Office de la Propriété Intellectuelle du Canada
Un organisme d'Industrie Canada

Canadian Intellectual Property Office
An agency of Industry Canada

CA 2657298 A1 2009/09/07

(21) 2 657 298

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

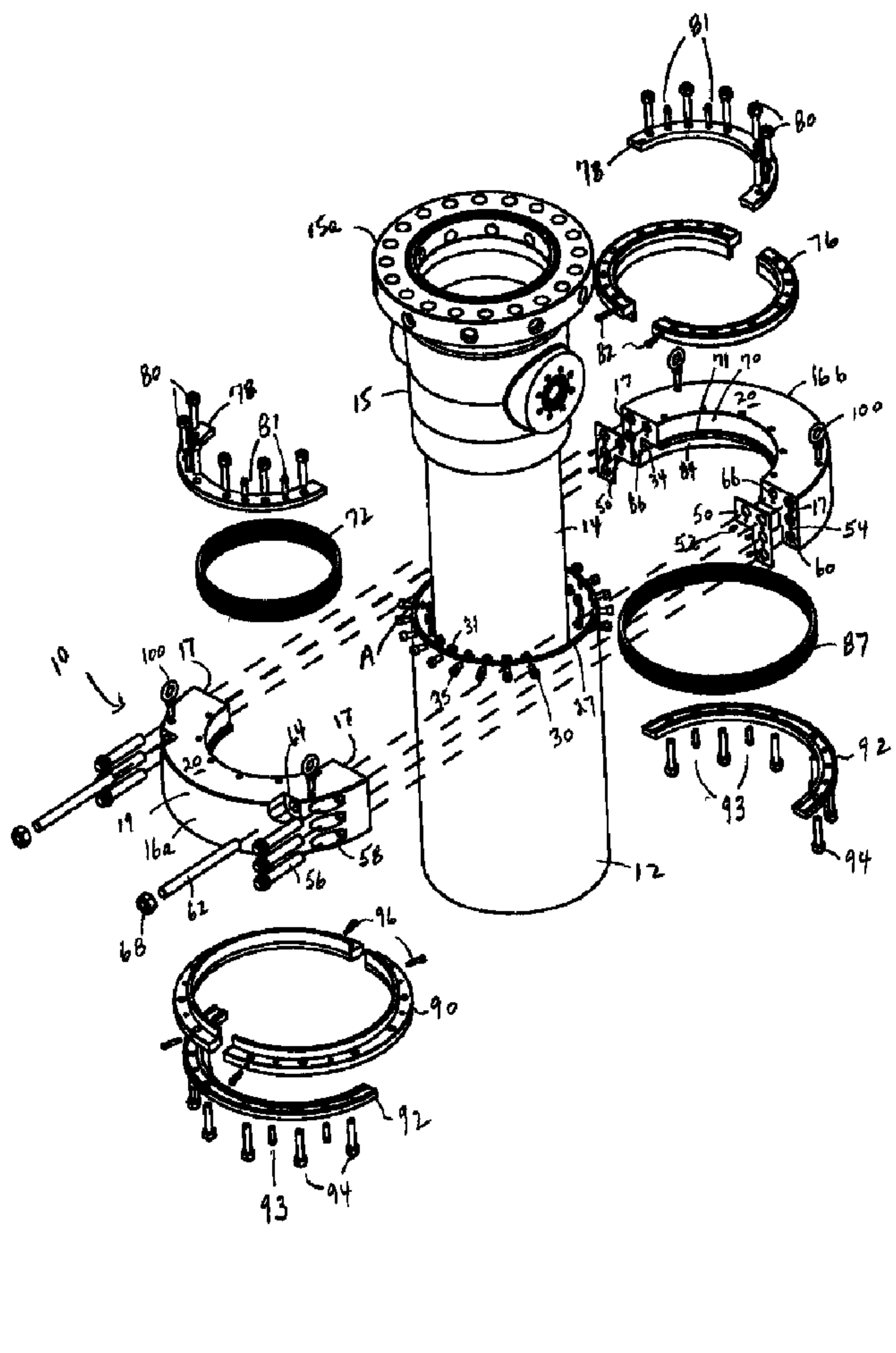
(22) Date de dépôt/Filing Date: 2009/03/06
(41) Mise à la disp. pub./Open to Public Insp.: 2009/09/07
(30) Priorité/Priority: 2008/03/07 (US61/068,482)
(51) Cl.Int./Int.Cl. *E21B 33/04* (2006.01)

(71) Demandeur/Applicant:
STREAM-FLO INDUSTRIES LTD., CA

(72) Inventeurs/Inventors:
KHAZANOVICH, ABRAM, CA;
KHAZANOVICH, IRINA, CA

(74) Agent: MCKAY-CAREY & COMPANY

(54) Titre : TETE DE TUBAGE FRACTIONNEE ET NON SOUDEE POUR EXPLOITATION A HAUTE TEMPERATURE
(54) Title: SPLIT NON-WELDED CASING CAP FOR HIGH TEMPERATURE SERVICE



(57) Abrégé/Abstract:
A casing cap to seal the annulus formed between an upper end of an outer casing and an inner casing extending through and above the outer casing. An annular casing cap housing is formed in split portions which when joined at their splits form the casing

(57) Abrégé(suite)/Abstract(continued):
cap housing to cover and seal the annulus. The joined casing cap split portions form a side wall which surrounds the outer casing, and which has upper and lower ends. The upper end forms an annular top section adapted to rest on the upper end of the outer casing, cover the annulus and form an upper annular seal to the inner casing. The lower end is adapted to form a mechanical connection, preferably non-welded, to the outer casing and to form an annular seal to the outer casing. Each casing cap split portion forms a sealing surface at each split for sealing together around a sealing element such as epoxy, graphite or elastomer seals. Connectors between the casing cap split portions clamp together the sealing surfaces of the casing cap split portions with the sealing element to form pressure-containing, non-welded seals.

ABSTRACT

A casing cap to seal the annulus formed between an upper end of an outer casing and an inner casing extending through and above the outer casing. An annular casing cap housing is formed in split portions which when joined at their splits form the casing cap housing to cover and seal the annulus. The joined casing cap split portions form a side wall which surrounds the outer casing, and which has upper and lower ends. The upper end forms an annular top section adapted to rest on the upper end of the outer casing, cover the annulus and form an upper annular seal to the inner casing. The lower end is adapted to form a mechanical connection, preferably non-welded, to the outer casing and to form an annular seal to the outer casing. Each casing cap split portion forms a sealing surface at each split for sealing together around a sealing element such as epoxy, graphite or elastomer seals. Connectors between the casing cap split portions clamp together the sealing surfaces of the casing cap split portions with the sealing element to form pressure-containing, non-welded seals.

SPLIT NON-WELDED CASING CAP FOR HIGH TEMPERATURE SERVICE

FIELD OF THE INVENTION

This invention relates to a casing cap for use in high temperature wellhead applications. The invention also extends to a method of making the casing cap connection to inner and outer casings.

BACKGROUND OF THE INVENTION

The typical fashion in which a well is drilled in the ground, for example for oil and gas, is to first drive or drill a shallow large diameter pipe, commonly called the conductor pipe or casing, into the ground, and to then drill a smaller and deeper hole inside the boundary defined by the conductor casing so that a smaller diameter and longer pipe, commonly called the surface casing, can be placed into the hole. The annular space between the surface casing and the conductor pipe is then filled with cement. If the well is of sufficient depth or due to geological requirements, multiple strings of casing may be required. Each casing string will be cemented in place. Further drilling beyond the depth of the surface casing is done to a sufficient depth that geological formations encountered may cause pressurized fluid to escape into the hole and travel to the surface. To control this fluid, and to prevent its escape into the atmosphere, the drilling is done through a sealed pressure vessel at the surface wellhead that is known as the blowout preventer stack. In addition, drilling at these depths requires the use of a weighted column of fluid, known as drilling mud, to control the well, to aid drilling by cooling the drilling bit, and to remove cut rock. A pressure vessel known as the casing head, attaches to and seals around the surface casing or production casing to provide a means for hooking up the blowout preventer stack and the drilling mud lines located thereabove.

A casing cap is sometimes needed to seal off the annulus formed between the conductor casing and the surface casing or between the surface casing and the production casing. In thermal applications the casing string strings are cemented to surface to limit the thermal growth of the casing. Due to the large temperature changes the well can be exposed to (650°F to -50°F), the inner and outer casing strings will be subject to differential thermal expansion and contraction. The casing cap ideally does not lock the two casing strings together constraining this movement as this differential expansion and contraction can induce large stresses on the casing and the casing cap. These large temperature changes and the movement of the casing can compromise the cement in the annulus between the casing strings. If the pressure integrity of the cement is compromised the pressure in the formation can escape to the surface where the casing cap is installed to control the pressure. Ideally this pressure is vented out a port in the casing cap in a controlled manner.

Once the casing head or wellhead is already in place on the surface casing and/or production casing, a conventional casing cap can no longer be installed. In this circumstance, a split type casing cap design is required, where the casing cap components are split in half with weld preparations to allow for installation of the halves around the surface and/or production casing, below the existing casing head. However, welding is not always convenient or permissible, for example on a remote wellhead where welding expertise is not available, or on a live well where welding is not recommended or safe. In Alberta, Canada a process known as Steam Assisted Gravity Drainage (SAGD) requires high thermal energy input through the wellhead to a heavy oil formation. Particularly when the well is in production and the cement (to the surface casing) may fail, split casing caps may need to be installed. Welding in these SAGD producing wells or steam injecting wells is not safe, so a split casing cap that can be installed without welding is desirable.

Thus, there is a need for a casing cap of a split type design for use in applications where the casing head or wellhead is already in place, and where welding is not recommended or available.

SUMMARY OF THE INVENTION

The split type casing cap of this invention provides a pressure barrier between an outer and an inner casing (ex. between a conductor casing and a surface casing, or between a surface casing and a production casing), preferably without the use of welding. The casing cap may be adapted for concentric as well as eccentric casing applications. The casing cap is used in applications where the wellhead is already in place and where pressure control between the casings is required. The preferred embodiments have particular application where elastomer seals may not be used due to elevated operating temperature (although the casing cap also works with elastomer seals).

Broadly stated, the invention provides a casing cap to seal the casing annulus formed between an upper end of an outer casing and an inner casing extending through and above the outer casing. The casing cap includes a generally annular casing cap housing formed in two or more split portions which when joined at their splits form the casing cap housing to cover and seal the casing annulus. The joined casing cap split portions form a side wall having an upper and a lower end. The upper end forms an annular top section adapted to be supported by the outer casing, to cover the casing annulus and to form an upper annular seal to the inner casing. The lower end is adapted to form a mechanical connection to the outer casing and to form a lower annular seal to the outer casing. Each casing cap split portion forms a sealing surface at each split for sealing together to form the annular casing cap housing. A sealing element is included for placement between opposing sealing surfaces. Connectors between the casing cap split portions clamp together the sealing surfaces of the casing cap split portions with the sealing element to form pressure-containing, non-welded seals at the splits.

Preferably, the casing cap housing is formed in two split half portions with one or more sealing surfaces being formed at each left and right split of each casing cap split half portion. The sealing element is preferably a gasket seal or a ring seal adapted for sealing when clamped between the sealing surfaces, or a sealing compound such as epoxy or gasket compounds adapted for sealing when applied and clamped between the sealing surfaces. Preferred connectors used with sealing compounds are external clamp connectors provided at the top and side walls of the housing at the splits. Preferred connectors used with gasket seals are screw connectors extending through the side walls and the sealing surfaces. Particularly preferred are high temperature gasket seals formed from a graphite sealing materials.

The casing cap housing preferably forms annular compression seals to the inner and outer casings which accommodate relative axial movement of the casings, for example with thermal expansion and contraction.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an exploded top perspective view of the components of the casing cap of the present invention, showing the components in horizontal alignment for installation on an outer conductor casing and an inner surface casing.

FIG. 2 is a top perspective view showing the split casing cap housing halves joined around the conductor and surface casings, with split surfaces mated with epoxy and bolting steps in progress.

FIGS. 3A and 3B show side by side top and bottom perspective views showing the top and bottom split packing glands and compression packings vertically aligned for sealing the casing cap to the surface and conductor casings respectively.

FIGS. 4A and 4B show side by side top and bottom perspective views of the completed casing cap, showing the top and bottom packing glands bolted in place to seal the surface and conductor casings respectively.

FIG. 5 is a top sectional view taken above the casing cap, showing the split casing cap housing halves bolted together and showing the top packing gland bolted in place.

FIG. 6 is a side sectional view taken along line A-A of FIG. 5, showing the casing cap and top and bottom packing glands bolted in place, and showing the casing cap retained on the outer conductor casing by a split retainer ring.

FIG. 7 is a partial side view of a preferred external clamping arrangement for the split casing cap housing halves, showing the clamping plate formed with bottom ridges which are received in V-grooves on the top section of the casing cap in order to transfer the vertical bolting force to a horizontal clamping force.

FIG. 8 is an exploded top perspective view of a second embodiment of the components of the casing cap, showing the components in horizontal alignment for installation on an inner and outer casing, with retention cap screws at the upper end of the outer casing replacing the retention ring of FIGS. 1-7 for mechanical connection to the outer casing, and with a gasket seal at the split cap housing halves.

FIGS. 9A and 9B show side by side top and bottom perspective views of the embodiment of FIG. 8, showing the top and bottom split packing glands and packings vertically aligned for sealing the casing cap to the inner and outer respectively.

FIGS. 10A and 10B show side by side top and bottom perspective views of the completed casing cap of FIG. 8, showing the top and bottom packing glands bolted in place to seal the inner and outer casings respectively.

FIG. 11 is a top sectional view taken above the casing cap of FIG. 8, showing the split casing cap housing halves bolted together and showing the top packing gland bolted in place.

FIG. 12 is a side sectional view taken along line A-A of FIG. 11, showing the casing cap with the top and bottom packing glands and retainer rings bolted in place, and showing the split gasket seal connection at the sealing surfaces.

FIG. 13 is a side sectional view taken along line B-B of FIG. 11, showing the casing cap with top and bottom packing glands and retainer rings bolted in place, and showing the casing cap retained on the outer conductor casing by the retention cap screws.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention has application in sealing the casing annulus between concentric or eccentric casings at a wellhead where the inner casing is already connected to the upper wellhead components, such as a casing head. Generally, the casing cap is used to seal the casing annulus between inner and outer casings such as an outer conductor casing and a surface casing (as shown in FIGS. 1-13), or between an outer surface casing and an inner production casing. The term "casing" as used herein and in the claims is meant to include any casing, tubing, pipe or other similar device located at the wellhead and known to persons skilled in the art. Thus the invention has application where a casing annulus between an inner and outer casing needs to be sealed at the upper terminated end of the outer casing. While the inner and outer casings will generally be vertical at a conventional wellhead, the casings might deviate from the vertical as in the case of directionally drilled wells where the wells are angled from vertical toward the horizontal.

In the Figures, two exemplary embodiments of the invention are shown. FIGS. 1-7 show an embodiment where the casing cap is retained on the outer casing by a retention ring and where epoxy is used as a sealing element to form a seal at the split sealing surfaces. FIGS. 8-13 showing an embodiment where the casing cap is retained on the outer casing by a plurality of cap screws fastened around the upper end of the outer casing, and where a sealing element in the form of a gasket seal is used to form a seal at the split surfaces. Both embodiments show the casing cap and other components formed in split halves (left and right half portions). It will be recognized that a different plurality of split portions is possible, but split half portions is most preferred to minimize the number of sealing surfaces and thus the complexity of the overall casing cap. In the Figures, like components are labeled with the same reference numerals. It will further be recognized that alternate retention devices might be used with the outer casing, for example friction type connectors such as slip lock connectors. Exemplary slip lock connectors to a casing are shown in U.S. Patent 6,834,718 issued December 28, 2004 and U.S. Patent 7,069,987 issued July 4, 2006 to Kwasniewski *et al.*, both owned by Stream-Flo Industries Ltd. (assignee for this patent application). The retention device to the outer casing might not be needed as a separate component in the event that a collar or similar limiting device is already in place on the outer casing at or near its upper terminated end.

Having reference to Figures 1 - 7, a first preferred embodiment of the split type casing cap of this invention is shown generally at 10. FIG. 1 shows the components in horizontal alignment for assembly. FIGS. 2, 3 show components during assembly. FIGS. 4 - 7 show the assembled casing cap 10. Where components of the casing cap 10 are provided in split halves, the halves are identified in the figures by the same reference numerals, for assembly in left and right mating relationship around the outer conductor casing 12 and inner surface casing 14. A pressure-containing casing head

15 is shown connected to the top of the inner surface casing 14 in Figures 1 - 4. The top flange 15a of the casing head 15 connects to the wellhead members (not shown) located thereabove, as is known in the art. The casings 12, 14 are shown as concentric in the Figures, but the present invention can accommodate eccentric casings as well, in which case measurements are taken to determine the eccentricity, and the casing cap dimensions are customized for the off-centre casing annulus. The casing cap 10 is adapted and sized to cover the annulus A formed between the casings 12, 14 at the upper end 27 of the outer casing 12, and to seal to each of the outer surfaces of the casings 12, 14.

The casing cap 10 is formed in split housing portions 16, preferably two generally symmetrical left and right mating members (16a, 16b) which are connected together at vertical sealing surfaces 17 (preferably flat sealing surfaces or shaped for mating relationship) around the casings 12, 14 to form a completed annular cap housing 18. Each housing portion (left housing half 16a and right housing half 16b) forms two split faces which, when joined in mating relationship, form left and right hand splits (shown as S in the Figures). The sealing surfaces 17 may comprise the entire area of the split faces (as in the Figures, where 17 represents both the split face and the sealing surface), or only a portion of the area of the split faces. As well, multiple sealing surfaces may be formed on a split face with mating multiple sealing surfaces being formed on the opposing split face. Each split housing portion 16 includes a vertical side wall 19 which surrounds the outer casing 12, and an annular top section 20 which extends horizontally inwardly from the upper end 21 of the side wall 19 toward the inner casing 14 to cover and close the casing annulus A. An upper annular seal 22 (see FIG. 6) is formed by the top section 20 of the cap housing 18 at the inner casing 14. This seal 22 is preferably an annular compression seal such as a stuffing box type seal that allows for thermal expansion and contraction of the inner casing 14, as occurs during high temperature applications. Although in some applications welding might be used to attach the casing cap 10 to the outer casing 12, if welding is not feasible, it is generally preferable to provide a mechanical connection at the lower end 24 of the side wall 19 in order to retain the casing cap 10 on the outer casing 12. It is also preferable to form an annular seal 26 at the lower end 24 to the outer casing 12. The seal 26 is most preferably a lower annular compression seal. In alternate embodiments, the lower end 24 of the casing cap 10 may seal and connect to the inside surface of the outer casing 12, in a manner known to persons skilled in the art.

The casing cap 10 is shown resting on the upper end 27 of the outer casing 12, although the method of attachment to the outer casing 12 so as to resist upward movement of the casing cap, may vary using techniques generally known in the art. In the Figures, the top section 20 of the housing is shown resting on this upper end 27 of the casing 12. The mechanical connection to the outer casing 12 is shown in two embodiments in the Figures, in which an outwardly extending circumferential extension or limit device is attached to the outer casing 12 to anchor the casing cap 10 to the outer casing 12. Alternatively, the casing cap 10 may attach and seal on the inside surface of the outer casing 12, in which case the mechanical connection to the outer casing 12 includes an inwardly extending circumferential extension or limiting device.

The preferred embodiments of the mechanical connection to the outer casing 12 are best seen in cross sectional detail in FIG. 6 and FIG. 13. In FIG. 6, a split retention ring 28 is fastened with retention cap screws 30 and bolts 31 extending through drill holes 32 formed around the upper end 27 of the outer casing 12. This retention ring 28 thus provides an outwardly extending circumferential extension to the outer casing 12 to act as an anchor for the casing cap 10 to resist upward movement. The side wall 19 is formed with a C-channel recess 34 (or alternate shaped recess) to accommodate the retention ring 28. This C-channel recess 34 with the retention ring 28 provides a lower end anchor which mechanically connects the lower end of the casing cap to the outer casing to resist upward movement. In FIG. 13 the retention ring 28 is not present, and the heads 35 of the retention cap screws 30 provide the outwardly extending circumferential extension to the outer casing 12, sufficient to function with the C-channel 34 as the lower end anchor. The C-channel 34 is preferably discontinuous at the split sealing surfaces 17 (see section at the split surfaces in FIG. 12) to improve the seal at the splits. Alternatives to the C-channel recess 34 will be evident to one skilled in the art, for example an inwardly projecting bottom lip might be formed at the lower end 24 of the side wall 19. Alternatives to the retention ring 28 or retention cap screws 30 will be evident to one skilled in the art. For instance, in applications where welding is permitted, a ring, collar or stop lugs might be welded to the outer casing 12. In some instances a casing collar or lip might already be present on the outer casing 12, which might be used to anchor and attach the lower end 24 of the casing cap 10 to the outer casing 12. Still alternatively, the casing cap housing might accommodate a friction type mechanical connection such as a slip-lock connector (not shown) its lower end 24 to attach to the outer casing, as is known in the art with other wellhead members. A friction type connection such as a slip lock connector is particularly advantageous in applications where neither welding nor machining (such as drilling holes) is permitted, such as exist with flammable gas emissions.

In the embodiment of FIGS. 1-7, the facing sealing surfaces 17 of the split housing portions 16 are sealed together with the sealing element being a sealing compound such as an epoxy or gasket type compound. A metal high temperature epoxy compound is preferred. The sealing surfaces 17 are then clamped together at the left and right splits S using an external clamping system (i.e., clamps integral with, connected to, or separate from the cap housing which apply a horizontal clamping force to clamp together the half portions 16 at their splits). Epoxy is a binary (two component) bonding agent that is inert in its unmixed state, but which hardens when mixed. Epoxy is applied on at least a portion of the sealing surfaces 17 at the splits S of the casing cap half housings 16 and cures once the half portions 16 are clamped together. The casing cap housing portions 16 are formed with vertical compression plates 36 carried by the outside surface of the side wall 19 proximate to, but stepped back from, each of the sealing surfaces 17. The plates 36 are located to be parallel facing in spaced apart relationship when the casing cap housing portions 16 are joined. Aligned bolt holes 37 are formed in opposite plates 36, to receive stud and nut connectors 38 to bolt the casing cap housing portions 16 together. Preferably, a clamping plate 40 is bolted into the top section 20 over the joint or split S of the casing cap housing portions 16, with stud and bolt connectors 42 being used on each side of the adjoining casing cap housing portions 16. Generally V-shaped ridges 44 are formed on the bottom of the clamping plate 40 to be received in V-shaped radial grooves 46 formed in the top surface of the top section 20 adjacent each of the sealing surfaces 17. The staggered relationship of the V-angled grooves 46 (relative to the compression plates 36) allow the forces applied by vertical bolting down the clamping plate 40 to act perpendicular to the direction of the split, applying horizontal clamping force across the split S. For large differences in casing diameters, additional clamping devices can be used on the top section 20.

In the embodiment of FIGS. 8-13, the facing sealing surfaces 17 of the split housing portions 16a, 16b are sealed together with gaskets 50, such as high temperature graphite gaskets used as the sealing element. The gasket is placed at split covering at least a portion of the sealing surfaces 17. The left and right splits S are connected with a screw connection system in which threaded type connectors extend through the side wall 19 and through the gasket 50 and sealing surfaces 17 at the splits S in a manner that applies a horizontal clamping force to clamps together the half portions 16 with the sealing element at the splits. The graphite gaskets 50 may be formed from one or more expanded graphite sheets cut to cover at least a portion of the sealing surfaces 17. The gaskets 50 are held in place for assembly purposes by cap screws 52 received in tapped holes 54 formed on the surfaces 17 of housing portion 16b, with matching drilled holes being formed on the opposing face surfaces 17 of housing portion 16a to accept the heads of the cap screws 52. An exemplary and preferred graphite gasket is SIGRAFLEX™ BSSC (a graphite gasket with a stainless steel inner sheet made by SGL Group, Germany), but other high temperature gasket sheet or foil materials might be used. Depending on the application, alternate sealing elements may include other gasket seals such as graphoil seals, ring seals such as elastomeric O-rings, sealing compounds such as epoxy or gasket compounds (as shown above), or thermoplastic Teflon™ type seals. The cap housing portions 16 are clamped together using vertically aligned cap screws 56 (six shown) extending through recessed holes 58 formed on either side of the left half housing portion 16a (FIG. 8) proximate the outer peripheries of the side wall 19 and received in mating threaded holes 60 formed in the facing surface 17 of the right half housing portion 16b (FIG. 8). As well, threaded studs 62 extend through recessed holes 64 formed on either side of the left half housing 16a through the side wall 19 and top section 20 proximate the inner periphery of the housing 18 and are received in mating threaded holes 66 formed in the facing surface 17 of the right half housing portion 16b. The cap screws 56 and bolts 68 on the ends of the studs 62 are tightened against the side wall 19 to squeeze the gaskets 50 evenly, for example with about 400 ft-lb torque bolting to make up the high temperature gasket seal at the sealing surfaces 17. Any extruded edges of the gaskets 50 within the sealing areas for the upper and lower annular compression seals 22, 24 are removed prior to forming those seals to the casings 12, 14, as set out below.

Alternate non-welded sealing techniques such as O-ring seals secured by for example external C-clamp connectors may be used to clamp the seal element between the sealing surfaces 17.

In preferred embodiments the casing cap 10 forms upper and lower annular compression seals 22, 26 to the inner and outer casings 14, 12 respectively. A static form of stuffing box type seals (i.e., using compression packings and packing glands) is shown in the Figures at both of these locations, but other annular seals might be formed as will be evident to persons skilled in the art. These annular seals allow the inner casing 14 to move axially relative to the outer casing 12 (ex. thermal expansion/contraction) while maintaining the seals to the casings. In installation, the lower annular compression seal 26 is preferably formed before the upper annular compression seal 22. In the Figures, the lower annular compression seal 26 is shown below the mechanical connection to the outer casing 12 (shown below C-channel 34).

However, with alternate mechanical connections such as slip lock connectors the lower annular compression seal might be located above the mechanical connection.

For the upper annular compression seal 22 (best seen in FIG. 13), the inner surface of the top section 20 forms an annular upper seal pocket 70 to be located adjacent the inner casing 14. An inwardly extending lip or step 71 is formed at the base of the seal pocket 70 to retain the seals 22. A split top compression packing 72 , preferably in multiple rings, is provided in the seal pocket 70. Preferably compression packing materials include multiple rings (or rope windings) of expanded graphite packing materials, which might be wired reinforced in one or more of the rings. Exemplary material are ROBCO™ 1220 and ROBCO™ 1200 packings (Robco Inc., LaSalle, Quebec, Canada). Alternate high temperature compression packing materials which retain pressure when compressed might be used. The splits of each adjacent ring are preferably offset one from the other, for example by 120°, to improve sealing. One or more split metal washers 74 may be included below and/or above the graphite packings 72 to limit extrusion of the packings 72. In FIGS. 1-7, an annular split top packing gland 76 is shown bolted to the top section 20 with stud and nut connectors 80 to compress the top compression packings 72. In FIGS. 8-12, an annular split retaining ring 78 is bolted to the top packing gland 76 with cap screws 81 to form a more rigid packing gland, with the splits of the packing gland 76 being offset, preferably 90°, from the splits of the retaining ring 78. The assembled packing gland 76 and retaining ring 78 is bolted to the top section 20 with the stud and nut connectors 80 to compress the top compression packings 72. The splits of the top packing gland 76 are offset, preferably by 90°, from the splits at the casing cap housing half portions 16. These offsets improve sealing and more evenly compress the compression packings 72. Set screws 82 (see FIG. 8) may be used for temporary placement of the gland 76 against the casing 14 during installation.

The lower annular compression seal 26 (best seen in FIG. 13) is similar to the upper annular compression seal 22. The inner surface of the side wall 19 forms an annular lower seal pocket 84 to be located adjacent the outer casing 12. An inwardly extending lip or step 86 is formed at the base of the seal pocket 84 to retain the seal 26. A split bottom compression packing 87, preferably in multiple rings, is provided in the seal pocket 84. Preferred compression packing materials are as indicated above for the upper seal 22, with splits of adjacent rings being offset as above. One or more split metal washers 88 may be included below and/or above the graphite packings 87. An annular split bottom packing gland 90 and an annular split retaining ring 92 are bolted together with cap screws 93, and the assembled packing gland 90 and retaining ring 92 are bolted to the lower end 24 of the side wall 19 with stud and nut connectors 94 to compress the bottom compression packings 87. The splits of the packing gland 90, casing cap housing half portions 16, and the retaining ring 92 are offset as set out above for the upper annular compression seal 22. Set screws 96 may be used for temporary placement of the assembled packing gland and retaining ring 90, 92 against the casing 12 during installation.

As best seen in FIG. 13, a vent 98 may be formed to provide access to the annulus A. The vent 98 is shown to form an angled port through the top section 20, with a threaded outlet 99 to connect to gauges or containment equipment (not shown) as known in the art. Alternatively, a flanged outlet might be provided for the vent.

The top section 20 preferably includes a plurality of lifting eye hooks 100 for ease of installation of the casing cap at the wellhead.

As used herein and in the claims, the word "comprising" is used in its non-limiting sense to mean that items following the word in the sentence are included and that items not specifically mentioned are not excluded. The use of the indefinite article "a" in the claims before an element means that one of the elements is specified, but does not specifically exclude others of the elements being present, unless the context clearly requires that there be one and only one of the elements.

All references mentioned in this specification are indicative of the level of skill in the art of this invention. All references are herein incorporated by reference in their entirety to the same extent as if each reference was specifically and individually indicated to be incorporated by reference. However, if any inconsistency arises between a cited reference and the present disclosure, the present disclosure takes precedence. Some references provided herein are incorporated by reference herein to provide details concerning the state of the art prior to the filing of this application, other references may be cited to provide additional or alternative device elements, additional or alternative materials, additional or alternative methods of analysis or application of the invention.

The terms and expressions used are, unless otherwise defined herein, used as terms of description and not limitation. There is no intention, in using such terms and expressions, of excluding equivalents of the features illustrated and described, it being recognized that the scope of the invention is defined and limited only by the claims which follow. Although the description herein contains many specifics, these should not be construed as limiting the scope of the invention, but as merely providing illustrations of some of the embodiments of the invention.

One of ordinary skill in the art will appreciate that elements and materials other than those specifically exemplified can be employed in the practice of the invention without resort to undue experimentation. All art-known functional equivalents, of any such elements and materials are intended to be included in this invention. The invention illustratively described herein suitably may be practiced in the absence of any element or elements, limitation or limitations which is not specifically disclosed herein.

We claim:

1. A casing cap to seal the casing annulus formed between an upper end of an outer casing and an inner casing extending through and above the outer casing, the casing cap comprising:

a generally annular casing cap housing formed in two or more split portions which when joined at their splits form the casing cap housing to cover and seal the casing annulus, the joined casing cap split portions forming a side wall having an upper and a lower end, the upper end forming an annular top section adapted to be supported by the outer casing, to cover the casing annulus and to form an upper annular seal to the inner casing, the lower end being adapted to form a mechanical connection to the outer casing and to form a lower annular seal to the outer casing, and each casing cap split portion forming a sealing surface at each split for sealing together to form the annular casing cap housing;

a sealing element for placement between opposing sealing surfaces; and

connectors between the casing cap split portions to clamp together the sealing surfaces of the casing cap split portions with the sealing element to form pressure-containing, non-welded seals at the splits.

2. The casing cap of claim 1, wherein:

the casing cap housing is formed in two split half portions with one or more sealing surfaces being formed at each left and right split of each casing cap split half portion; and

the sealing element is a gasket seal or a ring seal adapted for sealing when clamped between the sealing surfaces, or a sealing compound adapted for sealing when applied and clamped between the sealing surfaces.

3. The casing cap of claim 2, wherein the sealing element is an epoxy sealing compound and the connectors are external clamp connectors provided at the top section and side walls of the cap housing at the splits.

4. The casing cap of claim 2, wherein the sealing element is a gasket seal and the connectors are screw connectors extending through the side walls and the sealing surfaces.

5. The casing cap of claim 4, wherein the sealing element is a high temperature gasket seal formed from a graphite sealing material.

6. The casing cap of claim 2, wherein one or both of the upper and lower annular seals is an annular compression seal.

7. The casing cap of claim 6, wherein:

the upper annular compression seal to the inner casing comprises an upper annular seal pocket formed by the top section of the cap housing; a top packing seal in the upper annular seal pocket, and a top packing gland adapted to connect to the top section and to compress the top packing seal in the upper annular seal pocket so as to seal the casing cap housing to the inner casing; and

the lower annular compression seal to the outer casing comprises a lower annular seal pocket formed by the side wall of the cap housing, a bottom packing seal in the lower annular seal pocket, and a bottom packing gland adapted to connect to the lower end of the side wall and to compress the bottom packing seal in the lower annular seal pocket so as to seal the casing cap housing to the outer casing.

8. The casing cap of claim 7, wherein:

the top packing seal and the bottom packing seal each comprise a plurality of stacked split ring graphite packings;

the top packing gland and the bottom packing gland each comprise a split packing gland connected to a split retaining ring, and which are bolted to the casing cap housing;

the splits of the split ring graphite packings are circumferentially offset one from another in the stack to improve sealing;

the splits of the packing gland are circumferentially offset from the splits of the casing cap housing portions; and

the splits of the packing glands are circumferentially offset from the splits of the retaining rings to more evenly distribute compression on the top and bottom packing seals.

9. The casing cap of claim 7, wherein:

the side wall surrounds the outer casing and is adapted at the lower end to form the mechanical connection and the annular seal to the outer surface of the outer casing; and

the mechanical connection to the outer casing is non-welded and includes an outwardly extending circumferential extension adapted to be fastened to the outer casing at the upper end of the outer casing, and a recess formed in the side wall of the casing cap split half portions to accommodate the circumferential extension and prevent upward displacement of the casing cap.

10. The casing cap of claim 7, wherein the mechanical connection to the outer casing is non-welded and includes a friction type connection to the outer casing.

11. The casing cap of claim 10, wherein the mechanical connection is a slip lock connection to the outer casing.

12. The casing cap of claim 9, wherein the circumferential extension is formed by a plurality of retention screws adapted to be fastened around and through the upper end of the outer casing such that a head end of each retention screws is outwardly extending from the outer casing, and wherein the recess in the side wall of the casing cap split half portions accommodates the head end of the retention screws.

13. The casing cap of claim 9, wherein the circumferential extension is formed by a split retention ring or ring portions adapted to be fastened to the outer surface of the

outer casing, and wherein the recess in the side wall of the casing cap split half portions accommodates the retention ring.

14. The casing cap of claim 7, wherein the casing cap further comprises a vent formed through the top section of the cap housing to provide access to the casing annulus.

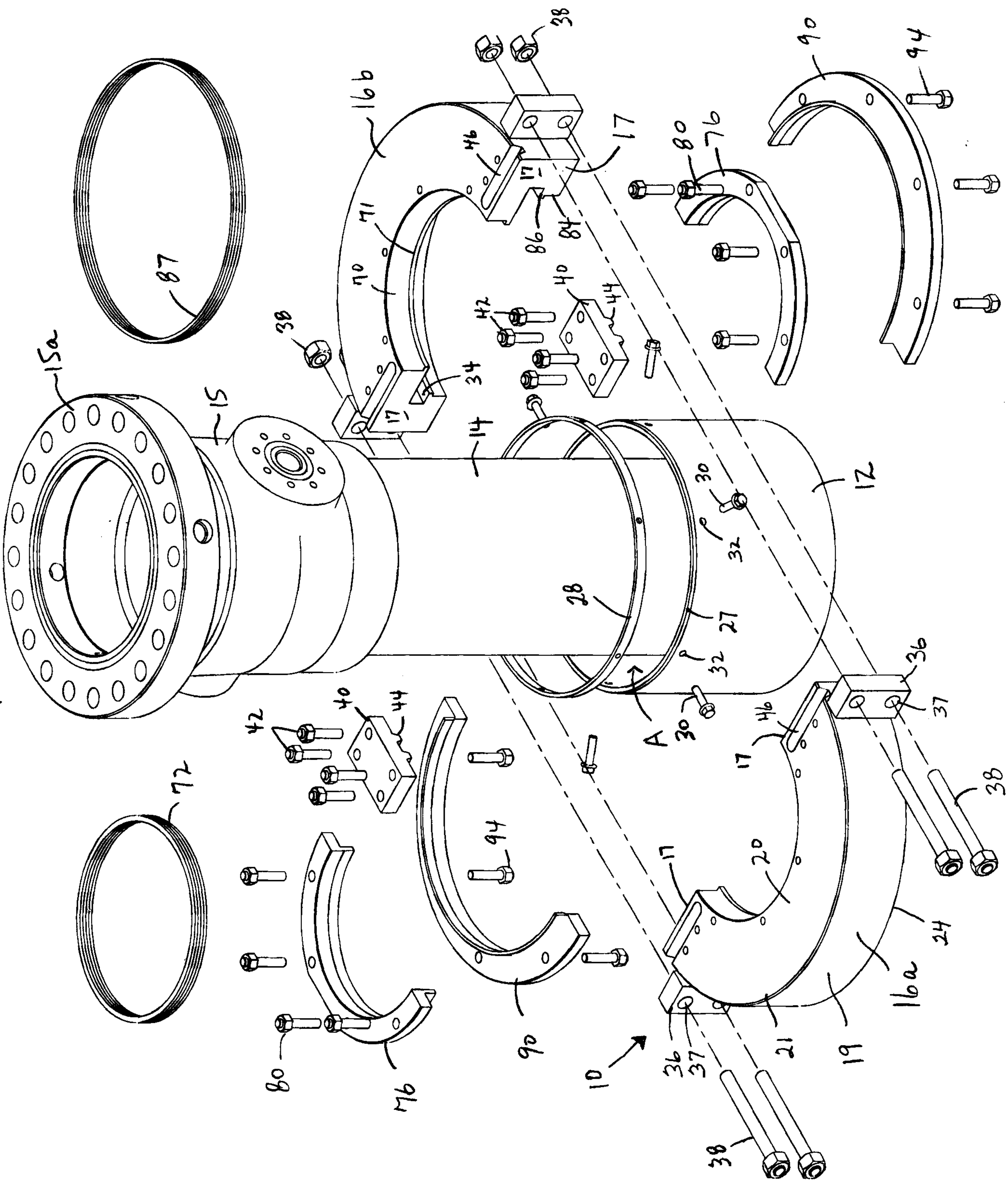

10
12
14
15
15a
16a
16b
17
19
20
21
24
27
28
30
32
34
36
37
38
40
42
44
46
70
71
72
76
80
84
86
87
90
94
A

FIG. 1

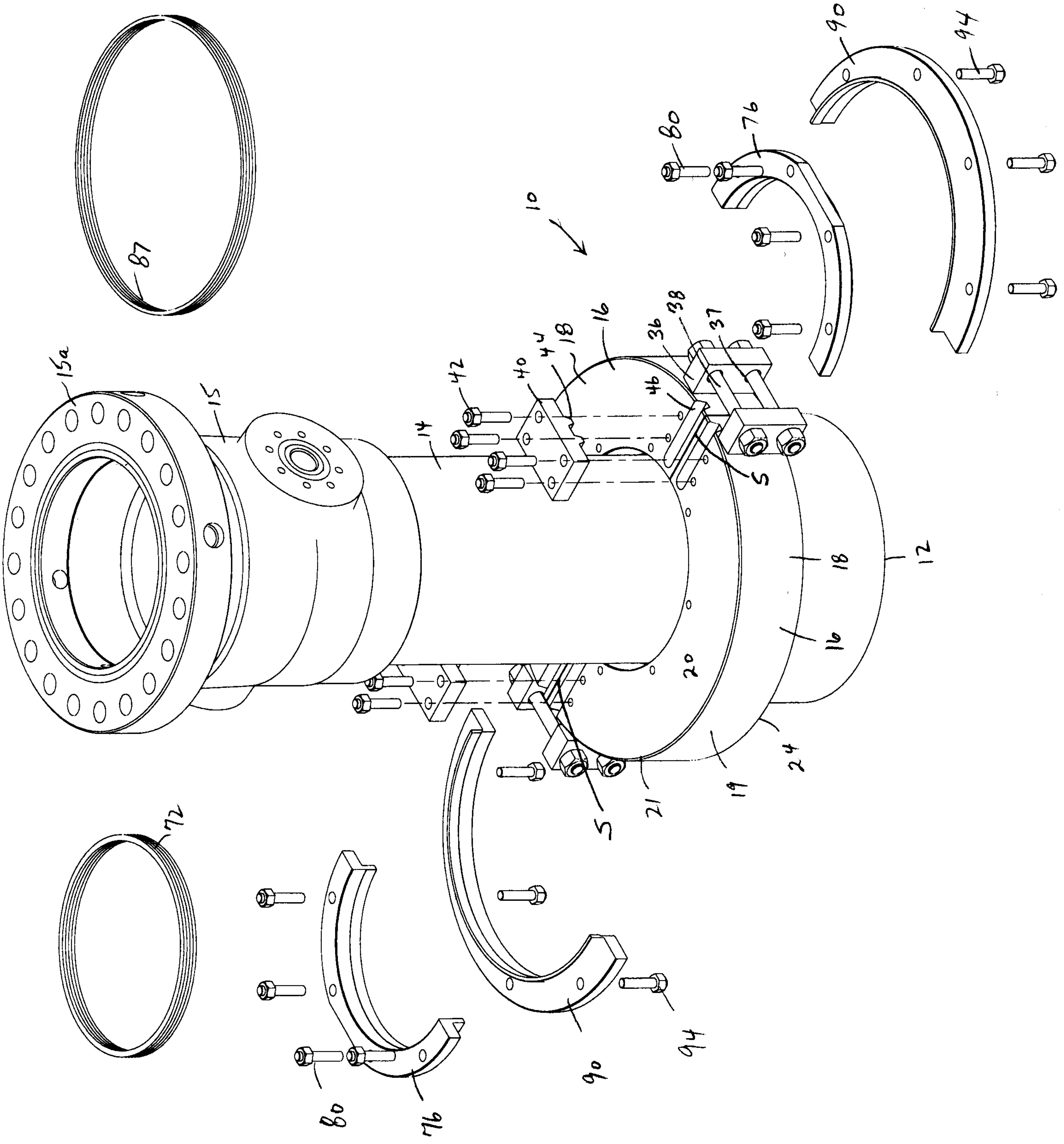

15a
15
14
42
40
44
18
16
36
38
37
46
5
10
80
76
90
94
87
72
12
18
16
20
24
19
21
5
94
90
80
76

FIG. 2

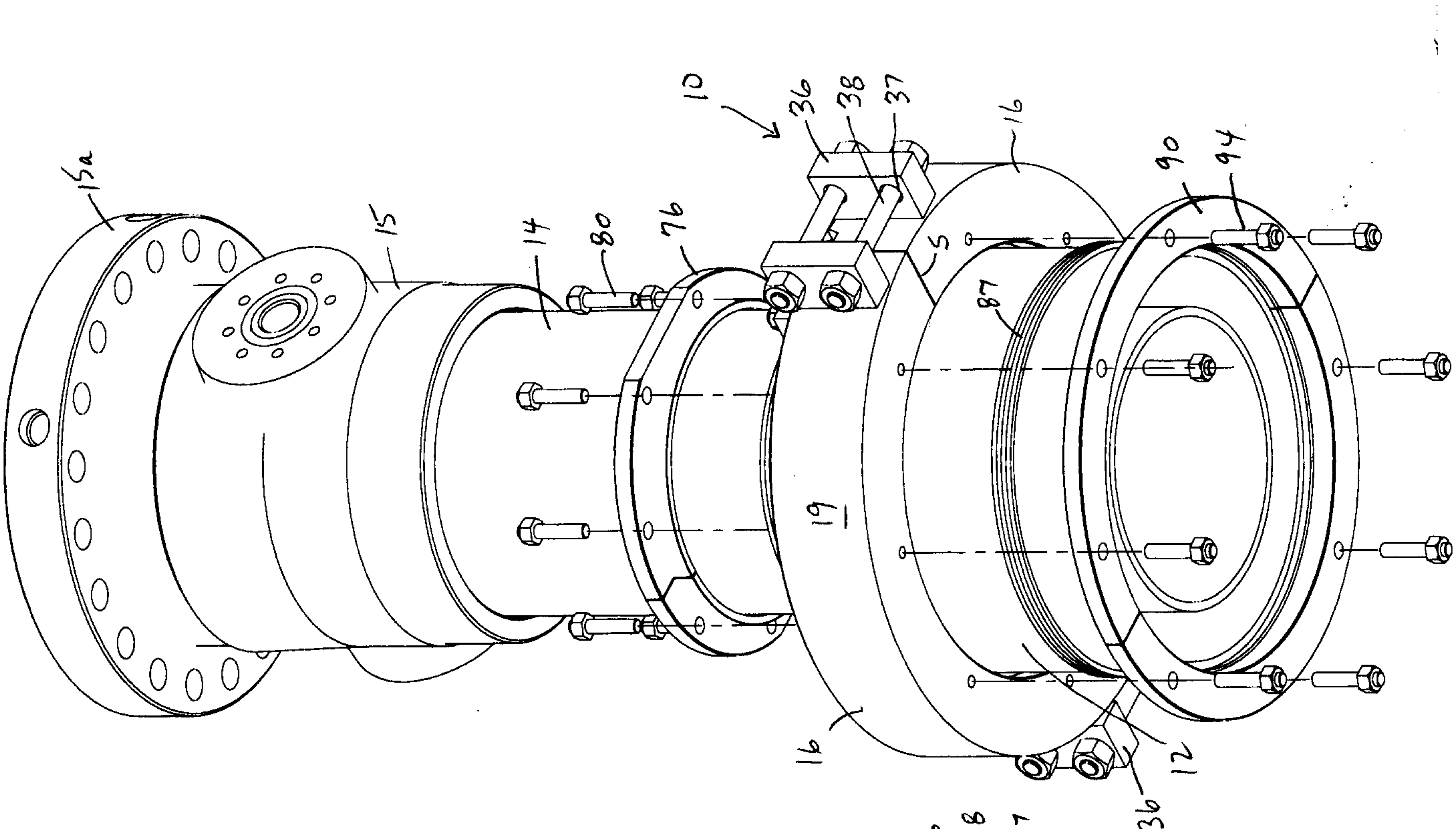

10
36
38
37
16
15a
15
14
80
76
5
87
19
90
94
16
12
36

FIG. 3B

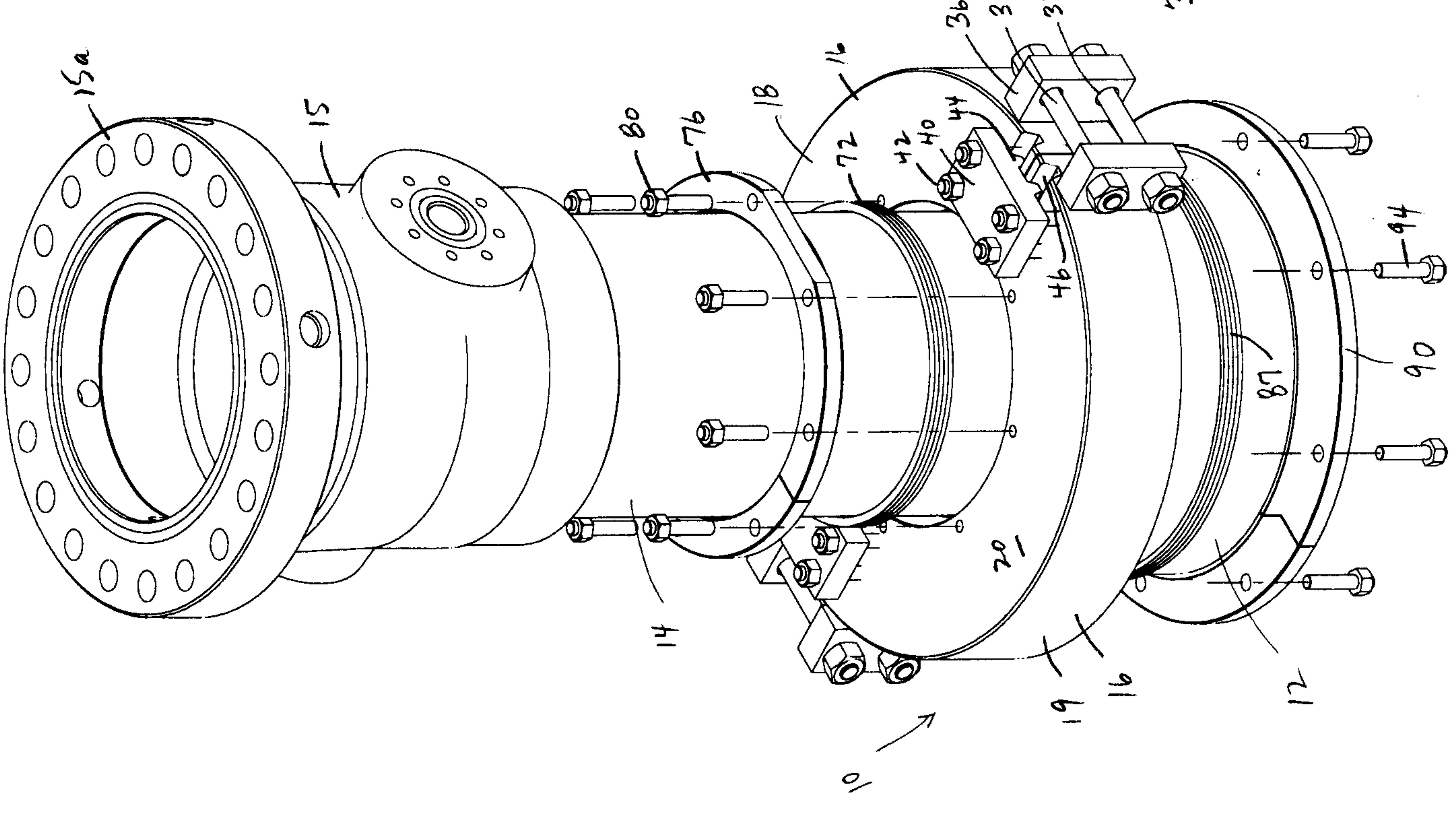

15a
15
80
76
18
16
36
38
37
44
40
42
72
46
94
87
90
14
20
19
16
12
10

FIG. 3A

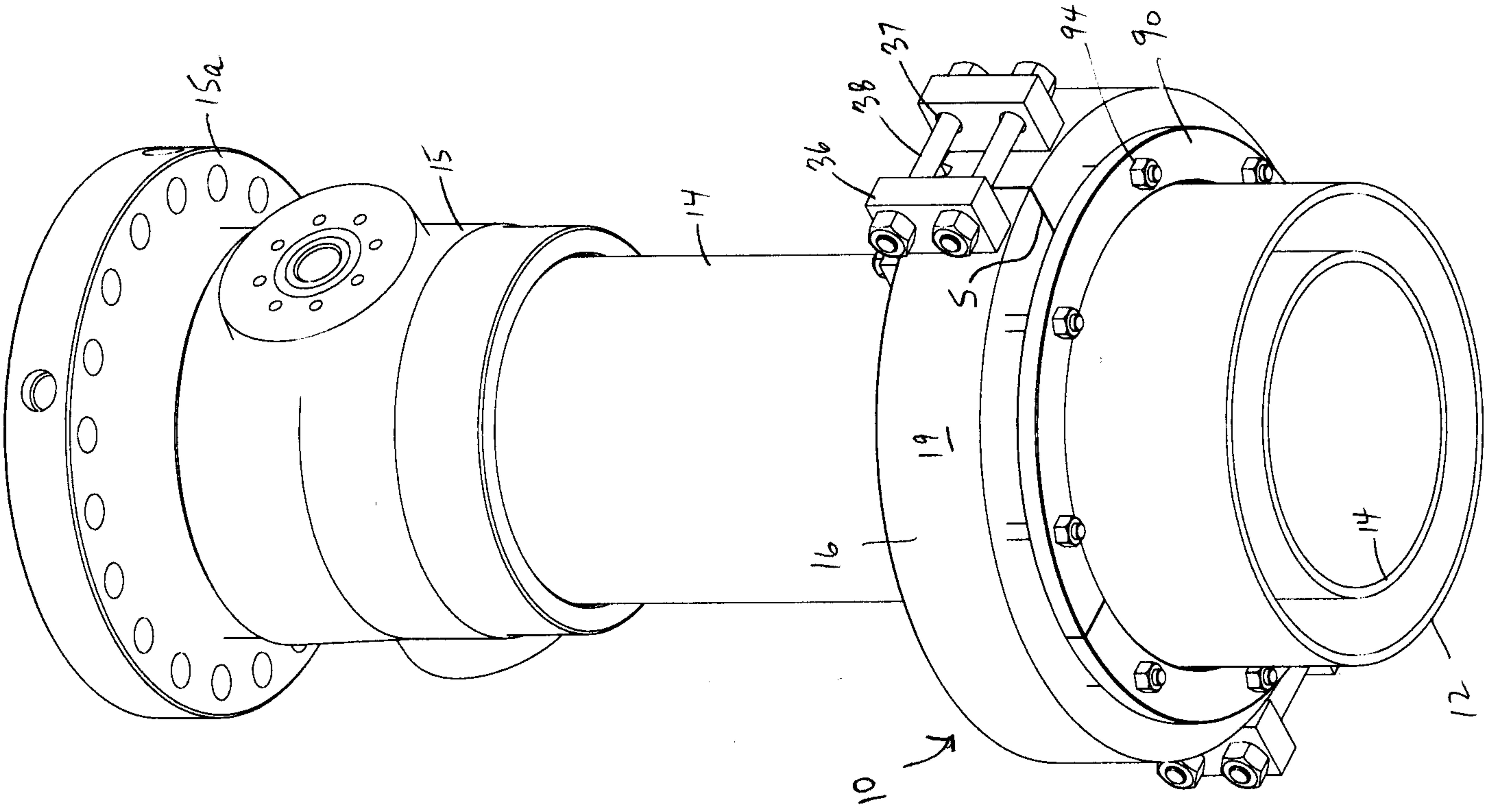

15a
15
14
36
38
37
94
90
5
19
16
14
12
10

FIG. 4B

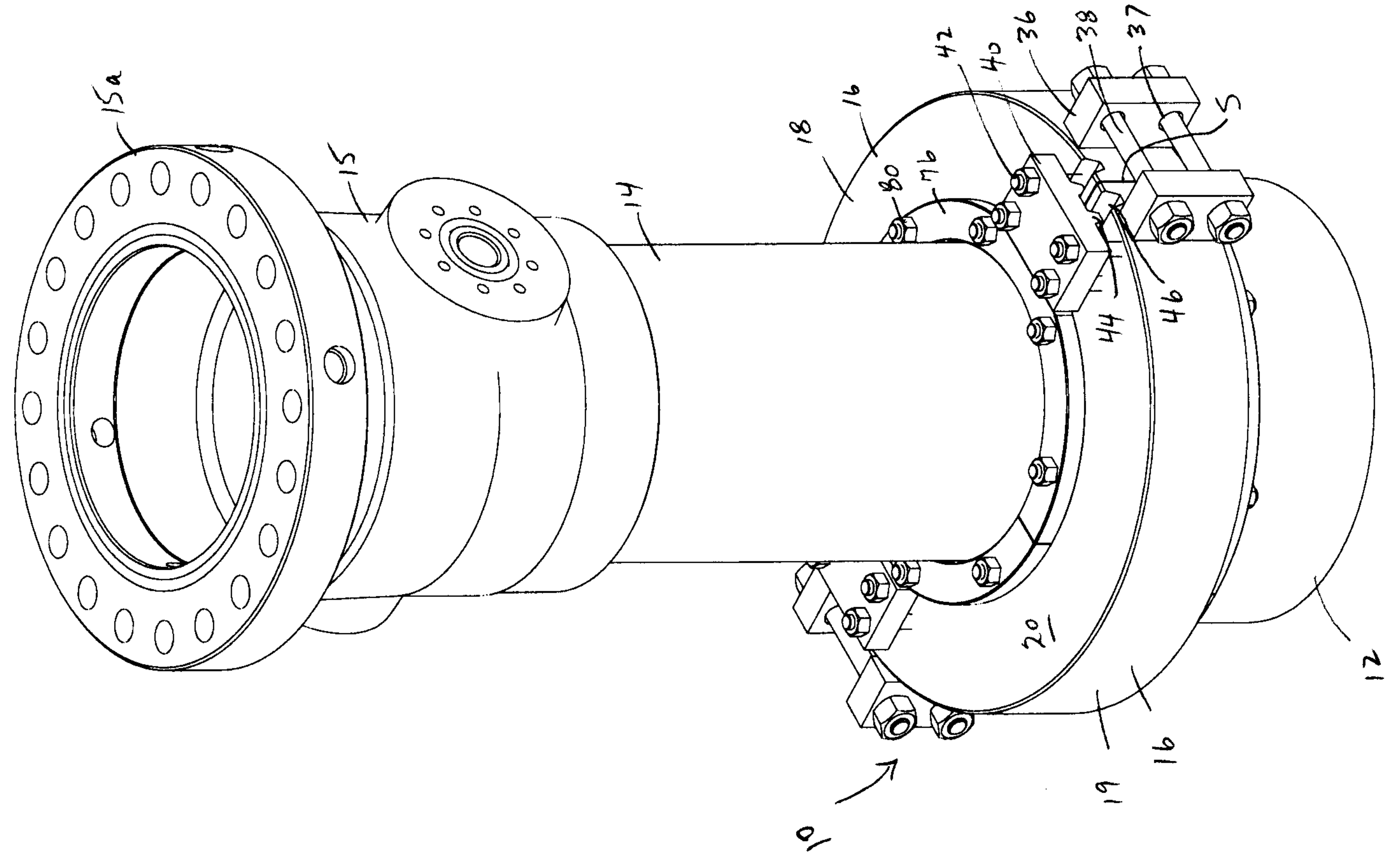

15a
15
14
18
16
80
76
42
40
36
38
37
5
44
46
20
19
16
12
10

FIG. 4A

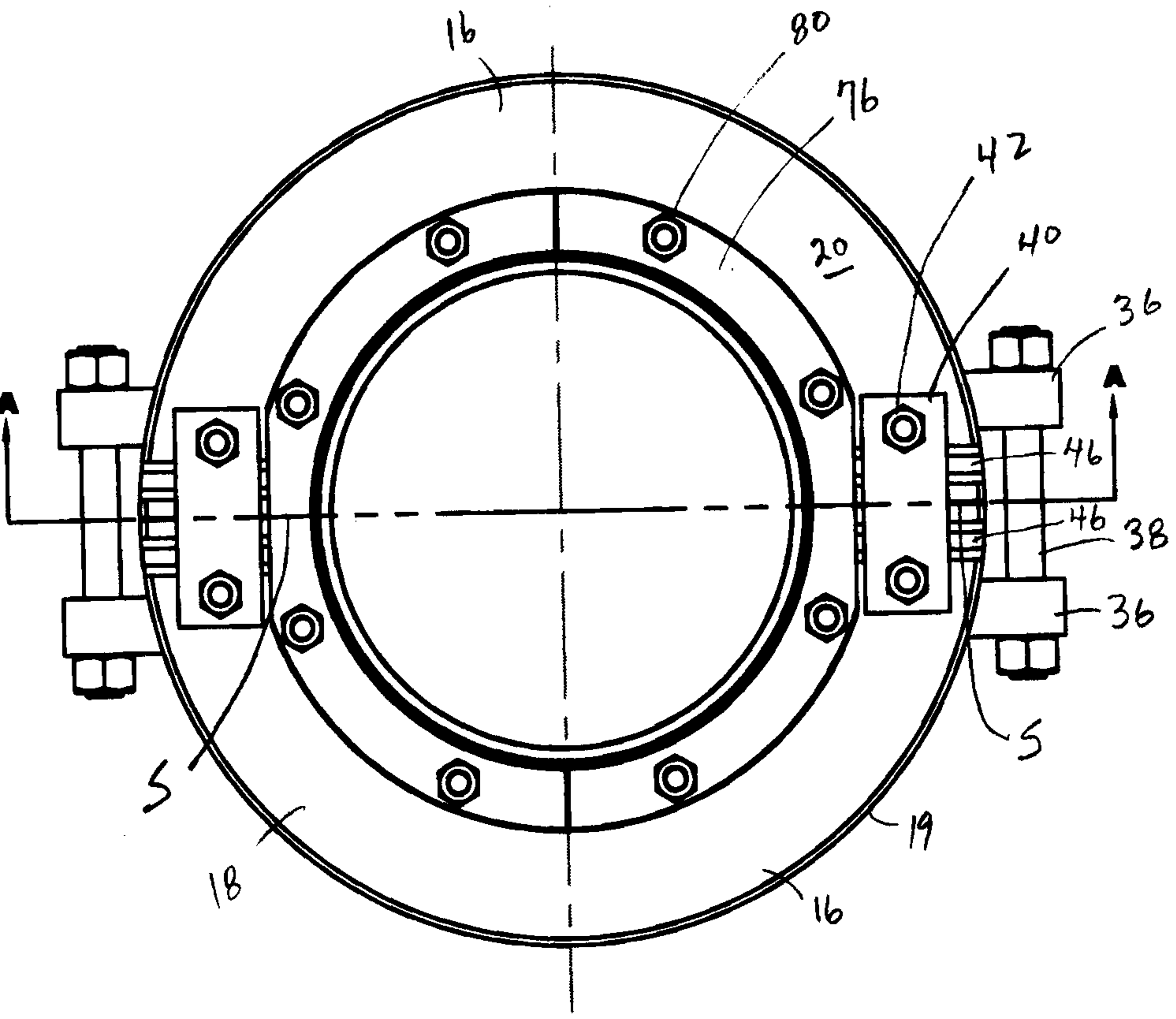


FIG. 5

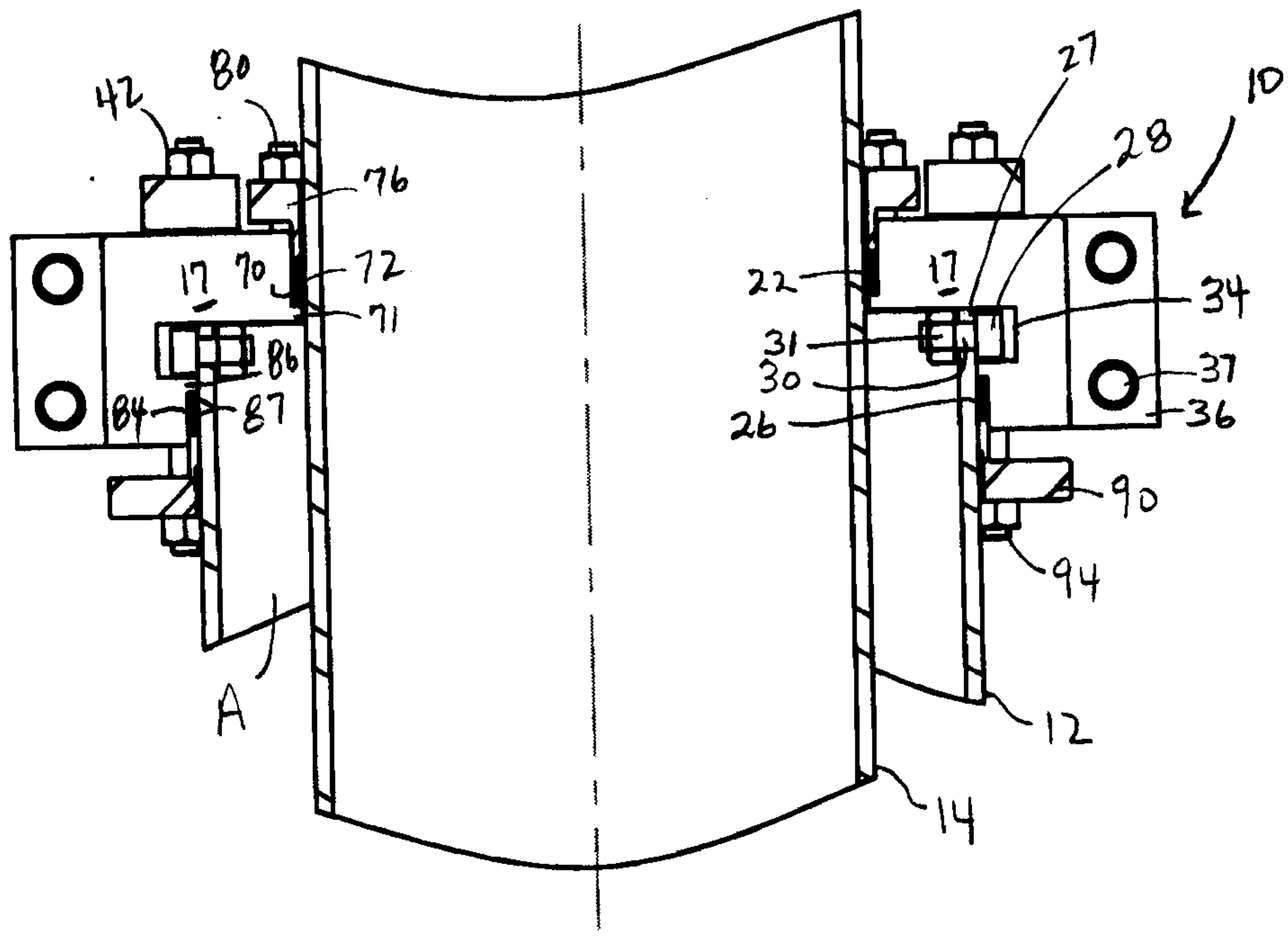


FIG. 6

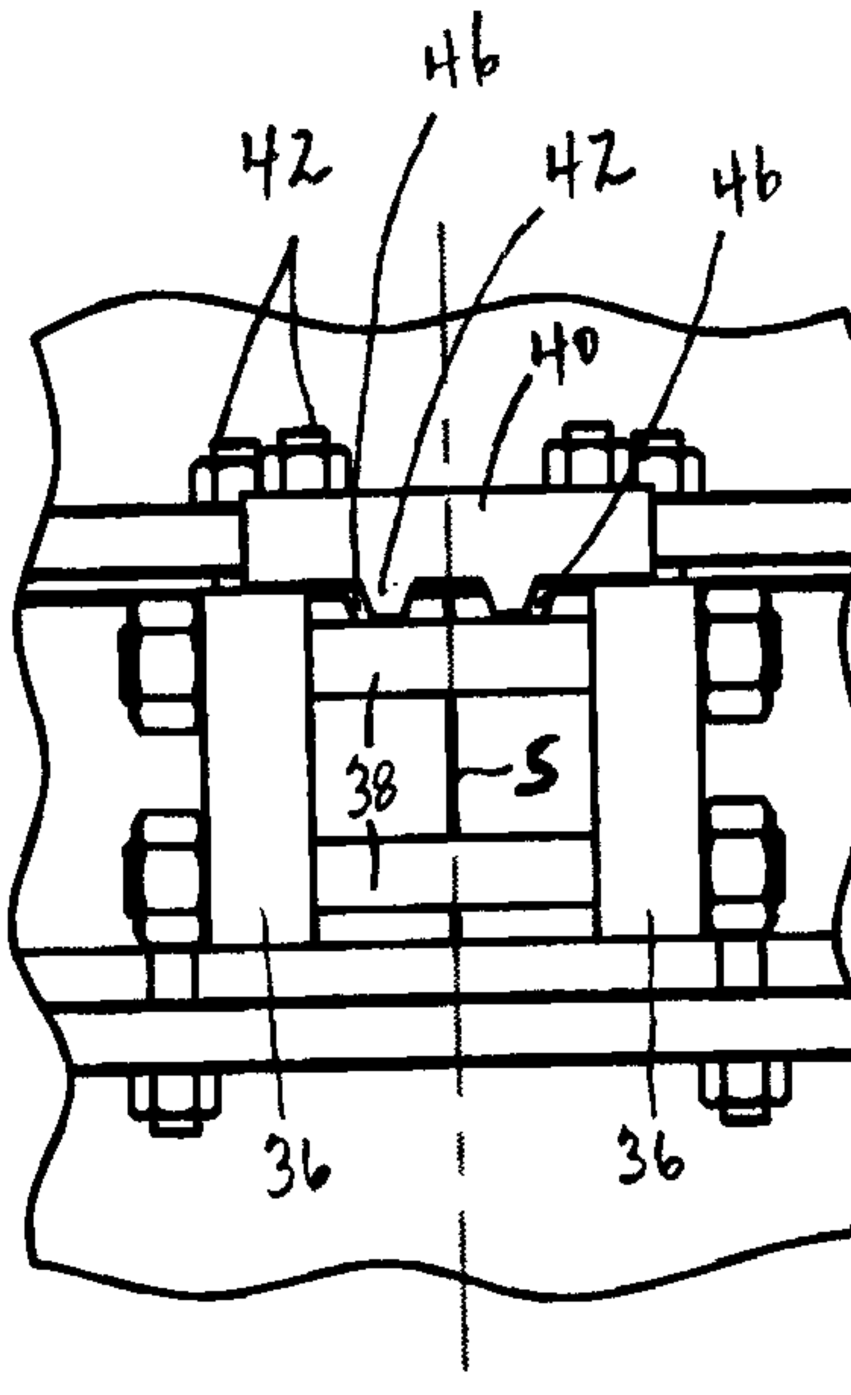


FIG. 7

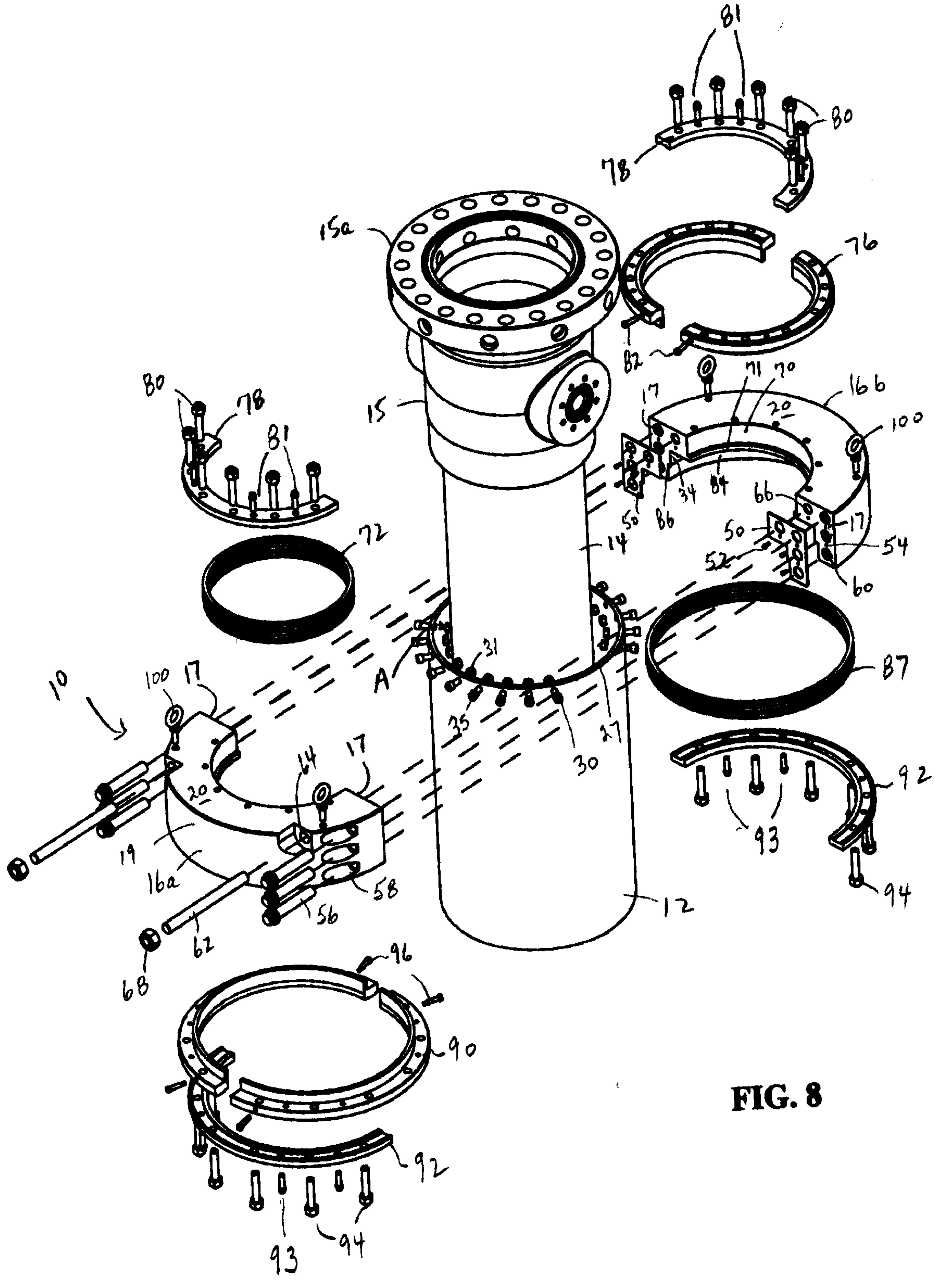

81
80
78
15a
76
82
80
78
81
71
70
17
20
16b
100
15
66
17
50
86
34
84
50
54
52
60
14
72
87
31
A
27
35
30
10
100
17
20
64
17
92
19
16a
93
58
56
94
62
68
96
90
92
93
94

FIG. 8

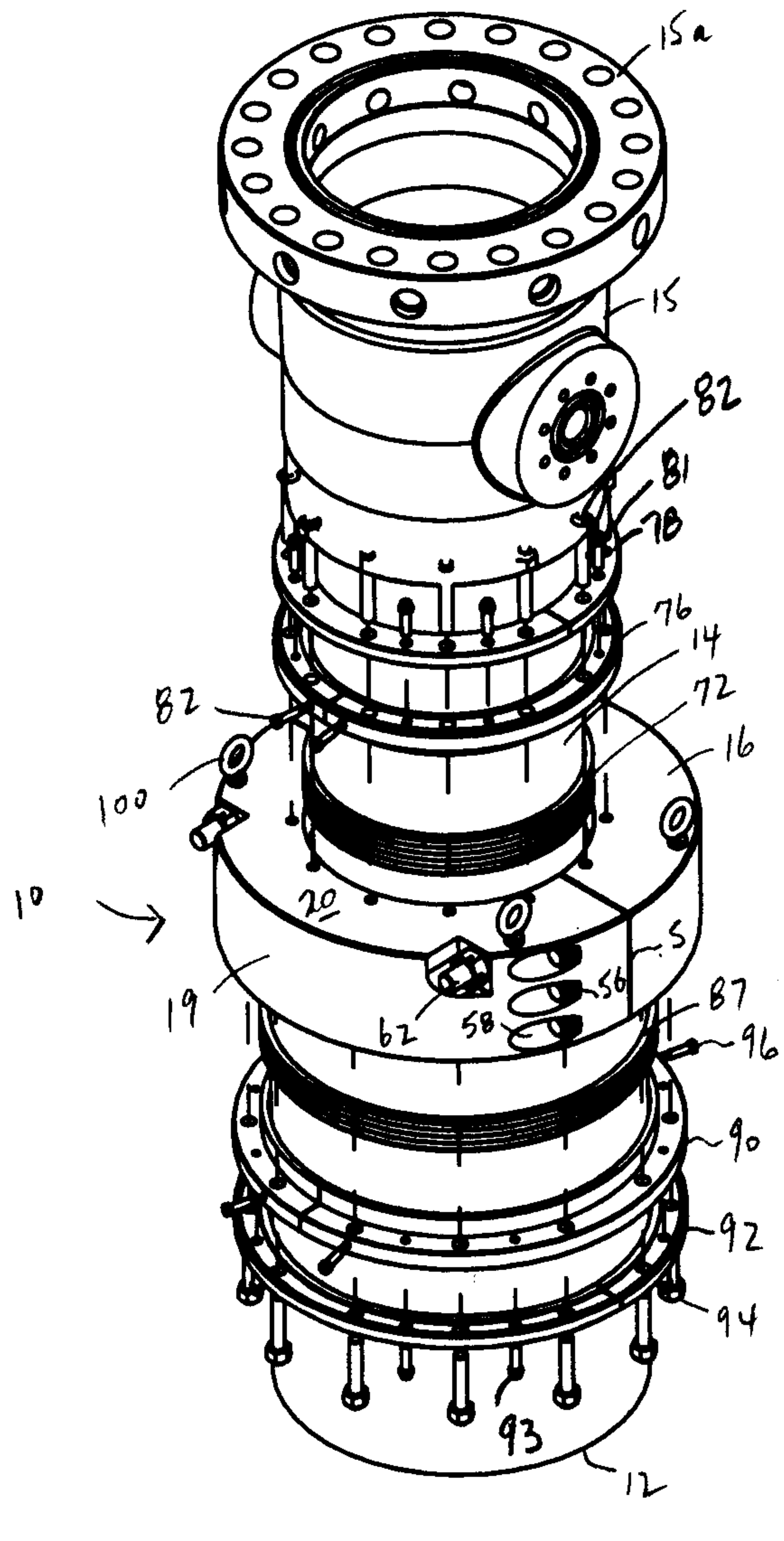

15a
15
82
81
78
76
14
72
82
16
100
10
20
19
62
58
56
S
87
96
90
92
94
93
12

FIG. 9A

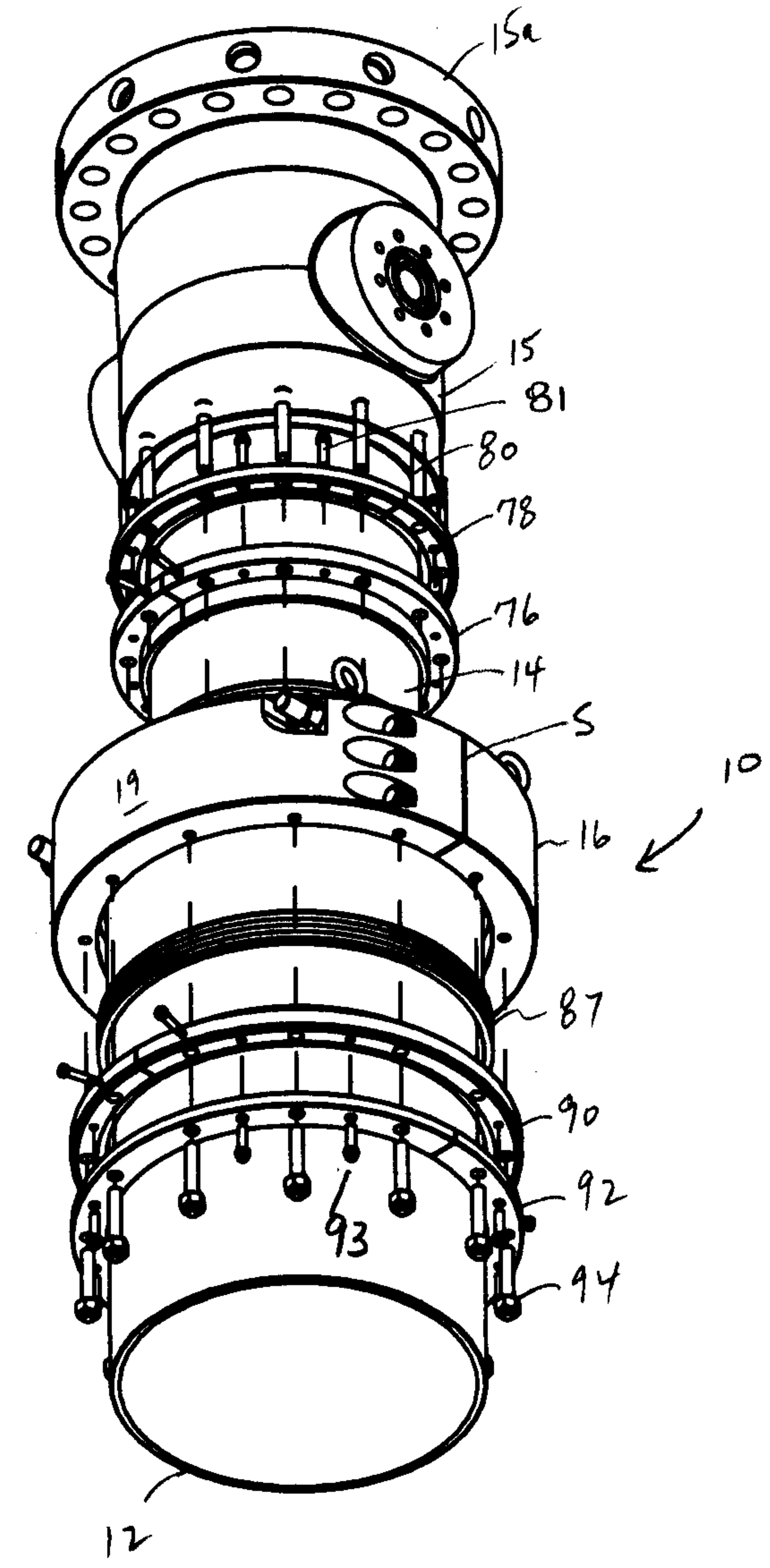

15a
15
81
80
78
76
14
S
19
10
16
87
90
92
93
94
12

FIG. 9B

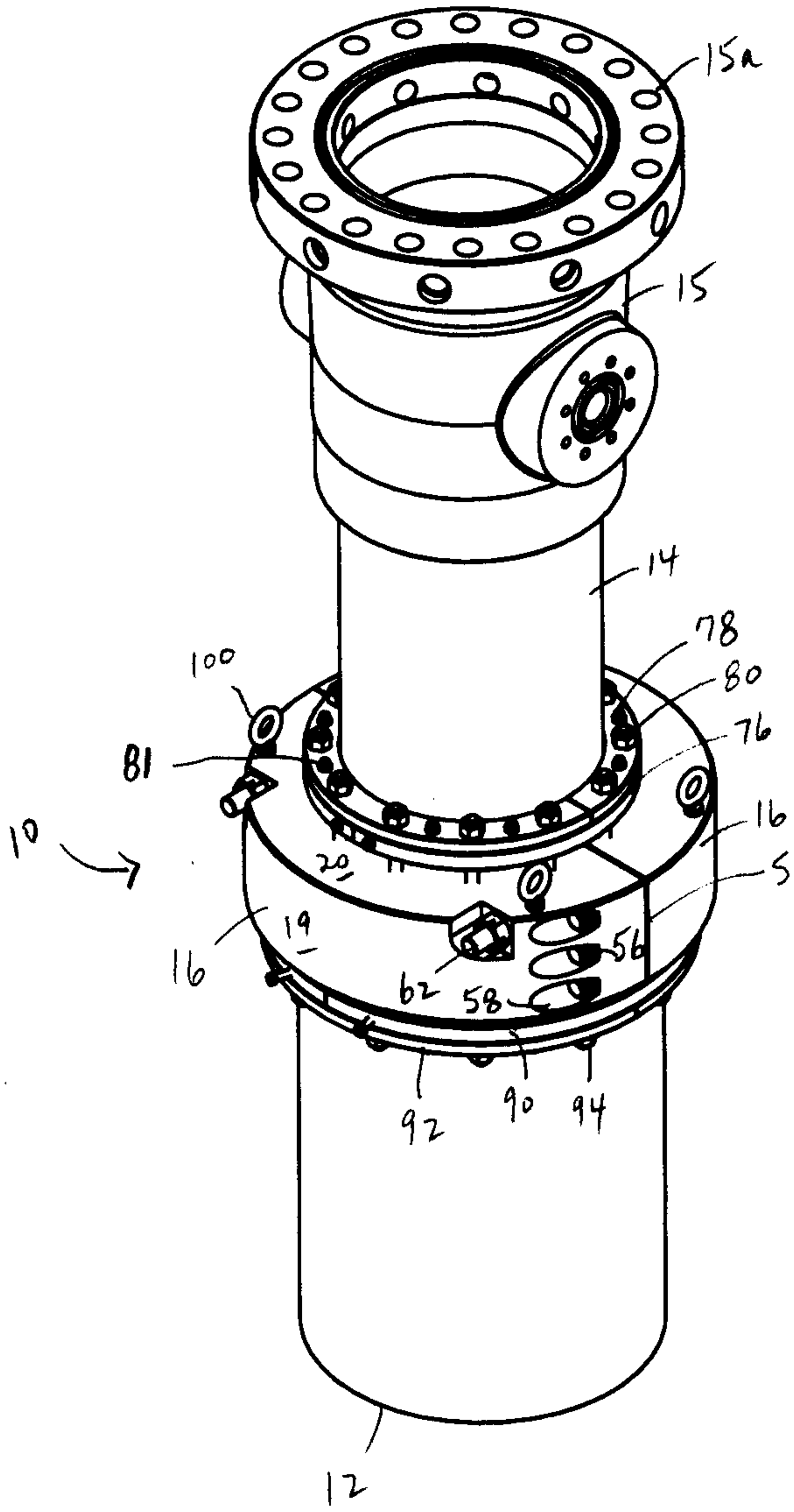


FIG. 10A

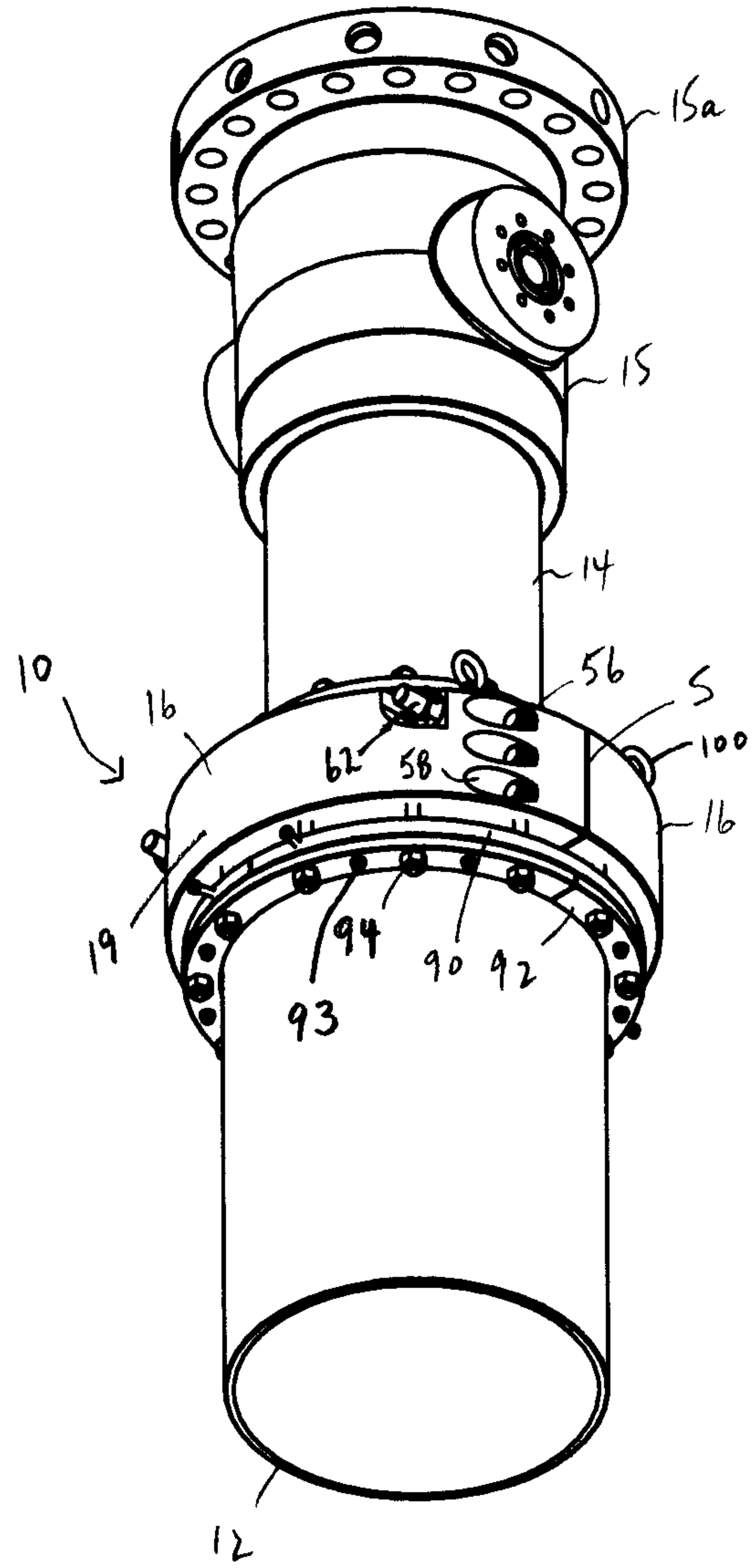


FIG. 10B

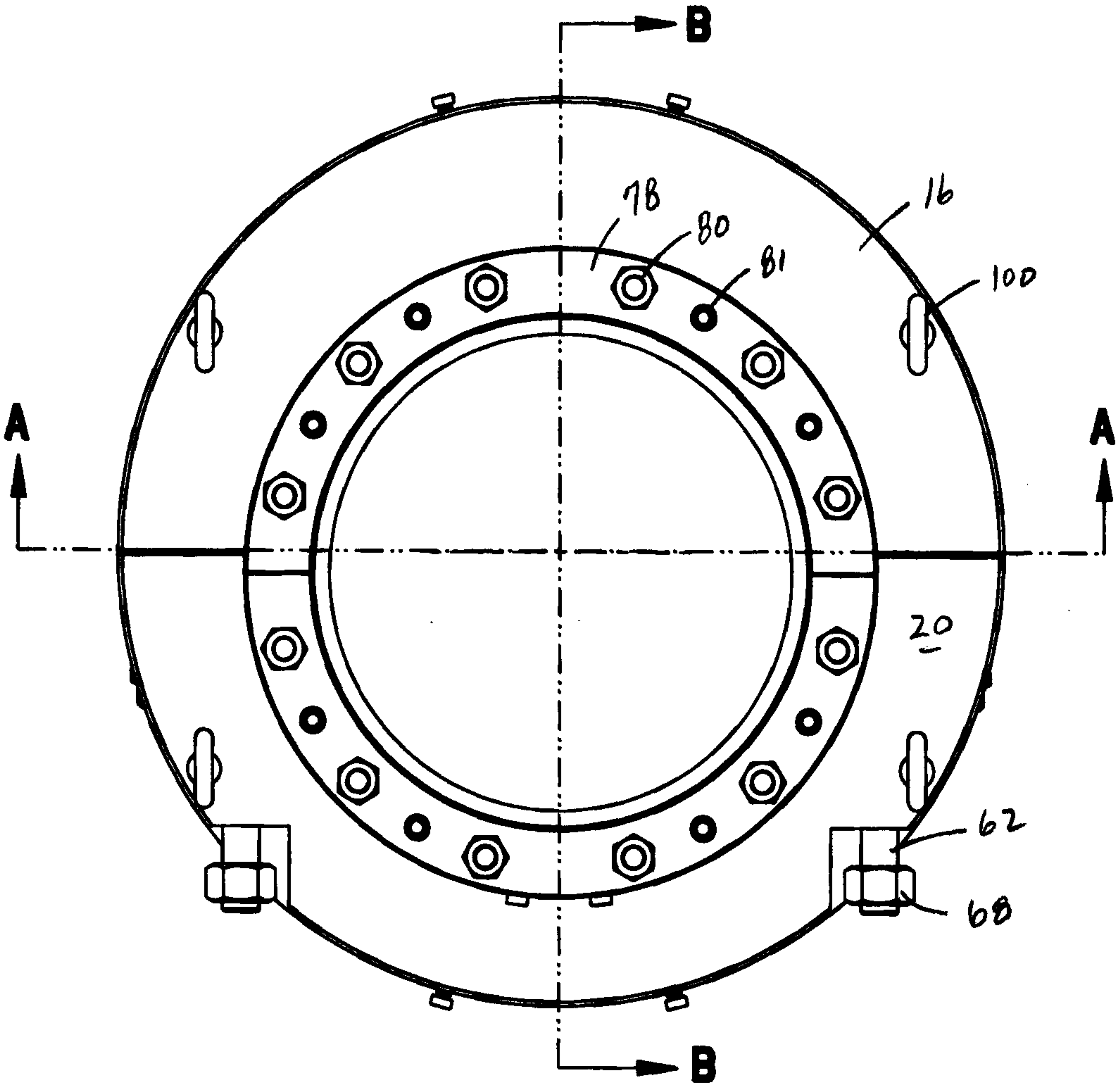

B
78
80
16
81
100
A
A
20
62
68
B

FIG. 11

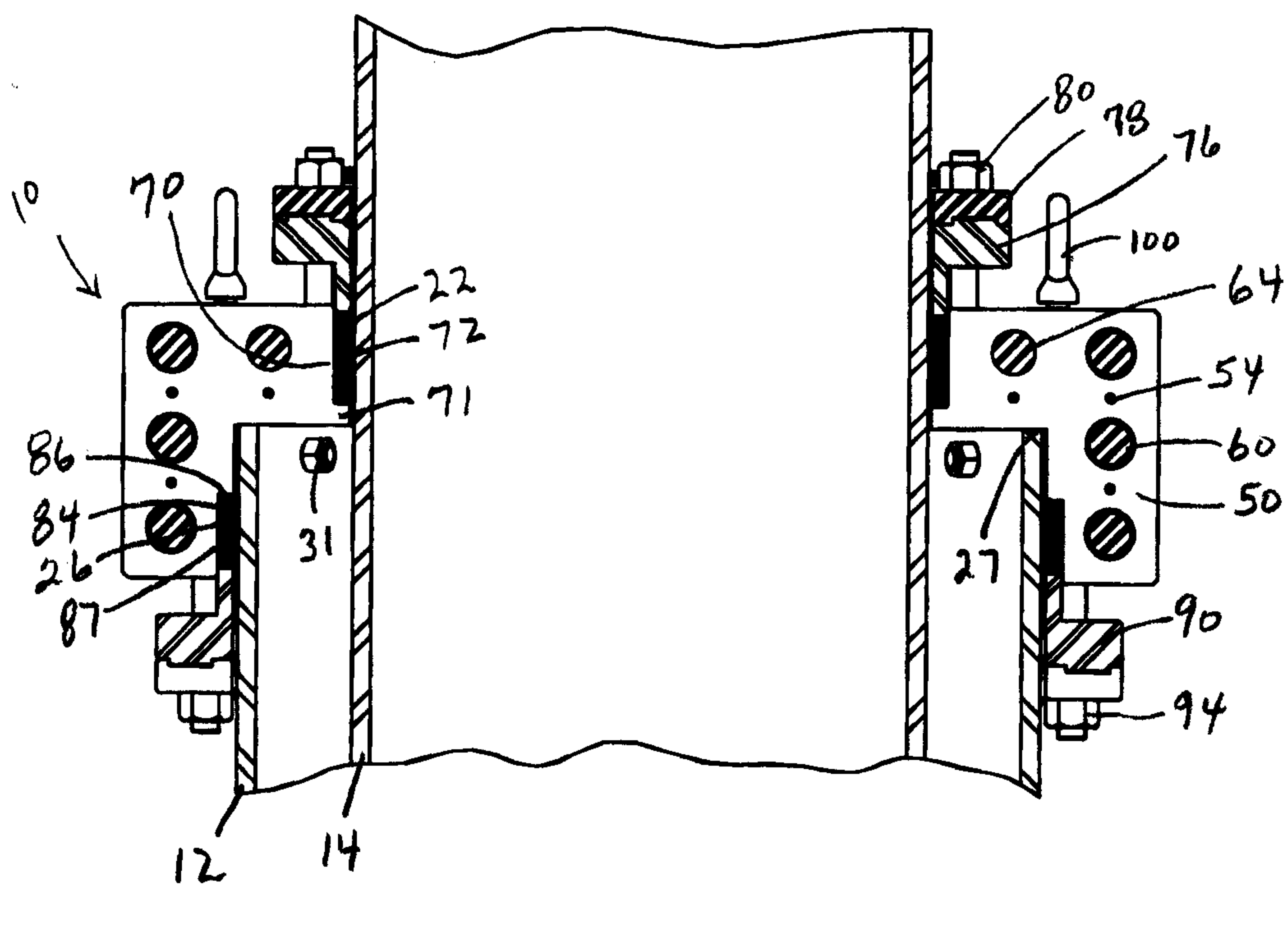

80
78
76
10
70
100
22
72
64
54
71
86
60
84
50
26
31
27
87
90
94
12
14

FIG. 12

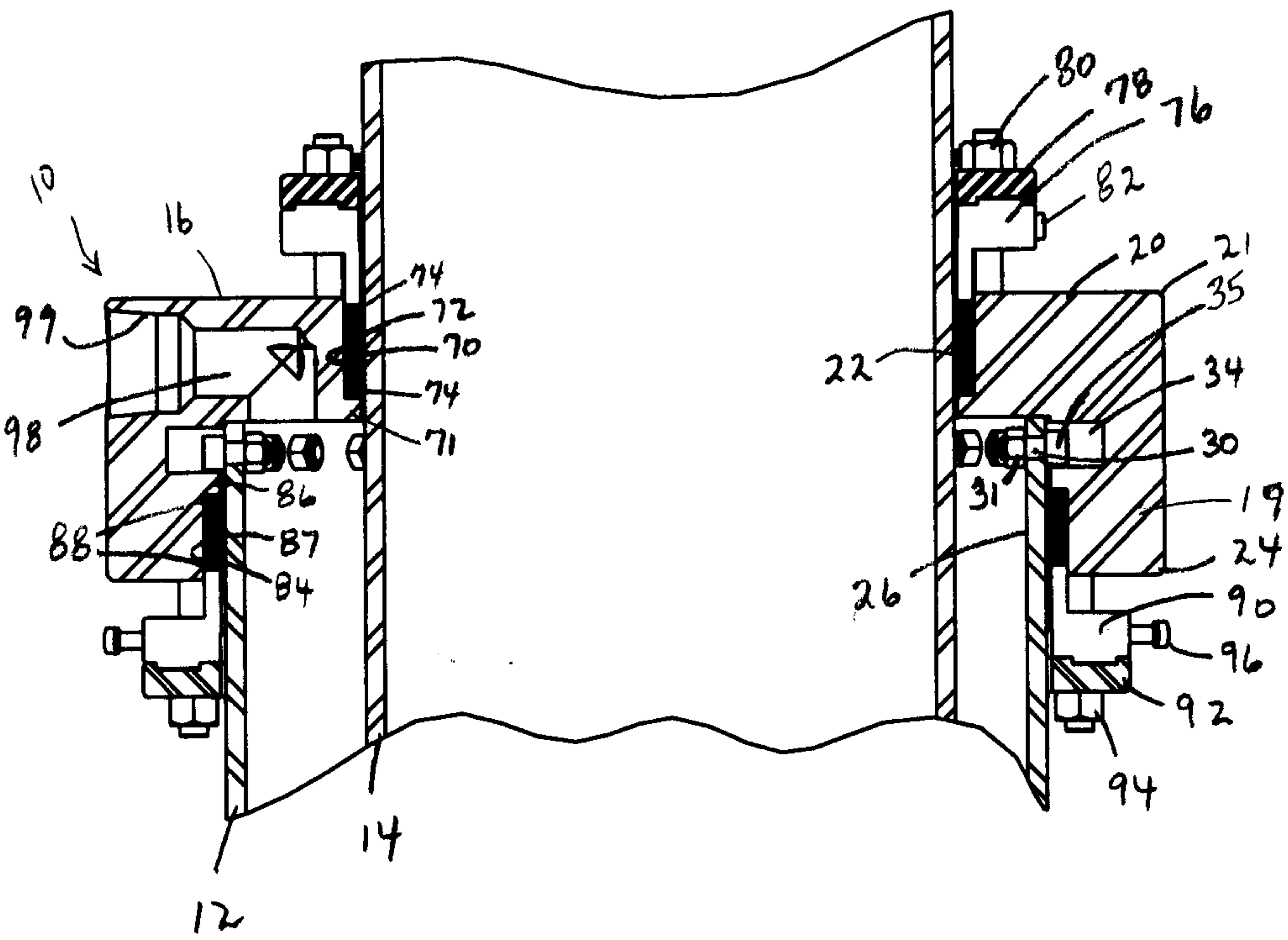
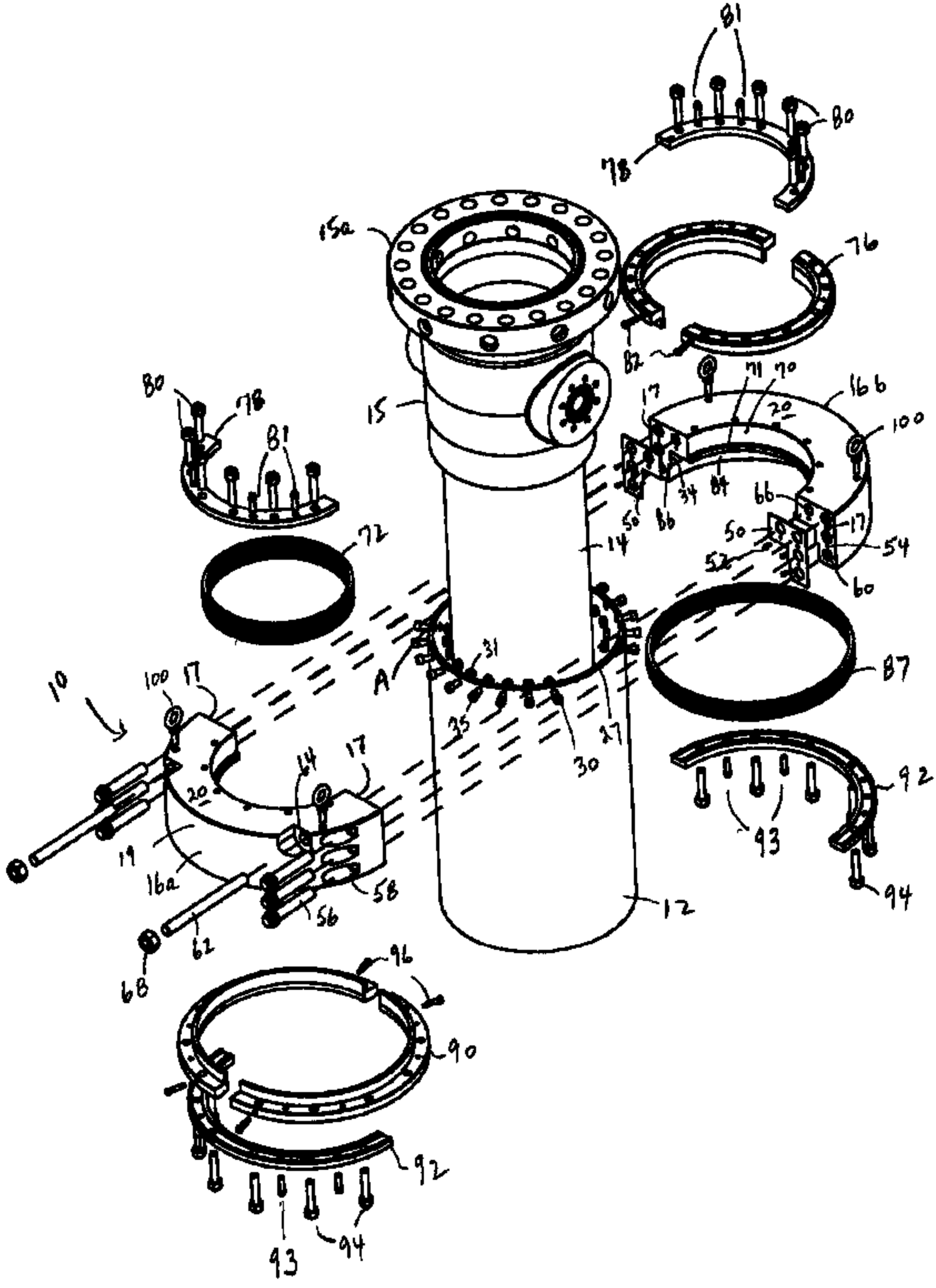

10
16
99
98
88
86
87
84
74
72
70
74
71
80
78
76
82
20
21
35
22
34
30
31
19
24
26
90
96
92
94
14
12

FIG. 13



81
80
78
15a
76
82
15
80
78
81
71
70
16b
17
20
100
66
34
84
50
86
17
50
54
52
60
72
14
31
A
87
10
100
17
17
64
20
35
30
27
19
16a
58
56
92
93
94
62
12
68
96
90
92
93
94