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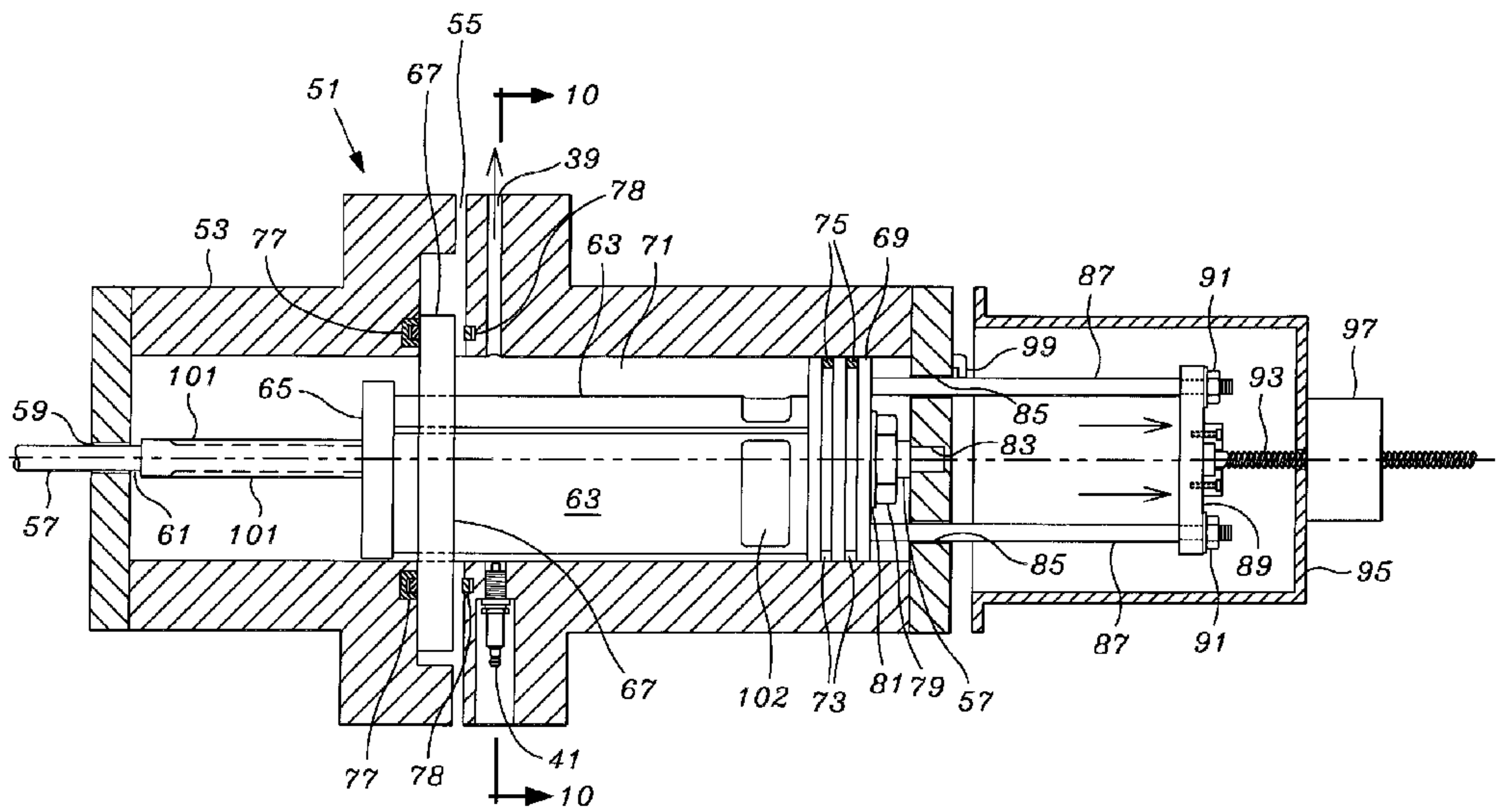
(30) 1996/08/30 (697,787) US
(54) **MOTEUR ROTATIF VARIABLE**
(54) **VARIABLE ROTARY ENGINE**



(57) L'invention porte sur un moteur rotatif qui comporte un élément rotatif se déplaçant latéralement qui est engagé de façon étanche et coulissante par une plaque de rotor modifiée pour être étanche et se déplaçant dans un cercle excentrique en même temps que le rotor, mais assurant une étanchéité entre la plaque et le rotor en se servant de joints d'angle et de joints de surface. En outre, l'élément est encore plus étanche par rapport au carter du moteur de sorte que les gaz de combustion près du rotor et de la plaque de rotor ne s'échappent pas de l'espace entre le rotor et les surfaces de la plaque de rotor ni de l'espace entre les surfaces de la plaque de rotor et les

(57) A rotary engine contains a laterally displaceable rotary member which is sealably and slidably engaged by a rotor plate which has been modified for sealing, travels in an eccentric circle along with the rotor, but provides sealing against the rotor using corner seals and surface seals, and is also further sealed against the engine housing so that combustion gasses in the vicinity of the rotor and rotor plate do not escape either between the rotor and rotor plate surfaces nor between the rotor plate surfaces and the engine housing surfaces. The other end of the rotor rotatably depends from a reducing piston which is sealably engaged against the internal portion of

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surfaces du carter du moteur. L'autre extrémité du rotor dépend de façon rotative d'un piston de réduction qui est engagé de façon étanche à la partie interne du moteur de sorte qu'il puisse se déplacer latéralement, afin de déplacer le rotor latéralement. Pendant que le moteur fonctionne, le rotor peut être déplacé axialement ou poussé à travers la plaque de rotor pour réduire le volume effectif de combustion. Le piston de réduction est manipulé physiquement de l'extérieur du moteur en actionnant une série de tiges de commande qui relient le piston de réduction à un actionneur. Un actionneur fait fonctionner la plaque de va-et-vient, et un capteur mesure le déplacement des tiges de commande et de la plaque de va-et-vient afin de mieux maîtriser le déplacement résultant du moteur.

the engine so that it can travel laterally, in order to laterally displace the rotor. During engine operation, the rotor can be made to be axially displaced or pushed through the rotor plate to lower the effective combustion volume. The reducing piston is physically manipulated from outside of the engine by actuation of a plurality of push-pull rods which connect the reducing piston ultimately to an actuator. An actuator is used to operate the push-pull plate and a sensor can be utilized to measure the displacement of the push-pull rods and plate to better control the resulting engine displacement.

Abstract of the Invention

A rotary engine contains a laterally displaceable rotary member which is sealably and slidably engaged by a rotor plate which has been modified for sealing, travels in an eccentric circle along with the rotor, but provides sealing against the rotor using corner seals and surface seals, and is also further sealed against the engine housing so that combustion gasses in the vicinity of the rotor and rotor plate do not escape either between the rotor and rotor plate surfaces nor between the rotor plate surfaces and the engine housing surfaces. The other end of the rotor rotatably depends from a reducing piston which is sealably engaged against the internal portion of the engine so that it can travel laterally, in order to laterally displace the rotor. During engine operation, the rotor can be made to be axially displaced or pushed through the rotor plate to lower the effective combustion volume. The reducing piston is physically manipulated from outside of the engine by actuation of a plurality of push-pull rods which connect the reducing piston ultimately to an actuator. An actuator is used to operate the push-pull plate and a sensor can be utilized to measure the displacement of the push-pull rods and plate to better control the resulting engine displacement.

VARIABLE ROTARY ENGINE

This invention claims priority from a provisionally filed application number 60/003,125 filed on September 1, 1995, and from U.S. Patent Application No. 08/697,787 filed 8/30/96.

Field of the Invention

The present invention relates to the field of internal combustion engines and more particularly to a Wankel rotary-type engine, but having structure to enable the size of the combustion volume to be continuously varied to yield higher efficiency operation.

Background of the Invention

The Wankel rotary engine has been in use for some time and has offered mechanical motion efficiencies over that of a standard internal combustion engine chiefly because the continuous inertia of the internal moving parts. However, the mechanical efficiency gained from having a continuous mechanical motion has been offset by inefficiency in overall use and a generally lower fuel efficiency derived from overall use.

At high power outputs, a sort of efficiency is obtained where the mechanical efficiency helps to facilitate power output at high power output. In general useage, however and where only a portion of the output power is needed, the inefficiency in operation dominates. The full volume displacement of the engine still requires a large volume of air to be compressed, and much of the energy value from the fuel is spent in compressing the still large volume of air pulled into the combustion chamber.

Summary of the Invention

The rotary engine of the present invention contains a laterally displaceable rotary member which is sealably and slidably engaged by a rotor plate which has been modified for sealingly allowing the rotor to be pushed through it. The rotor plate travels in an eccentric circle along with the rotor, but provides sealing against the rotor using corner seals and surface seals, and is also further sealed against the engine housing so that combustion gasses in the vicinity of the rotor and rotor plate do not escape either between the rotor and rotor plate surfaces nor between the rotor plate surfaces and the engine housing surfaces.

The other end of the rotor rotatably depends from a reducing piston which is sealably engaged against the internal portion of the engine so that it can travel laterally, in order to laterally displace the rotor. During engine operation, the rotor can be made to be axially displaced or pushed through the rotor plate to lower the effective combustion volume.

The spark plug, inlet and exhaust ports are located relatively close to the rotor plate so as to never become isolated by lateral movement of the reducing piston. The reducing piston is physically manipulated from outside of the engine by actuation of a plurality of push-pull rods which connect the reducing piston ultimately to an actuator. In a preferred embodiment, the push-pull rods are connected to a push-pull plate and it is the push pull plate which is actuated in order to actuate the push-pull rods simultaneously. An actuator is used to operate the push-pull plate and a sensor can be utilized to measure the displacement of the push-pull rods and plate to better control the resulting engine displacement.

In one preferred embodiment there is provided a variable displacement rotary engine comprising: an engine housing having an internal space and an internal wall; a non-rotating reducing piston laterally displaceable within said internal space; a rotor rotatably supported by said reducing piston and said engine housing, and laterally displaceable with said reducing piston; and a rotor plate surrounding said rotor, said rotor slidably and sealably displaceable with respect to said rotor plate, said rotor plate rotatable within said engine housing and sealably engaged with said engine housing to define a combustion volume between said rotor plate, said rotor, said reducing piston and said internal wall of said engine housing, said displacement of said reducing piston to vary said combustion volume of said engine.

In another preferred embodiment the variable displacement rotary engine further includes a push-pull rod connected between said reducing piston and the outside of said engine housing and actuatable to laterally displace said reducing piston within said internal space; an actuator, connected to said push-pull rod to actuate said push-pull rod to displace said reducing piston to vary said combustion volume of said engine; and a position sensor proximate to said push-pull rod to measure the displacement of said push-pull rod into and out of said engine housing.

In a further preferred embodiment the rotor of the variable displacement rotary engine has a broad side and a wiper, the rotor plate further includes a first side and a second side and an opening in the middle of said rotor plate having a shape generally matching the outside shape of said rotor and further comprising: a surface seal carried between said first side and said second side of said rotor plate and opposing said broad side; a wiper seal carried between said first side and said second side of said rotor plate and opposing said wiper; and wherein said opening in said rotor plate has a curved triangular shape and wherein each curved side of said curved triangular shape defines a slot between said first side and said second side and wherein said surface seal further comprises: a spring carried in said slot; and a composite seal urged upward and out of said slot by said spring.

In a further preferred embodiment the variable displacement rotary engine also includes a direct mechanical link having a first end attached to said reducing piston and a second end extending outside said engine housing and actuatable into and out of said housing to laterally displace said reducing piston laterally within said internal space.

Brief Description of the Drawings

The invention, its configuration, construction, and operation will be best further described in the following detailed description, taken in conjunction with the accompanying drawings in which:

Figure 1 is a schematic view of a prior art rotary engine in a position where it will intake a fuel and air mixture;

Figure 2 is a schematic view of the prior art rotary engine shown in Figure 1 in compression position;

Figure 3 is a schematic view of the prior art rotary engine shown in Figures 1 and 2 and illustrating the power position;

Figure 4 is a schematic view of the prior art rotary engine shown in Figures 1 - 3 and illustrating the exhaust position;

Figure 5 is a semi-sectional view of the engine of the present invention illustrating sectional views of the housing and a non-sectional view of the engine internals, the engine in a first position maximizing the combustion volume;

Figure 6 is a semi-sectional view as shown in Figure 5, but in a second position minimizing the combustion volume;

Figure 7 is an exploded view of the rotor and associated structures;

Figure 8 is an assembled view of the rotor and associated structures;

Figure 9 is an end view of the rotor end plate shown in

Figure 8 and taken along line 9 - 9 of Figure 5 and illustrating the distribution of bolt heads securing the rotor plate;

Figure 10 is an end view taken along line 10 - 10 of Figure 8 and illustrating the threaded apertures within an eccentric shaft which are used to support the rotor plate of Figure 9;

Figure 11 is an end view of the rotor plate of Figures 5 - 8 and illustrating the open space which will slidably and sealably accommodate the rotor and further illustrating sealing details thereof;

Figure 12 is a view taken along line 12 - 12 of Figure 11 and looking into the slot and square seal aperture of the rotor plate of Figure 11;

Figure 13 is a detail as taken along line 13 - 13 of Figure 12 and illustrating a small exploded view of the seal which abuts the wiping seal of the rotor;

Figure 14 is an end view, taken along line 14 - 14 of Figure 6 and which gives a more complete view of the engine of the invention including water cooling spaces, inlet and outlet ports and the push-pull rods;

Figure 15 is an orientational view of the sealing structure used against the rotor;

Figure 16 is an exploded view, similar to that whown in Figure 7, but with the addition of an optional lubrication system for lubrication and cooling between the rotor and eccentric shaft;

Figure 17 is a closeup view of the assembled portions of the rotor and eccentric shaft to facilitate a discussion of the path of travel of the lubrication and cooling oil;

Figure 18 is a sectional view taken along line 18 - 18 of

Figure 17 and illustrating the grooving and orientation of a pair of internal conduits;

Figure 19 is an end view of a rotor having an improved exterior shape with a shallow cavity extending the length of the rotor;

Figure 20 is a partially exploded sectional view taken along line 20-20 of showing in detail the interfitting fo the rotor with a pair of end bushings and the internal grooving which facilitates lubricative cooling; and

Figure 21 is an end view of the rotor plate, similar to the view of Figure 11 and illustrating the open space which will slidably and sealably accommodate the rotor and further illustrating sealing details thereof; and

Figure 22 is a partially exploded view of the sealing components used in conjunction with the rotor plate of Figure 21 and the rotor of Figure 19 and shown in an orientation similar to that seen in Figure 15.

Detailed Description of the Preferred Embodiment

The description and operation of the invention will be best described with reference to Figure 1. Figure 1 is a schematic lateral section view of a prior art rotary engine 21. The engine 21 has an engine housing 23 which includes a plurality of cooling water ports 25 and a combustion chamber 27.

The stationary gear 29 is surrounded by a rotor 33 having an internally disposed rotor gear 35 which engages the stationary gear 29 as the rotor 33 eccentrically rotates. The positions A, B, and C are shown to illustrate the positions of the rotor as it progresses through the rotary cycle.

As is well known, Figure 1 illustrates the rotary engine 21 in its intake position as an air-fuel mixture is drawn through an inlet manifold 37. Also seen is the exhaust manifold 39 and a standard electric spark plug 41. Referring to Figure 2, a the rotary engine 21 has advanced to the compression position where the air-fuel mixture previously admitted is being compressed. Referring to Figure 3, the power position is shown as the point at which the spark plug ignites the air fuel mixture. Figure 4 illustrates the exhaust position, where combustion gasses exit the exhaust manifold 39. Having thus illustrated the basic working of the prior art as a starting point, the inventive structure will be better understood.

Referring to Figure 5, a side semi-sectional view of an engine 51 is shown without the details of cooling water ports 25 and other engine wall structures as would be found in a typical rotary engine. A housing 53 is divided by a gap 55 only for illustration purposes. During operation, the engine 51 gap 55 would be eliminated. Beginning at the left, a linearly stationary rotatable rotor shaft 57 protrudes through the housing 53, using an end bore 59. The rotor shaft 57 has a stepped portion 61 just inside the bore 59 to keep the rotor shaft 57 from being laterally displaced out of the housing 53.

Surrounding the rotor shaft 57 is an elongate rotor 63. Elongate rotor 63 has a rotor end plate 65. Elongate rotor 63 is carried within a rotor plate 67 which moves eccentrically with the movement of the rotor 63. The end of the rotor 63 opposite the rotor end plate 65 is rotatably attached to a reducing piston 69. The reducing piston 69 is a rounded profile plate which is sized to closely fit the internals of the engine

51. The volume between the reducing piston 69, rotor 63, rotor plate 67, and internal surface of the housing 53 is the combustion chamber 71.

In order to control and derive work from the gasses within the combustion chamber 71, the combustion chamber 71 needs to be sealed against escape from the combustion chamber. For the reducing piston 69, a pair of axially spaced apart grooves 73 are shown which supports circular seals 75, shown in section at the upper portion of the reducing piston 75, and which will provide sealing yet enable the reducing piston 69 to be laterally displaced within the housing 53.

At points adjacent to the rotor plate 67, a more complex sealing arrangement is shown. The gap 55 has enabled some separation to show that the rotor plate 67 engages a circular seal and bearing member 77 supported by an internal wall of the housing 53, on the side of the rotor plate 67 facing away from the combustion chamber and situated to always engage the rotor plate 67 as it eccentrically moves about the inside of the housing 53. The pressure from the combustion chamber will cause the greatest force on the rotor plate to the left of the rotor plate 67 and thus a seal and bearing member 77, rather than a simple seal, will be needed. On the side of the rotor plate 67 facing the combustion chamber and only about the portion of the rotor plate 67 which faces an internal wall of the housing 53, a seal 78 is situated to always engage the rotor plate 67.

Although not shown in Figure 5, a second set of sealing structures seal the rotor 63 with respect to the rotor plate 67 and at the same time enable the rotor 63 to be laterally displaced through the rotor plate 67 when urged by the reducing piston 69. At the right side of the reducing piston 69 a nut 79 and washer 81 secure a rotor bearing structure to the other side of the reducing piston 69. Extending from the middle of the nut 79 and rotatably supported by a blind bore 83 in the housing 53 is the other end of the linearly stationary rotating shaft 57.

Adjacent the blind bore 83, two or more push-pull bores 85 are evenly spaced about the blind bore 83 to accommodate push-pull rods 87. The push-pull rods 87 have threaded ends and one threaded end is attached directly into the reducing piston 69, while the other ends extend through a push-pull plate 89 and are secured with nuts 91. The center of the push-pull plate 89 is engaged by an actuator member 93 which extends through an actuator housing 95. The lateral displacement of the actuator member 93 is controlled by an actuator 97. In one form of the embodiment shown in Figure 5, the actuator 97 may have an internally threaded member which engages the external threads of the actuator member 93. The actuation mechanism may be as swift or slow as is desired.

An actuation mechanism, regardless of type, may include a position sensor 99 to give an indication as to the exact displacement of the push-pull rods 87. The position sensor 99 shown is positioned to read the displacement directly from markings or other optical indicia directly on one of the push-pull rods.

Also seen in Figure 5 is a pair of key slots 101 running longitudinally on either side of shaft 57 which enable rotational keying of the structures associated with the rotor 63. Figure 5 also shows the conventional spark plug 41 and a conventional exhaust port 39. A cavity 102 is shown as a relatively large rectangular space and is provided to facilitate entry of combustion gasses into the combustion chamber 71, especially when the position of the rotor 63 is such that the combustion chamber volume is minimized. As such, the cavity will be located relatively closer to the reducing piston 69.

Referring to Figure 6, the engine 51 is shown in a position in which the push-pull rods 87 are inserted all the way inside the housing 53 to the maximum extent. As can be seen, this leaves a combustion chamber 71 of relatively smaller size. The space surrounding the bulk of the extent of the rotor 63 undergoes no compression and that portion of rotor 63 simply spins within the housing 53. Since the combustion chamber 71 shown in Figure 6 still has access to the spark plug 41, exhaust manifold 55 and intake manifold 37 (not shown) combustion can continue even though the volume and driving area of the rotor is reduced.

Actuation of the push-pull rods 87 simply push in when less energy is required from the engine 51, and pull out when more energy is required. The actuator 97 can be a part of a control scheme involving a microprocessor, the accelerator, or any other engine aspect or quantity.

Referring to Figure 7, an exploded view of the details of the structures making up portions of engine 51 are shown. Beginning at the left, the shaft 57 with key slots 101 will freely and rotatably axially slide through a bore 103 through the end plate 65. The end plate 65 also only shows a pair of tapped bolt apertures 105 and a pair of bolts 107 of multiple numbers which will secure the end plate 65 to the rotor assembly.

Rotor plate 67 is shown in section and defines a bowed slot 109 which will support an ordinary composite seal which may be springably urged by a wavy spring, and which will be shown in an orientational view in Figure 15. In fact, the triangular shape of the rotor is sealed by three such bowed slots 109 along the greater periphery around the rotor 63, and with three more specialized seals for the edges of the rotor 63 to be discussed.

The rotor 63 appears somewhat hollow and as having a thicker wall dimension on one side than the other, but this is only due to its triangular shape and that the upper section is through the midpoint of a wall, while the lower section is through an angled portion. At the end of the rotor 63, the internally disposed rotor gear 35 is seen.

At the lower left of Figure 7, an enlarged eccentric shaft 111 has a plurality of threaded bores 113, although only a pair are shown, for engaging the bolts 107 to lock the end plate 65 onto the left side of the eccentric shaft 111. The eccentric shaft 111 has an internal bore 115 having a pair of key ribs 117 to turnably engage the shaft 57. The eccentric shaft 111 leads to a reduced diameter portion 119 and having a threaded end 121 for engaging the nut 79.

Shown within the reducing piston 69 is a bearing member 123. The bearing member 123 is connected to and perhaps may even be formed integrally with the stationary gear 29. The bearing 123 secures the eccentric shaft from the right with the nut 79, while the eccentric shaft 111 secures the rotor 63 by the use of the end plate 65. In this configuration, the reducing piston will not turn while much of the other structures are allowed to turn, and the reducing piston can be actuated to move laterally while keeping the rotor assembly together as a unit. Also a plurality of threaded bores 125, a pair of which are shown, which engage the threaded ends 127 of the push-pull rods 87.

Figure 8 is an assembled view of the structures shown in Figure 7 and as can be further seen within the slot 109, an wavy spring 129 supports a composite bearing material 131 against the outer surface of the rotor 63. With this configuration, the rotor 63 may be shifted to the left or to the right and without breaching the integrity of the seal nor permitting any significant amounts of combustion materials to escape between the rotor 63 and the rotor plate 67.

Referring to Figure 9, a view taken along line 9 - 9 of Figure 8 illustrates the uneven distribution of the bolts 107 about the bore 103. Referring to Figure 10, a view taken along line 10 - 10 of Figure 8 shows the outer surfaces of the rotor 63 and in particular the wiping seals 135 which are located at each rounded corner of each side of the rotor 63. The rotor 63 is shown surrounding the eccentric shaft 111. The threaded bores 113 in the eccentric shaft 111 are also shown.

Referring to Figure 11, a view taken along line 11 -11 of Figure 7 gives an end view of the rotor plate and its defining elongate surfaces 137 which define the slot 109 and which are bordered by abbreviated slots 139 at the apex of any two of the elongate surfaces 137. Assuming that the rotor 63 has a close fit with respect to the surfaces 137, the seals 131 shown in Figure 8 as urged by the springs 129 will complete the sealing.

However, the internal opening in the rotor plate 67 must also accommodate and seal against the edges of the wiping seals

135. The slots 139 help accommodate the seals 135, but additional sealing help is also provided.

Referring to Figure 12, a view taken along line 12 - 12 of Figure 11 looks straight into slot 139. At the lower portion of the rotor plate 67 the slot 139 carries a dashed line structure illustrating accommodation of the wiping seal 135 at it begins to traverse the rotor plate 67. At the center of the view of the rotor plate 67 shown in Figure 12, a square structure is shown which is a seal member 141 which is axially urged toward the reader. The seal member 141 will press against the wiping seal 139 and partially block the slot 139. The partial blocking of the slot 139 only need be a length between the tip end of the wiping seal 135 and the greatest extent of the slot 135, and therefore the seal member 141 does not have very much space to seal against.

Referring to Figure 13, a view taken along line 13 - 13 of Figure 12 shows the seal member 141 displaced from its square bore 143 and being connected to and urged by a spring 145. The seal member 141 is urged outward when displaced back into its square bore 143 and against the spring 145. Once this arrangement is set, and once the seal 131 is also in place, the rotor 63 will be completely sealed against its opening in the rotor plate 67.

Referring to Figure 14, a view taken along line 14 - 14 of Figure 6 illustrates one basic possible configuration of the engine 51 and also frames engine 51 in an orientation similar to that shown in prior art Figures 1 - 4, simply in order to finally orient the inventive engine 51 with respect to conventional engines. The inlet manifold 37, exhaust manifold

39 and engine housing 51 is clearly seen and includes the cooling water ports 25. At the center, the shaft 57 can bee seen as having key slots 101. The nut 79 and washer 81 is clearly visible. A configuration of four push-pull rods 87 are arranged roughly evenly displaced from the shaft 57 and in order to apply an even pressure to the reducing piston 69.

Referring to Figure 15, and for completeness, an exploded view of the sealing structures in relative position are shown to illustrate how well the rotor 63 is sealed. Between each of the spring 145 and seal 141 sets extends a curved elongate seal 151, and which is backed up by a wavy spring 153. When assembled in the bowed slots 109, the wavy spring 153 evenly urges the curved elongate seal 151 against the surface of the rotor 63.

Based upon computations associated with the design of engine 51, it is expected that a fuel savings of from 60% to about 70% will be achieved. In normal operation, for example, when climbing a hill the engine 51 displacement will be maximized. When driving on open, flat roads, the engine displacement will be reduced to a level to maximize fuel efficiency. In some instances, the control can be set to maximize engine 51 displacement based upon driving habits, or when more power is needed in accelerating from a standstill.

Referring to Figure 16, a different embodiment of the components of the engine 51 of Figure 5 are shown in an exploded view similar to that seen in Figure 7. In this embodiment, a lubricative cooling system is introduced. Rather than have the eccentric shaft 111 turning within a clearance within the rotor 63, a system which introduces cooling lubrication oil through the rotor is shown.

Referring to Figure 16, and beginning at the left, many of the components seen in Figure 7 are now seen, although most appear as they did in Figure 7 for lack of detail. New components include a rotor shaft 201 and the rotor end plate 203 and rotor plate 205, with an oil distribution block 207 located to the left of the rotor end plate 203 and preferably anchored to some inside surface of the engine housing 53 (not shown in Figure 16). Certain modifications which will be shown later in greater detail relating to improvements to the exterior of the rotor 63 of Figure 7.

Figure 16 next shows a rotor 211 having a first end with an internal chamfer 213 to fit a first bushing 215, and a second end with an internal chamfer 217 to interfit with a second bushing 219. Note that for bushing 219, it fits past the internally disposed rotor gear 35 to seat well within and free of any interference to internally disposed rotor gear 35. Also seen in the rotor 211 and extending along the top side is an internal oil groove 221 which as will be shown is used to help distribute oil throughout the structure of Figure 16.

At the lower right of the Figure 16, an improved eccentric shaft 223 has an internal bore 225. The bore 225 contains an elongate oil groove 227 which generally extends along the length of bore 225 and facilitates the more rapid transmission of oil either into or out of the space between the shaft 57 and the internal bore 225. A series of oil conduits or ports 229 are seen extending from the groove 227, and into the other side of eccentric shaft 223. Since the eccentric shaft 223 is seen in cross section, there are another series of ports 229 in the side of eccentric shaft 223 which was cut away, and whic half of the internal bore 225 also has a series of ports 229.

At opposite ends of the eccentric shaft 223 are seen an oppositely disposed indentation representing a groove 231 surrounding the eccentric shaft 223. It is this groove which engages an associated one of the bushings 215 and 219. The bushings 215 and 219 provide a controlled surface on which the groove 231 rides, and further provides internal spacing between the rotor 211 and the eccentric shaft 223 with which to allow cooling oil to flow. The other details of the eccentric shaft 223 of Figure 16 and associated structures are the same as were shown in Figure 7.

Referring to Figure 17, a closeup and assembled view of the components of the cooling oil version of the of engine of the present invention is shown. Beginning at the left, the wall of the housing 53 is shown, and contains a tapped bore 235 for accepting a bolt 237 which secures the oil distribution block 207 to the inside of the engine. The oil distribution block 207 is shown as having an upper inlet 241, and which may also have a lower inlet groove 242 to feed cooling oild into the shaft 201 regardless of its position. Oil distribution block has a lower outlet 243, and which may also have an upper inlet groove 244 to feed cooling oil out of the shaft 201 regardless of its position. However, both the inlet 241 and outlet 243 are interchangeable and either can be used as an inlet or outlet. The shape of the inlet 241 and outlet 243 is for illustrative purposes, and fittings of any nature can be used.

Inlet 241 is in fluid communication with an inlet 245 of the shaft 201. As can be seen in dashed line format, and further with respect to Figure 18, the shaft 201 carries a pair of elongate oil distribution bores 247 and 249 which are on opposite sides of a center line of the shaft. Bore 249 has an exit port 251. As can be seen in Figure 18, the key slots 101 are still present and occupy positions on the shaft generally opposite or at a right angle to the orientation of the bores 247 and 249. A plane through the center of the bores 247 and 249 would be at a right angle to a plane through the key slots 101.

Just as the inlet port 241 and the exit port 243 of the oil distribution block 207 is offset from each other with respect to the length of the shaft 201, the inlet port 245 is linearly offset from the exit port 251 with respect to the length of the shaft 201, such that as the shaft 201 turns, the inlet port 245 only comes in contact with the inlet port 241 of the oil distribution block 207, and the exit port 243 only comes in contact with the the exit port 251 of the shaft 201. Thus, even though momentary fluid communication is had, the inputs are isolated from the outputs, and the momentary contact will easily cause the cooling oil to be moved.

Cooling oil which enters the bore 247 is isolated from the bore 249 and exits through an exit port 255. Cooling oil then moves into a close intermediate clearance space 257 between the shaft 201 and the eccentric shaft 223. The cooling oil then moves through an eccentric shaft port 259 and into the larger clearance space 261 between the eccentric shaft 223 and the rotor 211. The clearance space is created and controlled in accord with the distance between the inside diameter and outside diameters of the bushings 215 and 219. The inside of the rotor 211 carries a series of elongate grooves (not seen in Figure 17) which help disperse and distribute the cooling oil onto the inside of the rotor 211.

As the cooling oil moves across the inside of the rotor 211, it cools the inside surface thereof, drawing heat from the combustion face of the rotor 211. In addition, the bushing 215 is shown as having a lubrication port 263 in communication with a port 265 so that some cooling lubrication can be provided to the bushing 215.

Pressure from incoming fresh cooling oil causes cooling oil near the other side of the larger clearance space 261 to seek to enter a set of inlet ports 267 in the eccentric shaft 223. The inlet ports 267 are in communication with a close intermediate clearance space 271 which is somewhat isolated from the intermediated clearance space 257. The isolation is deliberate, but not designed to be an absolute seal. The isolation is enough that cooling oil is caused to circulate, and if a tiny degree of leakage across the boundary at the key slots 101 occurs, this is permissible.

The intermediate clearance space 271 is in communication with an inlet port 273 of the shaft 201 which communicates with the port 251 at the left side of Figure 17. To complete the sealing between the end of the shaft 201 and the inside clearance spaces 257 and 271 and insure that minimum cross leakage occurs, an end cap 275 is provided and which has an internal surface configuration to accommodate both the key slots 101 and the outside of the threaded end 121 of the eccentric shaft 223, and the shaft 201. The end cap 275 has a flat seal seal 276 to seal the tip end of the threaded end 121 of the eccentric shaft 223.

Referring to Figure 19, an end view of the rotor 211 is illustrated. The design of rotor 211 has an overall shape different than the outside shape of the rotor 63, in that rotor 211 is more triangularly shaped. The rotor 211 has a series of more shallow cavities 281 which extend the length of the rotor 211. This is compared to the cavity 102 which was located near the end of the rotor 63 which would always be exposed within the combustion chamber. By making the cavity 281 extend along the length, the relative ratio of cavity 218 per unit combustion volume will remain constant.

The corners of the rotor 211 have slots 281 which support the same wiping seals 135 seen in Figure 10. Inside the rotor 211, a series of ribs or internal oil grooves 221 are seen. The edge of the chamfer 213 is seen, as well as the relationship between of the chamfer 213 and oil grooves 221, and the oil grooves 221 uniform spacing. Referring to Figure 20, a sectional exploded view of the rotor 211 has the first and second bushings 215 and 219 in a position to be inserted into the rotor 211. Here it can be clearly seen that the second bushing 219 will easily fit past the ends of the internally disposed rotor gear 35. Also seen is an end seal 285, which circularly extends around the end of and which is intended to seal the end of the rotor 211 against its moving interaction with the reducing piston 69.

Referring to Figure 21, a rotor plate 289 is shown which may have an internal aperture 291 having a curved triangular wall 293 which may have a shallow extension 295 to fit within the groove 281 seen in Figure 19. The degree to which the internal aperture 291 is shaped will depend upon the depth of the groove 281. Rotor plate 289 also has three bowed slots 297, one of which is identified by number, the extent of which is seen in dashed line format, and a deep square slot 299 which is used to seal against the end of the wiping seal 135, as well as a notch 301 which has nearly the same shape as the wiping seal 135 and which is used to accomodate the wiping seal 135 portion outside of the rotor 211 as it passes through the rotor plate 289.

Referring to Figure 22, an oriented set of sealing members are shown which are used with rotor plate 289. A set of three curved seals 311, each having a groove 281 - shaped mid rise 313 to apply even pressure across the rotor 211 as well as its groove 281 to achieve a good seal. The curved seals 311 are urged inward within their bowed slots 297 of the rotor plate 289 by a set of three wavy springs 153. The seal member 141 and the spring 145 which urges it within its square bore 143 (seen in Figure 12) are the same as was the case for rotor plate 67. The only change in the design of rotor plate 289 from the rotor plate 67 is the rise in the mid section of the curved triangular wall 293 of the rotor plate 289, and the presence of a mid-rise 313 in the curved seals 311.

While the present invention has been described in terms of a variable displacement engine, and actuator system, one skilled in the art will realize that the structure and techniques of the present invention can be applied to many similar devices. The present invention may be applied in any situation where mechanical efficiency and variable use of the capacity of an engine is desired.

Although the invention has been derived with reference to particular illustrative embodiments thereof, many changes and modifications of the invention may become apparent to those skilled in the art without departing from the spirit and scope of the invention. Therefore, included within the patent warranted hereon are all such changes and modifications as may reasonably and properly be included within the scope of this contribution to the art.

WHAT IS CLAIMED:

1. A variable displacement rotary engine comprising:

an engine housing having an internal space and an internal wall;

a non-rotating reducing piston laterally displaceable within said internal space;

a rotor rotatably supported by said reducing piston and said engine housing, and laterally displaceable with said reducing piston; and

a rotor plate surrounding said rotor, said rotor slidably and sealably displaceable with respect to said rotor plate, said rotor plate rotatable within said engine housing and sealably engaged with said engine housing to define a combustion volume between said rotor plate, said rotor, said reducing piston and said internal wall of said engine housing, said displacement of said reducing piston to vary said combustion volume of said engine.

2. The variable displacement rotary engine of claim 1 and further comprising a push-pull rod connected between said reducing piston and the outside of said engine housing and actuatable to laterally displace said reducing piston within said internal space.

3. The variable displacement rotary engine of claim 2 and further comprising an actuator, connected to said push-pull rod to actuate said push-pull rod to displace said reducing piston to vary said combustion volume of said engine.

4. A variable displacement rotary engine comprising:

an engine housing having an internal space and an internal wall;

a reducing piston laterally displaceable within said internal space;

a rotor rotatably supported by said reducing piston and said engine housing, and laterally displaceable with said reducing piston;

a rotor plate surrounding said rotor, said rotor slidably and sealably displaceable with respect to said rotor plate, said rotor plate rotatable within said engine housing and sealably engaged with said engine housing to define a combustion volume between said rotor plate, said rotor, said reducing piston and said internal wall of said engine housing, said displacement of said reducing piston to vary said combustion volume of said engine;

a push-pull rod connected between said reducing piston and the outside of said engine housing and actuatable to laterally displace said reducing piston within said internal space;

an actuator, connected to said push-pull rod to actuate said push-pull rod to displace said reducing piston to vary said combustion volume of said engine; and

a position sensor proximate to said push-pull rod to measure the displacement of said push-pull rod into an out of said engine housing.

5. The variable displacement rotary engine of claim 1 and further comprising a power output shaft having a first end extending out of said engine housing and rotatable with said rotor and wherein said rotor is axially displaceable with respect to said power output shaft.

6. The variable displacement rotary engine of claim 1 and further comprising an eccentric shaft carried within said rotor and rotatably supporting said rotor with respect to said reducing piston and said engine housing.

7. The variable displacement rotary engine of claim 1 wherein said rotor has a broad side and a wiper, said rotor plate further includes a first side and a second side and an opening in the middle of said rotor plate having an shape generally matching the outside shape of said rotor and further comprising:

a surface seal carried between said first side and said second side of said rotor plate and opposing said broad side; and

a wiper seal carried between said first side and said second side of said rotor plate and opposing said wiper.

8. A variable displacement rotary engine comprising:

an engine housing having an internal space and an internal wall;

a reducing piston laterally displaceable within said internal space;

a rotor rotatably supported by said reducing piston and said engine housing, and laterally displaceable with said reducing piston;

a rotor plate surrounding said rotor, said rotor slidably and sealably displaceable with respect to said rotor plate, said rotor plate rotatable within said engine housing and sealably engaged with said engine housing to define a combustion volume between said rotor plate, said rotor, said reducing piston and said internal wall of said engine housing, said displacement of said reducing piston to vary said combustion volume of said engine;

and wherein said rotor has a broad side and a wiper, said rotor plate further includes a first side and a second side and an opening in the middle of said rotor plate having an shape generally matching the outside shape of said rotor and further comprising:

a surface seal carried between said first side and said second side of said rotor plate and opposing said broad side;

a wiper seal carried between said first side and said second side of said rotor plate and opposing said wiper; and

wherein said opening in said rotor plate has a curved triangular shape and wherein each curved side of said curved triangular shape defines a slot between said first side and said second side and wherein said surface seal further comprises:

a spring carried in said slot; and

a composite seal urged upward and out of said slot by said spring.

9. A variable displacement rotary engine comprising:

an engine housing having an internal space and an internal wall;

a reducing piston laterally displaceable within said internal space;

a rotor rotatably supported by said reducing piston and said engine housing, and laterally displaceable with said reducing piston;

a rotor plate surrounding said rotor, said rotor slidably and sealably displaceable with respect to said rotor plate, said rotor plate rotatable within said engine housing and sealably engaged with said engine housing to define a combustion volume between said rotor plate, said rotor, said reducing piston and said internal wall of said engine housing, said displacement of said reducing piston to vary said combustion volume of said engine;

and wherein said rotor has a broad side and a wiper, said rotor plate further includes a first side and a second side and an opening in the middle of said rotor plate having an shape generally matching the outside shape of said rotor and further comprising:

a surface seal carried between said first side and said second side of said rotor plate and opposing said broad side;

a wiper seal carried between said first side and said second side of said rotor plate and opposing said wiper; and

wherein said opening in said rotor plate has a curved triangular shape and wherein curved angle of said curved triangular shape defines a bore extending radially away from the center of said rotor plate and wherein said wiper seal further comprises:

a spring carried in said bore; and

a composite seal urged upward and out of said bore by said spring.

10. A variable displacement rotary engine comprising:

an engine housing having an internal space and an internal wall, and wherein said engine housing further includes:

an inlet manifold adjacent said rotor plate;

an exhaust manifold adjacent said rotor plate; and

a spark plug adjacent said rotor plate;

a reducing piston laterally displaceable within said internal space;

a rotor rotatably supported by said reducing piston and said engine housing, and laterally displaceable with said reducing piston; and

a rotor plate surrounding said rotor, said rotor slidably and sealably displaceable with respect to said rotor plate, said rotor plate rotatable within said engine housing and sealably engaged with said engine housing to define a combustion volume between said rotor plate, said rotor, said reducing piston and said internal wall of said engine housing, said displacement of said reducing piston to vary said combustion volume of said engine.

11. The variable displacement rotary engine of claim 1 and further comprising a power output shaft having a first end extending out of said engine housing and rotatable with said rotor and wherein said rotor is axially displaceable with respect to said power output shaft.

12. A variable displacement rotary engine comprising:

an engine housing having an internal space and an internal wall;

a reducing piston laterally displaceable within said internal space;

a rotor rotatably supported by said reducing piston and said engine housing, and laterally displaceable with said reducing piston, and wherein said rotor has a cavity to move gasses from one side of said rotor to another; and

a rotor plate surrounding said rotor, said rotor slidably and sealably displaceable with respect to said rotor plate, said rotor plate rotatable within said engine housing and sealably engaged with said engine housing to define a combustion volume between said rotor plate, said rotor, said reducing piston and said internal wall of said engine housing, said displacement of said reducing piston to vary said combustion volume of said engine.

13. A variable displacement rotary engine comprising:

an engine housing having an internal space and an internal wall;

a reducing piston laterally displaceable within said internal space and supported by said engine housing;

a rotor rotatably supported by said reducing piston, and laterally displaceable with said reducing piston;

a rotor plate surrounding said rotor, said rotor slidably and sealably displaceable with respect to said rotor plate, said rotor plate rotatable within said engine housing and sealably engaged with said engine housing to define a combustion volume between said rotor plate, said rotor, said reducing piston and said internal wall of said engine housing, said displacement of said reducing piston to vary said combustion volume of said engine; and

a direct mechanical link having a first end attached to said reducing piston and a second end extending outside said engine housing and actuatable into and out of said housing to laterally displace said reducing piston laterally within said internal space.

14. The variable displacement rotary engine as recited in claim 13 and further comprising a rotor plate laterally and rotationally displaceable within said engine housing and having an aperture, said rotor place surrounding said rotor through said aperture and forming a combustion chamber between said

rotor plate, said displacement piston, said rotor and said engine housing, and wherein the outer surface of said rotor has a triangular shape and wherein said aperture of said rotor plate conforms to said triangular shape.

15. The variable displacement rotary engine as recited in claim 6 wherein said power output shaft has a first and second cooling oil bores parallel to said power output shaft, an inlet in communication with said first cooling oil bore and an outlet in communication with said second cooling oil bore and wherein said eccentric shaft has a first port in communication with said first cooling oil bore and an inside of said rotor and outside of said eccentric shaft and a second port in communication with said second cooling oil bore and said inside of said rotor and said outside of said eccentric shaft, to provide cooling oil flow to the inside of said rotor.

16. The variable displacement rotary engine as recited in claim 15 and further comprising an oil distribution block attached to the inside of said engine housing and partially surrounding said power output shaft and having an inlet bore in alignment with said inlet of said power output shaft, and having an outlet bore in alignment with said outlet of said power output shaft.

17. The variable displacement rotary engine as recited in claim 15 and further comprising an oil distribution block attached to the inside of said engine housing and partially surrounding said power output shaft and having an inlet bore in alignment with said inlet of said power output shaft, and having an outlet bore in alignment with said outlet of said power output shaft.

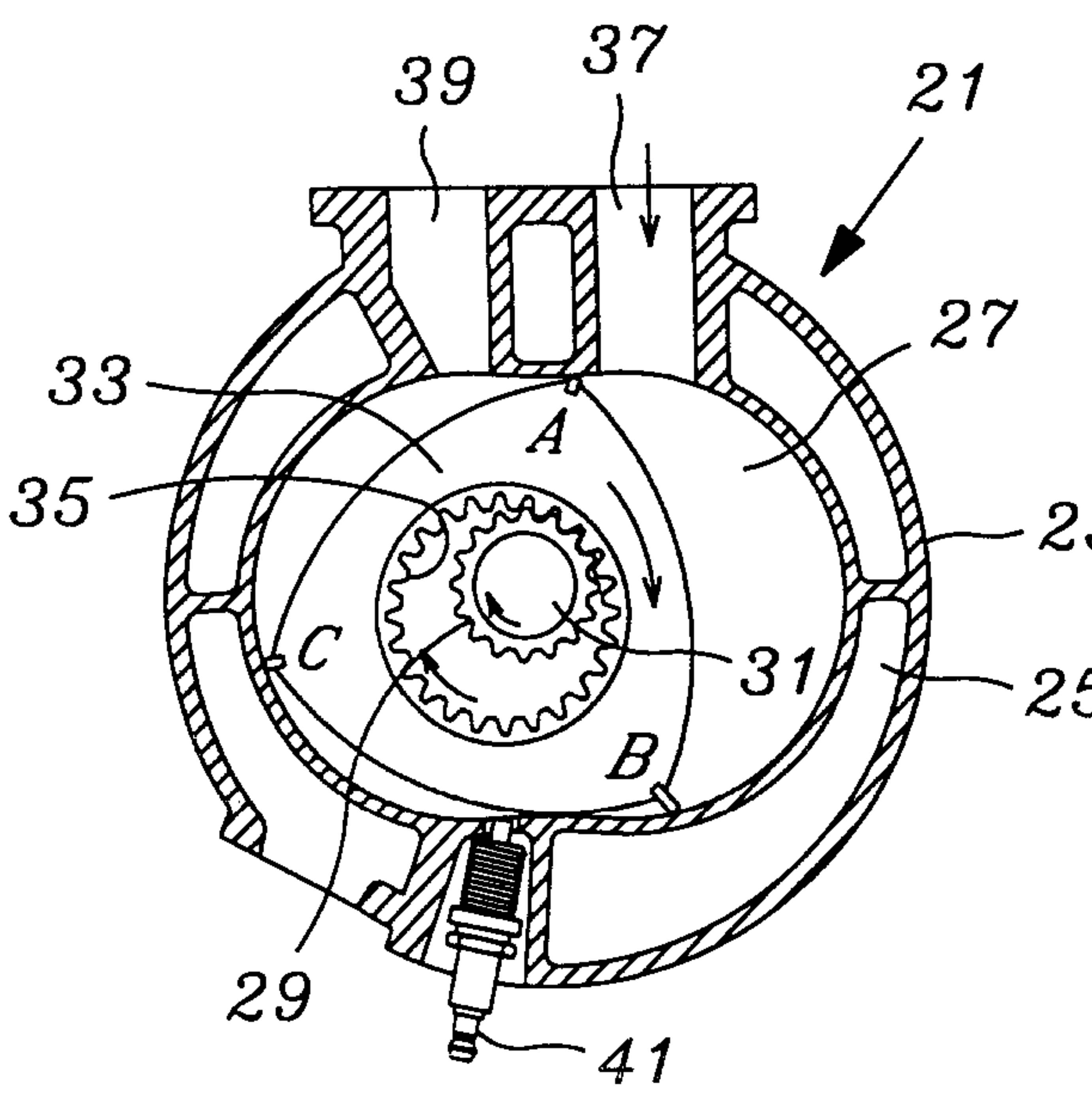

Fig. 1
(PRIOR ART)

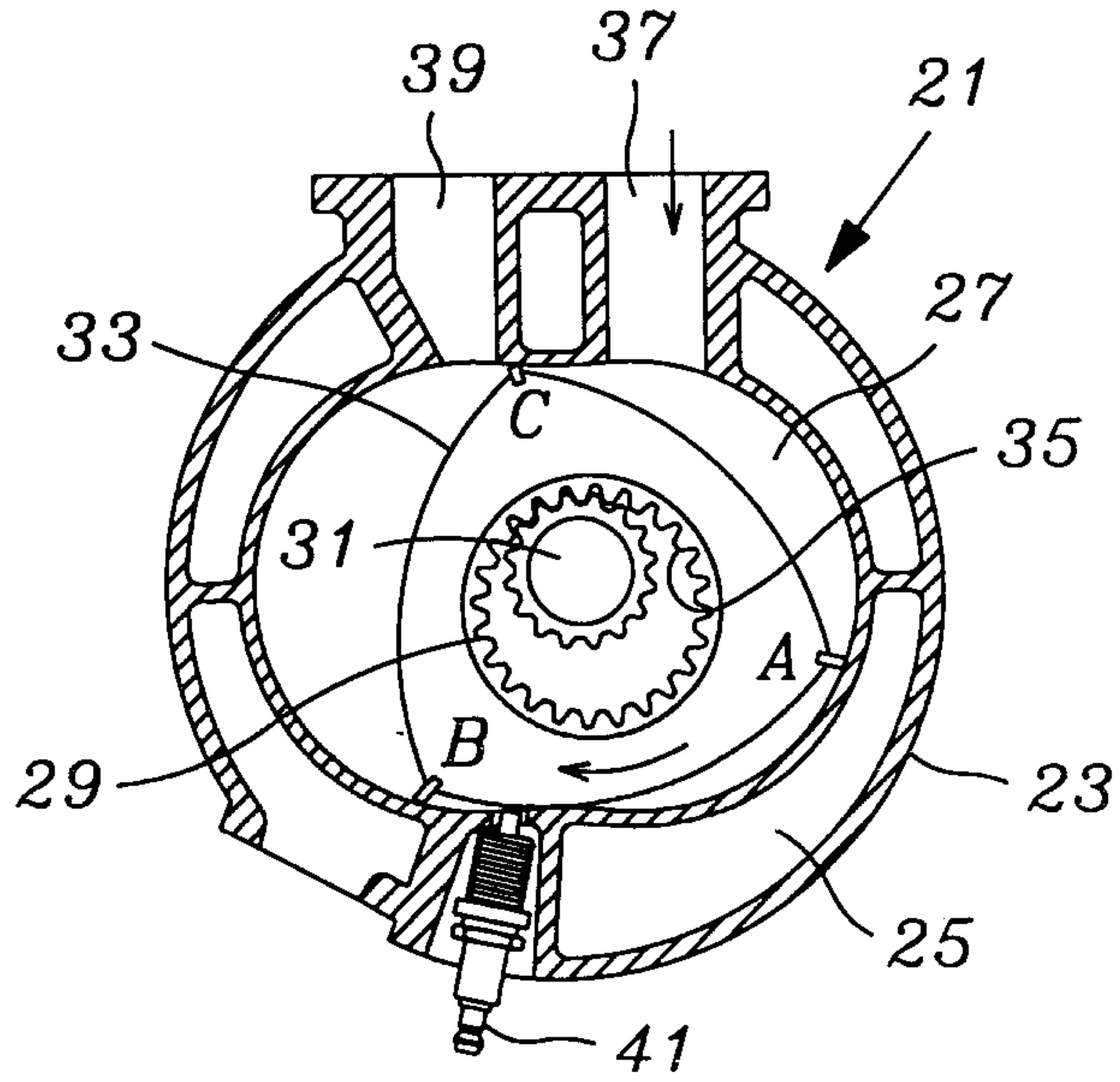

Fig. 2
(PRIOR ART)

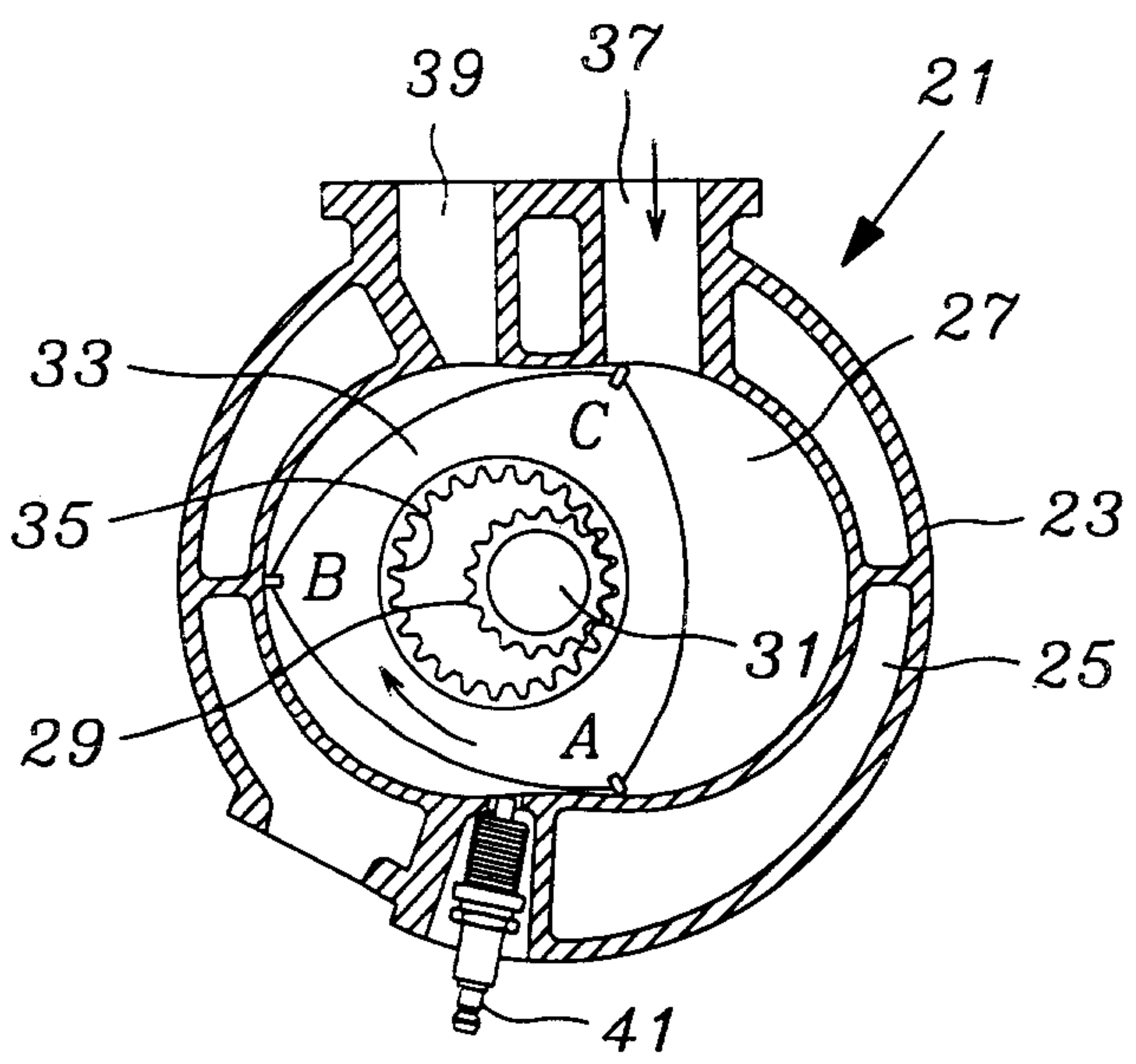

Fig. 3
(PRIOR ART)

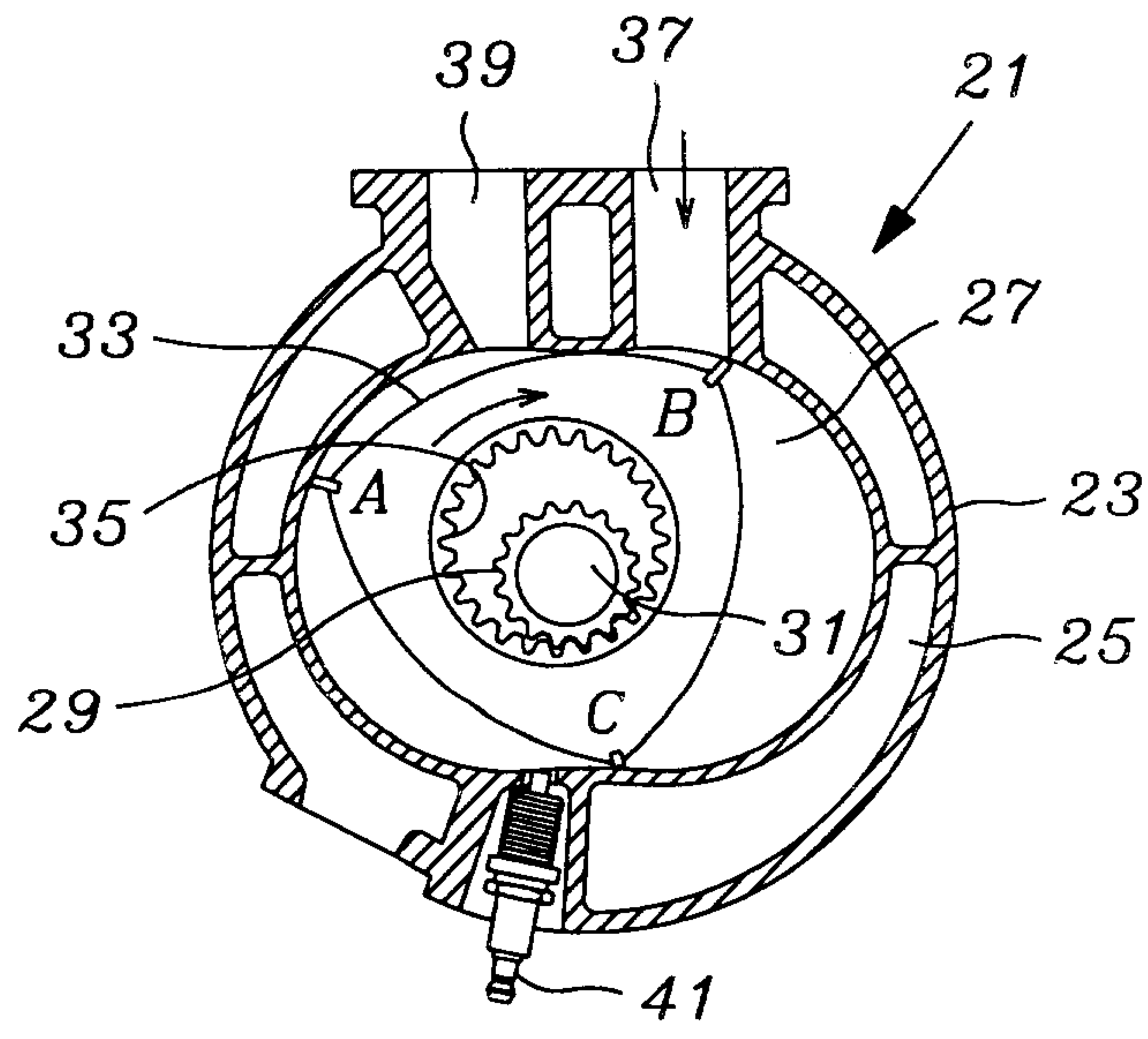

Fig. 4
(PRIOR ART)

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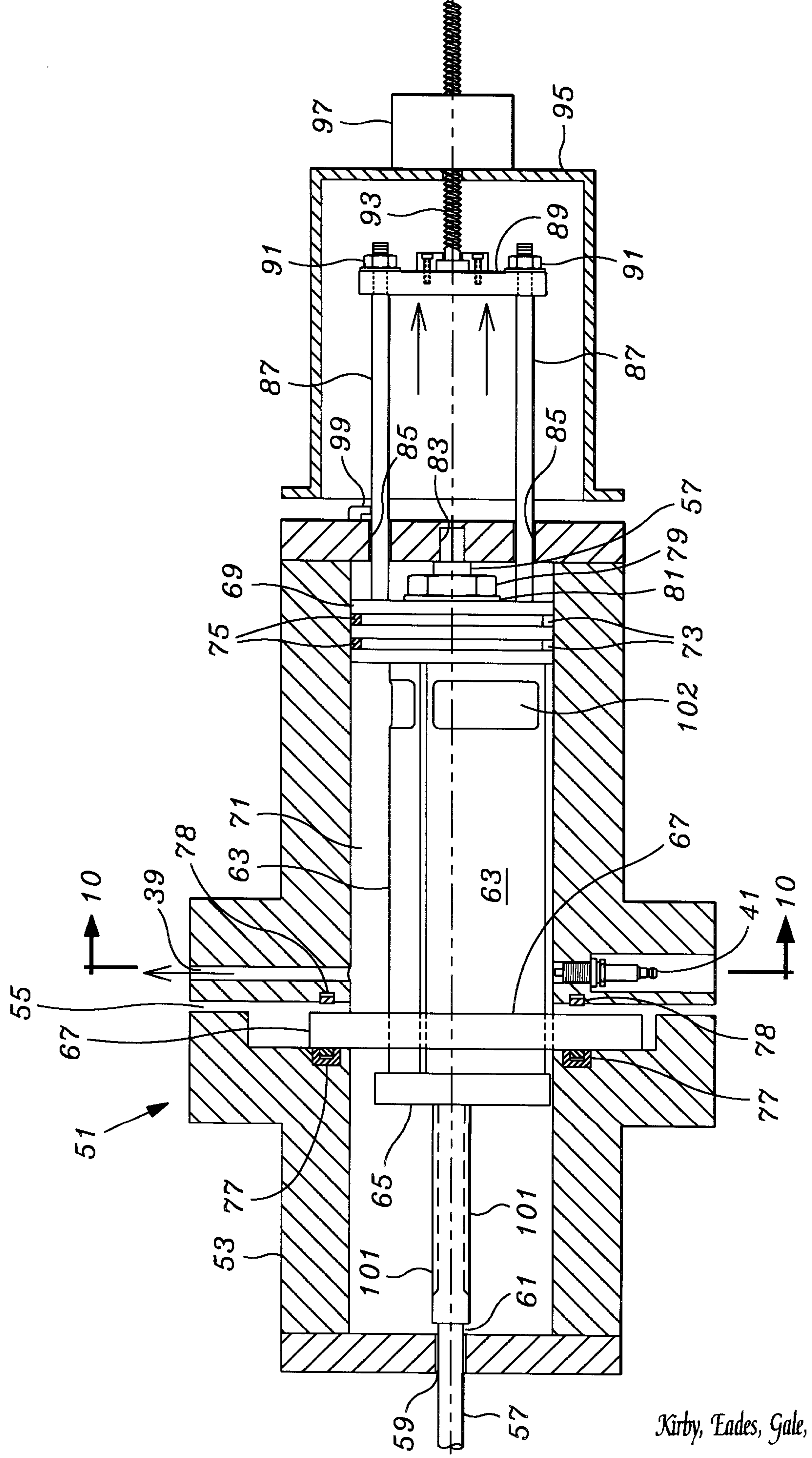

Fig. 5

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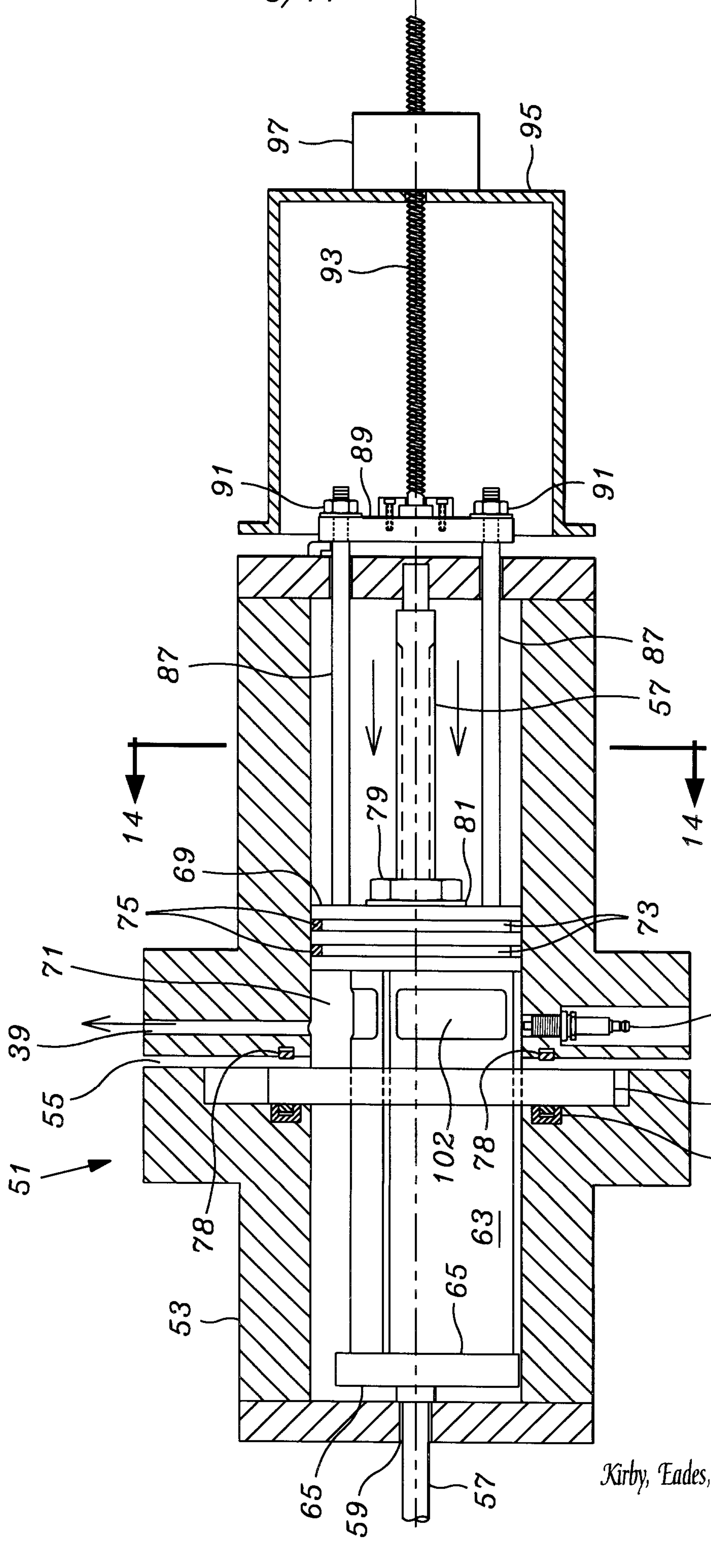

Fig. 6

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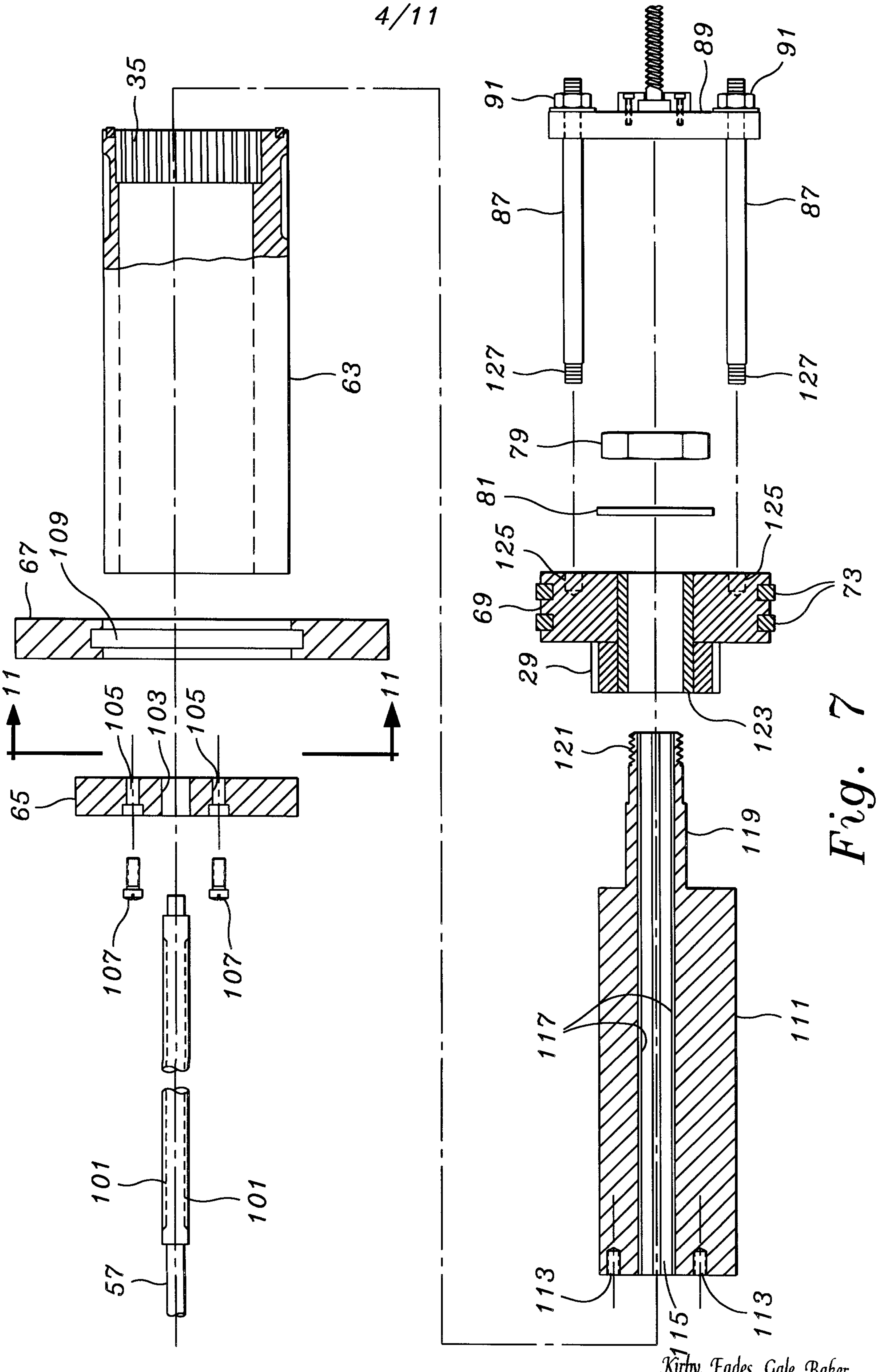

Fig. 7

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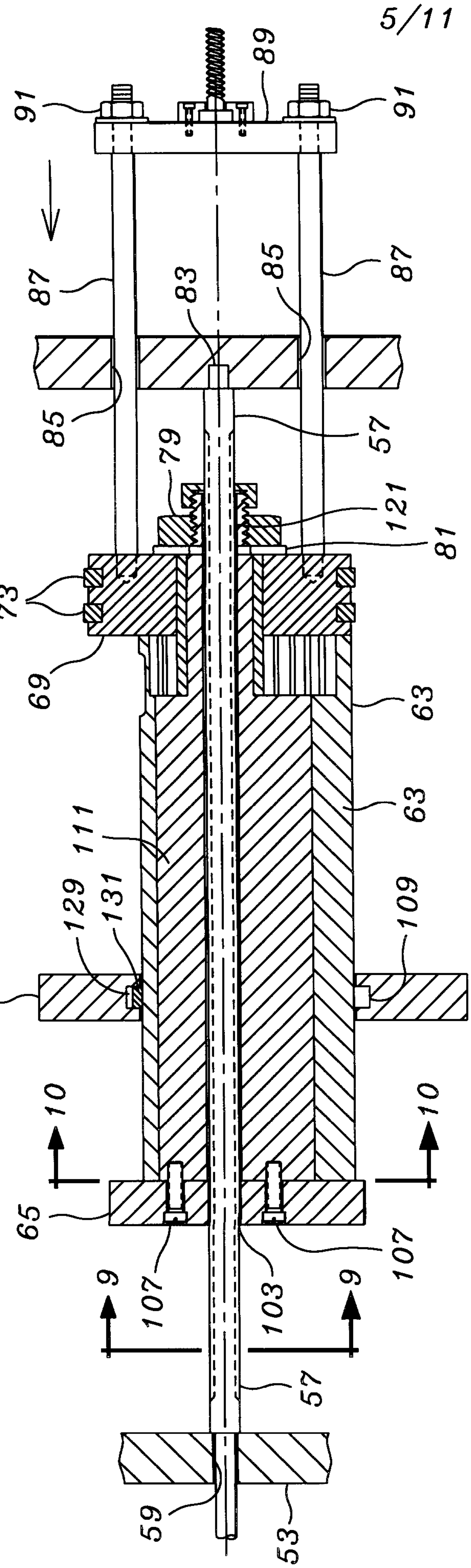

Fig. 8

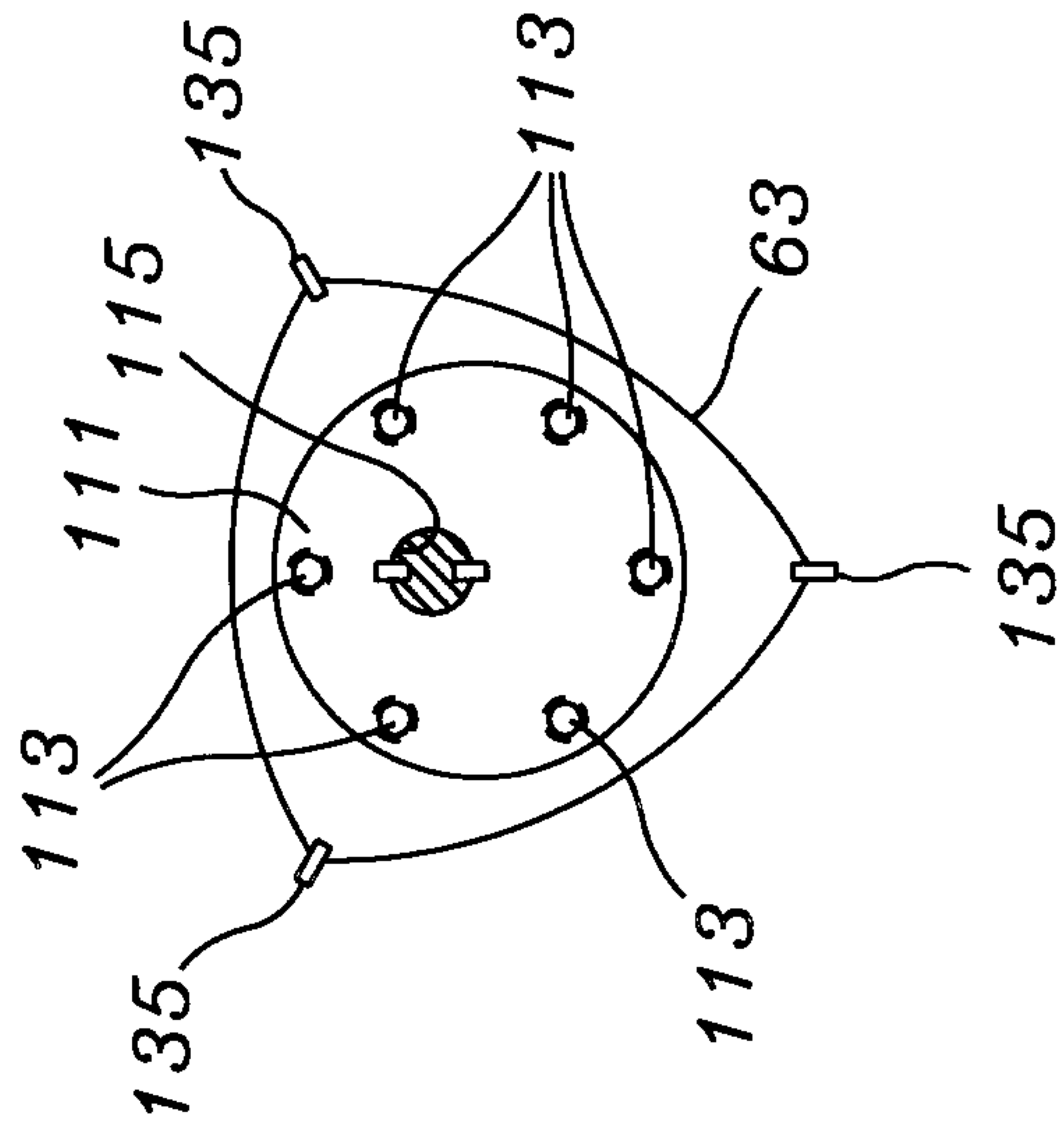

Fig. 10

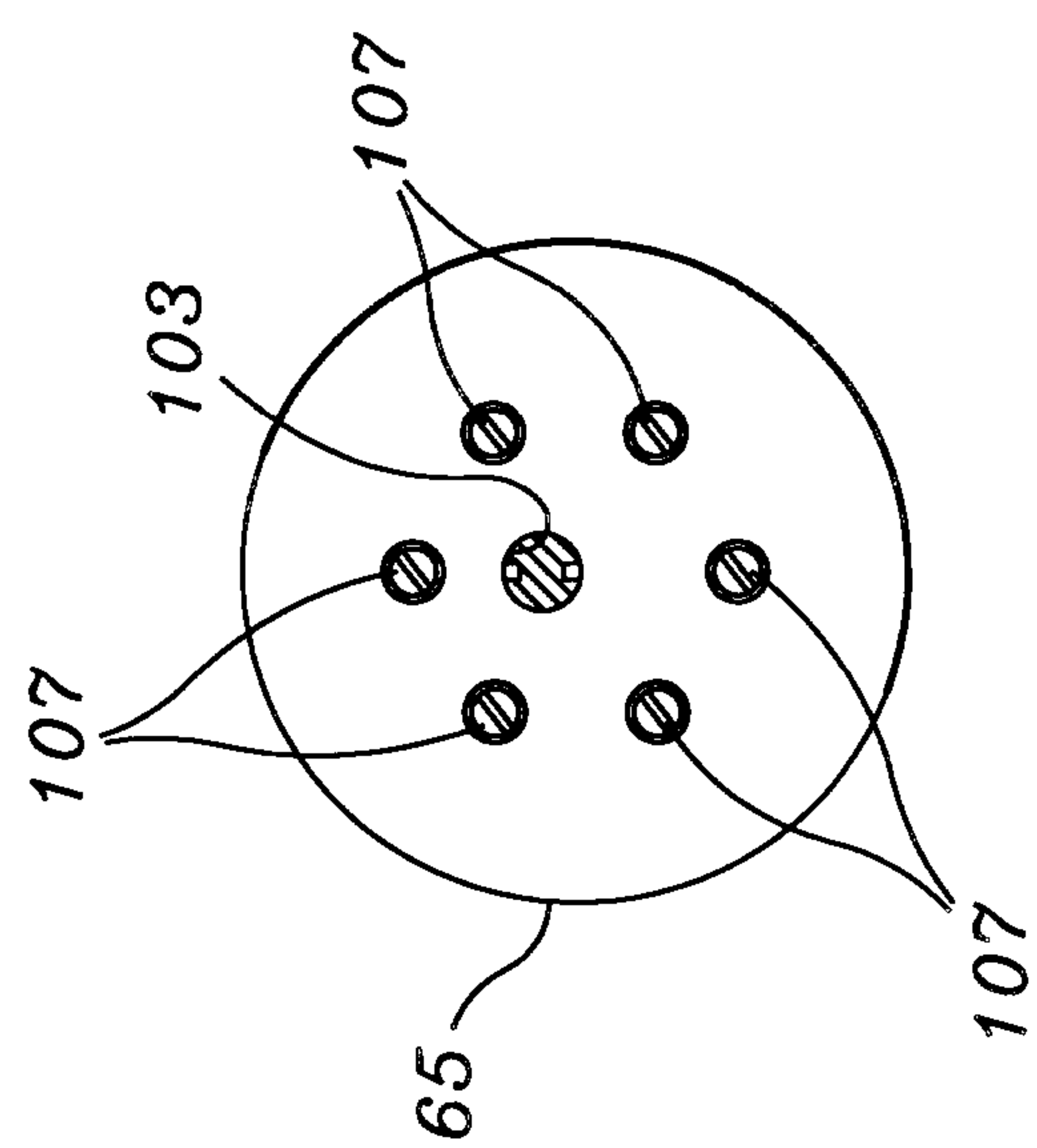

Fig. 9

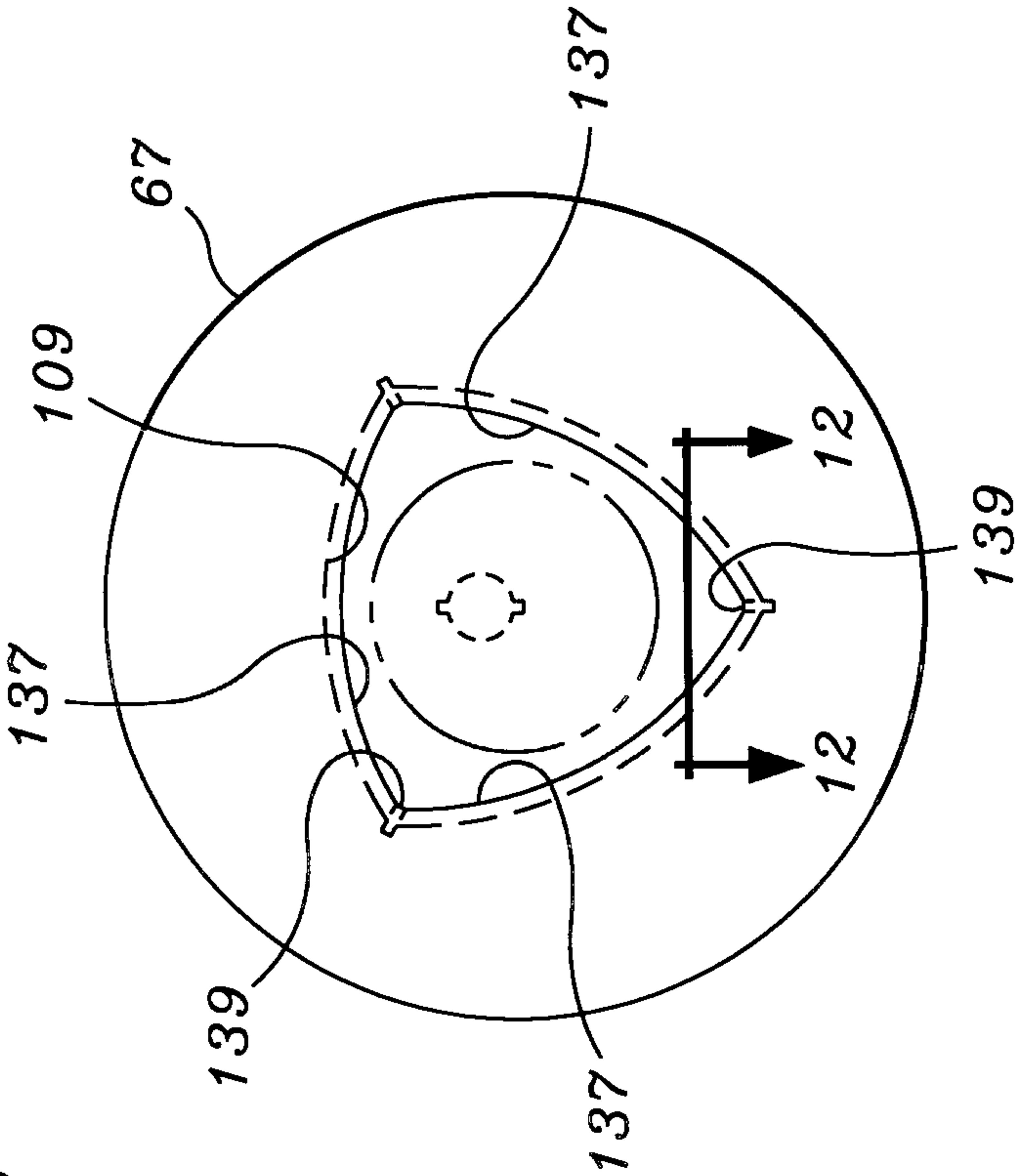

Fig. 11

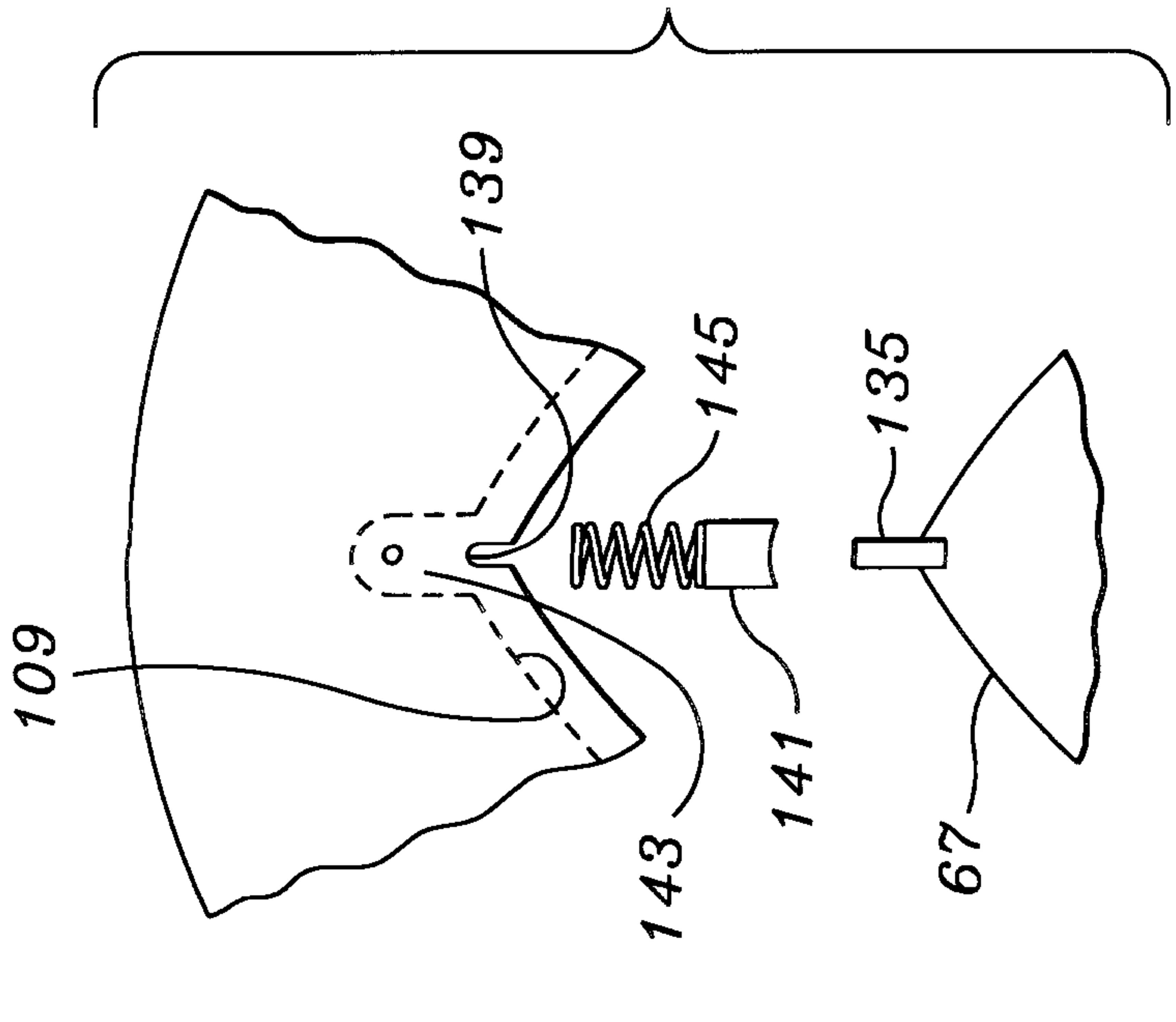

Fig. 13

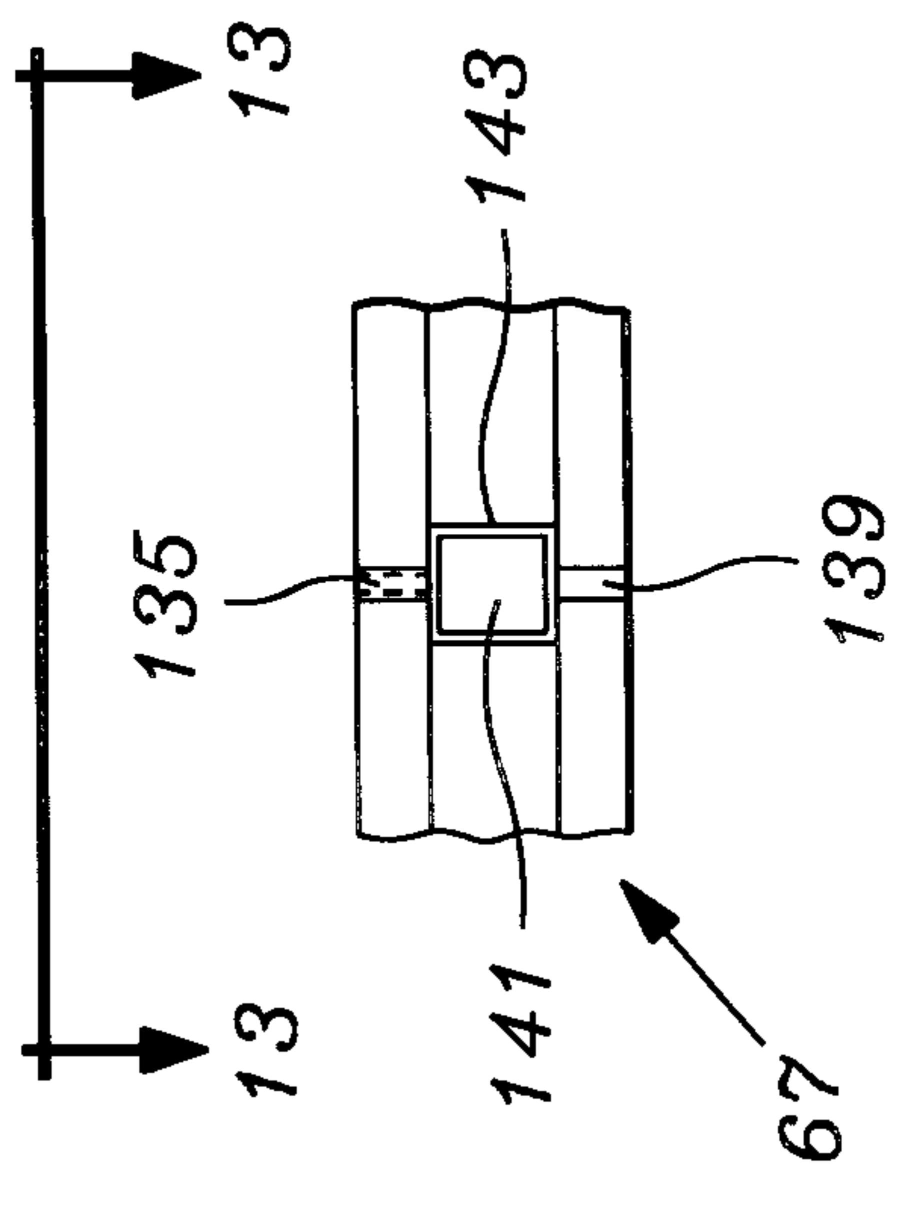

Fig. 12

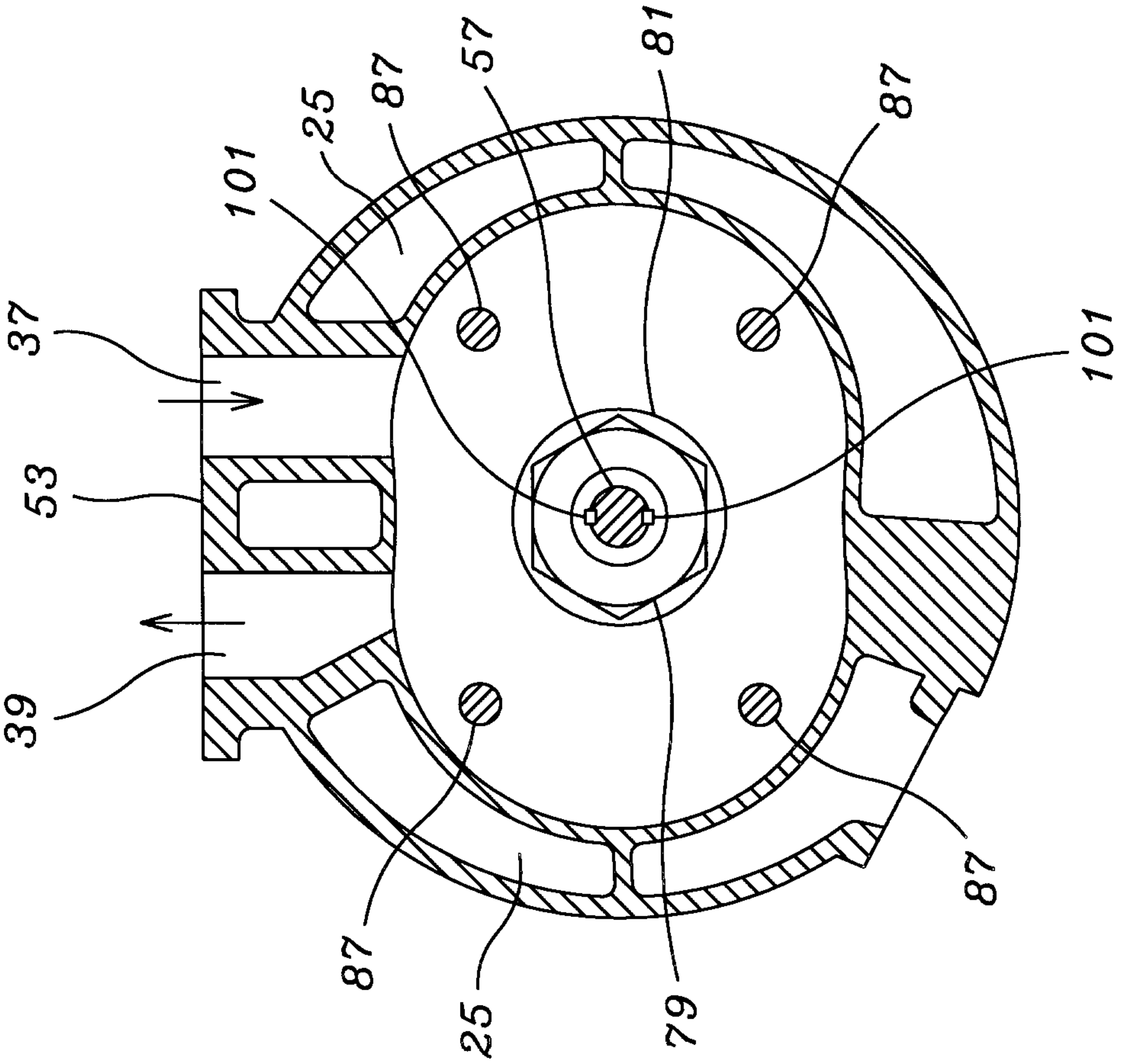
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Fig. 14

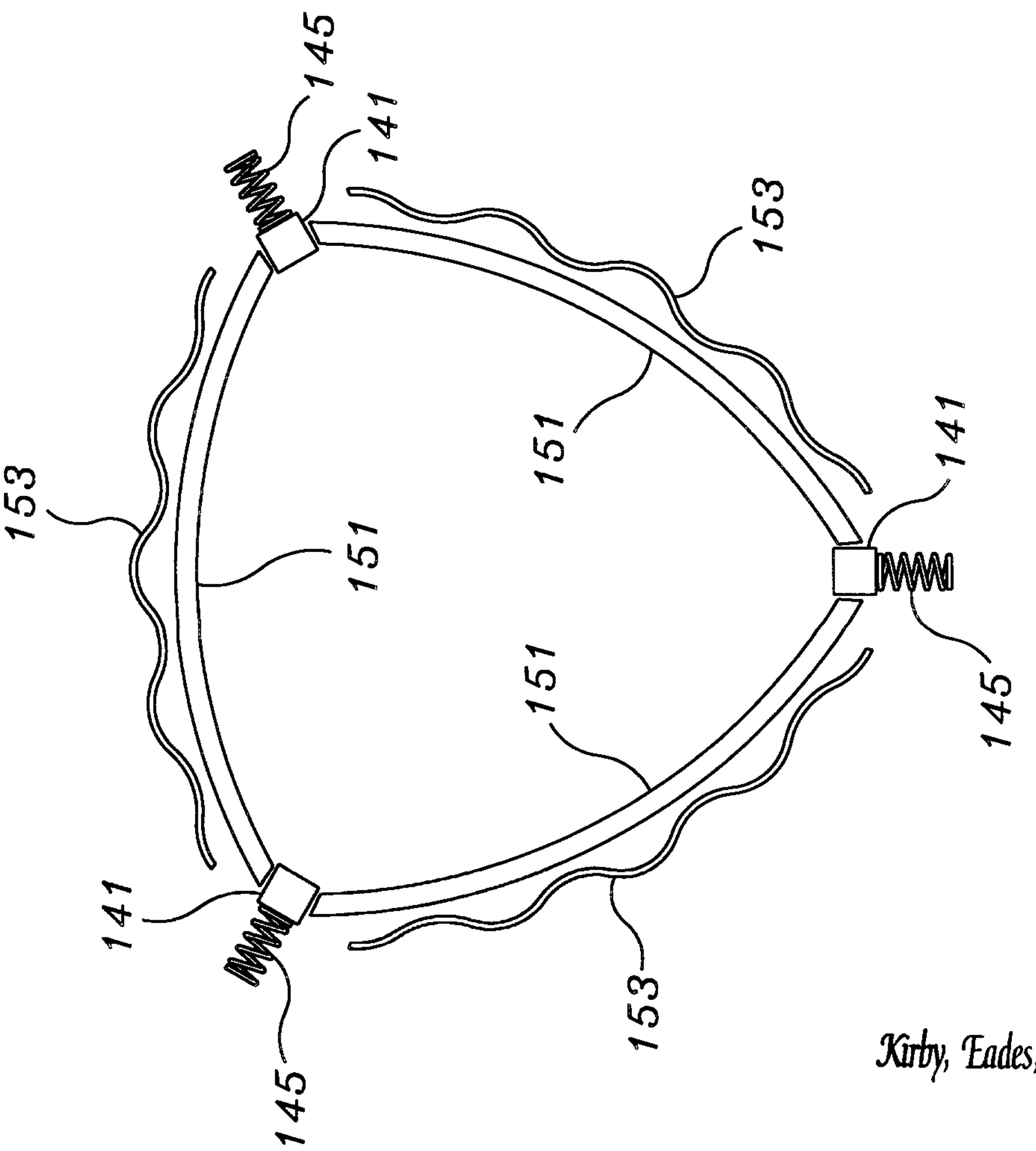
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Fig. 15

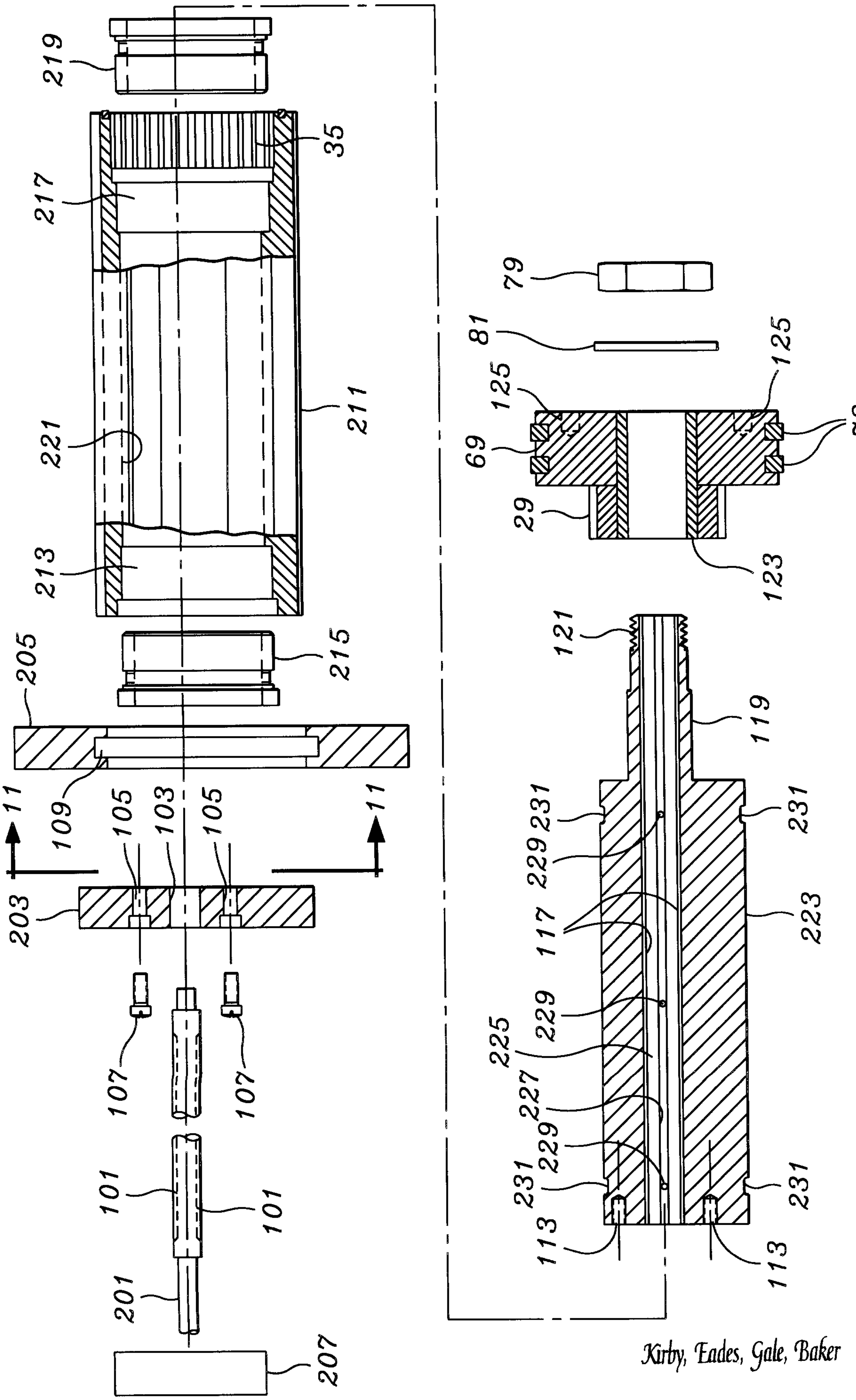

Fig. 16

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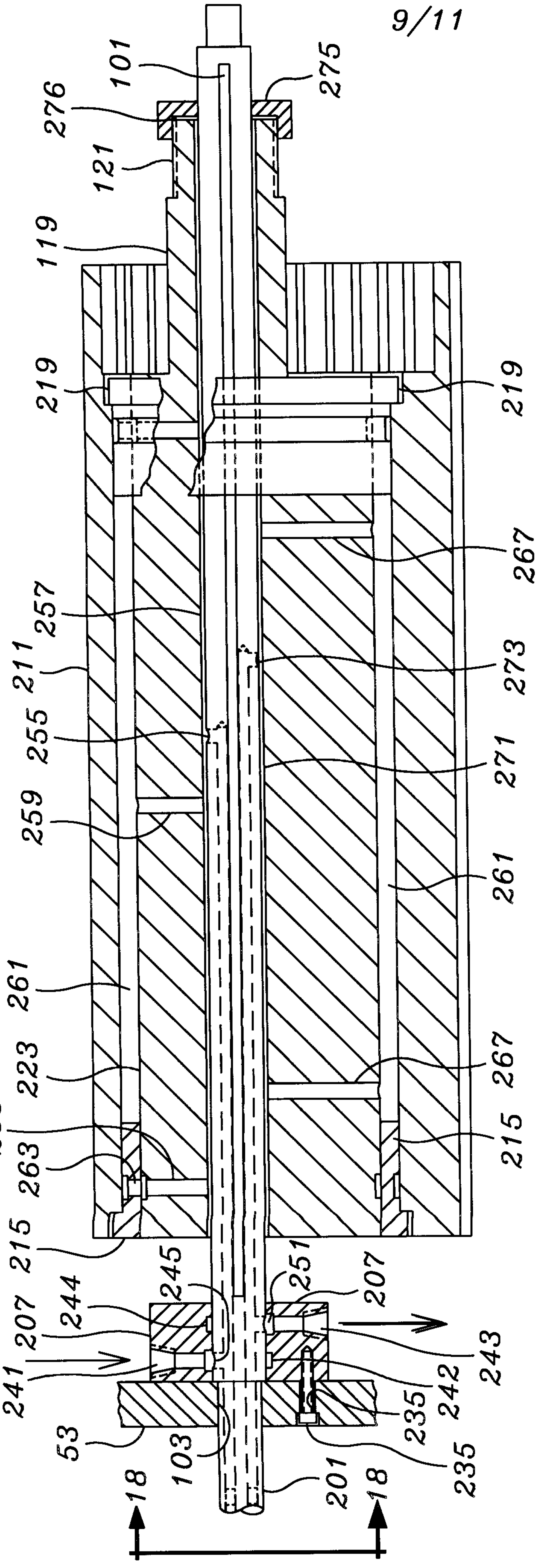

Fig. 17

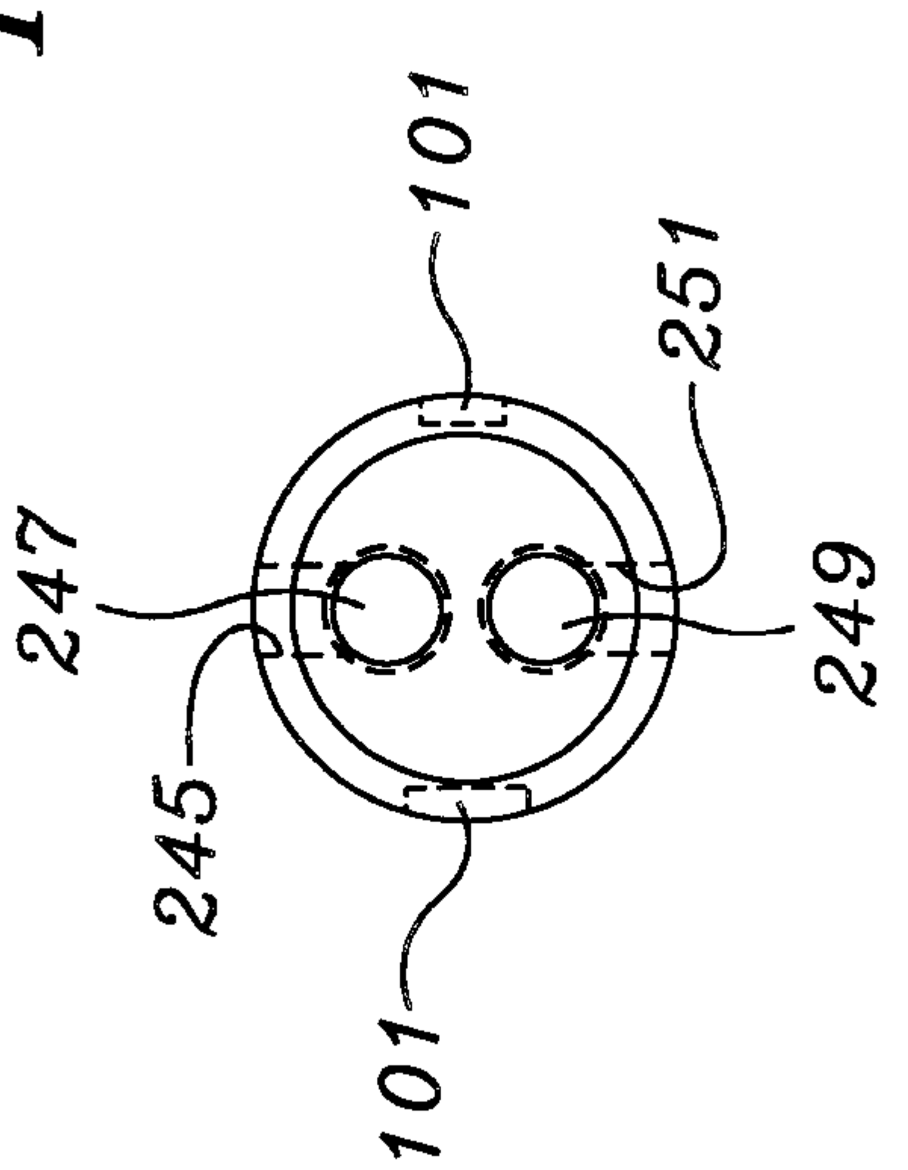

Fig. 18

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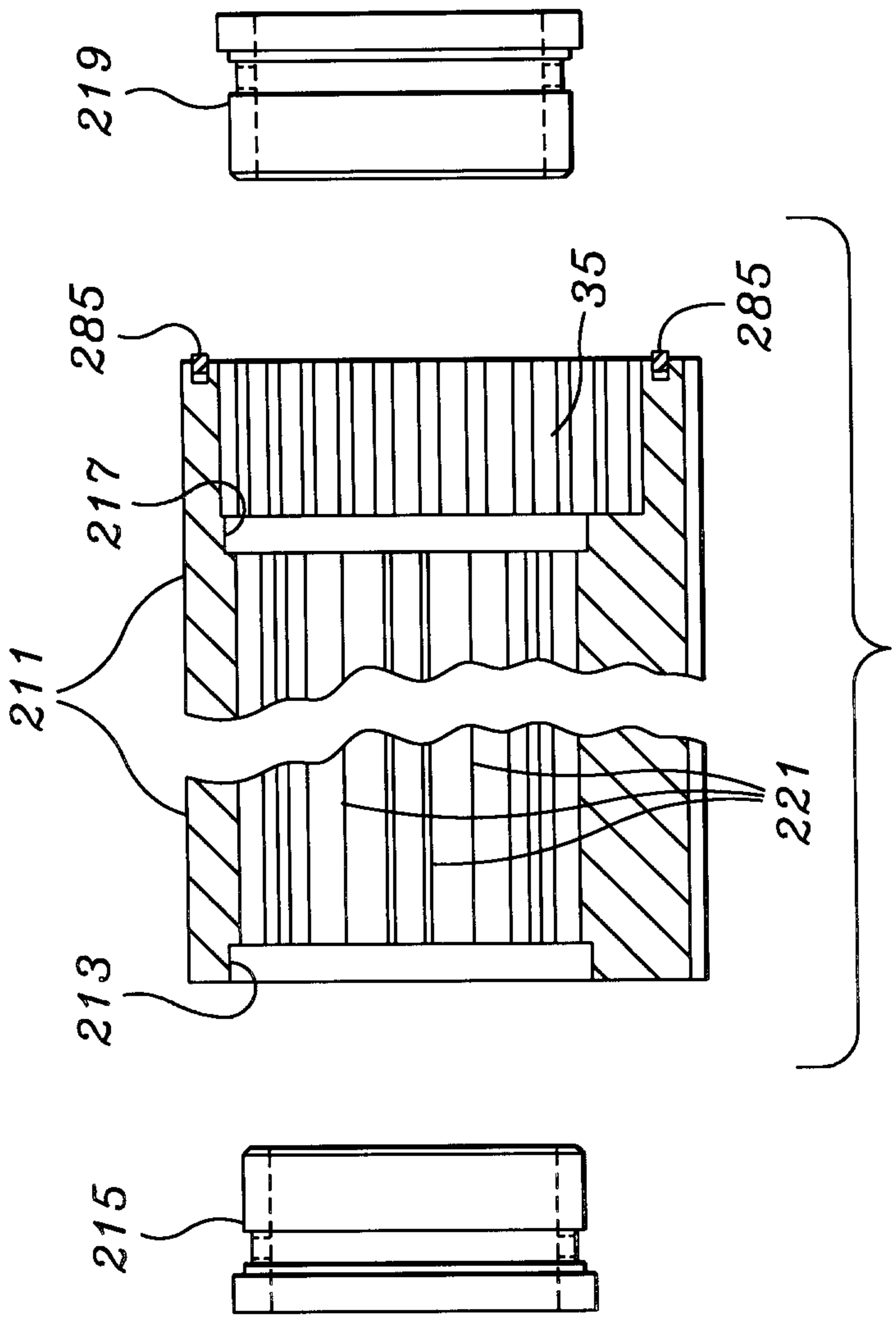

Fig. 20

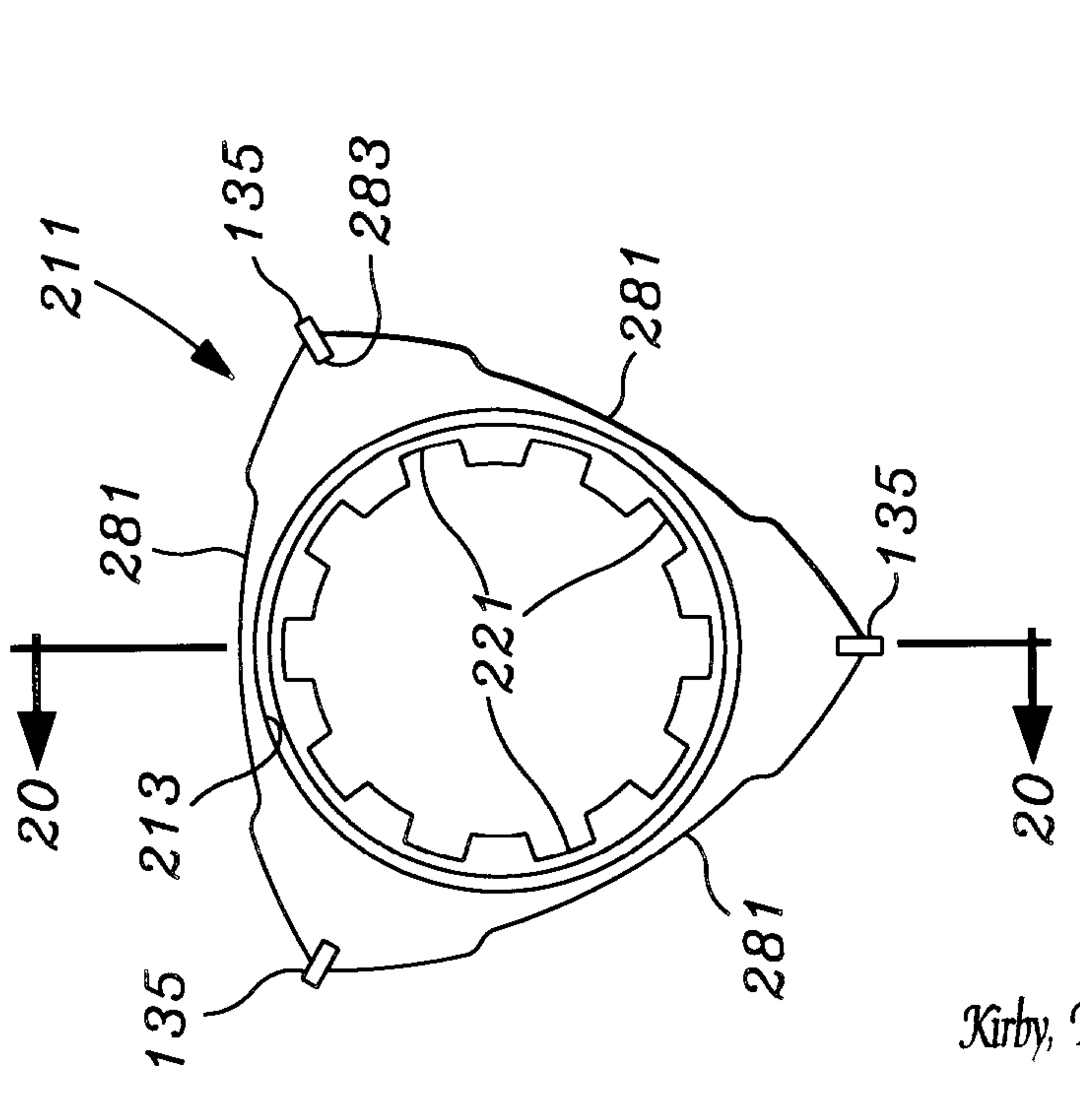

Fig. 19

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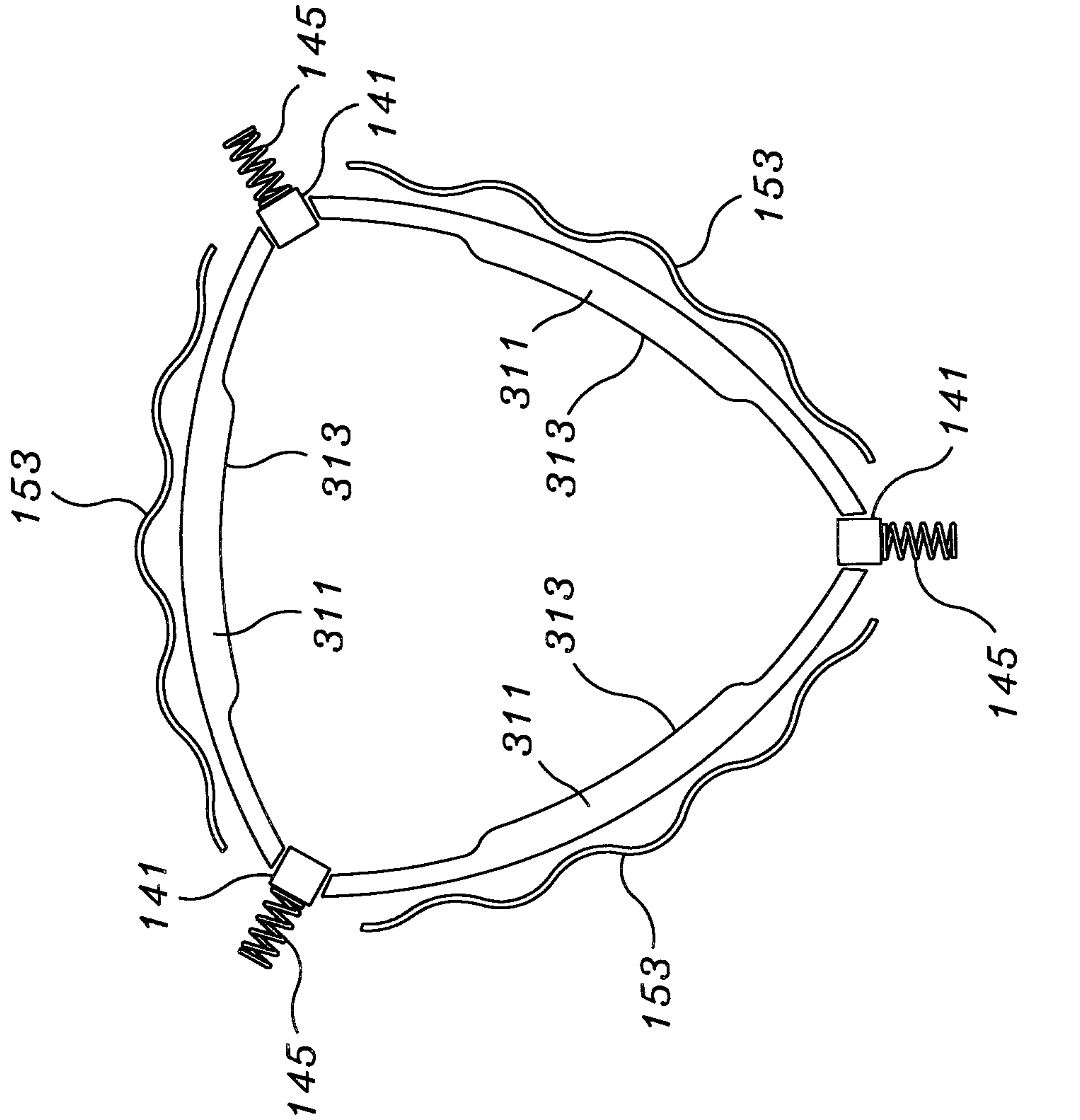

Fig. 22

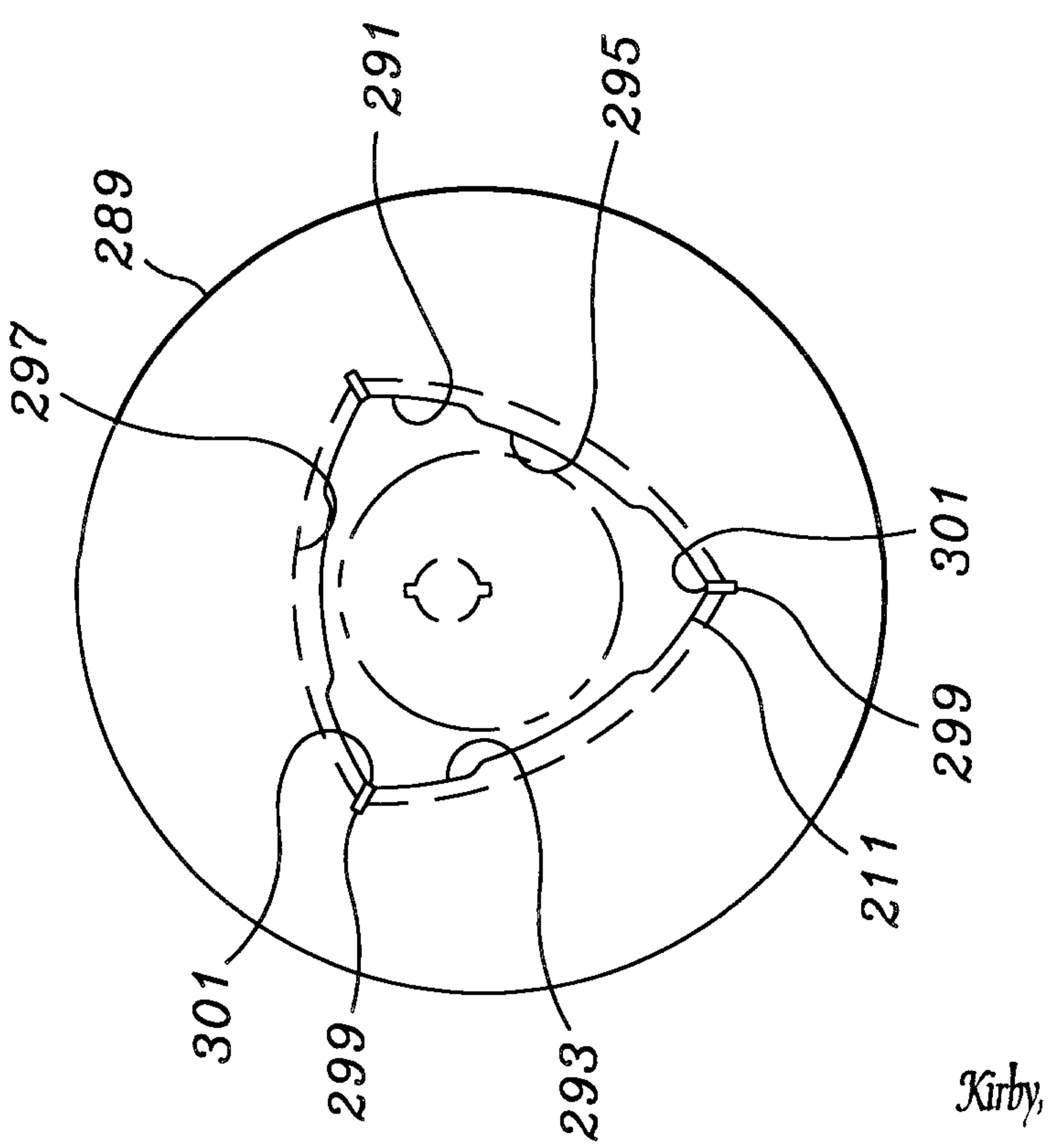

Fig. 21

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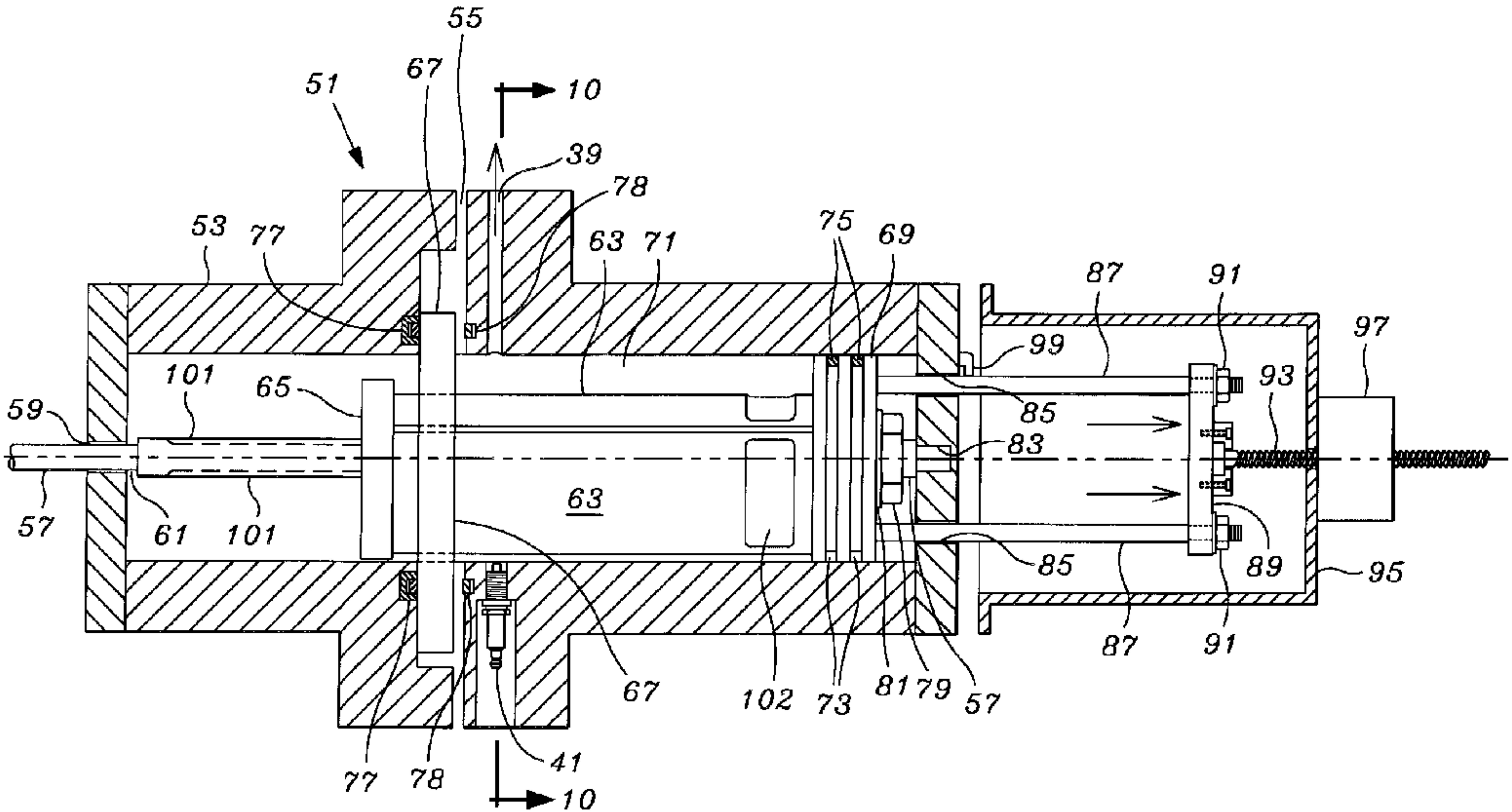

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