 415b and metal bar

415b is similarly formed or bent around metal bar 415c. The metal bars may be flexible or partially flexible to allow connection to two rigid members. The purpose of busbar system 315 is to conduct power from the source side active switching elements to the tap side active switching elements. Thus, if one of the active switching elements opens such that a source side or tap side cable is disconnected from the busbar system, the remaining source and tap side cables remain connected and can transmit power.

**[0031]** Insulation is provided between the busbars and the active switching elements to prevent electrical arcing. There are three common types of insulation typically used in conventional switchgear: oil, sulfur hexafluoride (SF.sub.6) gas, and air. Each type of insulation insulates each part of the switchgear from the other parts of the switchgear (busbar and active switching elements), and from the outer surfaces of the container of the switchgear.

**[0032]** A completely deadfront switchgear is made from a busbar system that is itself deadfront. To be deadfront, the busbars include shields that are coupled to ground. This allows for the switchgear to be made smaller by eliminating the previously required spacing between the bars and the active switching elements for conventional types of insulation. More specifically, the busbars and push-on connectors include insulation and semiconducting shields. When a busbar is coupled to an active switching element that also includes a semiconducting shield that is coupled to ground, the busbar and the active switching elements are themselves deadfront. This makes the switchgear that includes the busbar deadfront as well, whether or not the outer surface of the switchgear (i.e., the box) is coupled to ground. This in turn means the switchgear can be manufactured without air, oil, or SF.sub.6 insulation while maintaining the highest degree of safety.

**[0033]** Switchgear that includes solid dielectric insulation between the busbars and the active switching elements is also described. By using a solid dielectric, the spacing between the busbars may be reduced, which allows for the design of switchgear with a smaller footprint. In addition, conventional switchgear that use oil or SF.sub.6 insulation requires a container within the switchgear to prevent these materials from leaking out of the switchgear and into the

environment. Switchgear that uses solid insulation materials does not require such a container as the very nature of the solid insulation prevents the insulation from leaking out of the switchgear.

**[0034]** Another switchgear is described that uses busbars with push-on connections. These push-on connections make it easier for connections to be made to the active switching elements. In addition, push-on connections are used in assembling the busbars so that a busbar system can be made to desired specifications in a short amount of time, without the need for expensive equipment. In addition, push-on connections can be used to make bus and active switching element connections in switchgear configurations that can't be easily done with mechanical connections. Finally, the use of push-on connections eliminates threaded and other mechanical connections and allows for faster and easier replacement of switchgear components.

**[0035]** This completely deadfront solid dielectric switchgear includes active switching elements and busbars that are completely high voltage shielded, with a solid dielectric insulation system and a fully rated conductive ground shield. This deadfront equipment has no voltage on its exposed surfaces and thereby avoids the potential for burning and degradation of the surfaces that may result from such a voltage. In one general aspect, an improved, solid-dielectric, modular, busbar system is made from high voltage connectors and high voltage cables. This solid dielectric busbar and active element system eliminates the need for oil, SF.sub.6 or air insulation by creating completely shielded, solid dielectric switchgear. In addition, solid insulation switchgear does not have the risk of internal contamination from plants and animals that may be associated with air insulated switchgear.

**[0036]** In accordance with one implementation, switchgear includes a surface for mounting an active switching element that is coupled to a busbar that includes a cable coupled to a connector.

**[0037]** In accordance with another implementation, a busbar includes two individual legs coupled together. The connections in each of the legs may be push-on, mechanical, or a combination of both. This busbar also allows for non-co-planar connections.

**[0038]** The details of one or more implementations are set forth in the accompanying drawings and the description below. Other features will be apparent from the description and drawings, and from the claims.

**[0039]** As shown in FIG. 5, an exemplary busbar system 500 includes three busbars 505, 510 and 515. Busbar 510 includes a pair of connectors 512a and 512b coupled to a cable 513. Busbar 515 includes a pair of connectors 517a and 517b coupled to a cable 518. A cable typically is a group of concentrically-wound, shielded wires wrapped in insulation, capable of transmitting high voltage power, and covered by a conductive, grounded outer surface. A connector is an assembly of conductive elements that electrically and physically couples two elements together. In some implementations, a connector includes a protective sheath that may include a corona shield, insulation and a semi-conducting grounded shield.

**[0040]** As shown in FIG. 6, cable 513 is coupled to connector 512a by a compression connector 605. In one implementation, cable 513 is coupled to compression connector 605 by a compression threaded connection. That is, connector 512a is coupled to cable 513 by crimping connector onto cable 513. The crimping of the connector onto cable 513 provides mechanical support so that the connection between the cable 513 and the connector 512a cannot be pulled apart easily.

**[0041]** Connector 512a also includes a cable adapter 603. Cable adapter 603 adjusts or tightens around cable 513 to fit cable 513 onto connector 512a.

**[0042]** A semi-conducting insert 610 surrounds compression connector 605. The semi-conducting insert 610 provides corona-free electrostatic shielding of compression connector 605. Insulation 615 surrounds semi-conducting insert 610. In one implementation, insulation 615 is made from ethylene propylene diene monomer (EPDM) rubber.

**[0043]** A semi-conducting shield 620 surrounds insulation 615. The semi-conducting shield 620 may be coupled to ground to conduct to ground any stray charges. When the shield 620 is coupled to ground, the busbar is deadfront, which improves upon the insulative and protective features of connector 512a.

**[0044]** An eye 605a is located at one end of compression connector 605; threaded stud 625 passes through eye 605a. Probe 630a is threaded onto threaded stud 625 and makes contact with bushings coupled to an active switching element (not shown) to complete the electrical connection(s) to cable 513. The probe 630a is a connection point for making electrical connections used in making push-on connections. Threaded stud 625 is another connection point and makes a mechanical connection with a bushing coupled to an active switching element (not shown) by threading onto threaded stud 625. Spaces 635a and 635b in insulation 615 and semi-conducting shield 620 facilitate electrical connections to the bushings coupled to an active switching element (not shown) and the probe 630a and threaded stud 625.

**[0045]** Connector 512a shows two types of connections. Probe 630a is a connection point and is one-half of a push-on connection. The other half of the connection, such as, for example, a female finger contact, completes the electrical connection upon being pushed onto probe 630a. The female finger contact is another connection point. The two together are an example of a push-on connection.

**[0046]** Threaded stud 625 is another connection point that makes up one half of a connection. The other half of the connection is a conductive member made of conductive material with internal threads into which the threaded stud 625 is threaded. This conductive member is another connection point. When the threaded stud 625 and the conductive member are coupled together, the connection is completed. This is an example of a mechanical connection.

**[0047]** FIGS. 7 and 8 show a first exemplary implementation of busbar 505. In this implementation, busbar 505 includes two legs 710 and 760. Each leg 710 and 760 is a three-way "T" connector. These three-way connectors form electrical and physical connections with up to three other elements or devices.

**[0048]** Three-way connector 710 includes probes 715a, 715b and 730. Three-way connector 760 includes probes 765a and 765b and finger contact 780. Probes are elongated pieces of conductive material that are coupled to female finger contacts by pushing the two together. It should be noted that probes 715a and 715b are not shown in FIG. 8.

**[0049]** Three-way connectors 710 and 760 also include threaded studs 720 and 770, respectively. Each threaded stud includes an eye. Eye 720a in threaded stud 720 is shown in FIG. 8. Additional threaded studs 725 and 775 pass through the eyes of threaded studs 720 and 770, respectively. Probes 715a and 715b are threaded onto threaded stud 725, and probes 765a and 765b are threaded onto threaded stud 775. Each probe includes a hexagonal depression to receive a hexagonal wrench for tightening the probes onto their respective threaded studs. In particular, probe 715a includes depression 727a, probe 715b includes depression 727b, probe 765a includes depression 777a, and probe 765b includes depression 777b.

**[0050]** Three-way connector 710 includes three connection points for connecting three-way connector 710 to, for example, three-way connector 760. As shown in FIG. 7, the connecting point is a third probe 730. Probe 730 is threaded onto threaded stud 720. Three-way connector 760 includes another connection point used to connect the three-way connectors 710 and 760. The connection point included in three-way connector 760 is a female finger contact

780 that is threaded onto threaded stud 770. A female finger contact is a conductive device with a depression that is sized to receive a probe. As shown in FIG. 8, female finger contact 780 has, for example, six fingers. In other implementations, female finger contact 780 may include eight or any other number of fingers.

**[0051]** In FIG. 7, three-way connector 710 is joined to three-way connector 760 by connecting probe 730 to female finger contact 780. This is accomplished by pushing probe 730 into female finger contact 780. To reinforce the connection, a ring 735 made of spring material is placed in an outer groove of female finger contact 780. When probe 730 is inserted into female finger contact 780, ring 735 is stretched and holds the probe 730 in female finger contact 780. This is one way to form a push-on connection.

**[0052]** In the implementation shown in FIG. 7, each three-way connector 710 and 760 is made with its own protective sheathing and then the two pieces are coupled together to form busbar 505. As shown in FIG. 7, protective sheathing for three-way connector 710 includes corona-shielding 740. Corona shielding 740 generally surrounds the points of physical connection between the various conductive elements and prevents arcing or electrical discharge. Insulating material 745 surrounds the corona shielding 740 and probes 715a, 715b and 730. In one implementation, this insulative material is ethylene propylene diene monomer ("EPDM") rubber. The insulative material 745 prevents current and voltage from being transmitted to the outer shell 750 from either the corona shielding 740 or the probes 715a, 715b and 730.

**[0053]** Outer shell 750 is a semi-conducting material and is typically coupled to ground so that any stray charges that are transmitted to the outer shell 750 are discharged to ground. By grounding stray charges, outer shell 750 offers additional protection for the busbar system and the individuals who service it. Three-way connector 760 also includes corona shielding 790, an insulative material 795, and an outer shell 797. These elements are made of similar materials and perform similar functions to the corresponding elements of three-way connector 710. One difference between connector 710 and connector 760 is the physical dimensions of the insulative materials and outer shells around probe

730 and female finger contact 780. In particular, the insulative material 745 and outer shell 750 surrounding probe 730 have openings that are wide enough to accept the insulative material 795 and the outer shell 797 surrounding the female finger contact 780 (represented by the overlapping hash marks of 745 and 795 in FIG. 7). By sizing the insulative materials and outer shells in this way, the two three-way connectors can be coupled together with a friction fit between the insulative material 745 and the outer shell 750 of three-way connector 710 and the insulative material 795 and the outer shell 797 of three-way connector 760. It should be noted that the coupling of probe 730 to female finger contact 780 also aids in the coupling of connector 710 to connector 760.

**[0054]** Connections to elements external to busbar 505 are made through the reception points w, x, y and z in insulative materials 745 and 795 and outer shells 750 and 797. Exemplary connections to busbar 505 are to push the probes 715a, 715b, 765a and 765b onto bushings. The bushings include female finger contacts that are similar in structure to female finger contact 780 and are configured to accept the probes 715a, 715b, 765a and 765b. Thus, a connection between a bushing and busbar 505 is similar to the connection between three-way connectors 710 and 760. It should be noted that alternative implementations of busbar 505 use mechanical connections instead of any of the five push-on connections described. For example, probe 730 could be left off of threaded stud 720 and a conductive member with internal threads could be used to replace female finger contact 780. Leg 710 would be joined to leg 760 by turning the threaded stud 720 and the conductive member with respect to each other. Similarly, probes 715a, 715b and 765b could be removed leaving threaded studs 725 and 775 to accept internal threads of a conductive member for mechanical connections. Thus, the busbar 505 could be manufactured with all push-on connections, all mechanical connections or a combination of both.

**[0055]** It should be noted that while elements 720, 730, 770 and 780 are shown in FIG. 7 as separate parts, in alternative implementations these separate parts could be manufactured as a single, integral part.

**[0056]** FIG. 9 shows another implementation of busbar 505. The conductive elements are the same as previously described. However, instead of

surrounding each of the three-way connectors with its own separate corona shield, insulative material and outer shell as previously described, legs 710 and 760 are coupled together and then encapsulated in one corona shield 910, one insulative material 915 and one outer shell 920.

**[0057]** FIG. 9 also shows how busbar 505 can be oriented to place connection points in different planes. That is, a first set of connection points represented by probes 765a and 765b is in a different plane than a second set of connection points represented by probe 715a and 715b. This allows for the active switching elements to be oriented in different ways within the switchgear.

**[0058]** FIGS. 10 and 11 show another implementation of busbar 505. In this implementation, a single two-way connector 1030 includes threaded studs 1040 and 1050 that are connected, respectively, to three-way "Y" connectors 1010 and 1020, which are similar to connector 710 of FIG. 7. One such exemplary two-way connector 1030 is the 600 A connection plug manufactured by Cooper Power Systems. A description of this connection plug is provided in Cooper Power System's "Molded Rubber Products 600-46," the disclosure of which is incorporated by reference.

**[0059]** In this implementation, three separate components are assembled together to form the busbar 505. Two of the components of busbar 505 are the three-way "Y" connectors 1010 and 1020. Three-way connector 1010 receives a threaded stud 1012 and probes 1014 and 1016 that thread onto threaded stud 1012. Similarly, three-way connector 1020 receives a threaded stud 1022 and probes 1024 and 1026 that thread onto threaded stud 1022.

**[0060]** The third piece of the busbar 505 is the two-way connector 1030, which includes two internal sets of threads, with one on each end of a conductive rod. One set of threads is shown in FIG. 11. These threads receive threaded studs 1040 and 1050, which include, respectively, eyes 1040a and 1050a. Threaded studs 1012 and 1022 pass through eyes 1040a and 1050a, respectively. Probes 1014, 1016, 1024 and 1026 are tightened onto threaded studs 1012 and 1022 so as to engage threaded studs 1040 and 1050 and thereby complete the electrical connections. It should be noted that alternative

implementations of the busbar 505 shown in FIG. 10 include removing any of the probes 1014, 1016, 1024 and 1026 and using conductive members with internal threads to make mechanical connections to the various active switching elements (not shown).

**[0061]** FIG. 12 shows another implementation of busbar 505. Busbar 505 includes three components 1010, 1020 and 1290. Components 1010 and 1020 were described with respect to FIG. 10. It should be noted that the probes 1014, 1016, 1024 and 1026 and the threaded studs 1012 and 1022 shown in FIG. 10 are included in the busbar 505 of FIG. 12 but are not shown in FIG. 12. Threaded studs 1040 and 1050 are surrounded by corona shields 1205a and 1205b, respectively, which in turn, are surrounded by insulative materials 1210a and 1210b, respectively. Insulative materials 1210a and 1210b are surrounded by semi-conducting shells 1215a and 1215b, respectively. In general, these elements may be made of the same materials and perform the same functions as previously described.

**[0062]** The exemplary two-way connector 1290 shown in FIG. 12 includes two female finger contacts 1240a and 1240b threaded into a conductive base 1270. A variation of this element could include only one finger contact (1240a or 1240b) and a longer conductive base. These female finger contacts are coupled to probes 1245a and 1245b, which are threaded onto threaded studs 1040 and 1050, respectively. Corona shields 1260 and 1250 surround the finger contacts 1240a and 1240b, respectively, and the probes 1245a and 1245b. The corona shields 1260 and 1250 are surrounded by insulative material 1255 and a semi-conducting shell 1280. Corona shields 1260 and 1250, insulative material 1255 and shell 1280 maybe made of the materials previously noted and may function as previously described. The busbar 505 shown in FIG. 12 is assembled by pushing the probes 1245a and 1245b of connectors 1010 and 1020, respectively, into the female finger contacts 1240a and 1240b of two-way connector 1290.

**[0063]** FIG. 13 illustrates another exemplary busbar system. The descriptions of busbars 510 and 515 were previously provided in relation to the description of FIG. 5. Busbar 1300 is constructed of four standard three-way connectors 1305, 1310, 1315 and 1320 and two cables 1325 and 1330. Three-

way connectors 1305 and 1310 are coupled to cable 1325, and three-way connectors 1315 and 1320 are coupled to cable 1330. The structure of the three-way connectors and the connections between the three-way connectors and the cables are similar to those previously described. Three-way connector 1310 is coupled to three-way connector 1315 by two-way connector 1030, a threaded stud, or equivalent connecting device (not shown). Three-way connectors 1305, 1310, 1315 and 1320 may be implemented using the Bol-T connectors, catalog number 600-30 and 600-50 manufactured by Cooper Power Systems, the specifications of which are incorporated herein by reference.

**[0064]** Several observations can be made regarding the various implementations of the busbar system. For example, the busbar system is both modular and can be made from standard parts. That means that an individual can assemble a busbar by simply cutting cables to the appropriate length and connecting those cables to the three-way connectors. This differs from conventional busbar systems that include large copper or other metallic bars that must be formed or bent into a particular shape. The modularity provided by this busbar system allows for easy manufacture of multiple configurations of switchgear. In addition, some of the parts used to construct the busbar system are standard parts. More specifically, the threaded studs, probes and female finger contacts are used in other connectors (i.e., in the connectors used to connect the cables to the bushings on the switchgear). This means that a busbar system may be assembled using standard parts. In addition, this means that a manufacture can maintain a lower inventory of the types and total numbers of the parts for manufacturing busbars and switchgears because the modularity of the parts allows for greater interchangeability. Furthermore, having modular and interchangeable parts, for example connectors for fuses and switching elements that are of the same type, means that it is easier and faster to replace one type of part with another, such as replacing a switch with a fuse.

**[0065]** This interchangeability makes it easier for distributors and manufacturer to make minor modifications to the switchgear to satisfy particular requirements. This interchangeability also means that it is easier and faster for a person conducting maintenance on a switchgear in operation to replace active

switching elements if they fail or need to be maintained with a new version of the same switching element previously installed or another type of switching element. In addition, by standardizing many of the connectors for the components of the switchgear, a manufacturer, distributor or maintenance person can take a completed switchgear and remove a switching unit that is connected to one of the busbars, replace the switching unit with another multi-connector attached to the busbar, such as a three-way bus connector, and add additional switching components to the busbar and switchgear without having to start the switchgear manufacturing process from scratch. The same process could be completed several times to add substantially more switching elements as desired or required. In addition if a specification is received that does not match the switchgear that is on hand, the switch gear can be disassembled by disconnecting the switching elements from the busbar and a support structure inside of the switchgear. In addition, if necessary, the busbars can be disassembled by disconnecting the connectors from the cables and reconfiguring the busbars and switching elements to cover a span and orientation that satisfies the specification without having to make another switchgear with an entirely different set of parts, thereby reducing waste and improving the flexibility with regards to specifications of each switchgear. These changes can be made in the field, at a sales site (such as a distributor) or at the manufacturing site.

**[0066]** Furthermore, the exemplary switchgear is configurable repairable and upgradeable. Consistent interfaces, dimensions and modularity across several of the components, such as buses, fuses, switches, and interrupters, make standardization possible independent of the particular specifications or each use. The components are interchangeable, replaceable and upgradeable, providing flexibility in design, modification, maintenance, and operation. The standardization and modularity of the components makes equipment repair, replacement, or upgrading simpler, faster, and less costly and reduces inventory requirements of the manufacturer, distributor and owner of parts for manufacturing or replacement. Furthermore, standardization of switches, fuses, interrupters and bus components across multiple voltage classes adds flexibility in the design and operation of the switchgears. The consistency reduces

installation costs and, when combined with shorter lead-times, reduces inventory costs as well.

**[0067]** As an example, switchgear may be built to fit a new specification or as a retrofit to replace existing switchgear. In general, existing switchgear is designed earlier with specific dimensions, such as height, width and depth, as well as the number of ways on the switchgear and location and spacing (i.e., distance) between the bushings on the front plates of the switchgear and orientation of the bushings to one another (i.e., a straight horizontal line as shown in FIGS. 1 and 2), all of which provide at least a portion of what is called a switchgear's specification. The new switchgear is manufactured either to fit into a new space, in which the specification is created anew, or to replace existing switchgear, in which case the specifications of the existing switchgear are determined by either taking measurements of the existing switchgear or by reading the data from the existing switchgear's associated data sheet. In either case, the manufacturer receives the specification and begins assembling the switchgear by collecting the first set of modules needed to build the first busbar of the busbar system for carrying one phase of power.

**[0068]** As an example, if the first busbar is busbar 1300 of FIG. 13, the manufacturer would collect four connectors (1305, 1310, 1315 and 1320) and two cables 1325 and 1330 of appropriate length, based upon the received specifications, as a first set of modules and couple these modules so as to form busbar 1300. Active switching elements are then coupled to the busbar. The type of active switching elements (e.g., fuse or switch) is determined by the received specification. The active switching elements are then mounted onto a frame so that a portion of each active switching element, for example a bushing, protrudes towards an exterior working space of the new switchgear, as previously described. After all of the required busbars have been mounted, the internal space defined by the outer shell that encompasses the busbar system and the active switching elements is left with air surrounding the busbar system and active switching elements as opposed to other pieces of switchgear that may use oil or SF<sub>6</sub> to further insulate the busbars from each other, the active switching elements, and the outer shell. The semiconductor shields on the busbar

and active switching elements are then coupled to a point on the switchgear that is later coupled to ground upon installation of the switchgear so as to make the switchgear completely deadfront. It should be noted that these steps may be performed in an alternative order depending on the specification of the switchgear as well as the manufacturer's capabilities.

**[0069]** Similarly, if a second busbar is needed for the new switchgear, the manufacturer collects the modules needed and assembles them into the second busbar. For example, if the second busbar requires the reception points (the points on the busbar where the busbar is coupled to the active switching elements) to be further apart than on the first busbar, the manufacturer collects two connectors and a longer cable into a second set of modules. These modules would then be assembled to form a second busbar, like busbar 505, 510 or 515 in FIG. 5, and coupled to the frame. If a third busbar is required by the specifications, the manufacturer collects the required modules and assembles them into the third busbar and coupled to the frame. It should also be noted that other busbar systems can be built using any of the busbars shown in FIGS. 5 and 7-12 instead of the busbar 1300 shown in FIG. 13 as previously described. It should also be noted that alternative switchgear may be manufactured such that the space inside the outer shell of the switchgear is filled with an insulator other than air (e.g., EPDM).

**[0070]** It should be noted that the orientation of the bushings on the exterior of the new switchgear need not be limited to the horizontal line shown in FIGS. 1 and 2. For example, the new switchgear may have the bushings oriented in a straight vertical line, a sloping line, or multiple lines, may be co-planar or non-co-planar, and may even have the bushings on different exterior surfaces of the switchgear. As an example, the new switchgear may have some bushings mounted on a front-plate, as shown in FIGS. 1 and 2, and have some other bushings mounted onto the top surface of the switchgear (this surface not shown in FIGS. 1 and 2).

**[0071]** The modularity of the busbar system allows for multiple configurations of the switchgear. For example, the bushings on the switchgear do not need to be in a line as shown in FIGS. 1 and 2. The modularity allows for

busbars, and therefore switchgear, to be manufactured so that the bushings can be oriented anywhere along either of the two front plates or the frame of the switchgear. In addition to the various orientations of the bushings to each other, the spacing between the bushings can be similarly varied. The modularity of the busbar system allows for the bushings to be placed closer or further apart, depending on the needs of the customer. Similarly, the number of bushings is not limited to the number of bushings described in FIGS. 1 and 2. That is, a busbar system can easily be manufactured to accommodate any number of bushing on the switchgear. Similarly, busbar systems and associated switchgear may be created to support a single source and single tap system. Other configurations may support three or more source and tap systems.

**[0072]** Also, a busbar 505 can be assembled in multiple ways using the parts at hand. For example, the three-way connector 710 in FIG. 7 is identical to the three-way connector 1010 in FIG. 10. Thus, a maintenance or operating person who is replacing the busbar 505 can use parts on hand to make either the busbar 505 shown in FIG. 7 or 10 or the busbar 1300 shown in FIG. 13. Also, by using probes and finger contacts, busbar 505 is push-on connectable. This means that the assembly, maintenance or operating person does not need to use wrenches to disconnect the active switching elements from the busbar system.

**[0073]** In addition, the busbar systems of FIGS. 5-13 provide additional safety beyond conventional busbar systems. Implementations that include a semi-conductive outer shell coupled to ground prevent the area surrounding the busbar systems from collecting stray charge that could damage the components or harm a person who may make incidental contact with the switchgear. In these types of implementations, the construction of the switchgear can be modified. That is, in conventional dead-front switchgear, the switchgear includes a container that is made of a conductive outer shell. The front plates form a part of this container. However, in implementations where the semi-conductive outer shells of the components of the busbar system are coupled to ground, there is no need for the outer container to be part of the switchgear and coupled to ground. The busbar and active switching element(s) system themselves are deadfront such that the switchgear does not need an external container coupled to ground.

In such implementations, the dead front busbar system may be surrounded with solid insulation to protect it and avoid contamination, and the metal container of the convention switchgear is not used. Thus, by making the busbar system itself dead front, switchgear can be developed where the outer container or outer surface of the switchgear need not be coupled to ground, yet the switchgear is still dead front.

**[0074]** The busbar system shown in FIGS. 5-13 may be implemented in any type of switchgear, such as those that use, SF.sub.6 or air as insulation. In certain implementations, the busbar systems of FIGS. 5-13 are implemented in switchgear containing solid insulation. One type of solid insulation is ethylene propylene diene monomer (EPDM) rubber. This solid insulation has a higher dielectric strength constant than oil, air or SF.sub.6, which means that a certain amount of solid insulation provides more insulation between the busbars than the same amount of oil, SF.sub.6 or air. By using materials with stronger dielectric constants, the various busbars 505 or 1300 and 510 and 515 can be placed close together such that the overall size of the switchgear can be reduced.

**[0075]** Switchgear containing solid insulation attributes provides several advantages over conventional switchgear. First, switchgear made with solid insulation can be made smaller than conventional switchgear, which allows the switchgear to be installed in a less conspicuous manner. It should be noted that switchgear using solid insulation need not be made smaller, but can be manufactured to the same size as conventional switchgear to allow for older switchgear to be replaced on the same mounting surface without having to, for example, pour new concrete slabs or, more significantly, to realign or lengthen (by splicing) or replacing underground cables to get them to connect to the new bushing locations on the new piece of switchgear.

**[0076]** The combination of the modularity of busbars 505, 1300, 510 and 515 and the insulative properties of solid insulation allow for the inexpensive and fast construction of new switchgear with dimensions smaller than conventional switchgear.

**[0077]** Figure 14 is a logical flowchart diagram illustrating an exemplary method 1400 for repairing a switching element in a switchgear having modular components according to one exemplary embodiment of the present invention. Now referring to Figure 14, the exemplary method 1400 begins at the START step and proceeds to step 1405, where a switchgear is provided for repair. In one exemplary embodiment, the switchgear is at its site of operation and is currently in use. In step 1410, a maintenance person determines if any of the active switching elements needs to be repaired, replaced or modified. In one exemplary embodiment, the active switching elements include fuses, switches and interrupters. In step 1412, the cable is detached from the first end of the active switching element to be repaired, replaced or modified. The switching element to be replaced is detached from the support structure of the switchgear in step 1415. In one exemplary embodiment, the support structure may include the frame of the switchgear, the outer protective shell of the switchgear, or a structural body inside of the switchgear.

**[0078]** In step 1420, a switching element needing to be replaced is detached from the busbar. In step 1425, the switching element is replaced by coupling a new switching element to the busbar and the support structure. In one exemplary embodiment, the new switching element is coupled to a connector of the busbar. In another exemplary embodiment, the type of switching element may be changed as well. For example, a fuse may be removed and a switch may be put back in the position the fuse previously occupied. In step 1430, the cable is reattached to the switching element. The exemplary method then continues to the END step.

**[0079]** Figure 15 is a logical flowchart diagram illustrating an exemplary method 1500 for modifying the organization or arrangement of components in a switchgear having modular components according to one exemplary embodiment of the present invention. Now referring to Figure 15, the exemplary method 1500 begins at the START step and proceeds to step 1505, where an operating switchgear having at least one busbar and a plurality of switching elements attached to a portion of the connectors is provided. In one exemplary embodiment, the busbar may include cable and a multiple connections or may

include a solid busbar. In step 1507, the cable connection is removed from the first end of the switch element. In step 1510, the switching element can further be detached from the support structure in the switchgear.

**[0080]** In step 1515, one of the switching elements is detached from one of the connectors on the busbar. The switchgear configuration is modified to provide additional connection points in step 1520. In one exemplary embodiment, the first and second connectors are three-way connectors; however, other types of connectors having two or more connection points may be used within the scope of the current exemplary embodiment. In one exemplary embodiment, the connector is typically replaced with another connector having at least one more way. In step 1525, switching elements or additional connectors are coupled to the open connection points of the second connector. The additional switching elements are coupled to the support structure of the switchgear in step 1530. In step 1535, a connection between the cable and the other end of the active switching element is made. The method then continues to the END step.

**[0081]** Figure 16 is a logical flowchart diagram illustrating an exemplary method 1500 for making a switchgear having modular components according to one exemplary embodiment of the present invention. Now referring to Figure 16, the exemplary method 1600 begins at the START step and proceeds to step 1605, where a first leg of a busbar having multiple connection points is provided. In step 1610, a second leg of a busbar having multiple connection points is provided. The first leg is coupled to the second leg by coupling together one of the connection points of each leg to one another in step 1615.

**[0082]** In step 1620, standardized connections are provided at each coupling point for each of the connection points to reduce inventory of connection types. The reduction in inventory may occur at the manufacturer, a sales site, or for the eventual owner of the switchgear. In one exemplary embodiment, the connection types may include push-on connectors, probe and female contact connectors, and mechanical connections, and a threaded stud and conductive member with internal threads connection, as well as other connection types known to those of ordinary skill in the art. At least one active switching element is

coupled to one of the remaining connection points on the first or second leg and includes a coupling made up of the standardized connection in step 1625. The method continues to the END step.

**[0083]** Figure 17 is a logical flowchart diagram illustrating an exemplary method 1700 for reconfiguring the organization or arrangement of components in a switchgear having modular components according to one exemplary embodiment of the present invention. Now referring to Figure 17, the exemplary method 1700 begins at the START step and proceeds to step 1705, where a completed switchgear having at least one busbar made up of connectors and cables and a plurality of switching elements attached to a portion of the connectors is provided. In step 1710, specifications for a new switchgear or a switchgear needing replacement are received. The number of switching elements is modified for the completed switchgear based on the specification requirements in step 1715. In one exemplary embodiment, the number of switching elements may be increased or decreased as needed.

**[0084]** In step 1720, one or more of the busbars may be partially or entirely broken down into its component parts. In one exemplary embodiment, the component parts of the busbar may include cables and connectors. The broken-down busbars are modified so as to include at least one more or less way in step 1725. In step 1730, the switching elements, which may include a fewer or greater amount of switching elements and different types of switching elements than in the original switchgear, are coupled to the modified busbars and the support structure of the switchgear as needed. The process continues to the END step.

**[0085]** Many alternative implementations to the implementations previously described also may be made. For example, instead of using push-on connections (e.g., probes and female finger contacts), the connections to the various busbars may be made using mechanical connections. While this variation makes replacing parts of the switchgear much more difficult as the technician or assembler must screw and unscrew replacement parts from the busbars, this alternative busbar system still uses modular parts that allow for quick and easy assembly of individual busbars.

**[0086]** Another alternative includes reversing the relative positions of the probes with the female finger contacts. That is, instead of mounting bushings that include female finger contacts onto the active switching elements and probes into the connectors of the busbars, an alternative implementation mounts probes onto the active switching elements and the female finger contacts onto the connectors of the busbars.

**[0087]** While probes, threaded studs and female finger contacts are typically made of copper and copper alloys, it is also known that other metals, alloys or compounds may be used to form the conductive components of the busbar system. In addition, while the general shapes of the female finger contacts and probes are cylindrical, other geometrical shapes are possible. It is also understood that the probes, female finger contacts and threaded studs described herein may be of various sizes that may or may not comply with industry, voluntary, international or otherwise accepted standards. The busbar system described herein also allows for flexibility in orienting the plane or planes of the bushings. That is, switchgear 100 shown in FIGS. 1 and 2 has its bushings (covered by connectors 114a-114b and 214a-214f) in a plane parallel to the pad on which the switchgear 110 rests. The busbar system shown in FIGS. 5 and 13 do not necessarily have to have co-planar, and horizontal, busbars.

**[0088]** Also, the busbars of the various busbar systems of FIGS. 5-13 do not require corona shielding, insulation and outer shells. In these implementations, just the conductive elements are used to assemble the various busbars. The busbars are then encapsulated in air, oil or SF<sub>6</sub> insulation inside the switchgear.

**[0089]** While the implementations described above are for 4W connections, it should be understood that other implementations are possible. For example, threaded stud 770 could have a second set of threads attached to the eye and extending to the right of the figure. This extension of threads would accept a female finger contact to then accept a third leg to make a 6W busbar. Similarly, busbar 505 could accept a third leg, identical to leg 760, that is coupled to probe 765 to create a 5W busbar. This 5W busbar implementation emphasizes the modularity of the system and the interconnectability of standard parts to

design a busbar of any size, as well as the flexibility in orientation of the planes of connections.

**[0090]** Other implementations of the busbars themselves are also possible with the components and techniques described herein. For example, other types of connectors, such as a two-way connection, are also possible. Referring again to FIG. 7, leg 710 can be modified to make a two-way connector by eliminating threaded stud 720, the probe 730 and the associated protrusion of corona shield 740, insulation 745 and protective sheathing 750. Threaded stud 725 is secured inside leg 710. One way of securing threaded stud 725 into leg 710 is to have insulation around the center portion of threaded stud 725 so as to form a friction fit with the remaining elements of this modified leg 710. Once secured, the probes 715a and 715b are threaded onto the threaded stud 725. This two-way connector can be used as a busbar by coupling two active switching elements to probes 715a and 715b. It should also be noted that this two-way connector may use two mechanical connections or female finger contacts instead of the probes previously described. In addition, the two-way connector may have one mechanical connection and one push-on connection. It should also be noted that the two-way connector 1030 of FIG. 10 and the two-way connector 1290 of FIG. 12 could also be implemented, without the three-way connectors 1010 and 1020, as busbars. It should be noted that the these busbars using only a two-way connector may be implemented using two mechanical connections, two push-on connections or one of each.

**[0091]** In one exemplary embodiment, a method of repairing a switching element in a switchgear has been described that includes: providing a switchgear in operation at an operating site the switchgear comprising: a support structure; an active switching element coupled to the support structure, the active switching element comprising: an internal active component; and an external point of connection; a busbar coupled to the active switching element, the busbar comprising a cable and a connector coupled to the first end of the cable and to the external point of connection of the active switching element; determining that the active switching element needs to be replaced; and replacing the active switching element with a replacement switching element. In another exemplary

embodiment, replacing the active switching element comprises: decoupling a semiconductor shield of the active switching element from an electrical ground on the switchgear; decoupling the active switching element from the support structure; decoupling the external point of connection for the active switching element from the connector on the busbar; coupling another external point of connection for the replacement switching element to the connector of the busbar; and coupling the replacement switching element to the support structure. In another exemplary embodiment, the internal active component of the active switching element is a switch. In another exemplary embodiment, the internal active component of the active switching element is a fuse. In another exemplary embodiment, the internal active component of the active switching element is an interruptor. In another exemplary embodiment, the external point of connection for the active switching element is a bushing. In another exemplary embodiment, the external point of connection for the active switching element and the replacement switching element are the same. In another exemplary embodiment, the switchgear further comprises: a plurality of active switching elements, each switching element coupled to the support structure and comprising: an internal active component; and an external point of connection; wherein each external point of connection for each switching element is substantially identical; and wherein the busbar further comprises a plurality of connectors for coupling to the external point of connection for the switching elements, each connector capable of coupling to each of the external points of connection. In another exemplary embodiment, the connector comprises a push-on connection point for coupling to the active switching element and replacement switching element. In another exemplary embodiment, connector comprises a mechanical connection point for coupling to the first active switching element.

**[0092]** In one exemplary embodiment, a method of adding additional switching elements to a switchgear has been described that includes the steps of providing a switchgear in operation at an operating site the switchgear comprising: a support structure; an active switching element coupled to the support structure, the active switching element comprising: an internal active component; and an external point of connection; a busbar coupled to the active switching element, the busbar comprising a cable and a connector coupled to the

first end of the cable and to the external point of connection of the active switching element; decoupling the active switching element from the busbar by terminating the connection between the connector and the external point of connection; coupling a second connector to the connector at the same position that the active switching element was coupled to the connector, wherein the second connector comprises at least three connection points and wherein the first connection point is coupled to the connector; coupling the active switching element to a second connection point of the second connector; and providing at least one additional active switching element, each switching element coupled to one of the connection points of the second connector. In another exemplary embodiment, the second connector is a three-way connector. In another exemplary embodiment, the second connection is coupled to the connector by way of a push-on connection. In another exemplary embodiment, the coupling of each of the active switching elements to the connection points of the second connector comprises a push-on connector.

**[0093]** In another exemplary embodiment, a switchgear has been described that includes a support structure; a bushing having a first end and a second end, the first end coupled to the support structure; an active switching element having a first and a second end, the first end coupled to the second end of the bushing, wherein the active switching element comprises: an internal active component; and a second connection point; a busbar coupled to the second end of the active switching element, the busbar comprising a cable and a connector coupled to the first end of the cable and to the second end of the active switching element, wherein each coupling comprises a standardized connection, whereby the use of standardized connections reduces the inventory of connections for manufacturing the switchgear. In another exemplary embodiment, the standardized connection comprises one of the connection points comprising a probe and another connection point comprising a female finger contact. In another exemplary embodiment, the standardized connection comprises one of the connection points comprising a threaded stud and another connection point comprising a conductive member with internal threads. In another exemplary embodiment, the standardized connection comprises a push-on connection.

**[0094]** In one exemplary embodiment, a method of manufacturing a switchgear has been described that includes a busbar comprising: providing a first leg comprising: a first connection point; a second connection point; a third connection point; providing a second leg comprising: a fourth connection point; a fifth connection point; a sixth connection point; wherein the first leg is coupled to the second leg by coupling the first and fourth connection point and wherein the connection of any two of the connection points comprises a standardized connection, whereby the use of standardized connections reduces the inventory of connections for manufacturing the switchgear. In another exemplary embodiment, the standardized connection comprises one of the connection points comprising a probe and another connection point comprising a female finger contact. In another exemplary embodiment, the standardized connection comprises one of the connection points comprising a threaded stud and another connection point comprising a conductive member with internal threads. In another exemplary embodiment, the standardized connection comprises a push-on connection. In another exemplary embodiment, the switchgear further comprises an active switching element coupled to one of the connection points, the coupling of the active switching element and the connection point comprising the standardized connection. In another exemplary embodiment, the switchgear further comprises a support structure, wherein the active switching element is coupled to the support structure, the coupling of the active switching element to the support structure comprising the standardized connection.

**[0095]** In one exemplary embodiment, a method of modifying a switchgear has been described that includes the steps of providing a switchgear comprising: a support structure; an first active switching element coupled to the support structure; a busbar coupled to the active switching element, the busbar comprising a cable and a connector coupled to the first end of the cable and to the first active switching element; decoupling the first active switching element from the support structure and the busbar; and coupling a second active switching element to the support structure and the busbar. In another exemplary embodiment, the first active switching element comprises a switch and the second active switching element comprises a fuse. In another exemplary embodiment, the first active switching element comprises a fuse and the second

active switching element comprises a switch. In another exemplary embodiment, the first active switching element comprises a switch and the second active switching element comprises a breaker unit. In another exemplary embodiment, the switchgear is positioned at an operating site.

**[0096]** In another exemplary embodiment, a method of reconfiguring a switchgear has been described that includes the steps of providing a first switchgear comprising: a support structure; a plurality of active switching elements coupled to the support structure, each active switching element comprising: an internal active component; and an external point of connection; at least one busbar, each busbar coupled to at least one of the active switching elements, each busbar comprising a cable and at least one connector, a portion of the connectors coupled to the first end of the cable and to at least one of the active switching elements; receiving specifications for a second switchgear, the second switchgear comprising a different configuration than the first switchgear; decoupling at least a portion of the active switching elements from the support structure and one of the busbars; and modifying the switchgear by coupling a new portion of switching elements to the support structure and at least one of the busbars in accordance with the specifications, the new portion of switching elements replacing the decoupled active switching elements. In another exemplary embodiment, the method further includes decoupling at least one of the busbars; and reconfiguring the decoupled busbar in accordance with the specifications. In another exemplary embodiment, reconfiguring the busbar comprises modifying the position of at least one of the connectors. In another exemplary embodiment, reconfiguring the busbar comprises adding additional connectors to the busbar. In another exemplary embodiment, the reconfiguration occurs at a sales site. In another exemplary embodiment, each couple comprises a standardized connection, whereby the use of standardized connections reduces the inventory of connections for modifying the switchgear. In another exemplary embodiment, the standardized connection comprises one of the connection points comprising a probe and another connection point comprising a female finger contact. In another exemplary embodiment, the standardized connection comprises one of the connection points comprising a threaded stud and another connection point comprising a conductive member

with internal threads. In another exemplary embodiment, the standardized connection comprises a push-on connection.

**[0097]** In one exemplary embodiment, a deadfront switchgear has been described that includes a surface; a first active switching element coupled to the surface; and a first bus bar coupled to the first active switching element, the first bus bar comprising a conductive material surrounded by solid insulation and by a semi-conducting shield.

**[0098]** In one exemplary embodiment, a high voltage busbar has been described that includes a first leg comprising: a first connection point; a second connection point; and a third connection point; a second leg comprising: a fourth connection point; a fifth connection point; and a sixth connection point; wherein the first leg is coupled to the second leg by coupling the first and fourth connection points together.

**[0099]** In one exemplary embodiment, a method of assembling a switchgear has been described that includes the steps of providing a surface of the switchgear; coupling a first active switching element to the surface; and coupling a first bus bar comprised of a first conductive material surrounded by first insulation and a first semi-conducting shield to the first active switching element.

**[00100]** In one exemplary embodiment, a method of repairing a switching element in a switchgear has been described that includes the steps of providing a switchgear in operation at an operating site the switchgear comprising: a support structure; a plurality of active switching elements, each switching element coupled to the support structure and comprising: a switch; and an external point of connection; wherein each external point of connection for each switching element is substantially identical; and a busbar coupled to the active switching element, the busbar comprising a cable and a plurality of connectors for coupling to the external point of connection for the switching elements, each connector comprising a push-on connection capable of coupling to each of the external points of connection for the active switching elements; determining that the active switching element needs to be replaced; and

replacing the active switching element with a replacement switching element, wherein replacing the active switching element comprises: decoupling a semiconductor shield of the active switching element from an electrical ground on the switchgear; decoupling the active switching element from the support structure; decoupling the external point of connection for the active switching element from the connector on the busbar; coupling another external point of connection for the replacement switching element to the connector of the busbar; and coupling the replacement switching element to the support structure.

**[00101]** In one exemplary embodiment, a method of reconfiguring a switchgear has been described that includes the steps of providing a first switchgear comprising: a surface; a plurality of active switching elements coupled to the surface, each active switching element comprising: an internal active component; and an external point of connection; at least one busbar, each busbar coupled to at least one of the active switching elements, each busbar comprising: a first leg comprising: a first connection point; a second connection point; a third connection point; and a second leg comprising: a fourth connection point; a fifth connection point; and a sixth connection point; a first insulation surrounding the first, second, and third connection points; a first semiconductor shield surrounding the first insulation; a second insulation surrounding the fourth, fifth and sixth connection points; and a second semiconductor shield surrounding the second insulation; wherein the first leg is coupled to the second leg by coupling the first and fourth connection points together; at least connection point comprising a push-on connection point, a portion of the connection points coupled to at least one of the active switching elements; receiving specifications for a second switchgear, the second switchgear comprising a different configuration than the first switchgear; decoupling at least a portion of the active switching elements from the support structure and one of the busbars; decoupling at least one of the busbars; reconfiguring the decoupled busbar in accordance with the specifications; and modifying the switchgear by coupling a new portion of switching elements to the support structure and at least one of the busbars in accordance with the specifications, the new portion of switching elements replacing the decoupled active switching elements.

**[00102]** Other implementations are within the scope of the following claims.

**WHAT IS CLAIMED IS:**

1. A method of repairing a switching element in a switchgear comprising the steps of:  
providing a switchgear comprising:  
a support structure;  
an active switching element coupled to the support structure, the active switching element comprising:  
an internal active component; and  
an external point of connection;  
a busbar coupled to the active switching element, the busbar comprising at least one connector;  
determining that the active switching element needs to be replaced; and  
replacing the active switching element with a replacement switching element.
2. The method of claim 1 wherein replacing the active switching element comprises:  
decoupling a cable from the active switching element;  
decoupling the active switching element from the support structure;  
decoupling the external point of connection for the active switching element from the connector on the busbar;  
coupling another external point of connection for the replacement switching element to the connector of the busbar;  
coupling the replacement switching element to the support structure; and  
coupling the replacement switching element to the cable.
3. The method of claim 1, wherein the internal active component of the active switching element is a switch.
4. The method of claim 1, wherein the internal active component of the active switching element is a fuse.
5. The method of claim 1, wherein the internal active component of the active switching element is an interrupter.

6. The method of claim 1, wherein the external point of connection for the active switching element and the replacement switching element are the same.

7. The method of claim 1, wherein the switchgear further comprises:

a plurality of active switching elements, each switching element coupled to the support structure and comprising

an internal active component; and

an external point of connection;

wherein each external point of connection for each switching element is substantially identical; and

wherein the busbar further comprises a plurality of connectors for coupling to the external point of connection for the switching elements, each connector capable of coupling to each of the external points of connection.

8. The method of claim 1, wherein the connector comprises a mechanical connection point for coupling to the first active switching element.

9. A method of adding additional switching elements to a switchgear comprising the steps of:

- providing a switchgear comprising:
  - a support structure;
  - an active switching element coupled to the support structure, the active switching element comprising:
    - an internal active component; and
    - an external point of connection;
  - a busbar coupled to the active switching element, the busbar comprising a plurality of connection points;
- decoupling a cable from a first end of the active switching element;
- decoupling a second end of the active switching element from the busbar;
- modifying the busbar to comprise additional connection points;
- coupling the active switching element to the busbar comprising additional connection points; and
- providing at least one additional active switching element, each switching element coupled to one of the additional connection points of the busbar; and
- coupling a cable to at least one of the active switching elements.

10. A switchgear comprising:

- a support structure;
- a bushing having a first end and a second end, the first end coupled to the support structure;
- an active switching element having a first and a second end, the first end coupled to the second end of the bushing, wherein the active switching element comprises:
  - an internal active component; and
  - and a second connection point;
- a busbar coupled to the second end of the active switching element, the busbar comprising a cable and a connector coupled to the first end of the cable and to the second end of the active switching element, wherein each coupling comprises a standardized connection, whereby the use of standardized connections reduces the inventory of connections for manufacturing the switchgear.

11. A method of manufacturing a switchgear comprising:  
a busbar comprising:

providing a first leg comprising:

- a first connection point;
- a second connection point;
- a third connection point;

providing a second leg comprising:

- a fourth connection point;
- a fifth connection point;
- a sixth connection point;

wherein the first leg is coupled to the second leg by coupling the first and fourth connection point and wherein the connection of any two of the connection points comprises a standardized connection, whereby the use of standardized connections reduces the inventory of connections for manufacturing the switchgear.

12. The method of claim 11, wherein the standardized connection comprises one of the connection points comprising a probe and another connection point comprising a female finger contact.

13. The method of claim 11, wherein the switchgear further comprises an active switching element coupled to one of the connection points, the coupling of the active switching element and the connection point comprising the standardized connection.

14. A method of modifying a switchgear comprising the steps of:  
providing a switchgear comprising:  
a support structure;  
an first active switching element coupled to the support structure;  
a busbar coupled to the active switching element, the busbar  
comprising a cable and a connector coupled to the first end of the cable and to the  
first active switching element;  
decoupling the first active switching element from the support structure and  
the busbar; and  
coupling a second active switching element to the support structure and the  
busbar.

15. A method of reconfiguring a switchgear comprising the steps  
of:  
providing a first switchgear comprising:  
a support structure;  
a plurality of active switching elements coupled to the support  
structure, each active switching element comprising  
an internal active component; and  
an external point of connection;  
at least one busbar, each busbar coupled to at least one of the active  
switching elements, each busbar comprising a cable and at least one connector, a  
portion of the connectors coupled to the first end of the cable and to at least one of  
the active switching elements;  
receiving specifications for a second switchgear, the second switchgear  
comprising a different configuration than the first switchgear;  
decoupling at least a portion of the active switching elements from the  
support structure and one of the busbars; and  
modifying the switchgear by coupling a new portion of switching elements to  
the support structure and at least one of the busbars in accordance with the  
specifications, the new portion of switching elements replacing the decoupled  
active switching elements.

16. The method of claim 15, further comprising:  
decoupling at least one of the busbars; and  
reconfiguring the decoupled busbar in accordance with the specifications.

17. The method of claim 15, wherein each couple comprises a standardized connection, whereby the use of standardized connections reduces the inventory of connections for modifying the switchgear.

18. The method of claim 17, wherein the standardized connection comprises one of the connection points comprising a probe and another connection point comprising a female finger contact.

19. A deadfront switchgear comprising:  
a surface;  
a first active switching element coupled to the surface; and  
a first bus bar coupled to the first active switching element, the first bus bar comprising a conductive material surrounded by solid insulation and by a semi-conducting shield.

20. A high voltage bus bar comprising:  
a first leg comprising:  
a first connection point;  
a second connection point; and  
a third connection point;  
a second leg comprising:  
a fourth connection point;  
a fifth connection point; and  
a sixth connection point;  
wherein the first leg is coupled to the second leg by coupling the first and fourth connection points together.

21. A method of assembling a switchgear, the method comprising:  
providing a surface of the switchgear;  
coupling a first active switching element to the surface; and  
coupling a first bus bar comprised of a first conductive material surrounded by first insulation and a first semi-conducting shield to the first active switching element.

22. A method of repairing a switching element in a switchgear comprising the steps of:

providing a switchgear comprising:

a support structure;

a plurality of active switching elements, each switching element coupled to the support structure and comprising:

a switch; and

an external point of connection;

wherein each external point of connection for each switching element is substantially identical; and

a busbar coupled to the active switching element, the busbar comprising a plurality of connectors for coupling to the external point of connection for the switching elements, each connector comprising a push-on connection capable of coupling to each of the external points of connection for the active switching elements;

determining that the active switching element needs to be replaced; and

replacing the active switching element with a replacement switching element, wherein replacing the active switching element comprises:

decoupling a cable from the active switching element;

decoupling the active switching element from the support structure;

decoupling the external point of connection for the active switching element from the connector on the busbar;

coupling another external point of connection for the replacement switching element to the connector of the busbar;

coupling the replacement switching element to the support structure;

and

coupling the replacement switching element to the cable.

23. A method of reconfiguring a switchgear comprising the steps of:
- providing a first switchgear comprising:
    - a surface;
    - a plurality of active switching elements coupled to the surface, each active switching element comprising
      - an internal active component; and
      - an external point of connection;
    - at least one busbar, each busbar coupled to at least one of the active switching elements, each busbar comprising:
      - a first leg comprising
        - a first connection point;
        - a second connection point;
        - a third connection point; and
      - a second leg comprising:
        - a fourth connection point;
        - a fifth connection point; and
        - a sixth connection point;
      - a first insulation surrounding the first, second, and third connection points;
      - a first semiconductor shield surrounding the first insulation;
      - a second insulation surrounding the fourth, fifth and sixth connection points; and
      - a second semiconductor shield surrounding the second insulation;
  - wherein the first leg is coupled to the second leg by coupling the first and fourth connection points together;
  - at least connection point comprising a push-on connection point, a portion of the connection points coupled to at least one of the active switching elements;
  - receiving specifications for a second switchgear, the second switchgear comprising a different configuration than the first switchgear;

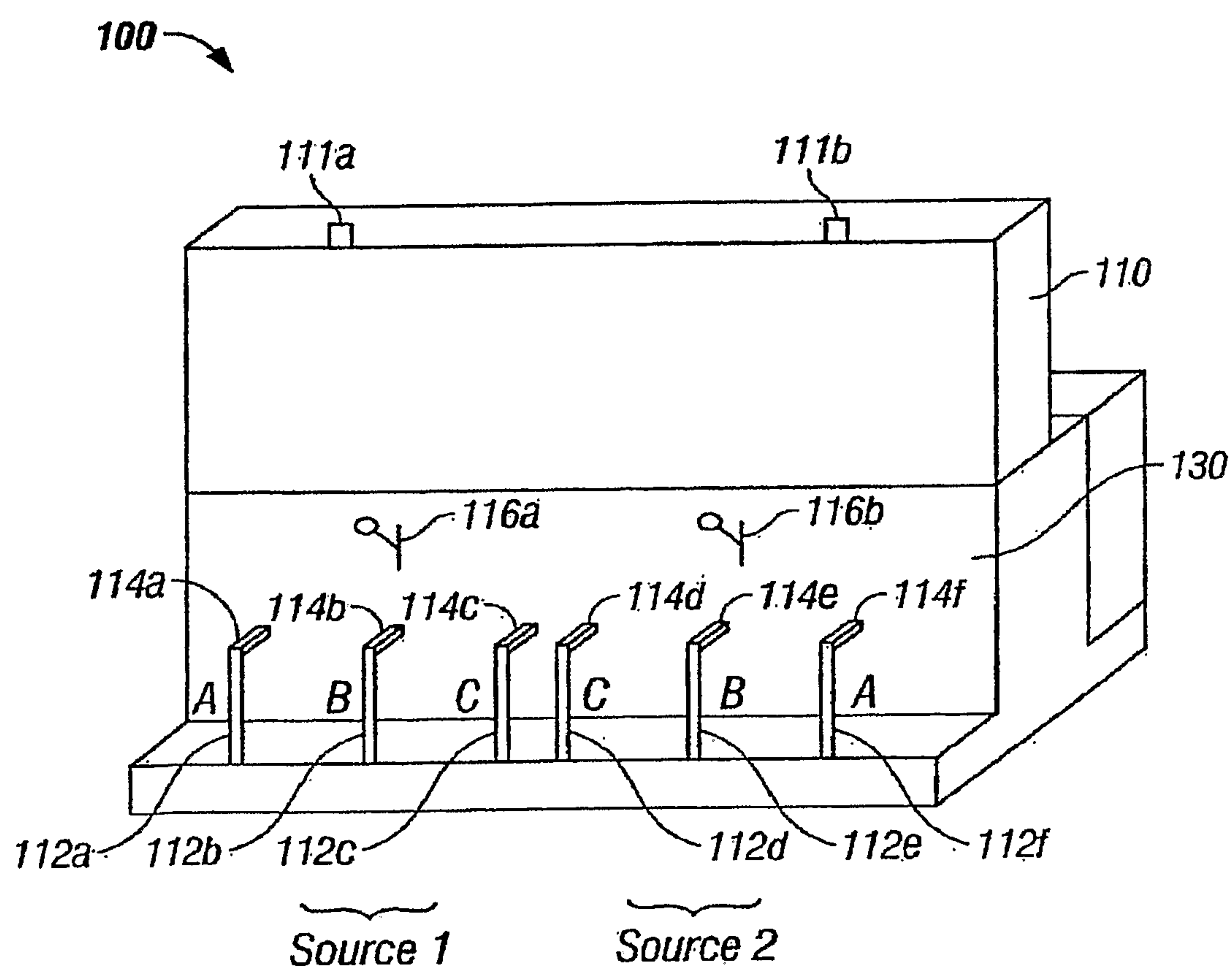
decoupling at least a portion of the active switching elements from the support structure and one of the busbars;

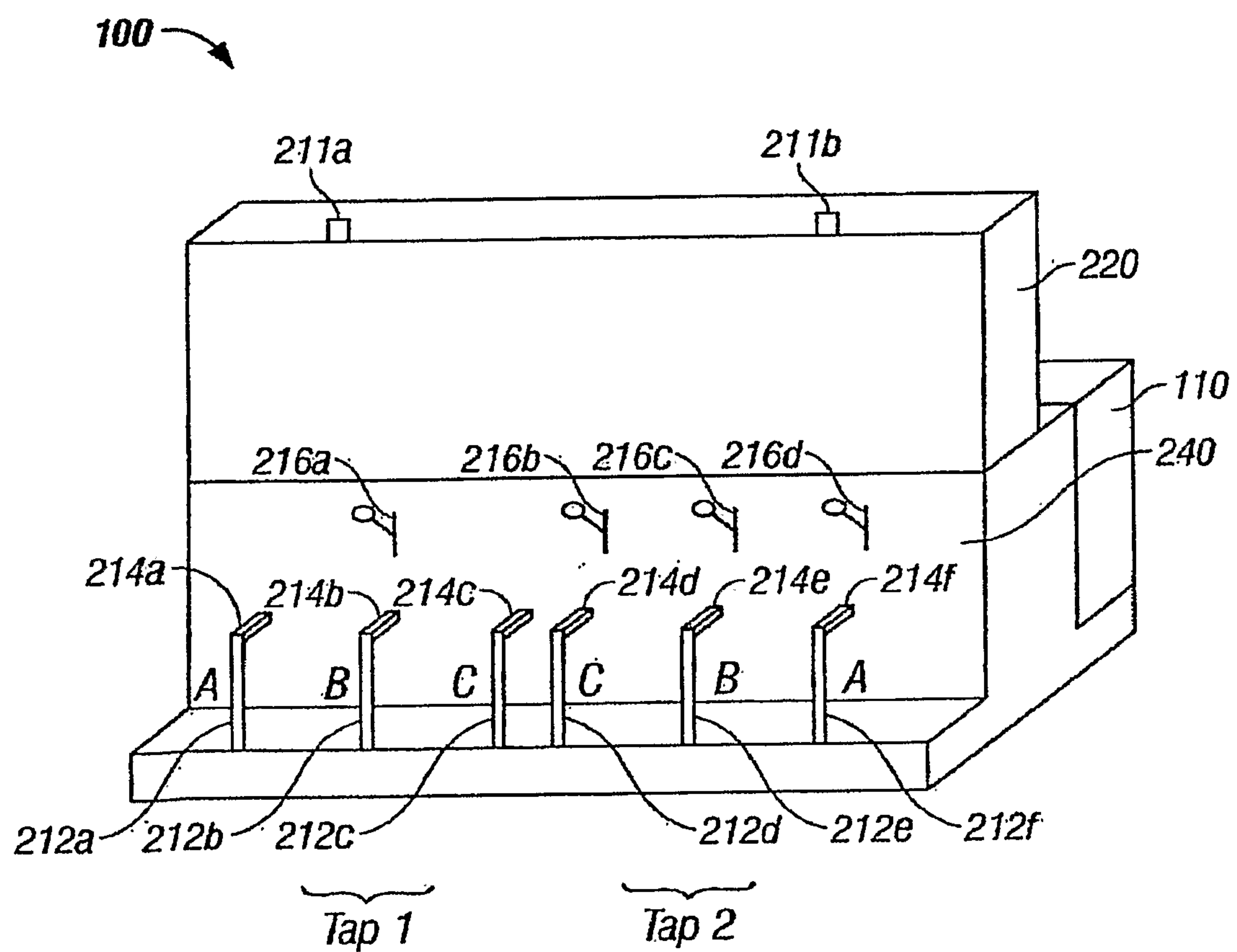
decoupling at least one of the busbars;

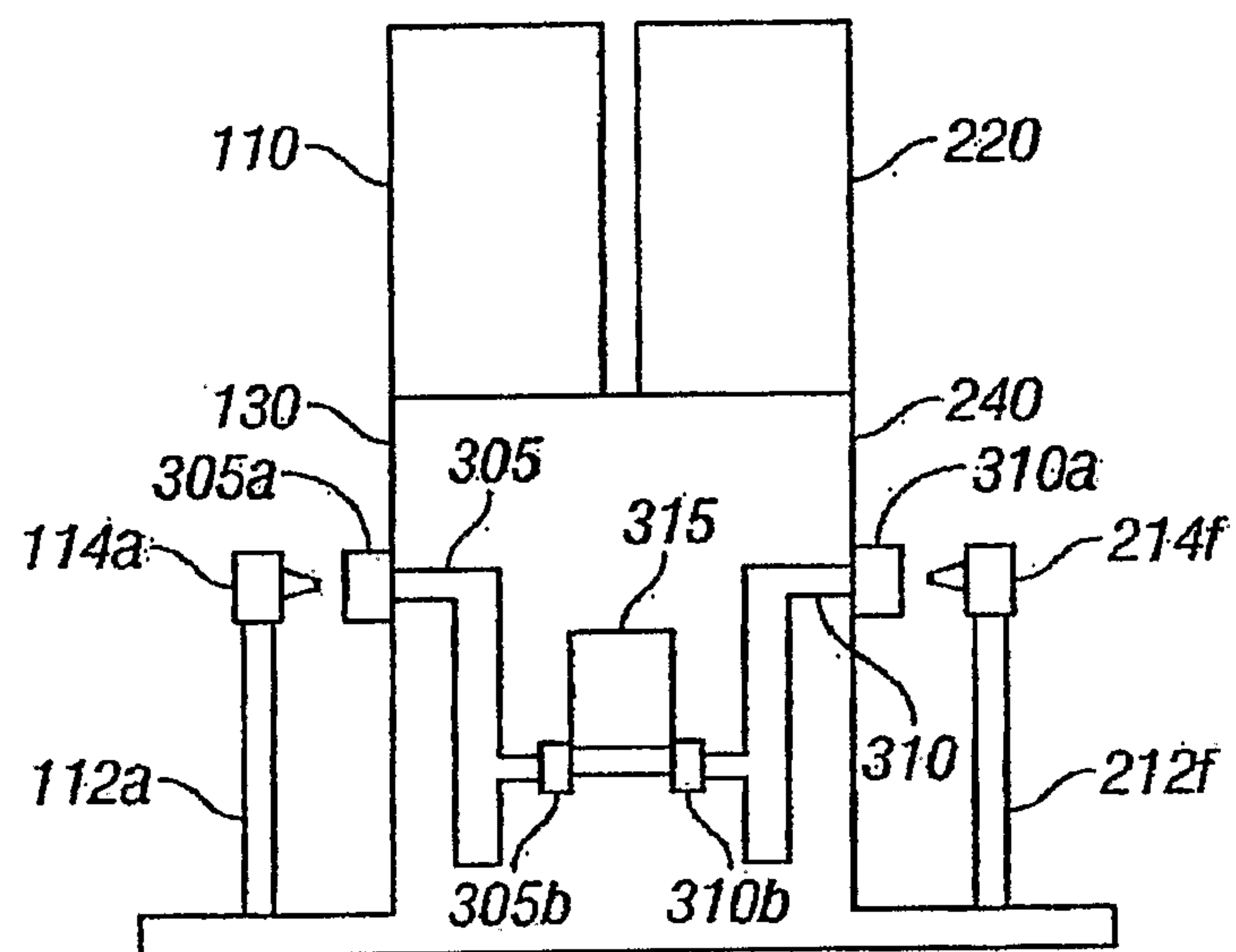
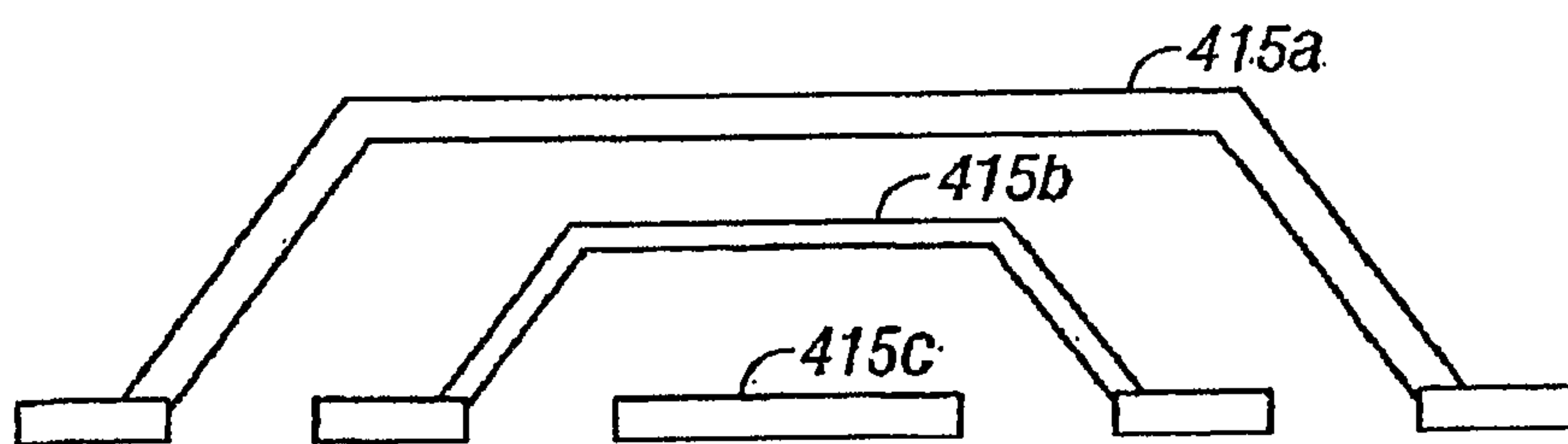
reconfiguring the decoupled busbar in accordance with the specifications;

and

modifying the switchgear by coupling a new portion of switching elements to the support structure and at least one of the busbars in accordance with the specifications, the new portion of switching elements replacing the decoupled active switching elements.

**FIG. 1**

**FIG. 2**

**FIG. 3****FIG. 4**

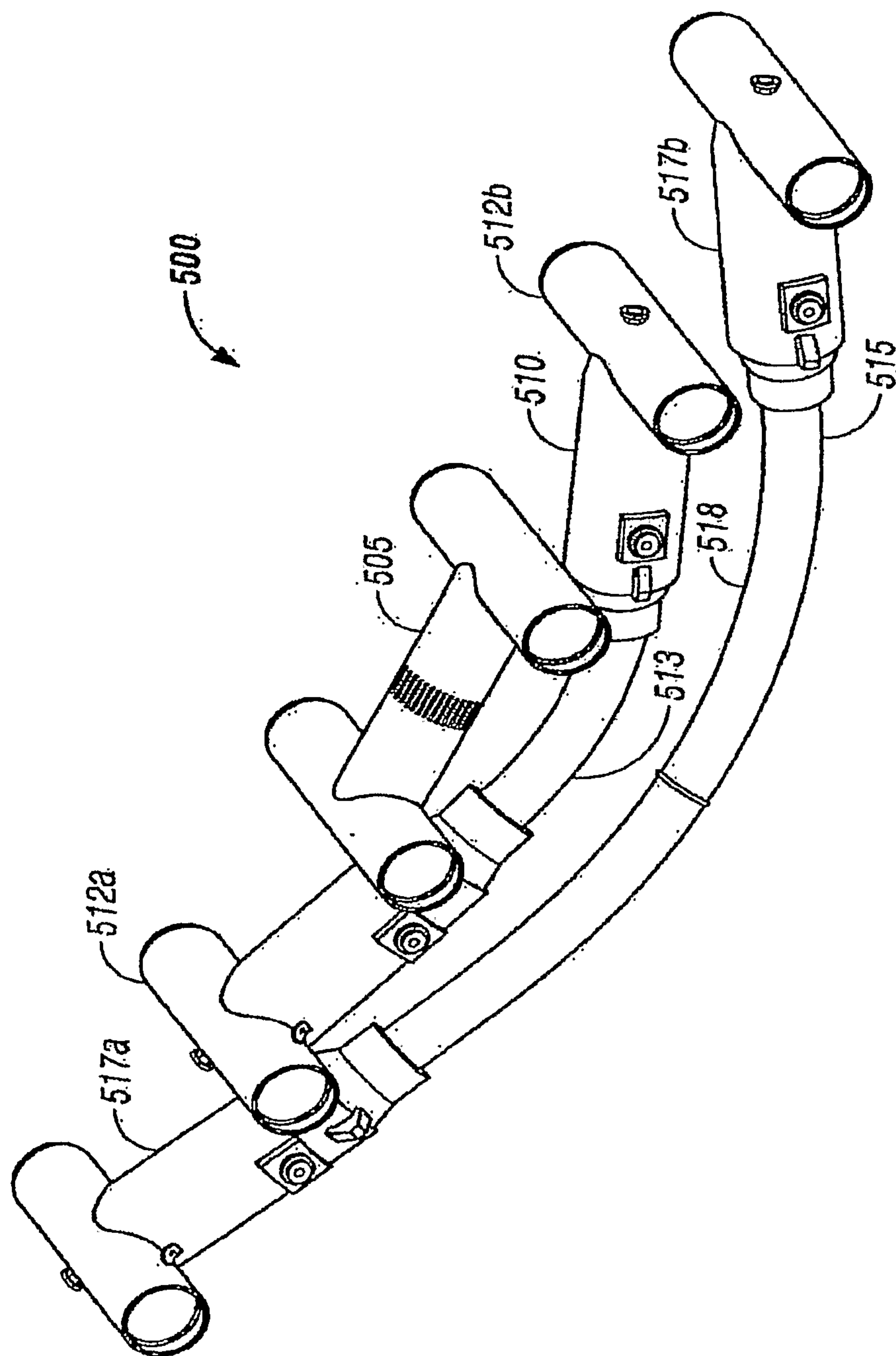
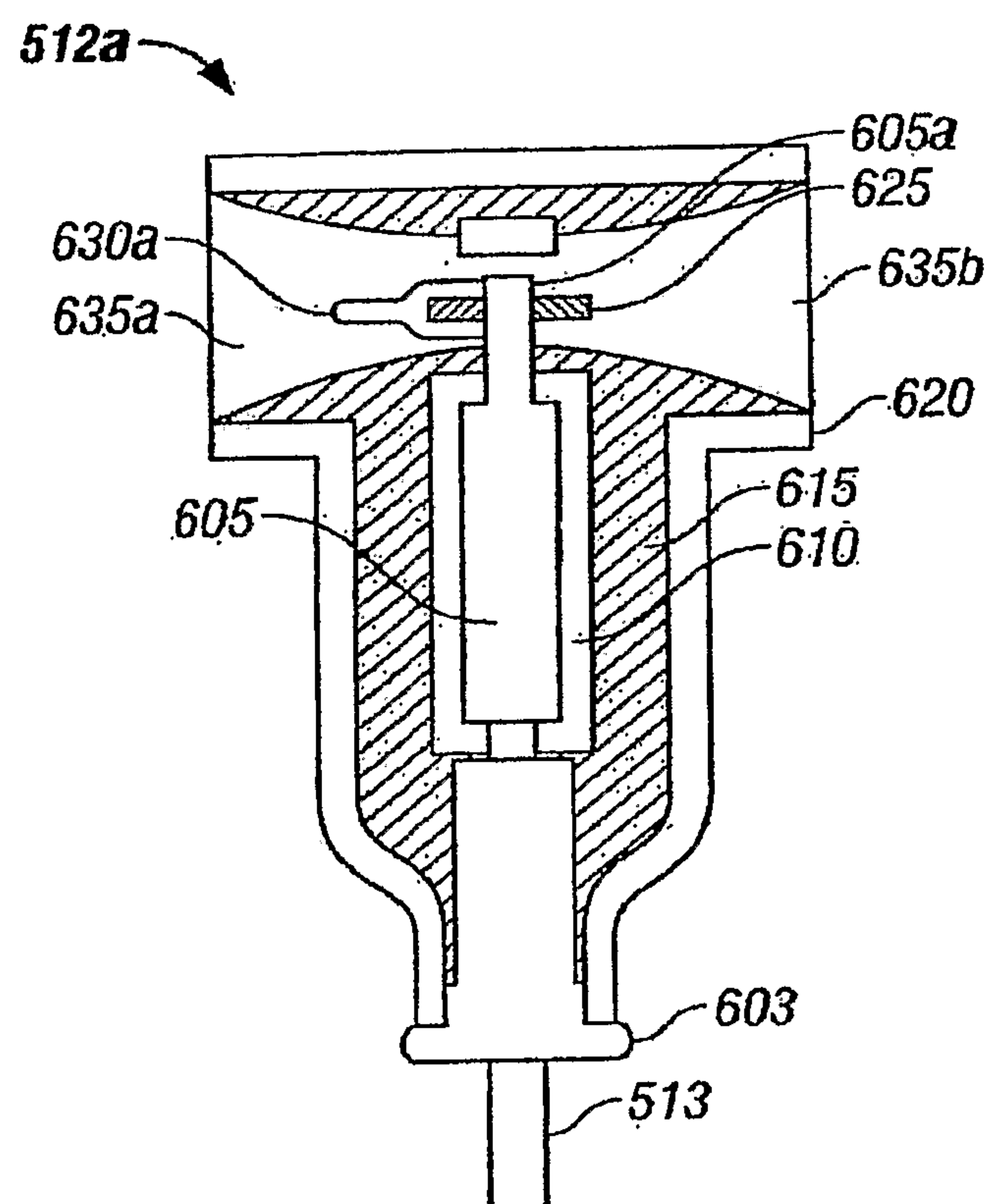
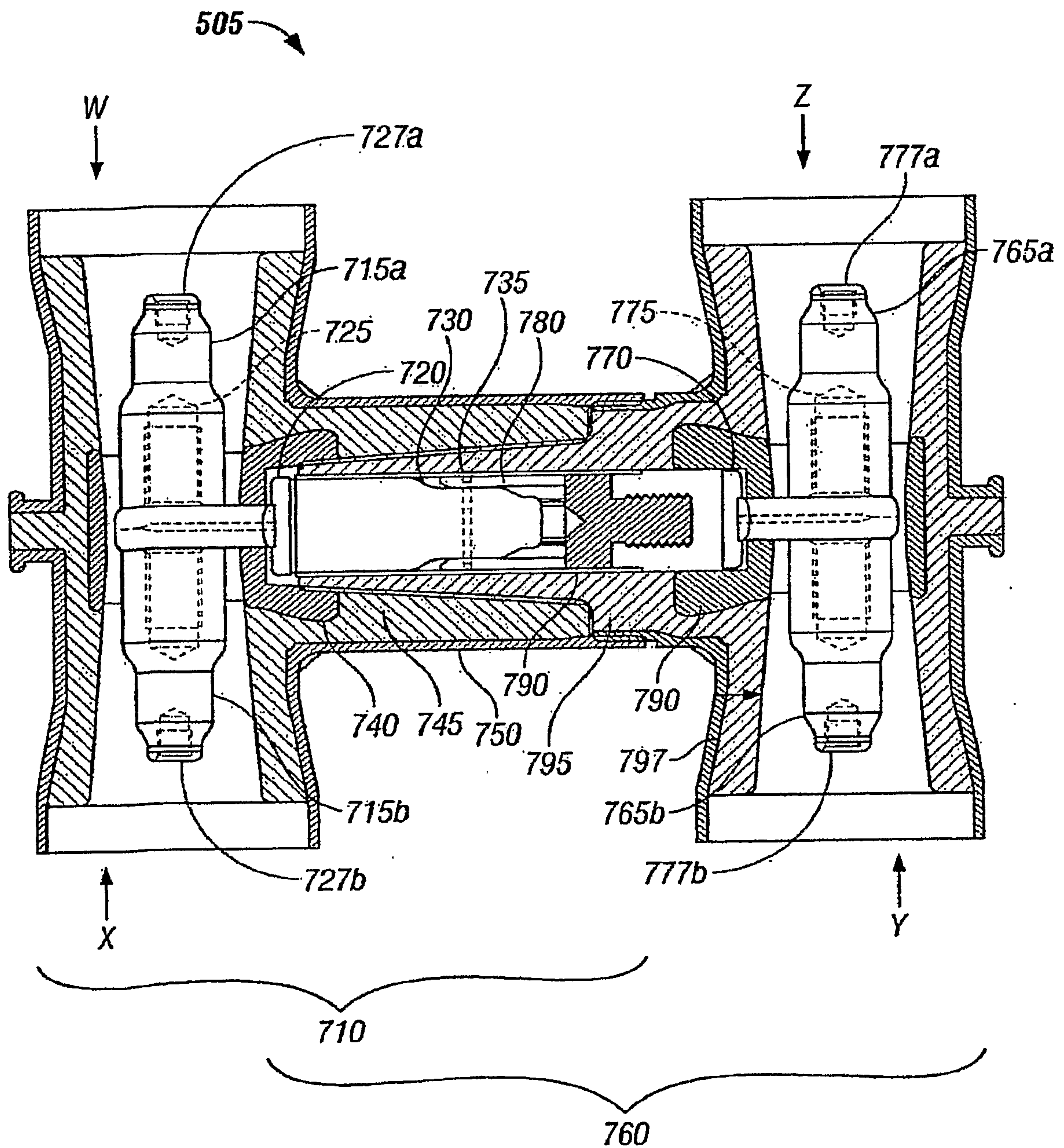


FIG. 5

**FIG. 6**



**FIG. 7**

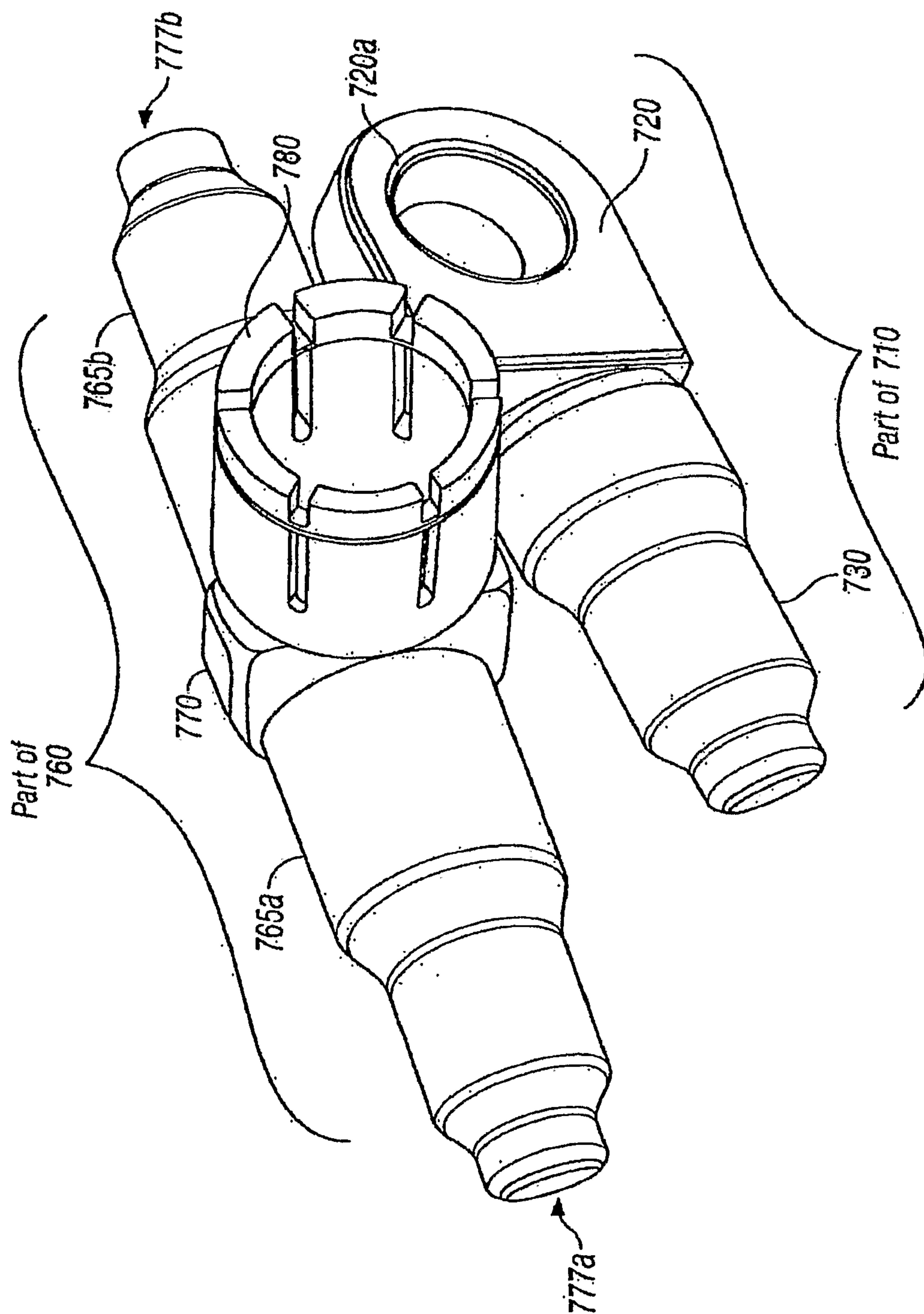
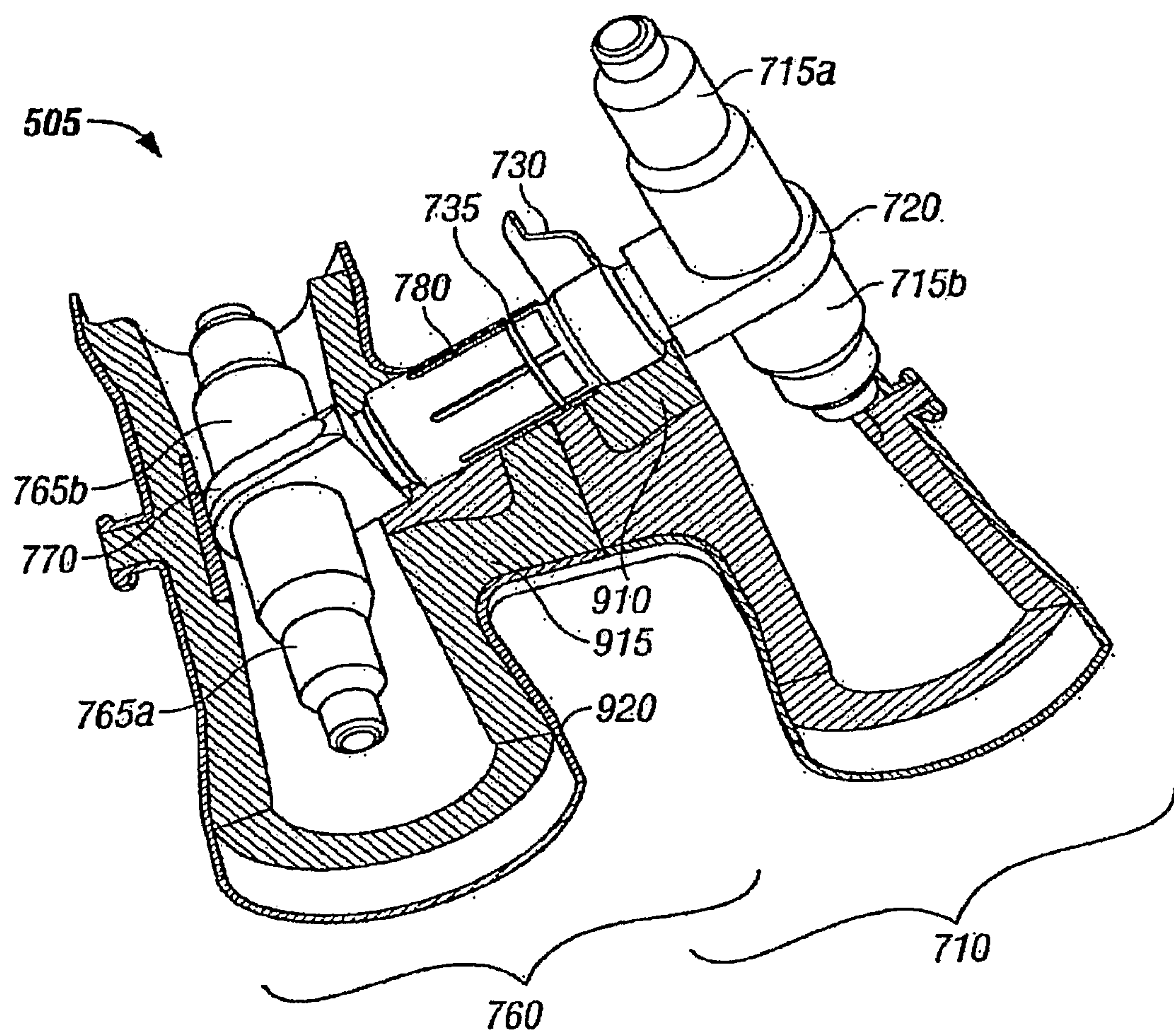


FIG. 8

**FIG. 9**

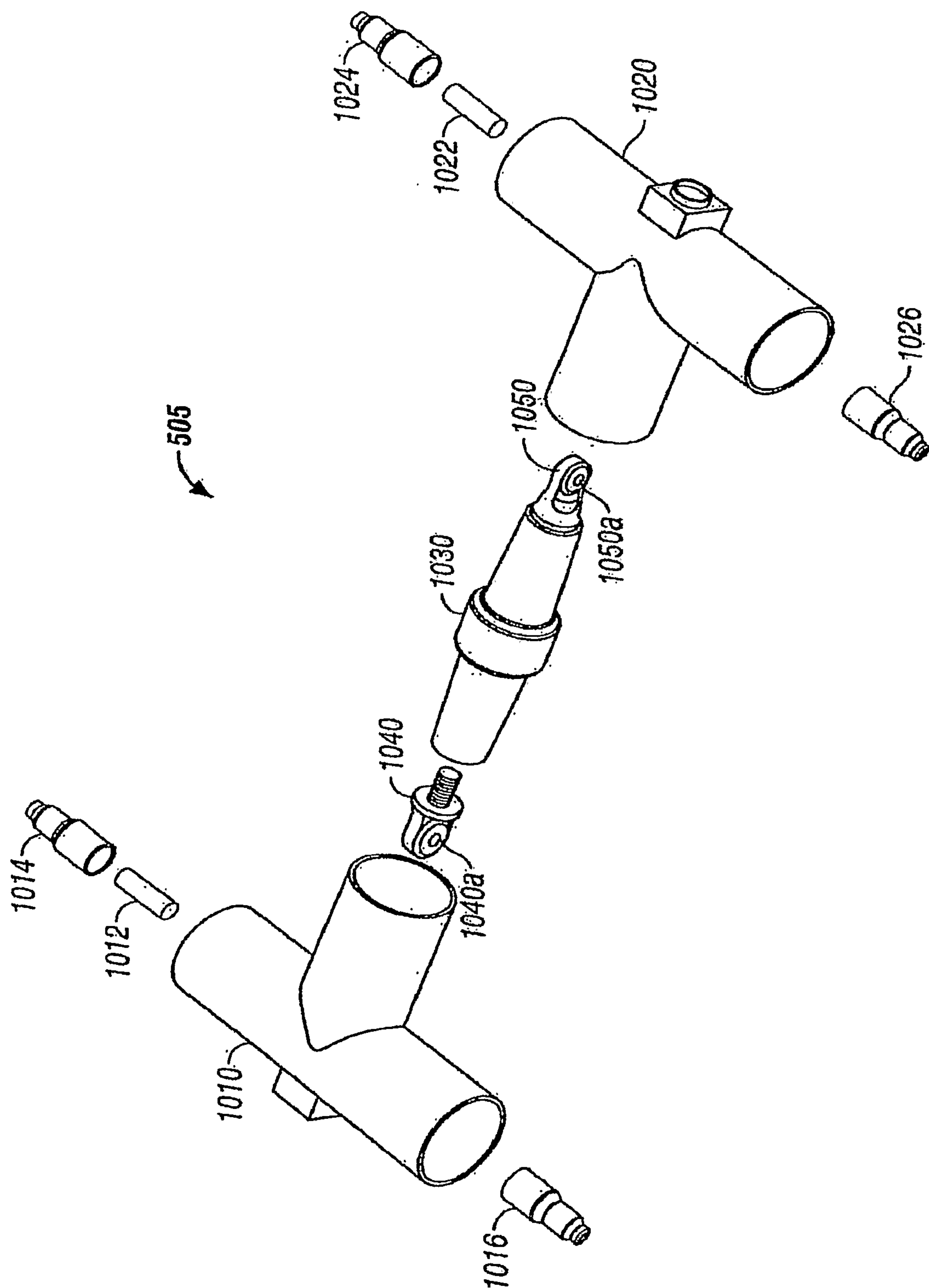
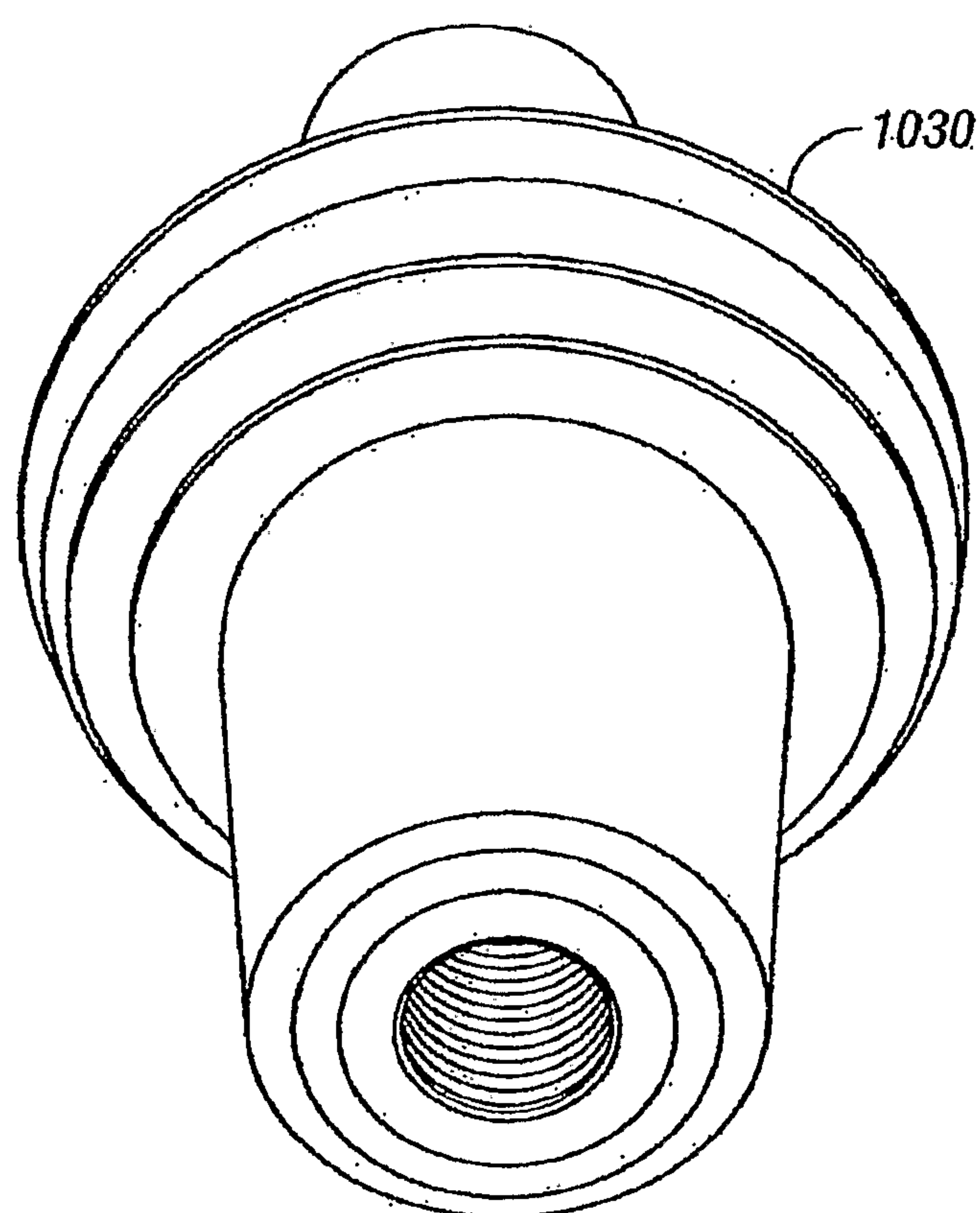


FIG. 10



**FIG. 11**

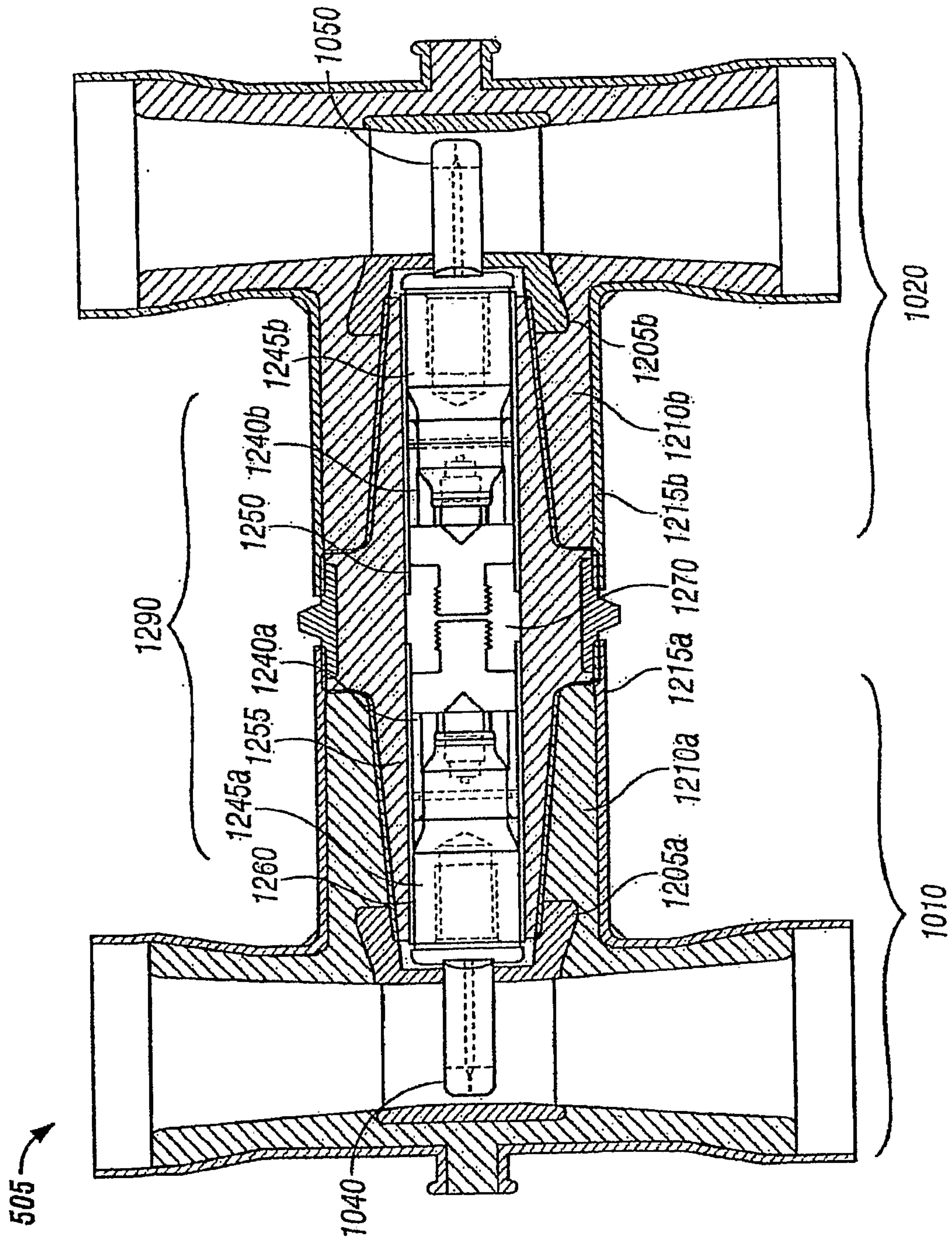
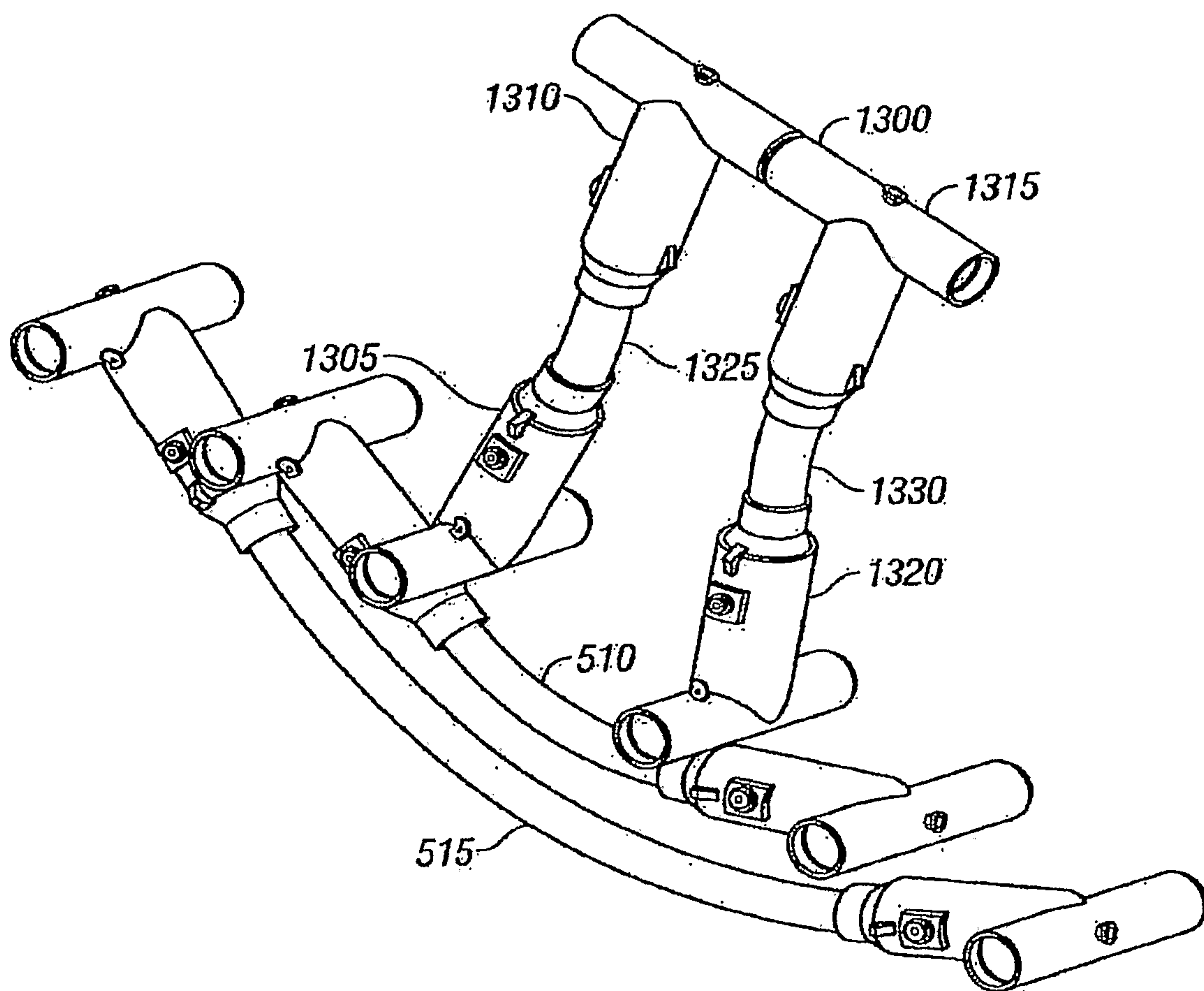


FIG. 12

**FIG. 13**

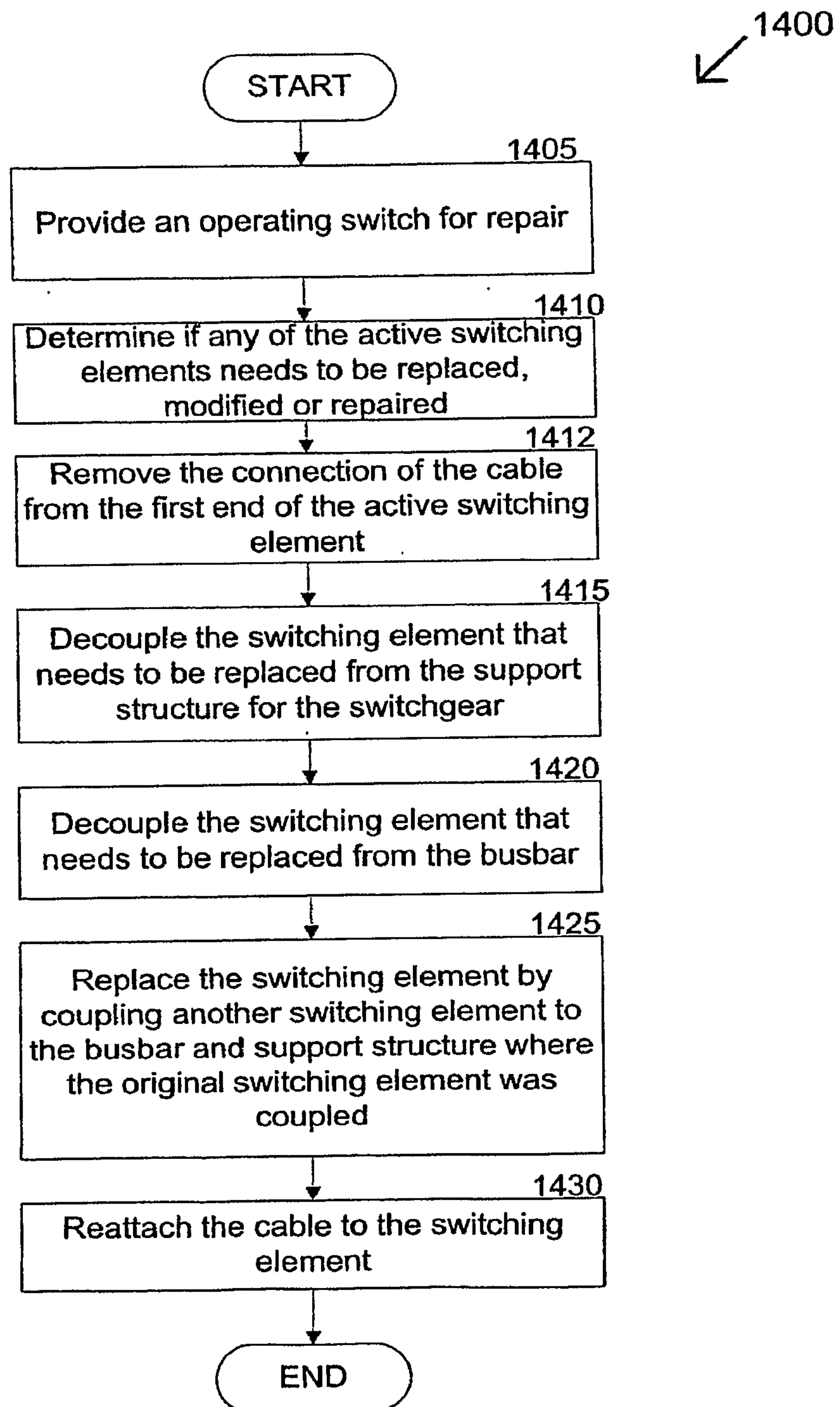


Fig. 14

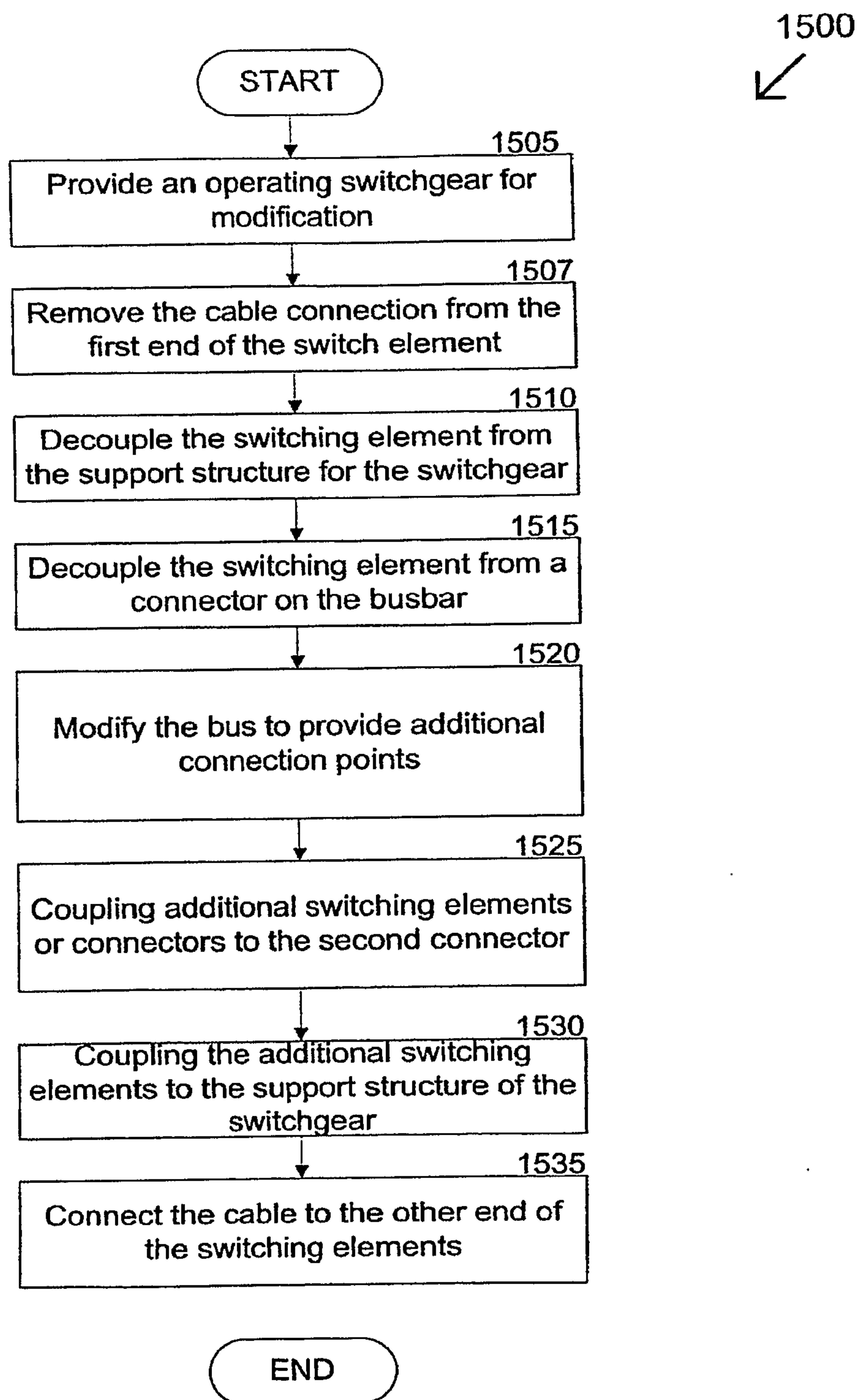


Fig. 15

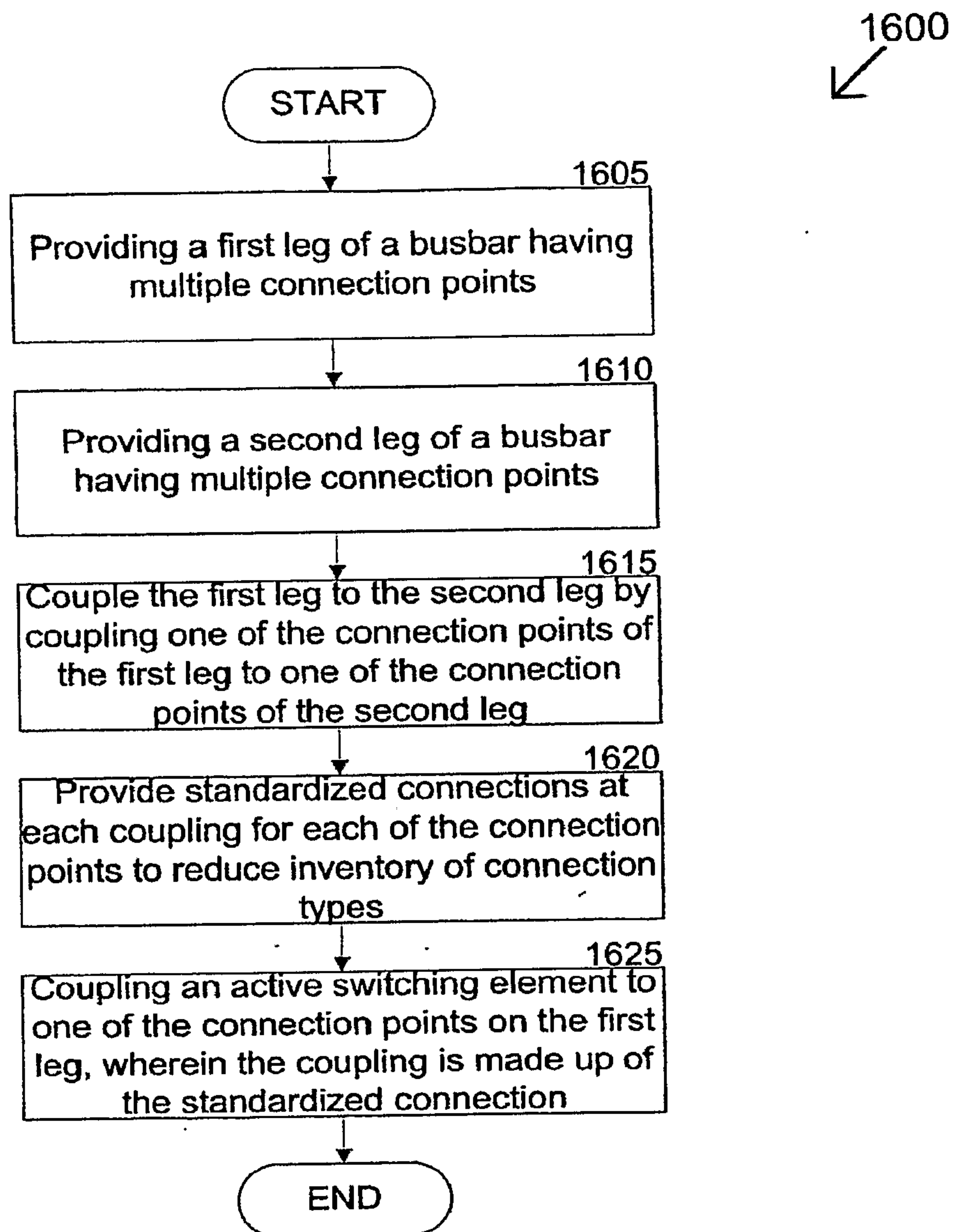


Fig. 16

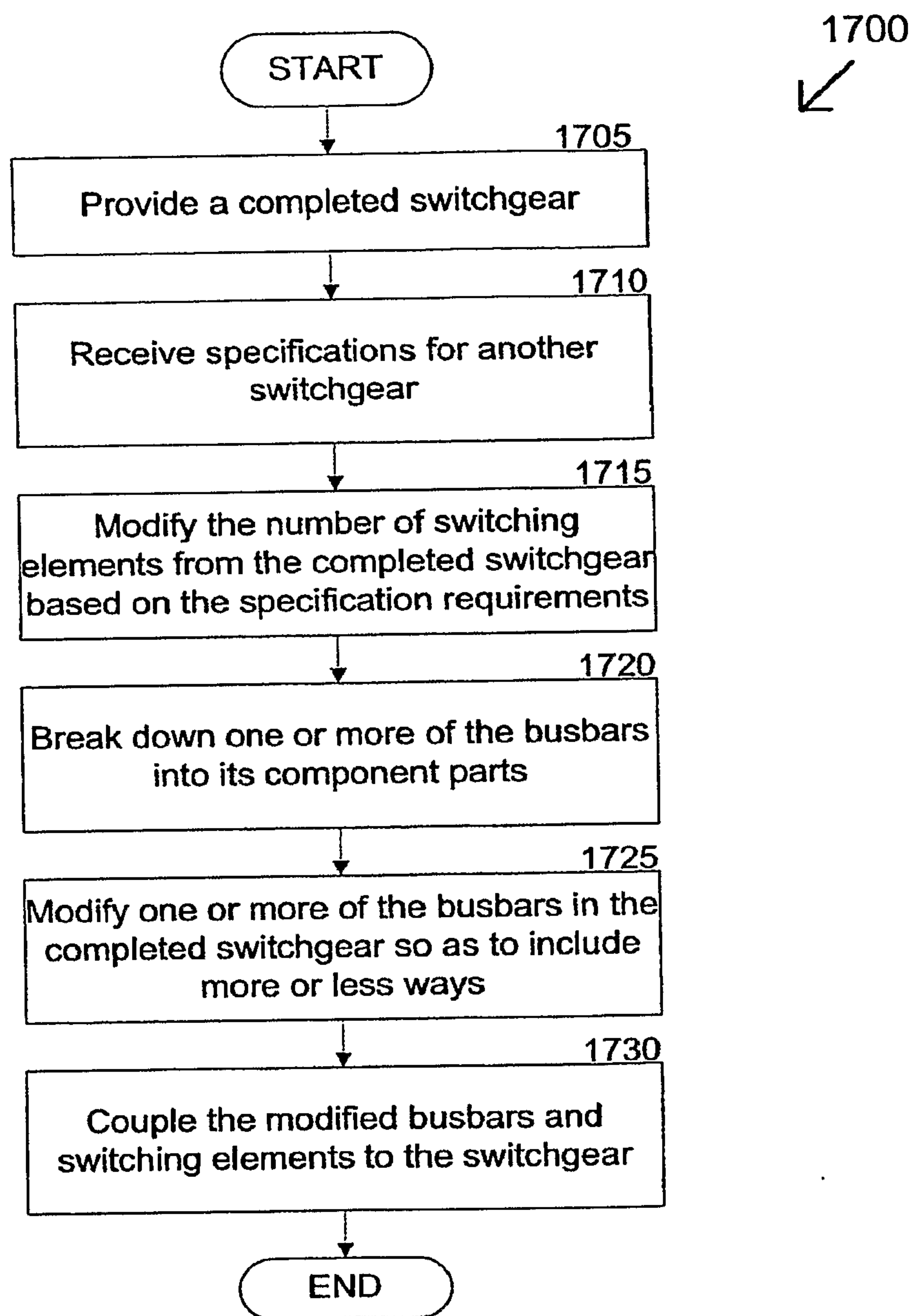


Fig. 17

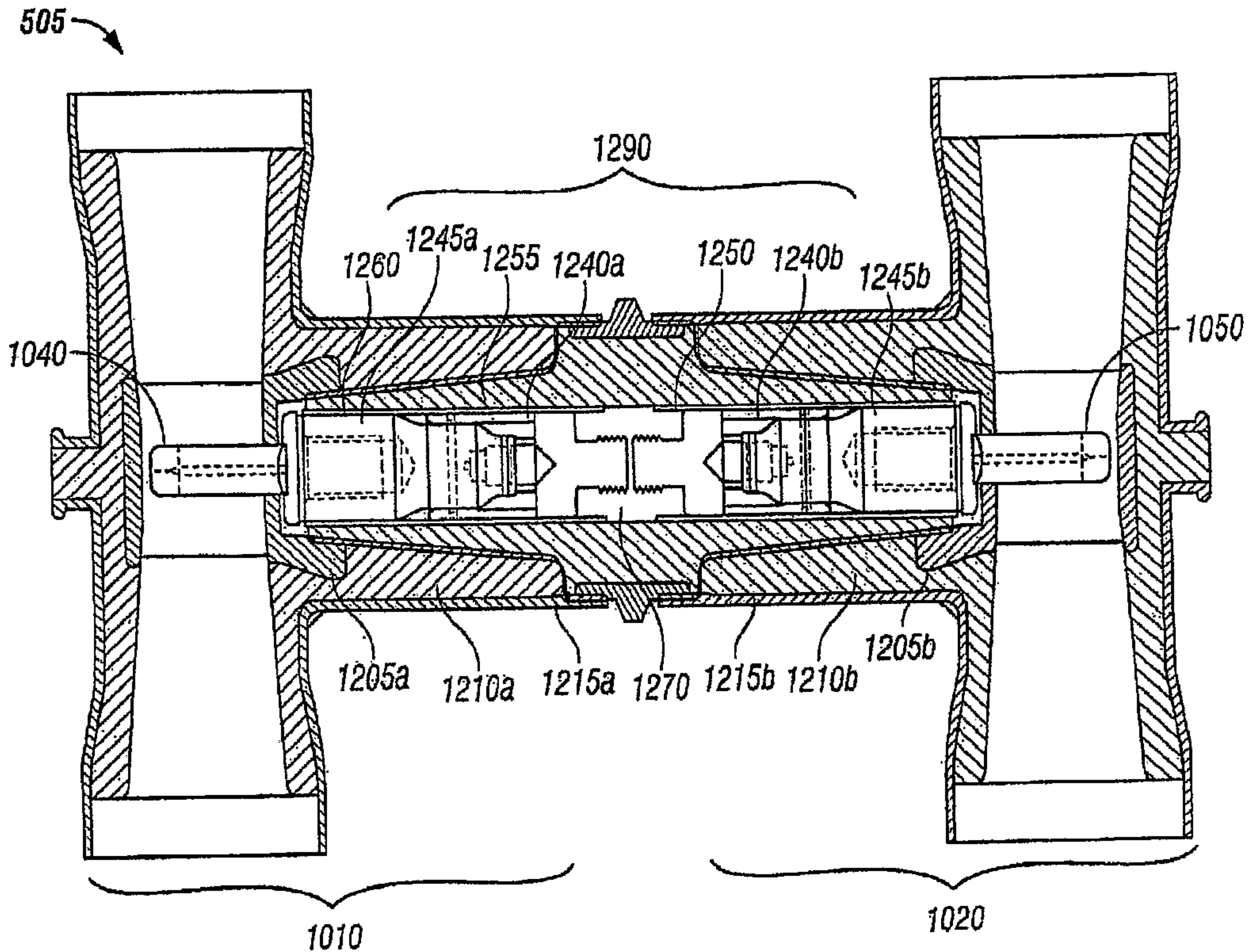


FIG. 12