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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : F16L 55/11, 55/136 — A1

(11) International Publication Number: **WO 00/61987**

(43) International Publication Date: 19 October 2000 (19.10.00)

(21) International Application Number: PCT/US99/17299

(22) International Filing Date: 30 July 1999 (30.07.99)

(30) Priority Data:
09/132,077 10 August 1998 (10.08.98) US

(63) Related by Continuation (CON) or Continuation-in-Part (CIP) to Earlier Application
US Not furnished (CIP)
Filed on Not furnished

(71) Applicant *(for all designated States except US)*: TDW DELAWARE, INC. [US/US]; Suite 780, 1100 Market Street, Wilmington, DE 19801 (US).

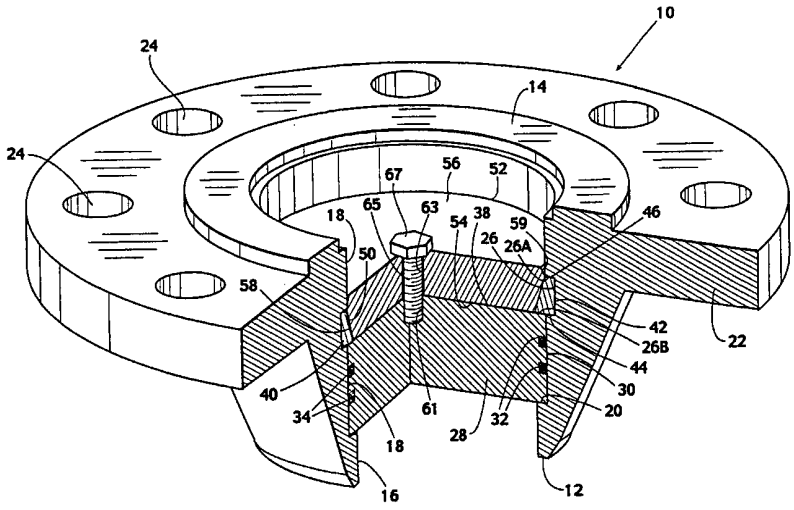
(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: WILSON, Michael, L. [US/US]; Route 1, Box 1214, Kellyville, OK 74039 (US). MORGAN, Mark, A. [US/US]; 5420 South Marion Place, Tulsa, OK 74135 (US).

(74) Agent: JOHNSON, Paul, H.; Head, Johnson & Kachigian, 228 West 17th Place, Tulsa, OK 74119 (US).

(81) Designated States: AU, BR, CN, JP, KR, MX, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: A REMOVABLE CLOSURE SYSTEM



(57) Abstract

A closure for a tubular member (10) having a first surface (16) of a first internal diameter and a second surface (18) of an enlarged internal diameter providing a circumferential ledge (20), and, in the second surface (18) an increased internal diameter circumferential slot (26), the closure being formed of a cylindrical plug (28) removably positioned within the tubular member (10) and in engagement with the circumferential ledge (20) and an expandable snap ring (40) having a collapsed and an expanded condition and receivable when in the expanded condition within the circumferential slot (26) to capture the plug between the circumferential ledge (20) and the snap ring (40) and a keeper plate (52) of external diameter equal the internal diameter of the snap ring (40) when the snap ring (40) is in its expanded condition, the keeper plate (52) being receivable within the snap ring (40) when said snap ring (40) is within the circumferential slot (26) and serving to prevent dislodgement of the snap ring (40).

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A REMOVABLE CLOSURE SYSTEM

Background of the Invention

It is frequently necessary to close an opening in a tubular member either permanently or semi-permanently, that is, to close an opening where a valve is not required or is not desirable. One example of a semi-permanent closure arises when a hot tap is made into a pipeline or a vessel through a fitting connected to the pipeline or vessel. In the typical hot tapping application as utilized in the petroleum industry, a fitting usually in the form of a flange is welded on the exterior of a pipe that has flowing gas or liquid under pressure. A valve is then secured to the flange and a hot tapping machine secured to the valve. By use of highly specialized equipment, a hole can then be drilled through the wall of the pipe while a gas or liquid continues to flow through it to provide access to the interior of the pipe, such as for inserting equipment to temporarily block flow through the pipe while repairs are being made. After the repairs are complete the equipment is removed but the opening that provides communication to the interior of the pipe needs to be closed. Preferably the closure is made in such a way that at some future date access can be again obtained through the fitting to the interior of the pipe. This is just one example of the need for a closure for an opening in a tubular member.

For background information relating to closure devices, reference may be had to the following United States patents:

PATENT NO.	INVENTOR	TITLE
2,010,200	Reufener et al.	Sealing Device for Pressure Containers
2,281,145	Duey	Pipe Plug
2,287,750	Clayton	Fill Pipe Cap
2,431,778	Sosaya	Test Cap
2,512,041	Steele	Temporary Drainpipe Closure
3,114,528	Forest	Base and Lock Assembly for Pipe
3,155,116	Ver Nooy	Apparatus for Closing Side Openings into Pipelines
3,179,446	Paterson	Extension Fitting Having Initial Flexible Lip Seal Gasket
3,483,894	Finocchiaro	High Pressure Pipe Test Plug
3,765,456	Karpenko	Chemical Cleaning Line Connector
3,766,947	Osburn	Fluid Tight Closure
4,377,185	Katz	Hydrotest Apparatus
4,387,740	Vanzant	Cam-Flange
4,466,550	Sullivan	Closure for a Cylindrical Opening Having Improved Venting Means
4,576,778	Ferree et al.	Core Barrel Plug
4,609,209	Ralls	Precise Alignment Adapter Flange
4,693,278	Wilson et al.	Safety Closure Member
4,902,043	Zillig et al.	Fluid Coupling and Seal Assembly
5,035,266	Benson et al.	Mechanical Plug for Clean-Out Tees
5,038,830	Arnaud	Pipe and Sealing Device
5,437,309	Timmons	Lockable Well Cap
5,450,765	Stover	Apparatus for Providing Signal Communication Between the Interior and Exterior of a Pipeline

Brief Summary of the Invention

This invention provides a removable closure including a tubular member having a cylindrical opening for the passage of tools or for flow of liquids or gases. In a typical application of the invention the closure may be in the form of a flange member, that is, a tubular member that has an integral radially extending flange portion that is readily adaptable for the attachment to other structural or piping devices. The tubular member has an inner end and an outer end and an internal passageway that is defined by a first surface of a first internal diameter adjacent the inner end and a second surface of a larger internal diameter adjacent the outer end, the difference in internal diameters providing a circumferential ledge. The tubular member second cylindrical surface has an increased internal diameter circumferential slot therein that is spaced from the circumferential ledge.

A cylindrical plug is positioned within the tubular member. The plug has at least a portion that is of external diameter greater than the tubular member first cylindrical surface and slightly less than that of the second cylindrical surface. The cylindrical plug is telescopically positionable within the tubular member second internal cylindrical surface and in engagement with the tubular member internal circumferential ledge.

An expandable snap ring has a collapsed and an expanded condition. When in the collapsed condition the snap ring has an external cylindrical diameter less than said tubular member second internal cylindrical diameter so that the snap ring is telescopically positionable within the tubular member above the plug. In its expanded condition, the snap ring fits into the tubular member circumferential slot so that the plug is captured between the circumferential ledge and the snap ring.

The snap ring is toroidal, having a cylindrical axis and an internal and an external circumferential surface. The external circumferential surface is preferably cylindrical

whereas the internal circumferential surface is on one embodiment frusto-conical so that when the snap ring is in its expanded condition and fully outwardly received in the circumferential slot the snap ring presents an internal frusto-conical surface.

A keeper plate is telescopically positionable within the tubular member second cylindrical surface and within the expanded snap ring. In the preferred arrangement the keeper plate has an external circumferential surface that is frusto-conical, matching the frusto-conical internal surface of the snap ring when the snap ring is in its expanded condition.

The invention includes a way to retain the keeper plate within the expanded snap ring. One way includes an opening through the keeper plate in alignment with a threaded recess in the plug. A threaded bolt extends through the keeper plate and threadably into the plug so that the bolt, when tightened, holds the keeper plate securely within the snap ring.

To ensure against leakage of fluids or gases past the plug, one or more circumferential grooves are provided on the plug external circumferential surface, each groove receiving an O-ring or other form of sealing gasket.

In a preferred embodiment of the invention the snap ring is, in its natural state, that is when not otherwise under force to enlarge it, in the collapsed condition in which its external diameter is less than the tubular member second internal surface. The snap ring is radially outwardly expanded by the keeper plate. Specifically, the interaction of the keeper plates external frusto-conical surface and the snap ring internal frusto-conical surface is such that when the keeper plate is forced into the snap ring in the direction towards the plug the keeper plate causes the snap ring to externally expand into the circumferential slot. When the keeper plate is removed the snap ring will, on its own, resiliently contract towards its normal collapsed condition thereby automatically extracting itself, or at least substantially extracting itself, from the circumferential groove. This action permits easy removal of the

snap ring to permit removal of the plug member to provide access through the tubular member.

Another preferred embodiment of the invention includes the use of a snap ring that is positively moved from a contracted to an expanded condition- that is, that doesn't depend on the resiliency of the snap ring. In either the first discussed or the second embodiment the snap ring, when in the collapsed condition has an external diameter less than the tubular member second internal cylindrical surface and in the expanded condition an external diameter greater than the tubular member second internal cylindrical surface so that the expandable snap ring is locked in place when in the expanded condition within the circumferential groove formed in the tubular member. When in the circumferential groove the snap ring has an internal diameter that is less than the tubular member second internal surface and the plug is captured between the snap ring and the tubular member circumferential ledge.

In the second embodiment, a link plate is supported in a plane of the snap ring and within the snap ring and is radially displaceable inwardly and outwardly of the snap ring. The snap ring has a gap therein providing opposed first and second ends. Links extending from the link plate to the snap ring first and second ends serve to expand the snap ring when the link plate is moved radially outwardly and to contract the external dimension of the snap ring when the link plate is moved radially inwardly.

In a preferred arrangement a cam is utilized to radially inwardly or outwardly displace the link plate and thereby expand or contract the outer circumferential dimension of the snap ring to move it positively into or out of the circumferential slot in the tubular member.

When the link plate is in its outer position and the snap ring within the circumferential slot, a keeper in the form of a bolt may be threaded through the link plate and into the top

surface of the plug so that the snap ring is positively retained in its outwardmost position to retain the plug in position within the tubular member.

A better understanding of the invention will be obtained from the following description of the preferred embodiments and the claims, taken in conjunction with the attached drawings.

Description of the Drawings

Figure 1 is an isometric elevational view, shown cut away, of a tubular member in the form of a flange and showing the closure system of this invention. Specifically, Figure 1 shows a flange having a passageway therethrough and positioned within the passageway a cylindrical plug, a snap ring and a keeper plate by which the passageway is closed against the passage of liquids or gases.

Figure 2 is an isometric exploded view of the removable closure system of Figure 1 showing the basic components having been removed from the interior of the tubular flange member.

Figure 3 is an exploded view showing an alternate embodiment of a plug insertable into the opening through a flange for removably closing the flange. The plug of Figure 3 has means to positively expand or retract a snap ring used to hold the plug in place.

Figure 4 is an enlarged elevational cross-sectional view of the plug as shown in Figure 3 and showing the holder by which the plug is inserted into a tubular member and locked into position.

Figure 5 is an isometric view of a tubular member in the form of a flange, and showing the plug as illustrated in Figures 3 and 4 inserted into the flange and locked in position.

Figure 6 is an isometric view of the plug as shown in Figure 4 and showing the plug in condition in which the lock ring is withdrawn to a reduced external circumferential diameter in the state in which the plug is inserted into or removed from a tubular member.

Figure 7 is an isometric view as in Figure 6 but showing the condition in which the lock ring is radially expanded to an increased external circumferential diameter by which the plug is locked into position within a tubular member.

Figure 8 is an exploded view showing more details of the components making up the plug as illustrated in Figures 3 through 7 and the plug holder by which the plug is inserted into a tubular member and by which the plug is locked in position.

Figure 9 is an isometric view of a tubular member in the form of a flange as illustrated in Figures 3 and 5 and showing the plug inserted into and locked in position within the flange and with the plug holder removed. Figure 9 illustrates the appearance of the invention after the plug has been installed within a flange and the plug holder removed from it. In the normal practice, a blind flange (not seen) is used to close the top of the flange so that the plug permanently remains in the flange unless there is necessity for it to be removed.

Detailed Description of the Preferred Embodiments

Referring to the drawings, and first to Figures 1 and 2, a removable closure system of this invention is illustrated as applicable to a flange fitting generally indicated by the numeral 10. A "flange" is a commonly employed piping fitting frequently utilized in the piping industry, including the petroleum and petrochemical industries. The invention is not limited to the use of a flange but is a system for removably closing a tubular member, flange 10 being an example of a tubular member and is illustrated herein only because it is a typical environment for the application of the closure system of this invention. Flange 10 has an inner end 12 and an outer end 14. Inner end 12 is shown of the type that is particularly configured for welding to the end of a length of pipe or to other equipment. Flange 10 has an opening therethrough defined by a first internal cylindrical surface 16 and a second internal cylindrical surface 18. Second cylindrical surface 18 is of enlarged internal diameter compared to first cylindrical surface 16 providing a circumferential ledge 20.

Flange 10 illustrated as an example of a tubular member has an integral radially extending flange portion 22 with openings 24 therein by which another flange or other apparatus may be secured to it, it being understood that the radial flange portion 22 is not material to this invention. Other features of flange 10 are illustrated as are typical of this type of device but are not important to the invention. The only elements of flange 10 that are important is the passageway defined by first cylindrical surface 16, second cylindrical surface 18, circumferential ledge 20 and an increased internal diameter circumferential slot 26 formed in second cylindrical surface 18, slot 26 having a planar top end surface 26A and an opposed, paralleled, bottom end surface 26B.

To removably close the opening through flange 10 a cylindrical plug 28 is employed. Plug 28 has an external cylindrical surface 30 that is larger than flange first cylindrical

surface 16 and slightly less in diameter than flange second cylindrical surface 18 so that plug 28 is telescopically positionable within the opening in the flange and rests upon circumferential ledge 20.

To seal against the passage of liquids or gases through the flange, plug 28 is illustrated to have two spaced apart circumferential grooves 32, each of which receives an O-ring or other form of gasket 34. In Figure 2 grooves 32 are shown in the external cylindrical surface 30 of plug 28 but the O-rings are not shown. While two grooves 32 and O-rings 34 are shown only one may be employed and other types of seals may be employed to prevent leakage through the closed passageway.

Plug 28 has a bottom surface 36, the outer circumferential edge of which rests on circumferential ledge 20, and a top surface 38.

In order to retain plug 28 in position within the flange an expandable snap ring, generally indicated by the numeral 40, is employed. Snap ring 40 is toroidal having an external cylindrical surface 42, a bottom end 44 and a top end 46. Snap ring 40 is dimensioned to be received within circumferential slot 26 between the slot end surfaces 26A and 26B when the snap ring is radially outwardly extended to its expanded condition. In Figure 2 snap ring 40 is shown in its normal, collapsed condition, that is, wherein the slit 48 formed in the snap ring is closed or at least substantially closed. Snap ring 40 can be radially outwardly expanded to move into circumferential slot 26. Radially outwardly expansion increases the width of slit 48.

Snap ring 40 has an internal circumferential surface 50 that is frusto-conical. The frusto-conical surface 50 tapers downwardly and inwardly to a reduced internal circumferential diameter at the snap ring bottom end 44.

In order to radially outwardly expand snap ring 40 and to maintain the snap ring in its expanded condition, a keeper plate 52 is employed. Keeper plate 52 has a bottom surface 54 and a top surface 56, both of which are preferably planar. Keeper plate 52 is dimensioned to be telescopically positionable within flange passageway second cylindrical surface 18 and has an external circumferential surface defined primarily by a frusto-conical surface 58. The frusto-conical surface 58 terminates at its upper end, that is, at the keeper top surface 56 by a circumferential bevel 59, however, bevel 59 is not critical or important and bevel 59 may be eliminated with the frusto-conical surface 58 extending all the way to keeper top surface 56. Instead of circumferential bevel 59, a short height cylindrical surface of external diameter slightly less than the diameter of flange second cylindrical surface 18 may be employed.

The interrelationship between keeper plate external frusto-conical surface 58 and snap ring internal frusto-conical surface 50 is important. A fundamental purpose of keeper plate 52 is to maintain snap ring 40 in its expanded condition within circumferential slot 26. In addition to maintaining the snap ring in its expanded condition to thereby keep plug captured within the flange, keeper plate 52 is also important in the installation of the closure system within the flange. As previously stated, in the preferred embodiment snap ring 40 is, when in its normal condition, collapsed as illustrated in Figure 2. When the closure system is assembled, plug 28 is first positioned within the flange followed by positioning snap ring 40 on plug upper surface 38. Since the snap ring in its collapsed condition has an external cylindrical surface of a diameter less than flange second internal surface 18 it is easily positionable within the flange. In order to expand the snap ring within circumferential slot 26, keeper plate 52 is placed on top of the snap ring and the plate is then forced downwardly towards plug 28. The interaction of external frusto-conical surface 58 of keeper plate 52 with

snap ring internal frusto-conical surface 50 causes the snap ring to radially outwardly expand into circumferential slot 26 as illustrated in Figure 1.

When a workmen desires to open the passageway through flange 10, keeper plate 52 is removed from within snap ring 40 and the natural resilient memory of the snap ring causes it to collapse to its minimum external diameter condition thereby withdrawing or at least substantially withdrawing the snap ring from circumferential slot 26. If the snap ring does not fully withdraw from the circumferential slot at least the withdrawal will be sufficient that by means of pliers or other tools, the snap ring can be fully extracted from the slot and thereby removed from within the flange permitting the subsequent removal of plug 28.

The action of snap ring 40 is opposite to the action of a typical snap ring placed in an internal circumferential slot in that typical snap rings are biased to radially expand outwardly and must be compressed against natural resilience in order to permit the typical snap ring to be removed from an internal circumferential slot. Since snap ring 40 functions contrary to the typical snap ring, keeper plate 52 is imperative in the operation of the closure system.

In the preferred practice of the invention a way is required to maintain keeper plate 52 in position within the snap ring. One way of maintaining the keeper plate in contact with the internal circumferential surface of the snap ring is illustrated in the drawings in which plug 28 has a threaded recess 61 and keeper plate 52 has an opening 63 in alignment with recess 61. A threaded bolt 65 extends through opening 63 and is threaded into threaded recess 61, the head 67 of the bolt serving to maintain the keeper plate in fixed position with respect to plug 28 and thereby to maintain the keeper plate within snap ring 40. In the illustrated and preferred arrangement, the snap ring and keeper plate are dimensioned so that when the keeper plate is in contact with the top surface 38 of plug 28, snap ring 40 is fully radially outwardly positioned within circumferential slot 26.

To open the closure in flange 10 a workmen first removes bolt 65 by applying a wrench to head 67. Keeper plate 52 may then be removed from within snap ring 40, permitting the snap ring to contract to its natural condition by which it withdraws, or at least substantially withdraws from circumferential slot 26. After the snap ring is removed, plug 28 may then be removed. To augment removal of keeper plate 52 threaded recesses (not shown) may be provided in the top surface 56 to receive bolts for use in attaching tools to extract the keeper plate and once the keeper plate is extracted, bolt 65 can be reinserted into threaded recess 61 to aid in the removal of plug 28.

In the drawing a single bolt 65 is employed to maintain keeper plate 52 in position, however, a plurality of bolts may be employed.

An advantage of the removable closure system as described herein, particularly when it is applied to flange 10 of the type illustrated in Figures 1 and 2 is that flange 10 may be manufactured by modifying an off-the-shelf available flange fitting. All that is required to modify a typical flange fitting is to internally turn second cylindrical surface 18 and circumferential slot 26. None of the other typical features of the commercially available flange need to be modified to enable it to function to accept the removable closure system as has been described herein. Thus the entire system as illustrated in Figures 1 and 2, including flange 10, can be manufactured at a substantially reduced cost compared to other closure systems.

Figures 3-9 of the drawings show a second embodiment of the invention in which the snap ring that holds the plug in position is positively expanded or retracted in a different way compared to the embodiment of the invention illustrated in Figures 1 and 2. Referring first to Figure 3 the basic components of the removable closure system are illustrated. A tubular member in the form of a flange generally indicated by the numeral 60 has an inner

end 62 and an outer end 64. A passageway is formed through the flange, the passageway being defined by a first cylindrical surface 66 and a slightly enlarged second cylindrical surface 68. Since second cylindrical surface 68 is of larger internal diameter than first cylindrical surface 68 an internal circumferential ledge 70 is formed in the passageway.

Flange 60 typically has an integral radially extending flange portion 72 having bolt opening 74 therein. However the invention is applicable to any type of tubular device that needs to be removably closed.

Formed in the second cylindrical surface 68 of the flange above ledge 70 is an increased diameter circumferential groove 76.

A plug member generally indicated by the numeral 78 is used to removably close the interior of flange 60. The plug member, shown in cross-sectional view in Figure 4, includes a first external cylindrical surface 80 and a second, increased external diameter cylindrical surface 82, the difference in the diameters of surfaces 80 and 82 providing an external circumferential ledge 84. The external diameter of first cylindrical surface 80 is slightly less than the internal diameter of the flange first cylindrical surface 66 and in like manner, the external diameter of the plug second cylindrical surface 82 is slightly less than the internal diameter of the plug second cylindrical surface 68. Thus the plug body 86 can be positioned within the interior of flange 60 with the plug external cylindrical ledge 84 resting on the plug internal circumferential ledge 70.

Plug body 86 has a lower surface 88 and a top surface 90. Intermediate the top and bottom surfaces and below ledge 84, is an external circumferential groove 92 that receives an elastomeric gasket or seal that is preferably in the form of an O-ring, that is an elastomeric toroid 94. When plug 78 is placed in flange 60 elastomeric toroid 94 serves to seal the passageway through the flange against the escape of fluids, either liquids or gases.

Plug body 86 has, in communication with the lower surface 88, an opening 96. In axial alignment with this larger opening is a smaller diameter opening 98 that communicates with a cup recess 100 that communicates with the plug body top surface 90. The difference in diameter between openings 96 and 98 provides a circumferential valve seat surface 102. A ball valve 104 is positioned in larger opening 96. Below ball valve 104 is a compression spring 106 held in place by means of a keeper 108 that fits in a short length circumferential groove in opening 96. Spring 106 urges ball valve 104 towards a closed position in which the ball is seated against the valve seat surface 102. When seated, the passage of fluid upwardly past the plug 78 is prevented but when ball valve 104 is displaced downwardly, as illustrated in Figure 4, fluids and/or gases can pass upwardly through opening 98 to thereby equalize any pressure across the plug.

An important feature of the invention is a snap ring element 110, used to hold plug 78 in position within flange 60. The action of the snap ring is best illustrated in Figures 5, 6 and 7. Snap ring 110 is a toroidal member of square or rectangular cross-sectional configuration, a squared cross-sectional configuration being illustrated in the drawings, and has an internal circumferential surface 112 and an external circumferential surface 114. Snap ring 110 has a gap providing a first end 116 and a second end 118 the ends being spaced apart from each other. When the gap between ends 116 and 118 is narrowed the external diameter of circumferential surface 114 of the snap ring is retracted or reduced so that the external diameter is less than the internal diameter of flange second cylindrical surface 68. Thereby plug 78 can be inserted into or removed from within flange 60. On the other hand, when the space between ends 116 and 118 is increased, as shown in Figure 7, the external diameter of circumferential surface 114 of the snap ring increases so that it is greater than the internal diameter of the plug second cylindrical surface 68. The external diameter of the snap ring

can be increased greater than the internal diameter of the plug second cylindrical surface 68 only when the snap ring is free to pass into the circumferential groove 76. With snap ring 110 positioned within groove 76 as shown in Figure 5 the upper portion of plug 78 is captured between internal circumferential ledge 70 and the snap ring so that the plug is firmly held in position within flange 60. The mechanisms used to radially expand and contract snap ring 110 can be generally characterized as a linkage mechanism.

As illustrated in Figures 6 and 7, the expanded or contracted condition of snap ring 110 is controlled by a link plate 120. A first link 122 is pivotally connected between snap ring first end 116 and link plate 122 and second link 124 in like manner connects the second end 118 of the snap ring to the link plate. When link plate 120 is radially outwardly displaced as shown by the arrows in Figure 7 snap ring 110 is expanded in diameter so that it can, when plug 78 is in position within the flange, extend within the flange groove. On the other hand, when link plate 120 is retracted radially inwardly as shown by arrows in Figure 6, the external diameter of the snap ring is reduced, retracting the snap ring from within the groove and permitting the plug to be removed from the flange.

As illustrated in Figures 6 and 7, the snap ring is held in position on plug body top surface 90 by means of guides 126, three guides being shown. Each guide is spaced from plug body top surface 90 by a spacer 128 that is slightly greater in thickness than snap ring 110 so snap ring is free to move. The guides 126 and spacers 128 are held in position on plug body top surface 90 by means of bolts 130. Guides 126 and spacers 128 could each be easily made of a single part.

Figure 4 taken with Figures 6, 7 and 8 illustrate the mechanisms by which link plate 120 is radially inwardly and outwardly positioned to expand and contract snap ring 110. Removably attached to the top surface 90 of the plug body is a plug holder generally

indicated by the numeral 132, the plug holder being attached by screws 134. A vertical opening 138 (see Figure 4) extends through plug holder body 136 and rotatably receives a cam-shaft 140 that has, on the lower end thereof. an integral eccentric cam-portion 142. A yoke 144 is slidably positioned in a slot 146 in the bottom surface of plug holder body 136. Yoke 144 has an elongated slot 147 that receives the cam-shaft cam-portion 142 so that rotation of the cam-shaft 140 reciprocally displaces yoke 144. The outer end of yoke 144 has attached to it a linkage member 148, the linkage member having a downwardly extending portion that fits in a slot 150 in link plate 120. Linkage member 148 is held to yoke 144 by bolts 152.

As seen in Figure 4, yoke 144 that functions in expanding and contracting snap ring 110 has, in the lower surface thereof, semi-circular grooves 154. Axially displacably received within a vertical opening 156 in cam-shaft 140 that is within plug holder body 136 is a stem 158. The lower end of stem 158 is threaded and receives a safety lock 160 that is cup shaped so that it has a circumferential upstanding lip 162. Safety lock 160 is received in cup recess 100. When yoke 144 is radially outwardly advanced by the rotational position of cam-portion 142, safety lock 160 can rise so that circumferential lip 162 extends within circumferential groove 154 in the yoke allowing stem 158 to a full upward position. Safety lock 160 is held to stem 158 by a nut 164 and a portion 166 of the stem extends below the nut. When stem lower end portion 166 is downwardly depressed and the lip 162 is out of groove 154 and therefore below yoke 144 stem lower end portion 166 engages ball valve 104 (as seen in Figure 4) pressing it downwardly against spring 106 so that a pressure equalizing vent through plug body 86 is provided.

This means that ball valve 104 can be in a closed position only when safety lock 160 is in the full upward position meaning that yoke 144 is radially outwardly expanded with

snap ring 110 in groove 76, securely locking the plug within the flange 60.

Link plate 120 has spaced apart vertical openings 168 and 170 (see Figure 6). In alignment with openings 168 and 170 when the link plate 120 is radially outwardly positioned, expanding snap ring 110, are threaded openings 172 in plug body top surface 90 as seen in Figure 8. When plug 78 has been fully installed the installation equipment that is secured to the top surface of flange 60 can be removed and bolts 174 and 176 threaded through openings 168 and 170 to secure link plate 120 in its fully forward position. Openings 168 and 170 in link plate 120 are illustrated as being round to receive bolts 174 and 176 only when link plate 120 is fully advanced, that is, when snap ring 110 is in position within circumferential groove 76. Instead of being round, openings 168 and 170 can be keyhole shaped so that bolts 174 and 176 can at all relevant times be mounted in threaded openings 172 in plug body top surface 90. Such keyhole shaped slots allow the link plate to slide with respect to the bolts but when the snap ring is extended into the circumferential groove a workman can then fully downwardly advance bolts 174 and 176 to securely lock link plate 120 to the plug body top surface 90 and thereby securely lock the snap ring in the circumferential groove. Thereafter, plug holder 132, including stem 158 and safety lock 160 can be removed as a unit by removing screws 134. Snap ring 110 is then held in its fully expanded position. The appearance of the plug after it has been firmly seated in flange 60 and the plug holder 132 removed is seen in Figure 9. The passageway through the plug body 86 is closed by ball valve 104 urged into seating position by spring 106, these components being seen in Figure 4. In the condition as seen in Figure 9 a blind flange or cover plate can be placed over the outer end 64 of flange 60 to seal the flange against any possibility of leakage past elastomeric toroid 94.

During installation of plug 78 while the pipeline or other apparatus to which flange

60 is attached is under pressure and before completion of the plugging operation, bolts 174 and 176 are not employed. Instead, a first shear pin 180 (see Figure 8) loaded by a spring 182 is positioned within a first vertical opening 184 in the base of plug holder body 136. Pin 180 extends through a first opening 186 in yoke 144 when the yoke is fully advanced, that is, when the snap ring is fully expanded. A second shear pin loaded by a spring (not separately illustrated but visually the same as shear pin 180 and spring 182 in Figure 8) is positioned within a second vertical opening 188 in plug holder body 136. This second shear pin extends through a second opening 190 in yoke 144 when the yoke is fully retracted, that is, when the snap ring is fully reduced in diameter. The shear pins are severable by torque applied by an operator to cam-shaft 140. The shear pins provide information to an operator as to the position of the lock ring, that is, when it is fully expanded or fully contracted. While the removable closure system of the second embodiment has been described as it is particularly relevant to closing a flange that is used for providing access to a pipeline or other system under pressure, commonly referred to in the industry as "hot tapping", nevertheless, the closure system as described herein have other applications.

The claims and the specification describe the invention presented and the terms that are employed in the claims draw their meaning from the use of such terms in the specification. The same terms employed in the prior art may be broader in meaning than specifically employed herein. Whenever there is a question between the broader definition of such terms used in the prior art and the more specific use of the terms herein, the more specific meaning is meant.

While the invention has been described with a certain degree of particularity, it is manifest that many changes may be made in the details of construction and the arrangement of components without departing from the spirit and scope of this disclosure. It is understood

that the invention is not limited to the embodiments set forth herein for purposes of exemplification, but is to be limited only by the scope of the attached claim or claims, including the full range of equivalency to which each element thereof is entitled.

What is claimed:

1. A removable closure system comprising:

a tubular member having an inner end and an outer end, and an opening therethrough defined by a first cylindrical surface adjacent said inner end of a first internal diameter and a second cylindrical surface adjacent the outer end of an enlarged internal diameter providing a circumferential ledge, the second cylindrical surface having an increased internal diameter circumferential groove therein;

a cylindrical plug having an external cylindrical surface having at least a portion having an external diameter greater than said internal diameter of said tubular member first cylindrical surface and slightly less than said second cylindrical surface, the cylindrical plug being telescopically positionable within said tubular member second internal cylindrical surface and in engagement with said tubular member circumferential ledge;

an expandable snap ring having a collapsed and an expanded condition and when in the collapsed condition having an external diameter less than said tubular member second internal cylindrical surface and in the expanded condition an external diameter greater than said tubular member second internal cylindrical surface, the snap ring having a cross-section configured to be removably receivable when expanded within said circumferential slot, and when in said circumferential groove having an internal diameter that is, at least in part, less than said tubular member second internal surface whereby when the snap ring is in expanded position within said circumferential groove said plug is captured between said tubular member circumferential ledge and the snap ring; and

linkage mechanism engaged with said snap ring and moveable between a first

position and a second position, in the linkage mechanism first position said snap ring is radially inwardly collapsed and of external diameter less than said tubular member second cylindrical surface and in the linkage mechanism second position said snap ring is radially outwardly expanded and partially received in said tubular member circumferential groove.

2. A removable closure system according to Claim 1 wherein said tubular member is a flange member having an integral external flange portion.

3. A removable closure system according to Claim 1 including an attachment to maintain said snap ring in said expanded condition.

4. A removable closure system according to Claim 1 wherein said attachment is in the form of a bolt extendable through an opening in said linkage mechanism.

5. A removable closure system according to Claim 1 wherein said linkage mechanism is supported substantially in a plane of and within said snap ring and is displaced radially inwardly to collapse said snap ring and is displaced radially outwardly to expand said snap ring.

6. A removable closure system according to Claim 1 wherein said cylindrical plug has an upper surface and including a plug holder assembly removably attachable to said cylindrical plug upper surface, the plug holder having a rotatable cam-shaft connected to said linkage system whereby said snap ring can be expanded or contracted by rotation of said rotatable shaft.

7. A removable closure system according to Claim 6 wherein said linkage system includes a yoke having a longitudinal slot paralleled to said cylindrical plug upper surface; and

including an eccentric cam affixed to said rotatable shaft and received within said longitudinal slot in said yoke, the rotation of said rotatable shaft and thereby the rotation of said eccentric cam serving to radially displace said yoke to expand or contract said snap ring.

8. A removable closure system according to Claim 1 wherein said snap ring has a gap therein providing opposed snap ring first and second ends and is collapsible by inward force applied simultaneously to said opposed snap ring first and second ends to move said first and second ends towards each other and is expandable by outward force applied simultaneously to said opposed snap ring first and second ends to move said first and second ends away from each other.

9. A removable closure system according to Claim 8 wherein said linkage mechanism includes a first link connected to said snap ring first end and a second link connected said snap ring second end, said first and second links being connected to a link plate. Said link plate, said first and second links and said snap ring being at least substantially in a common plane.

10. A removable closure system according to Claim 1 wherein said cylindrical plug has an upper surface and wherein said snap ring and said linkage mechanism are movably positionable on said cylindrical plug upper surface.

11. A removable closure system according to Claim 10 including at least three guides supported to said cylindrical plug upper surface, each guide having a portion loosely overlying said snap ring and serving to retain said snap ring in position on said cylindrical plug upper surface while permitting radially inwardly and outward contraction and expansion of said snap ring.

12. A removable closure system according to Claim 1 wherein said cylindrical plug has a bypass opening therethrough and including:

a valve in said bypass opening biased to a closed position normally preventing the passage of fluid therethrough, the valve being displaceable to an open position by downward mechanical force applied through said bypass opening.

13. A removable closure system according to Claim 1 wherein said cylindrical plug external cylindrical surface has a circumferential groove therein; and

an elastomeric toroidal member received in said cylindrical plug circumferential groove and engage said tubular member first internal surface.

14. A snap ring positionable in a circumferential groove in a cylindrical wall, the wall having an internal diameter of "X" and the groove having an internal diameter greater than "X", the snap ring being toroidal and having a gap therein providing opposed snap ring first and second ends and being collapsible by inward force applied simultaneously to said opposed snap ring first and second ends wherein the snap ring has an external diameter less than "X" and

expandable by outward force applied simultaneously to said opposed snap ring first and second ends wherein the snap ring has a diameter greater than "X" and is receivable in said groove.

15. A snap ring according to Claim 14 including a first link pivotally connected to said snap ring first end and a second link pivotally connected to said snap ring second end, said snap ring being collapsible or expandable by force applied simultaneously to said first and second links.

16. A snap ring according to Claim 15 including a link plate positioned within said snap ring, an inner end of each of said first and second links being pivotally connected to said link plate, said snap ring, said first and second links and said link plate being in a substantially common plane, said snap ring being collapsible by radial inward movement of said link plate and said snap ring being expandable by radial outward movement of said link plate.

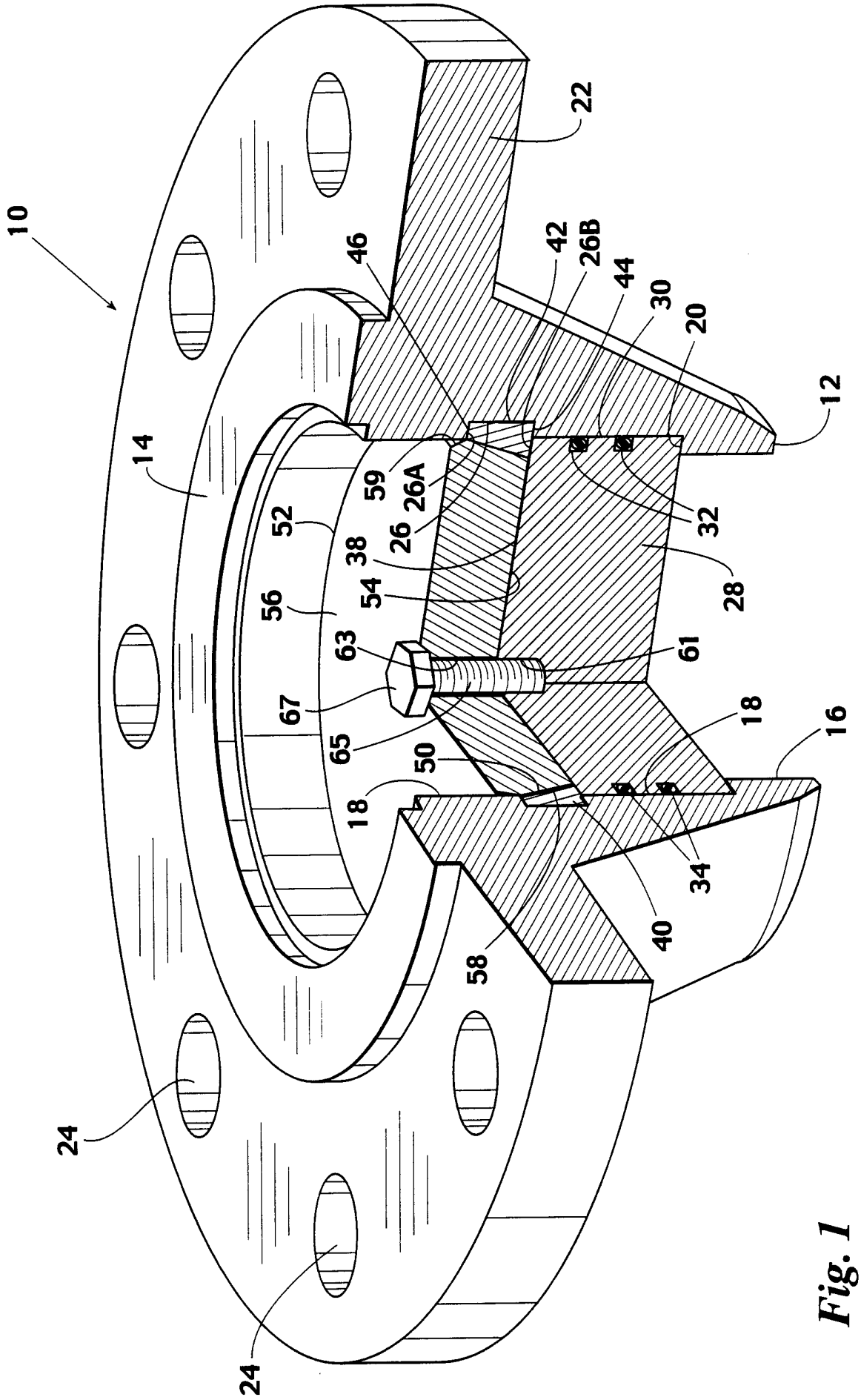
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Fig. 1

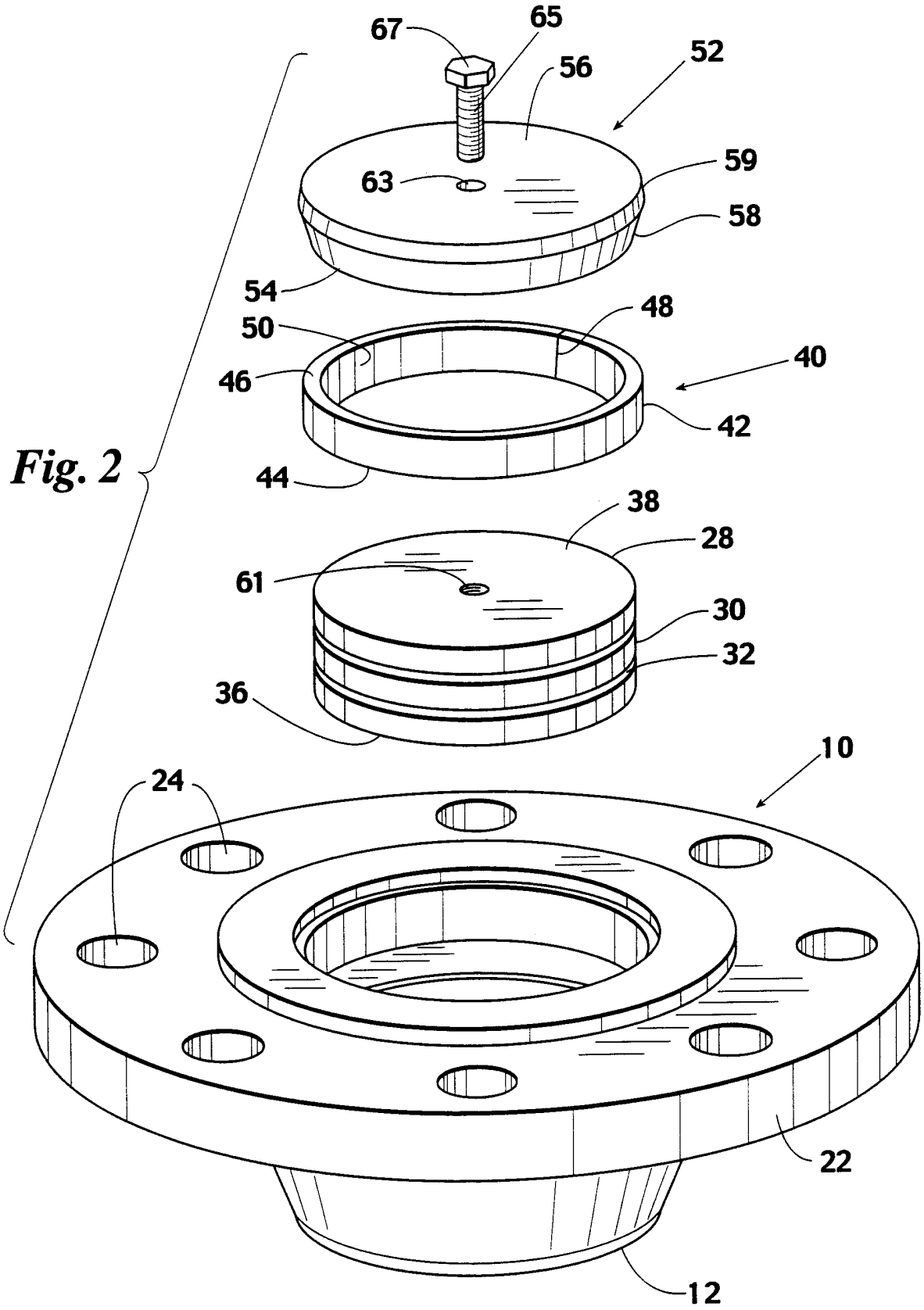
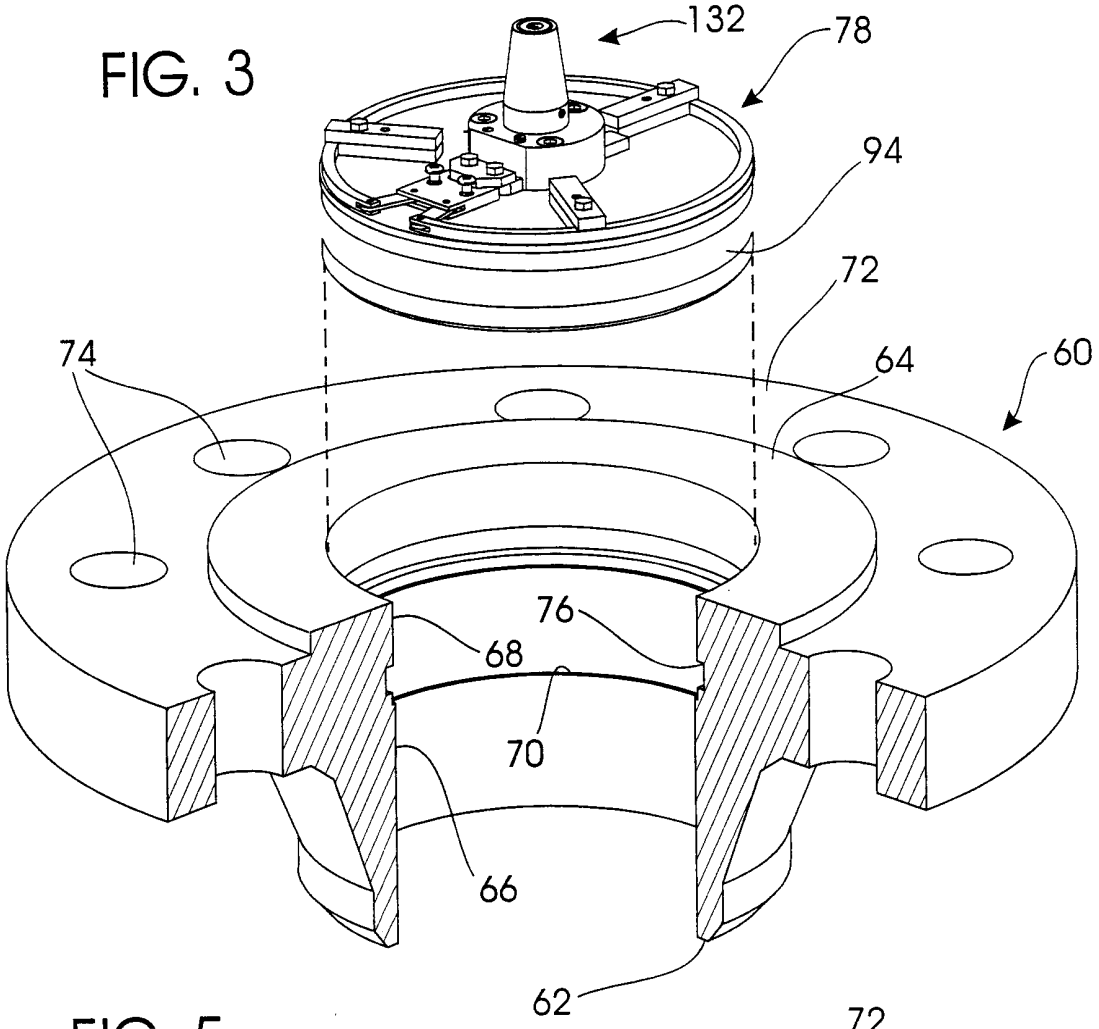


Fig. 2

FIG. 3



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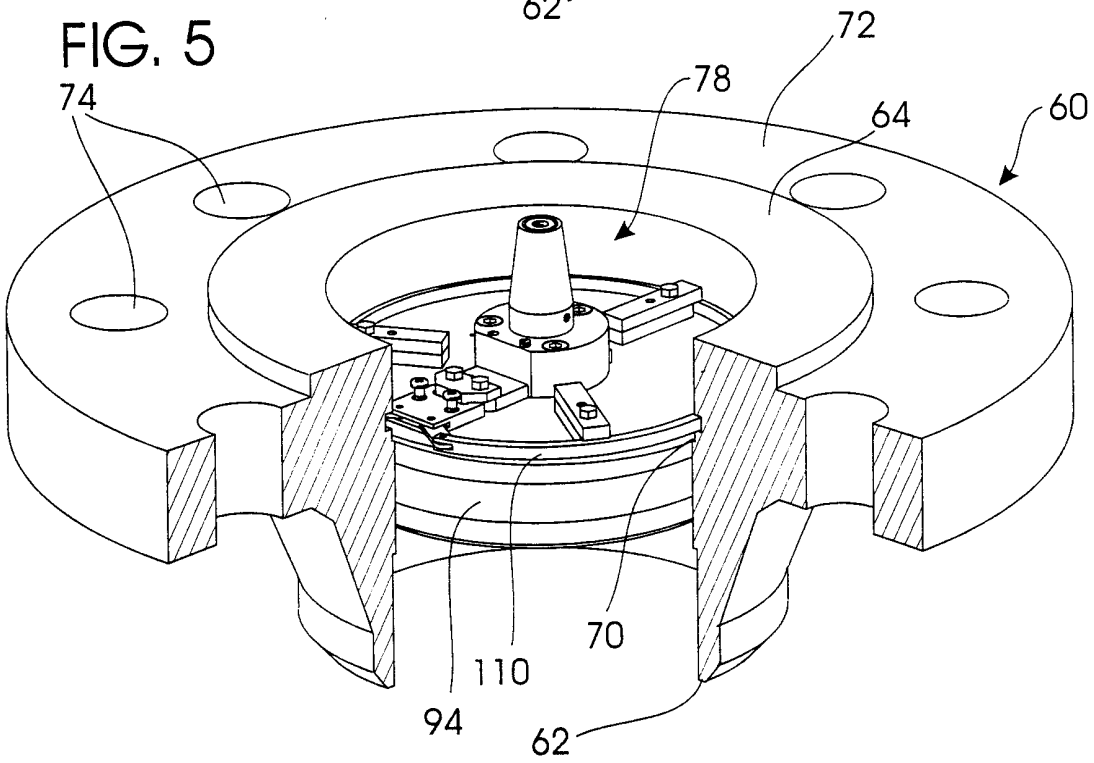

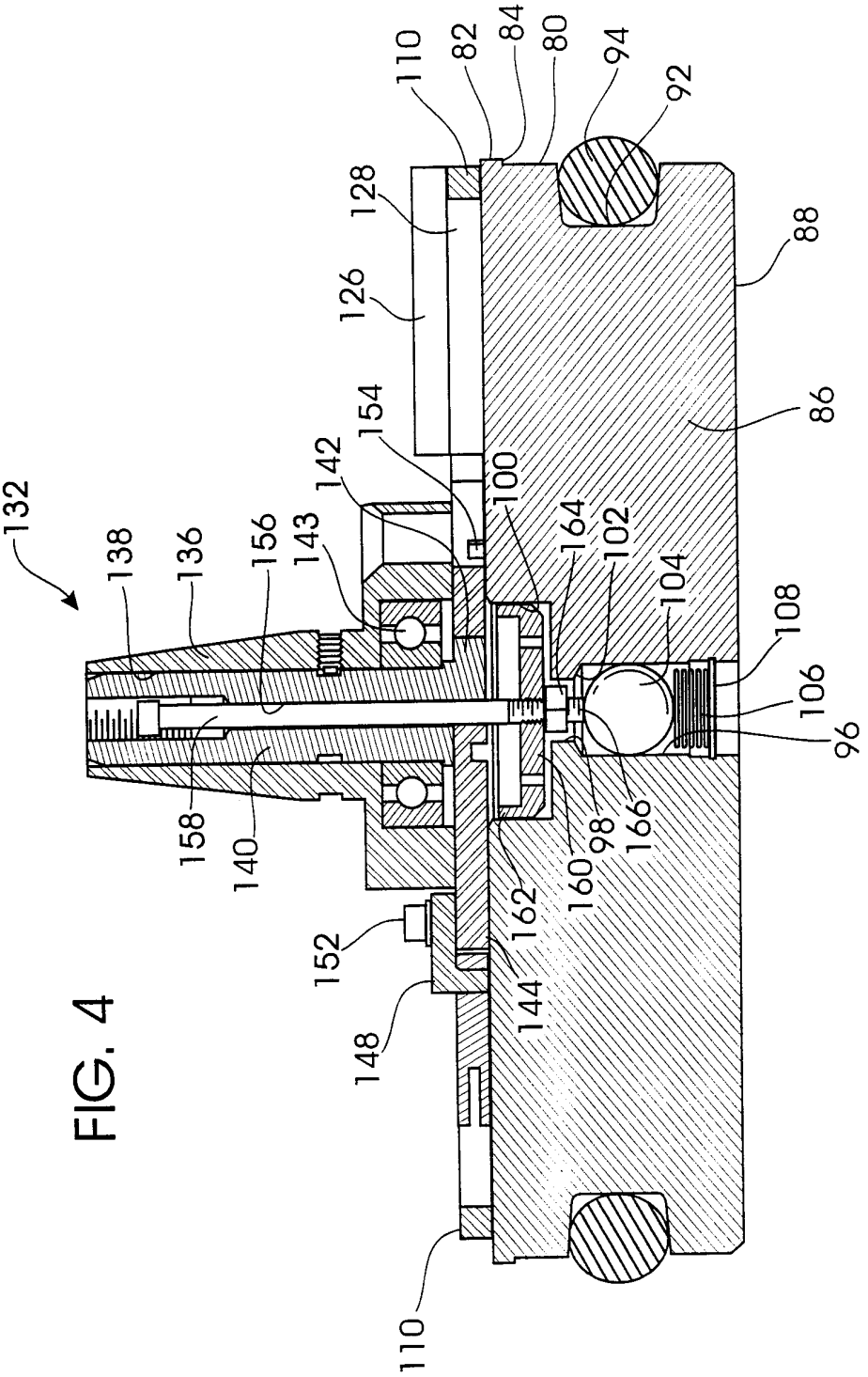
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FIG. 4

FIG. 6

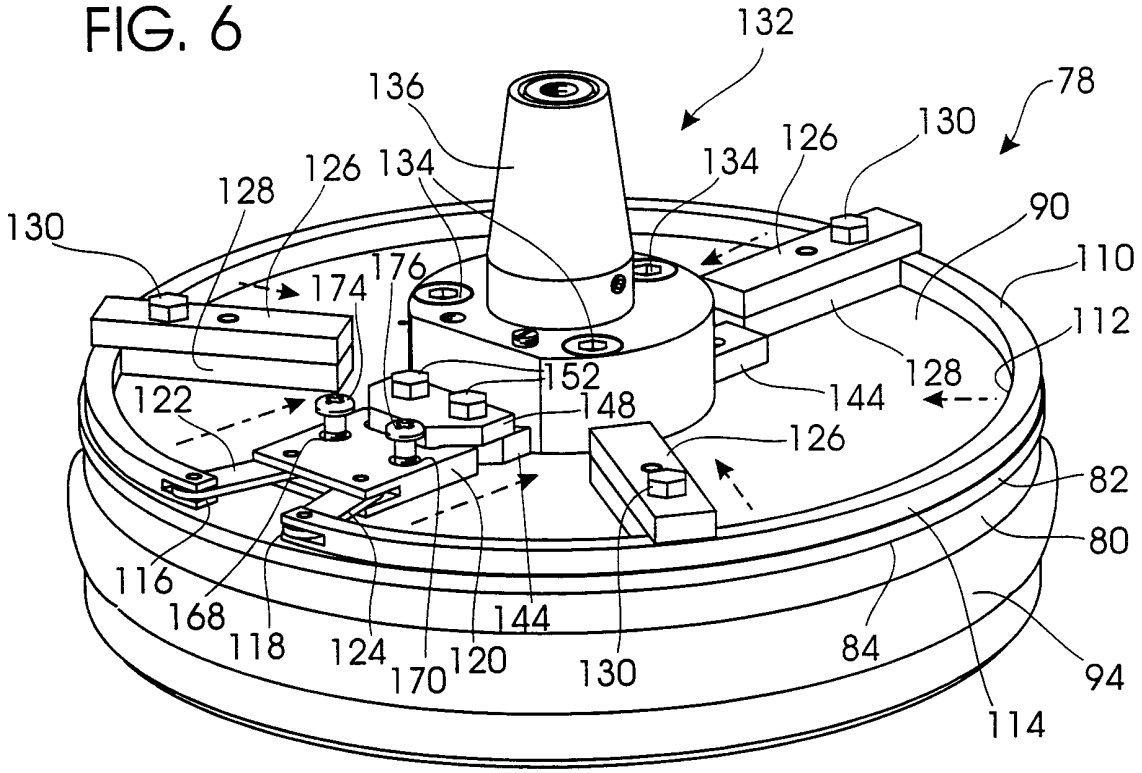
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FIG. 7

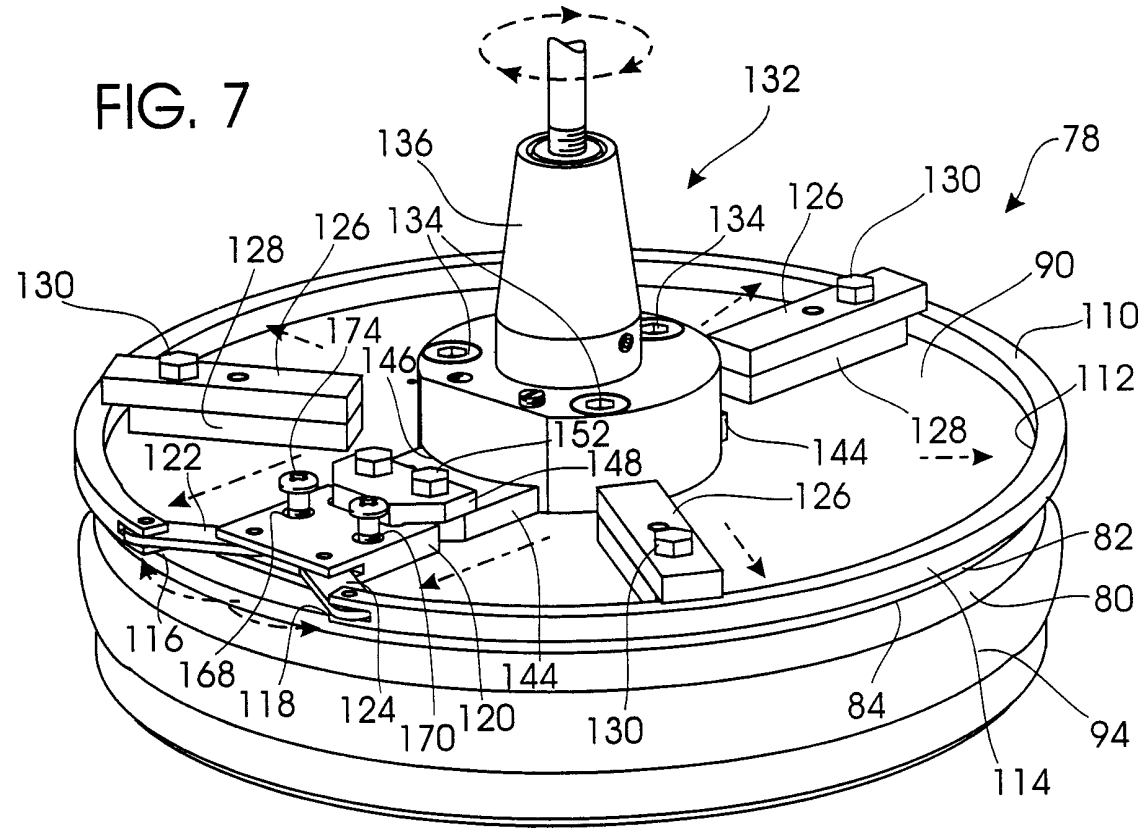
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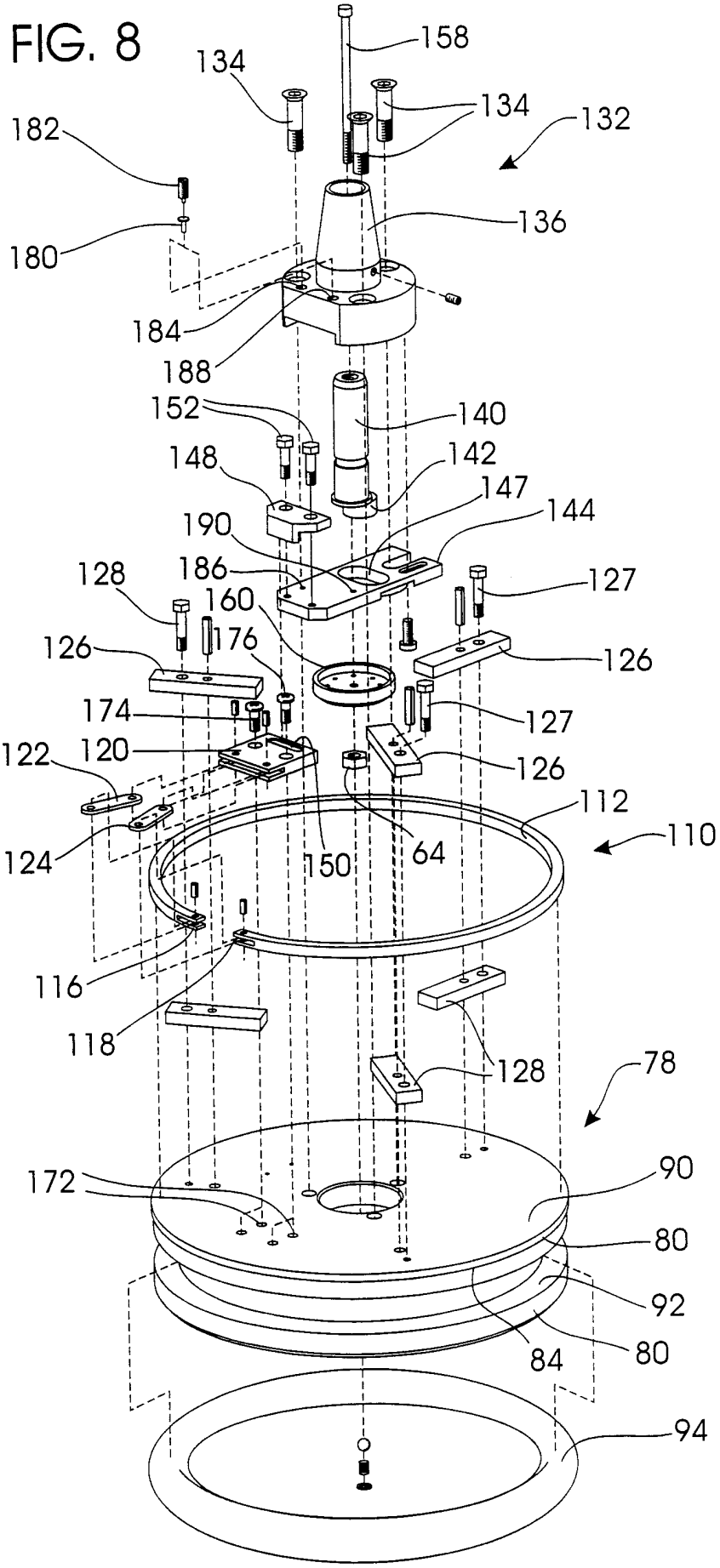
FIG. 8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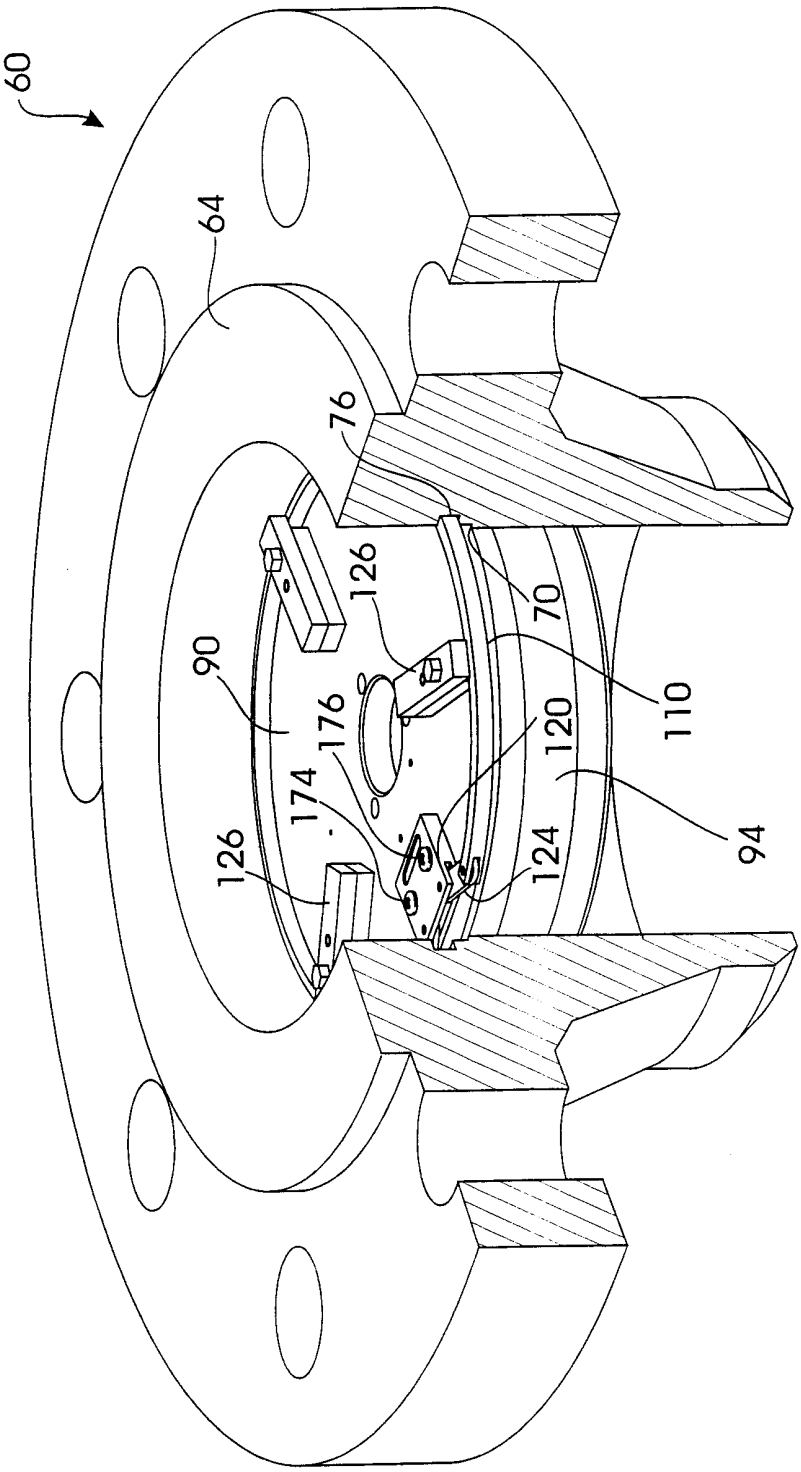

FIG. 9

INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/US 99/17299

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F16L55/11 F16L55/136

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F16L

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3 155 116 A (VER NOOY) 3 November 1964 (1964-11-03) cited in the application figures	1-3,13
A	US 4 387 740 A (VANZANT HERSHEL) 14 June 1983 (1983-06-14) cited in the application figures	1-4,6,13
A	US 4 693 278 A (OSBORN COY D ET AL) 15 September 1987 (1987-09-15) cited in the application figures	1-3,5,6, 10,12,13
X	US 5 606 939 A (SPATH MARK J) 4 March 1997 (1997-03-04) figures 3-7	14

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
3 November 1999	16/11/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Budtz-Olsen, A

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INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/US 99/17299

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 352 079 A (CROSKEY RONALD A) 4 October 1994 (1994-10-04) claim 1; figures	14
X	US 4 363 418 A (MATZ DUANE G) 14 December 1982 (1982-12-14) figures 1-3	14

INTERNATIONAL SEARCH REPORT

.formation on patent family members

Inter ɔnal Application No
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