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(54) VERTICAL ENGINE

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Filed: **Nov. 9, 1995**

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(58) **Field of Search** .... 123/73 AD, 196 W, 123/495, 447, 451, 507, 509, 508, 195 HC

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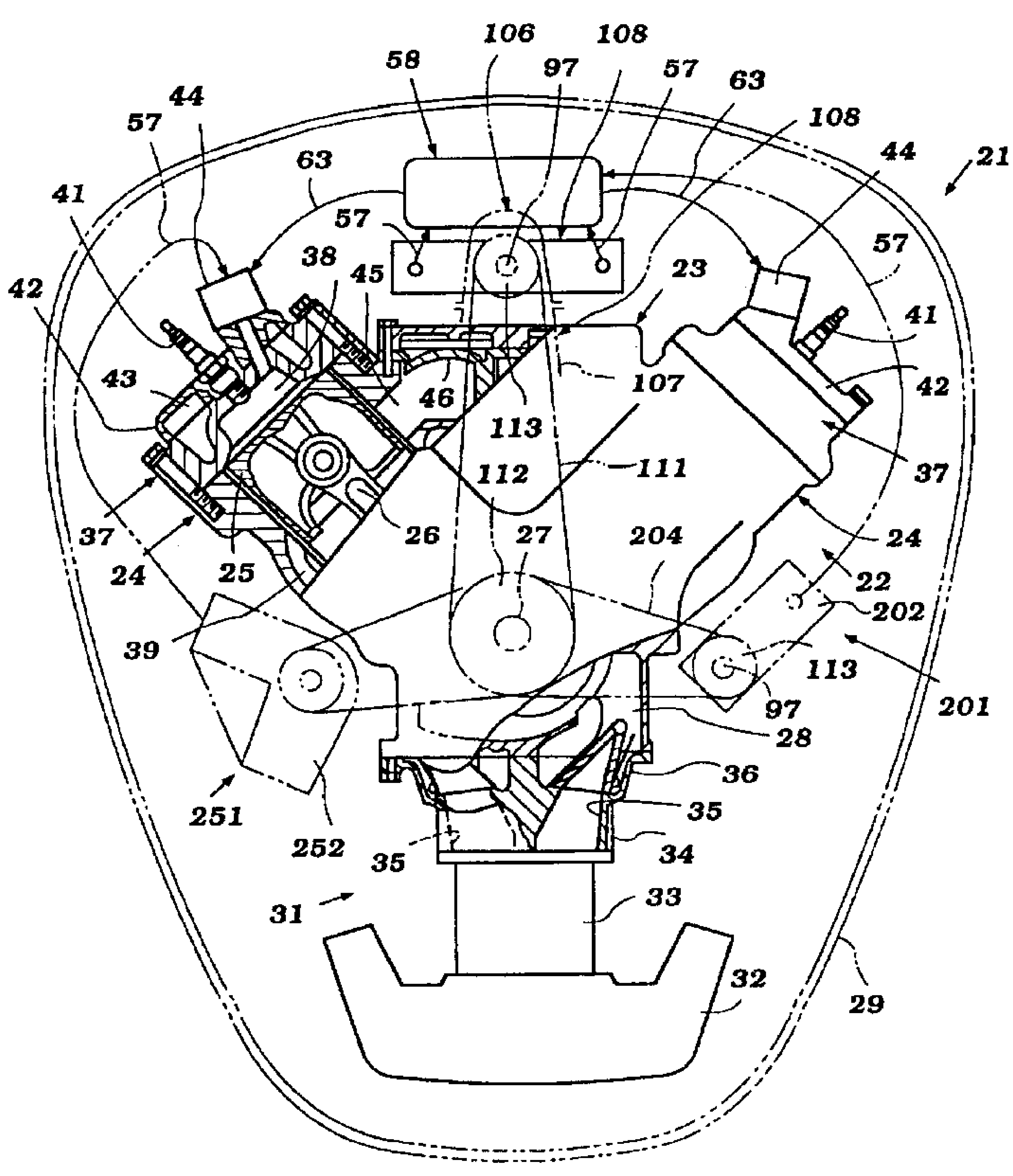
(57) **ABSTRACT**

A number of embodiments of high pressure pumps for internal combustion engines having vertically extending output shafts. In each embodiment, the high pressure pump has its pump driving shaft rotatable about an axis that is parallel to the crankshaft axis and is driven by the crankshaft. This arrangement lends itself to application in outboard motors. The high pressure pump includes an integral lubricating pump for lubricating components of the high pressure pump.

40 Claims, 10 Drawing Sheets



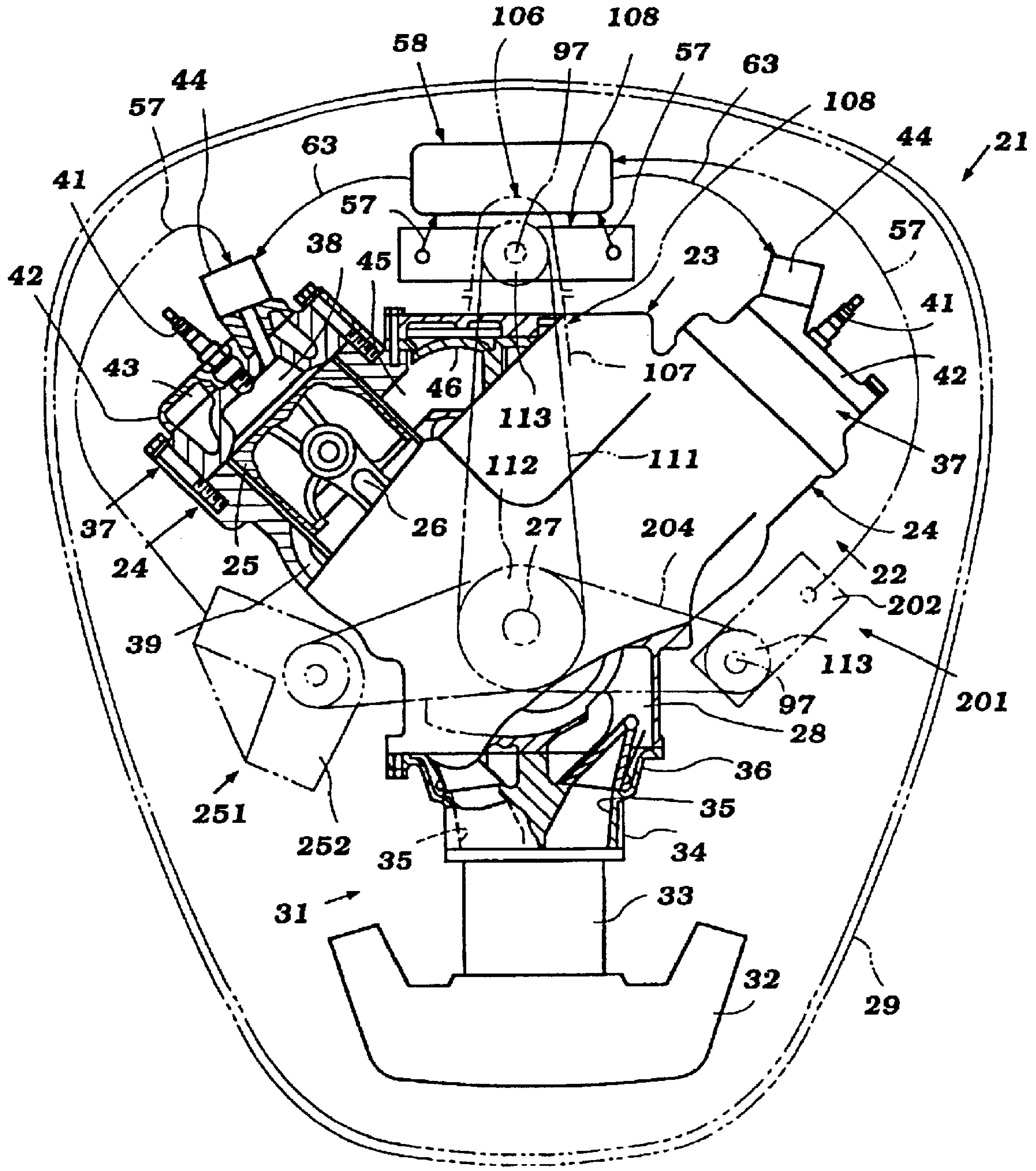

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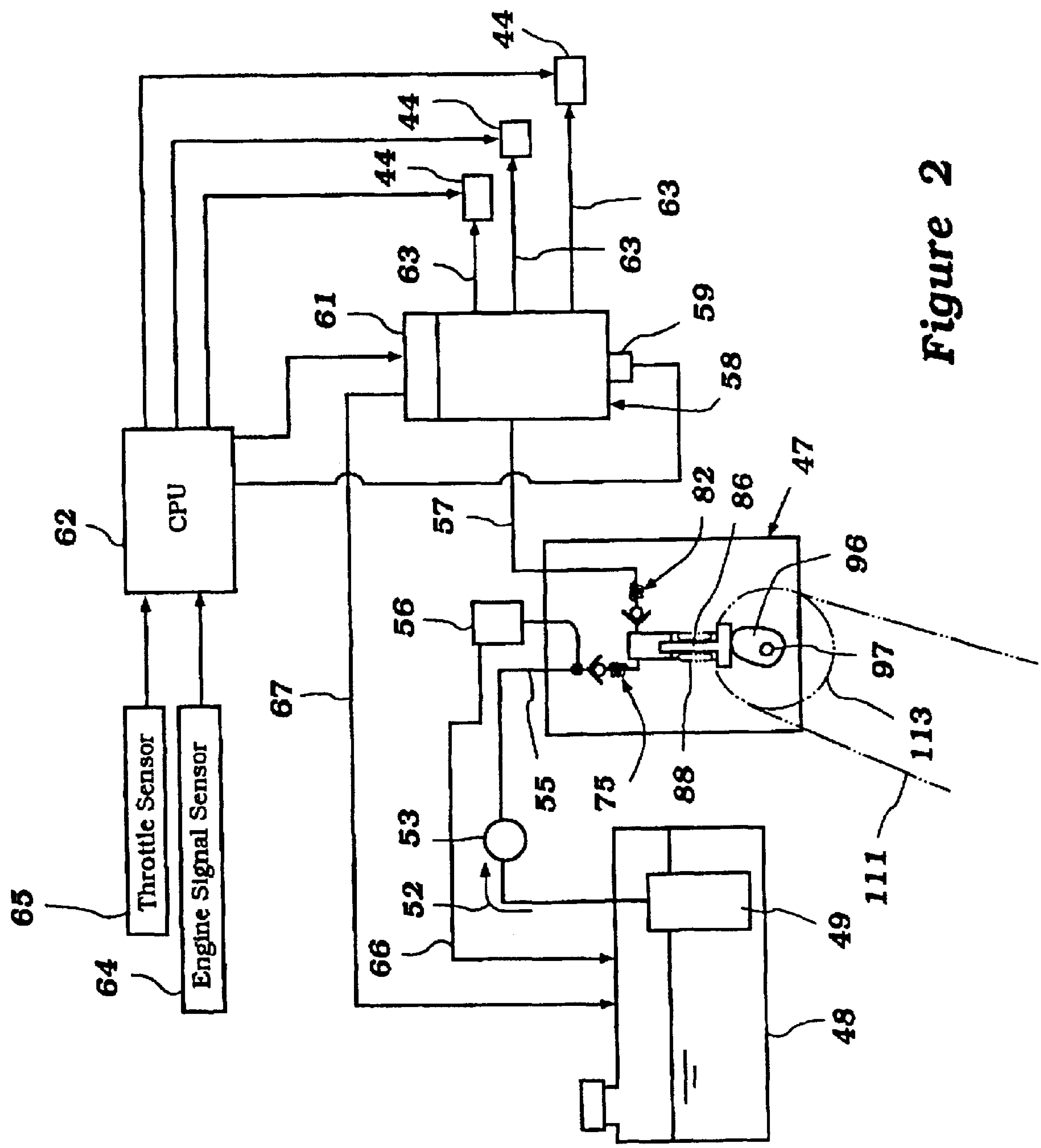
Figure 1



CPU
Throttle Sensor
Engine Signal Sensor
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Figure 2

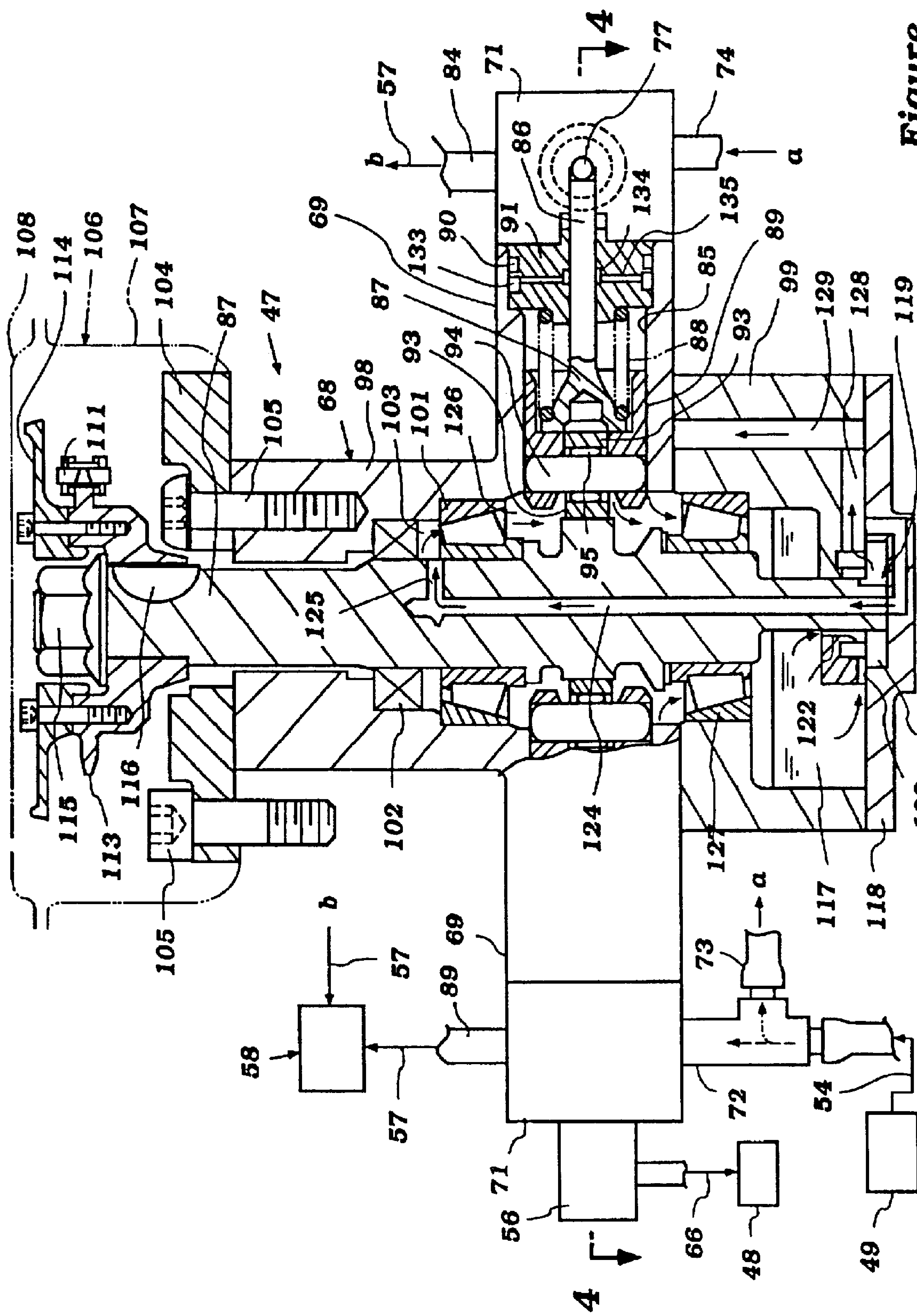

Figure 3

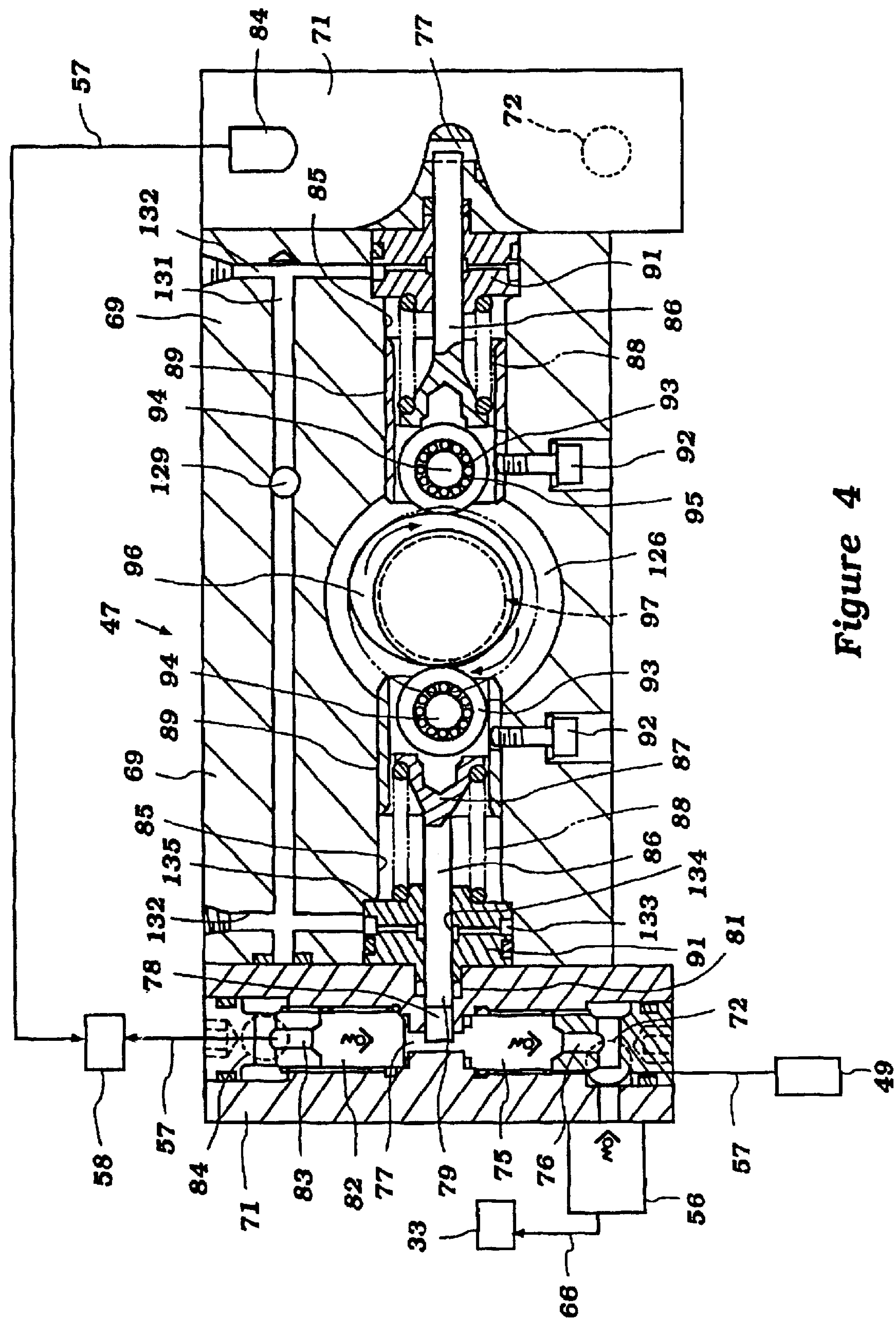
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Figure 4

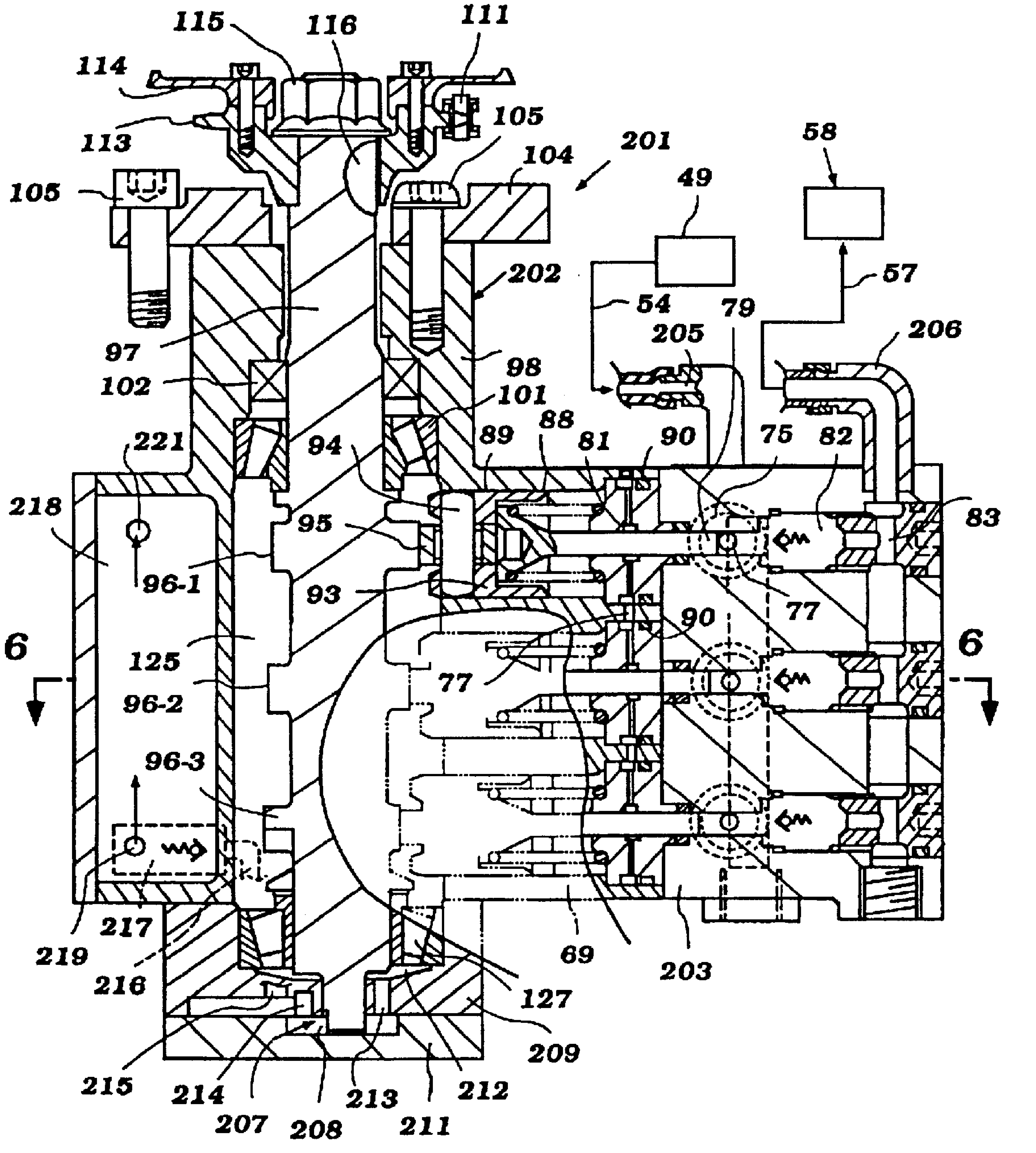

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Figure 5

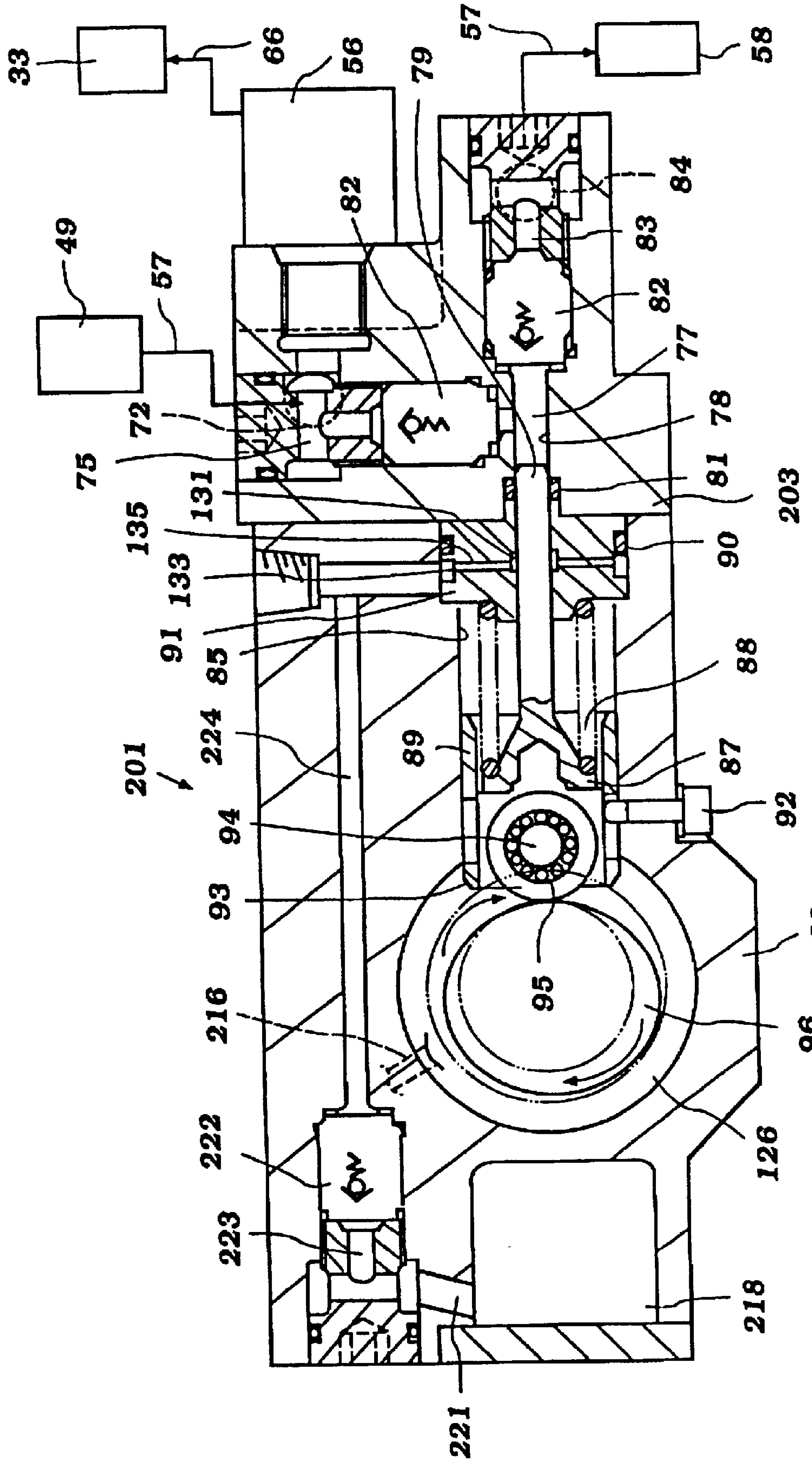
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Figure 6

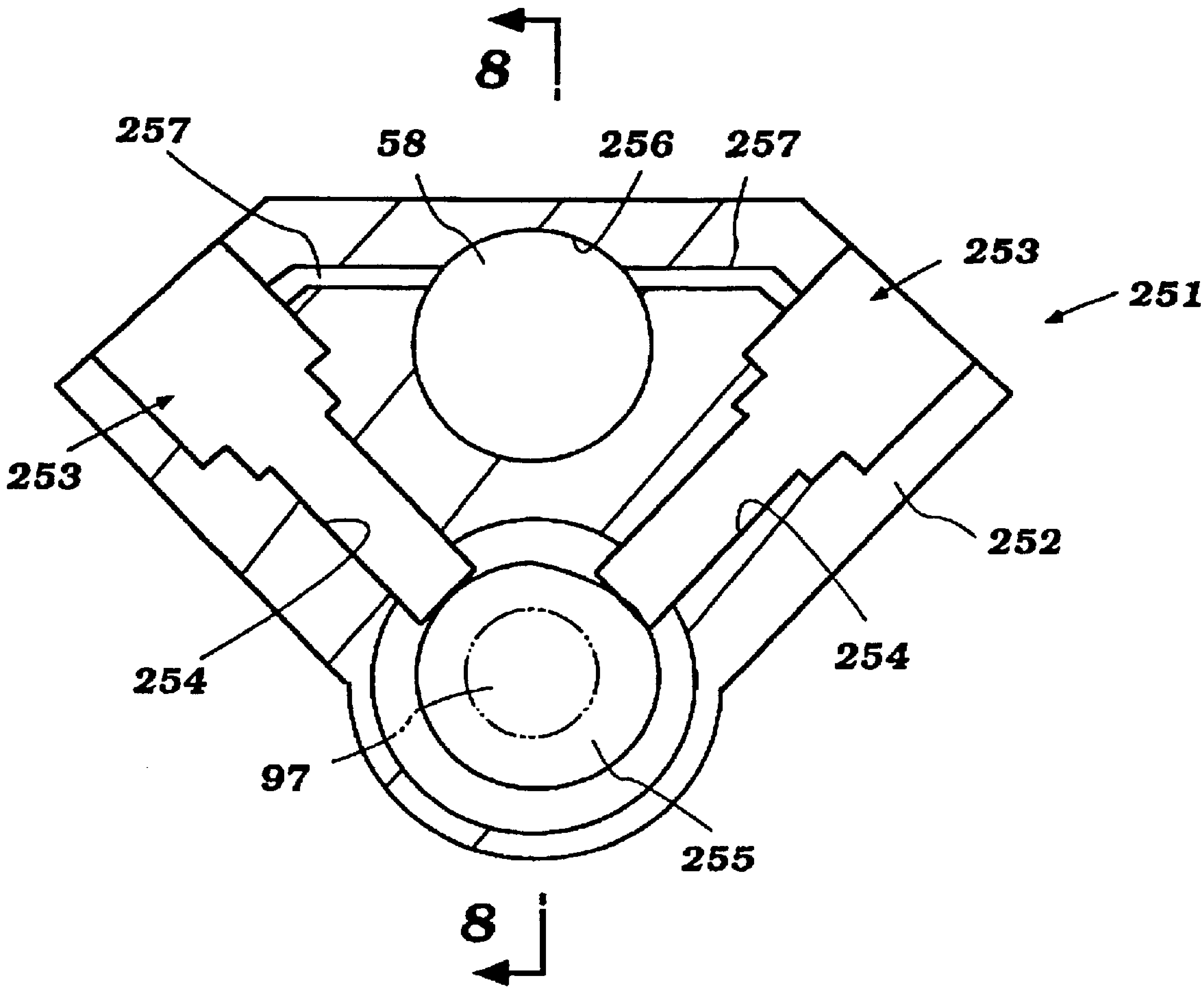

Figure 7

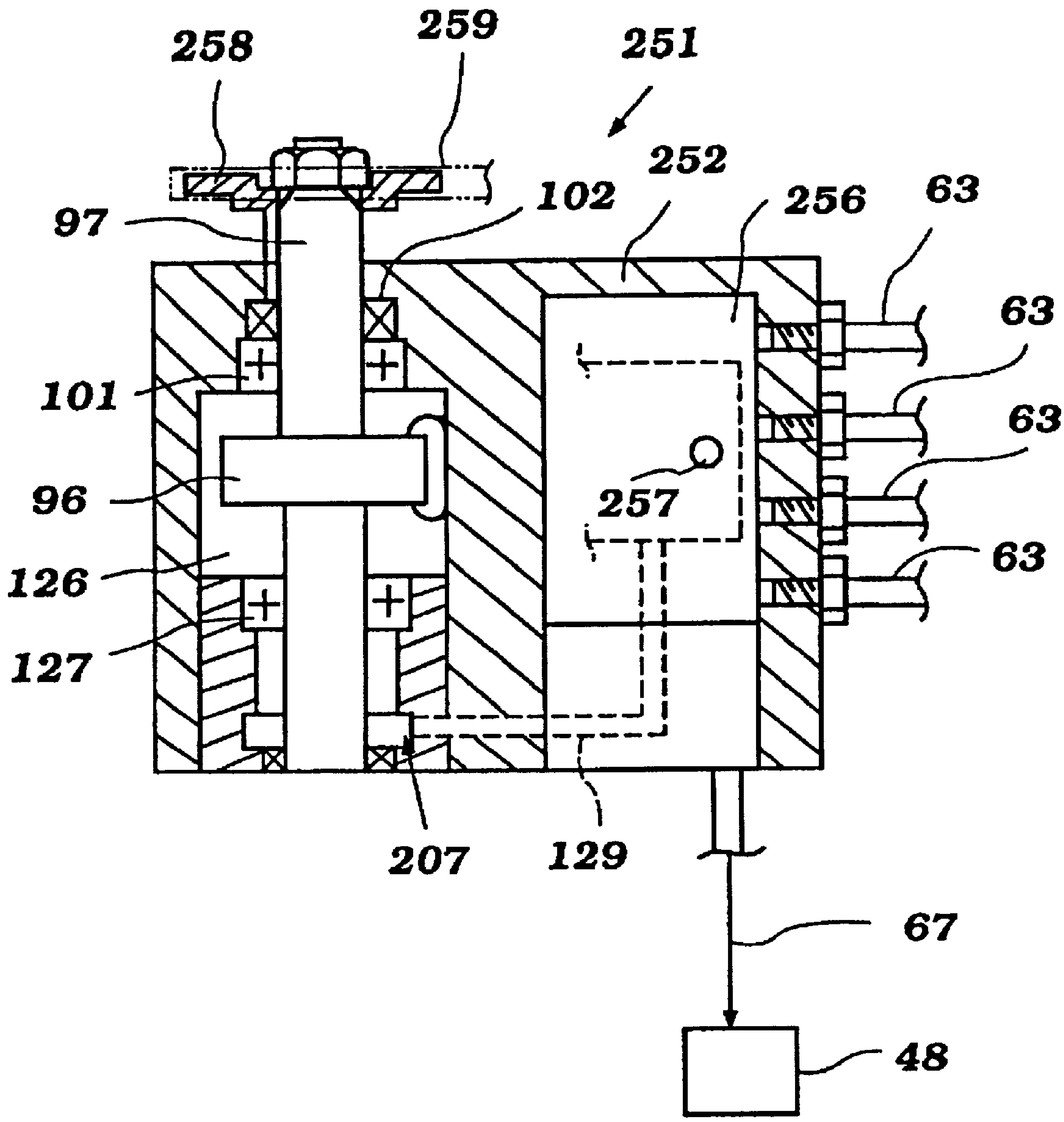
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Figure 8

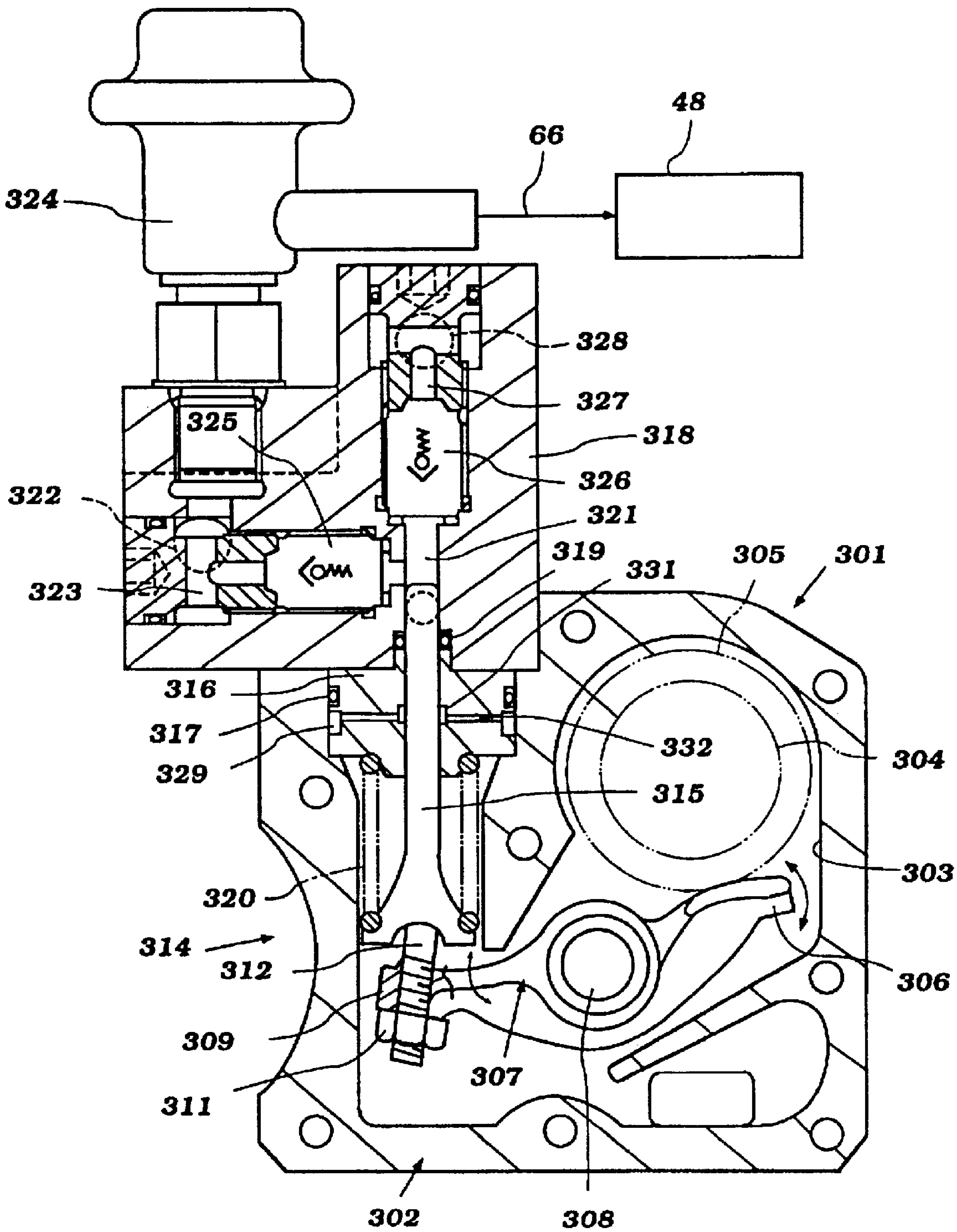
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Figure 9

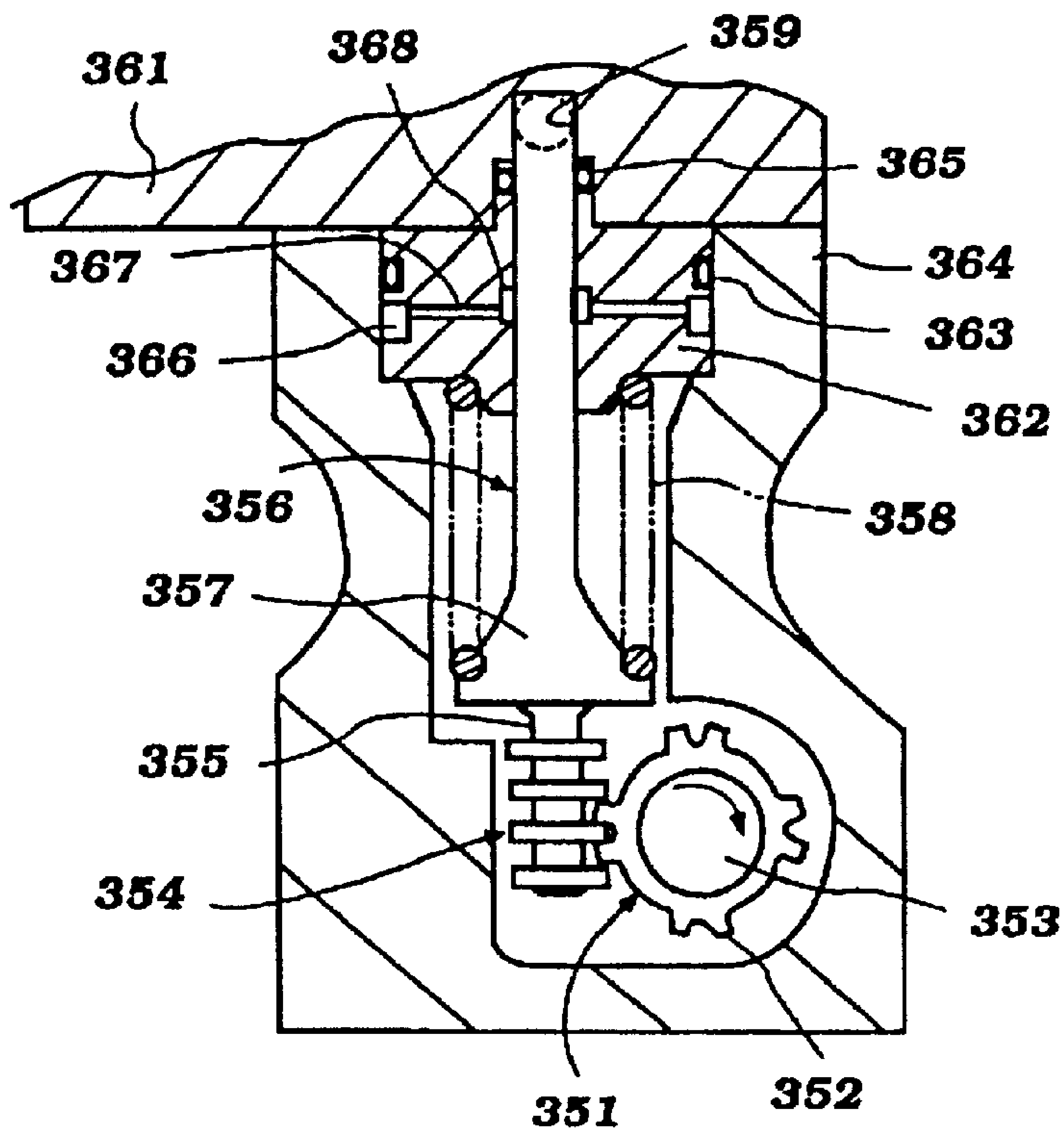

Figure 10

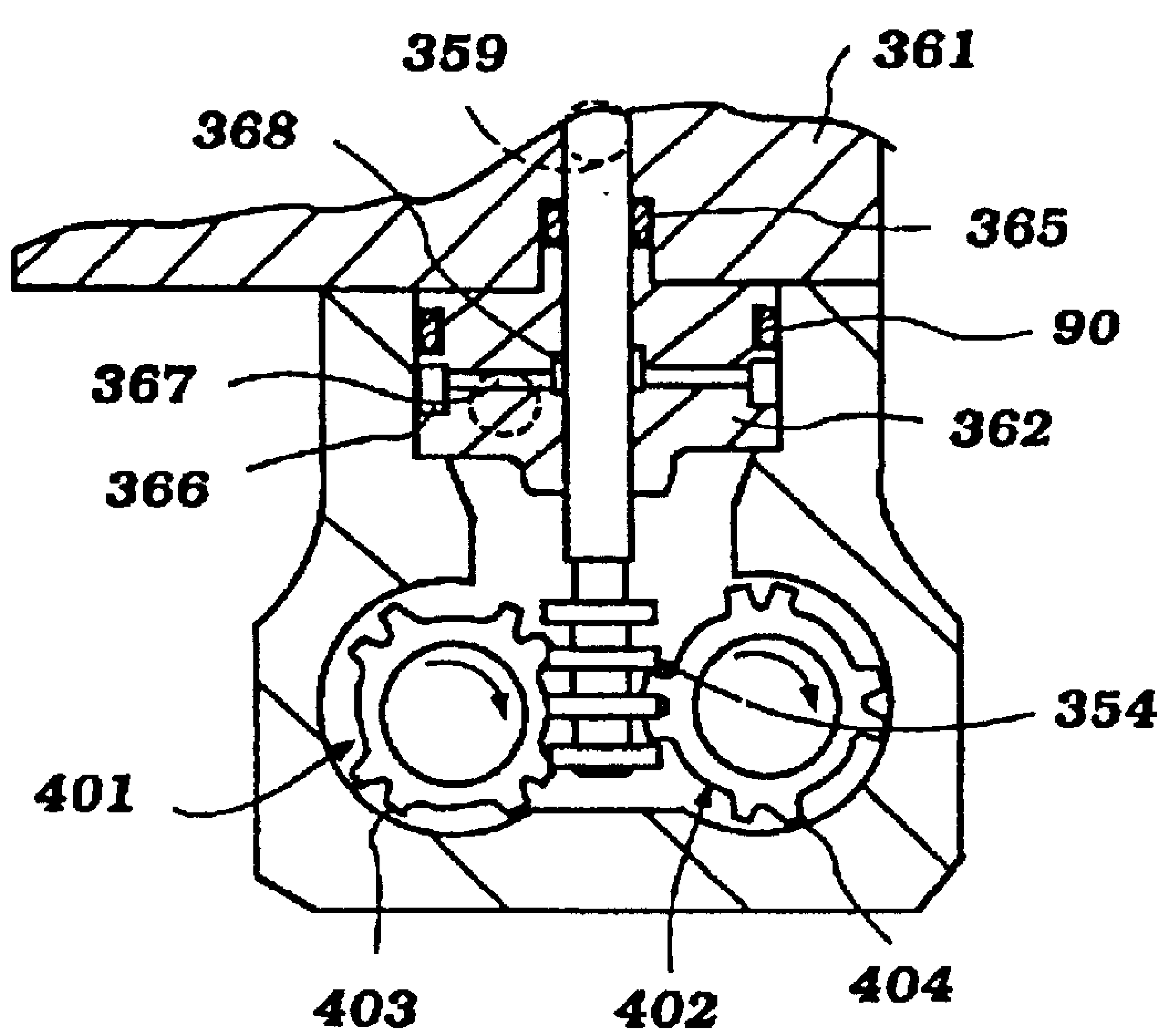

Figure 11

VERTICAL ENGINE

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

BACKGROUND OF THE INVENTION

This invention relates to a vertical engine of the type employed in outboard motors and more particularly to an improved fuel injection system for such vertical engines.

The use of fuel injection for internal combustion engines in order to improve performance, particularly fuel economy and exhaust emission control, is well known. A wide variety of types of fuel injection systems have been proposed for this purpose. Many of these systems inject the fuel into the induction system rather than into the combustion chamber. Such so-called "manifold injected" engines have advantages over carbureted engines. However, there are a number of additional advantages that can be obtained by utilizing direct cylinder injection.

By using direct cylinder injection, it is possible to more accurately control the actual fuel-air ratio in the combustion chamber on each cycle of operation. In addition, by utilizing direct cylinder injection, it is possible to obtain stratification in the combustion chamber and thus operate under a lean mixture under some or most running conditions. That is, by stratifying the charge in the combustion chamber, it is not necessary to have a homogeneous stoichiometric charge in the entire combustion chamber. All that is required is to have a stoichiometric charge present in the vicinity of the spark plug at the time that it is fired in order for combustion to be initiated.

There are, however, a number of reasons why direct cylinder injection is not utilized more widely. Not the least of these is cost. Not only are the injectors more costly and more critical with direct injected engines, but the supply system for supplying fuel to the injectors also becomes more complicated and expensive.

When direct cylinder injection is employed, the injection pressures must not only be higher, but they also must be more accurately controlled. As a result of this, it has been the practice to normally employ reciprocating plunger-type pumps for direct injected engines. Such pumps have a number of components, are complex, and in fact, can become quite bulky.

Although these problems may be overcome in some applications, there is a desire to employ direct cylinder or high pressure fuel injection systems for outboard motors. Like other vehicle applications, outboard matters are subject to concern over environmental control and also fuel economy. In addition, outboard motors frequently utilize two-cycle engines as their power plants. These engines can benefit as much or more from direct cylinder fuel injection as four-cycle engines.

In addition to the cost factor, the complexity of high pressure injection systems makes it more difficult to integrate them into outboard motors. One reason for this is that the outboard motor is a very compact type of device, and it may be difficult to locate the necessary components for a high pressure fuel injection system. In addition, the injection pump normally is driven off of the engine crankshaft and frequently in timed relationship thereto. This further complicates the placement and driving of such high pressure fuel injection pumps in outboard motors.

In addition to these problems, an outboard motor has another problem which is somewhat unique and different from automotive or other vehicle applications. That is, it is normally the practice to mount an outboard motor engine so that its crankshaft rotates about a vertically extending axis. As a result, the orientation of the engine is quite different than automotive and other applications. This further complicates the location and driving of accessories, such as high pressure fuel injection pumps.

When utilizing plunger or piston type high pressure fuel injection pumps, there are a number of mechanical components which are subject to wear. The fuel may not contact all of these components and in many instances, even if the fuel did, it does not have sufficient lubrication properties in order to prevent wear on the components.

For these reasons, it has also been the practice at times to incorporate a separate lubricating system for certain components of the high pressure pump. However, when the engine is mounted so that it its output shaft extends vertically, this further complicates the lubrication system for the fuel injection system and its high pressure pump.

It is, therefore, a principal object of this invention to provide an improved high pressure fuel injection pump for an internal combustion engine.

It is a further object of this invention to provide an improved high pressure fuel injection pump for a vertically disposed engine.

It is yet another object of this invention to provide an improved, compact and high efficiency fuel injection system for an outboard motor.

It is still another object of this invention to provide an improved high pressure fuel injection pump that can be operated with its driving shaft extending in a vertical direction.

It is a still further object of this invention to provide an improved lubricating system for such a vertically disposed high pressure pump.

SUMMARY OF THE INVENTION

This invention is adapted to be embodied in a fuel injected internal combustion engine having an output shaft rotatable about a vertically extending output shaft axis and driven by the combustion occurring in a combustion chamber. A high pressure piston pump is driven by a rotating pump drive shaft that is journaled for rotation about a vertically extending pump drive shaft axis that extends parallel to the engine output shaft axis. Pump driving means are provided for driving the pump drive shaft from the output shaft. A lubricant pump is driven off one end of the pump drive shaft for pumping lubricant to elements of the high pressure pump.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a top plan view of an outboard motor constructed in accordance with an embodiment of the invention, with the protective cowling shown in phantom and also illustrating alternate positions for the high pressure fuel injection pumps in phantom.

FIG. **2** is a schematic view showing the components associated with the fuel injection system, including the high pressure fuel injection pump.

FIG. **3** is an enlarged view which is partially in cross-section through the high pressure pump in accordance with one embodiment of the invention and shows the system components, in part schematically, and thus is related closely to FIG. **2**.

FIG. **4** is a cross-sectional view taken along the line **4**—**4** of FIG. **3**.

FIG. 5 is a cross-sectional view, in part similar to FIG. 3, and shows another of the pump embodiments, which is also shown in phantom lines in FIG. 1.

FIG. 6 is a cross-sectional view taken along the line 6—6 of FIG. 5.

FIG. 7 is a partial cross-sectional Kew taken through the cylinder block of a high pressure fuel injection pump constructed in accordance with another embodiment of the invention, which embodiment is also shown in phantom in FIG. 1.

FIG. 8 is a cross-sectional view taken along the line 8—8 of FIG. 7, and shows certain other components of the system schematically.

FIG. 9 is a cross-sectional view, in part similar to FIGS. 4 and 6, and shows another embodiment of the invention.

FIG. 10 is a cross-sectional view, in part similar to FIGS. 4, 6 and 9, and shows yet another embodiment of the invention.

FIG. 11 is a partial cross-sectional view, in part similar to FIGS. 4, 6, 9 and 10, and shows still another embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

Referring now in detail to the drawings and initially to FIG. 1, an outboard motor constructed in accordance with an embodiment of the invention is shown partially, with certain components being shown in phantom as well as alternative constructions being shown in phantom, and with portions broken away so as to more clearly show the construction of the basic engine. The invention is described in conjunction with an outboard motor because the invention has particular utility in conjunction with applications where a very compact construction is required, as is the case with outboard motors. In addition, the engine is depicted in conjunction with an outboard motor because outboard motors normally have their crankshafts rotatable about vertically extending axes, and the invention has particular utility in conjunction with engines having such orientations. Finally the invention also has particular utility, but is not so limited, for use with two-cycle crankcase compression internal combustion engines, and such engines are frequently employed as the power units in internal combustion engines.

Because of the fact that the invention deals primarily with the fuel injection system, and specifically the high pressure fuel injection pump therefore, components of the outboard motor which are not necessary to understand the invention are not illustrated. It will be readily apparent to those skilled in the art how the invention can be practiced in conjunction with any known type of outboard motor, if that is the specific application for the invention. Also, the details of the powering internal combustion engine, which engine is indicated generally by the reference numeral 22, will be described only briefly in order to permit those skilled in the art to understand the orientation of the invention and how it can be utilized with engines of varying types.

In the illustrated embodiment, the engine 22 is depicted as being a V-6, two-cycle, crankcase compression engine, but for the reasons already mentioned, it will be apparent to those skilled in the art how the invention can be utilized with a wide variety of types of engines and engine configurations. In addition, although the invention is described in conjunction with a reciprocating engine, it should also be apparent to those skilled in to an that the invention can be utilized with a wide variety of OEM types at engines, such as rotary engines.

The engine 22 is comprised of a cylinder block 23 which is provided with a pair of angularity disposed cylinder banks 24. Each cylinder bank 24 is formed with three in-line, horizontally extending cylinder bores in which pistons 25 reciprocate. As is typical with V-type engine practice, the cylinder banks 24 may be staggered axially relative to each other so that connecting rods, indicated by the reference numeral 26, can connect the pistons 25 to common throws of a crankshaft 27.

The crankshaft 27 is rotatably journaled within a crankcase chamber 28 that is formed in part by the cylinder block 23 and by a crankcase member that is affixed thereto in any known manner. As is well known in two-cycle crankcase compression engine practice, the crankcase chamber 28 is divided into individual sealed portions, each associated with a respective one of the cylinder bores in which the pistons 25 reciprocate.

The engine 22 is confined within a surrounding protective cowling that is shown in phantom and identified by the reference numeral 29. Thus, the engine 22 and protective cowling 29 form the powerhead of be outboard motor the vertical disposition of the crankshaft 27 permits its attachment to a drive shaft (not shown) that depends from this powerhead through a drive shaft housing into a lower unit for driving a propulsion unit for propelling an associated watercraft, as is well known in this art.

The protective cowling 29 is formed with a suitable atmospheric air inlet device which preferably is designed so as to permit air to be drawn in for the operation of the engine 22 while, at the same time, excluding water from entering within the protective cowling 29. This air is then delivered to an induction system, which is indicated generally by the reference numeral 31, through an air inlet device 32 of that induction system.

The air inlet device 32 may include internal baffling for accomplishing silencing of the inducted air. Air is delivered from the air inlet device 32 through intake pipes 33 to an intake manifold 34. The intake manifold 34 has individual passages 35 that serve the individual crankcase chambers 29. A throttle valve assembly (not shown) may be mounted in this intake manifold 34 or in the intake pipes 33 for controlling the speed of the engine.

Reed-type check valves 36 are disposed in each of the manifold runners 35 so as to permit a charge to be drawn into the crankcase chamber portions 28 when the pistons 25 are moving upwardly. When the pistons move downwardly, these reed-type check valves 36 will close and permit the inducted charge to be compressed in the crankcase chambers 28.

Combustion chambers are formed by the heads of the pistons 25, the cylinder bores in which they reciprocate, and by cylinder head assemblies 31 which an affixed to the cylinder banks 24 in any known manner, such as by the illustrated but unnumbered fasteners. Each cylinder head assembly 37 has a plurality of recesses 38 which complete the formation of these combustion chambers. The combustion chamber recesses 38 may, at times, be referred to as the combustion chambers since, at top dead center, they comprise the substantial clearance volume of the engine, as best seen in the left-hand side of FIG. 1, wherein the piston 25 is shown at this top dead center position.

The charge which has been drawn into the combustion chambers 28 through the induction system 31 and compressed therein is transferred to these combustion chambers 38 through one or mum scavenge passages 39 formed in the cylinder block 23. This charge is then further compressed in to combustion chambers **38** and eventually fired by a spark plug **41**. Obviously, there is and least one spark plug mounted is each cylinder head **37** for each cylinder. The spark plugs **41** are fired by a suitable ignition system in appropriate timed relationship.

As has been noted, the cylinder heads **37** are assemblies, and these include cover pieces **42** which assist in the formation of water cooling jackets **43** for water cooling of the engine. Such cooling jackets are also formed in other components of the engine **22** as is well known in this art. Water is drawn from the body of water in which the outboard motor operates for circulation through these water jackets in any manner known in this art.

Suitable high pressure fuel injectors, shown schematically and indicated by the reference numeral **41** are also mounted in the cover plates **42** and cylinder head assemblies **37**. These fuel injectors **44** are supplied with high pressure fuel from a fuel supply system which will be described later, and which forms the primary portion of the invention Thus, when the fuel-air mixture is present in the combustion chambers **38** and fired by the spark plugs **41**, the charge will burn and expand and drive the pistons **25** downwardly to drive the crankshaft **27**.

The charge is then expelled through exhaust ports formed in the cylinder block **23** and which communicate with an exhaust manifold **45** formed in the valley between the cylinder banks **24**. This exhaust manifold **45** is also formed by a cover plate assembly **46** which has a further water jacket for cooling of the exhaust manifold **45**. As is typical with outboard motor practice, the exhaust manifold **45** has one or more collector sections, depending upon whether me cylinder banks **24** share a manifold or have separate manifolds.

This collector section extends downwardly and discharges the exhaust gases through an exhaust system, which is typically formed in major part in the drive shaft housing of the outboard motor, as is well known in this art. For the reasons already described, it is not believed that a further description of this known portion of the construction is required to permit those skilled in the art to practice the invention.

The construction of the engine **22** as thus far described may be considered to be conventional, as it has already been noted. For that reason, any further description of the basic structure of the engine **22** or the outboard motor **21**, for that part, is believed to be unnecessary to enable those skilled in the art to practice the invention.

The fuel injection system will now be described in detail, initially primarily to the schematic view of FIG. **2**. It has been noted that the fuel injectors **44** are of any known high pressure type. Since the invention deals primarily with the high pressure fuel injection pump, indicated generally by the reference numeral **47**, the details of the fuel injectors **44** and other components of the injection system will be general in nature, and most of these components are illustrated merely schematically. Again, it will be readily apparent to those skilled in the art how the invention can be practiced in conjunction with any type of conventional components.

There is provided a remotely positioned fuel storage tank **48** which, in typical outboard motor practice, is positioned remotely within the hull of the associated watercraft. Obviously, however, the fuel tank **48** may be contained within the powerhead of the outboard motor **21**, or a small supply tank may be thus located that is served by a remote main tank.

An electrically driven low pressure fuel pump **49** is submerged in the fuel tank **48** below the fuel level therein and discharges fuel through an outlet fitting **51**. This fuel flows in the direction shown by the arrow **52** through a fuel filter **53**, which may be located in the powerhead somewhere within the protective cowling **29** to facilitate servicing. This fuel is then supplied through a conduit **54** to the delivery inlet **55** of die high pressure pump **47**. A low pressure regulator **56** regulates the pressure at which fuel is supplied to the high pressure pump **47**.

Before describing the details of the high pressure pump **47**, the remaining components of the system will be described.

The high pressure pump **47** supplies fuel under a high pressure in pulsed intervals through a pressure conduit **57** to an accumulator **58**. The accumulator **58** has an inlet fitting **59** to which the fuel is delivered. The pressure in the accumulator **58** may be controlled by an electronic control **61** under the direction of a CPU, indicated generally by the reference numeral **62**. This control **61** may also include a distributor arrangement for delivering fuel through respective conduits **63** to the fuel injectors **44**.

It should be noted tat FIG. **2** shows three fuel injectors **44** which are the fuel injectors associated with one cylinder bank. It has been noted already that the engine **22** is a V-6 engine and hence, there is another bank of fuel injectors. As will become apparent later, the high pressure pump **47** may have banks of plungers or may be of an in-line type, and this will determine to some extent how the fuel is actually supplied from the pump **47** to the individual injectors **44**. Again how this is done forms no major part of the invention.

Returning now to the description of the CPU **62**, this CPU **62** may have any control strategy that operates on input signals from a wide variety of sensors. In the illustrated embodiment, two such sensors are illustrated. These sensors comprise an engine speed sensor **64** which supplies signals not only of engine speed but of crank angle, and an operator demand sensor or load sensor, such as a throttle sensor **65**. Obviously, those skilled in the art will readily understand how the invention may be practiced with a wide variety of types of control strategies.

It has been noted that the low pressure fuel regulator **56** regulates the low pressure supplied to the high pressure pump **47**, and the control **61** of the accumulator **58** regulates the pressure therein. These pressures are regulated by dumping excess fuel back to the fuel tank **48** through respective return conduits **66** and **67**, as is well known in this art.

The construction of the high pressure pump **47** will now be described in detail by reference to FIGS. **3** and **4**, where the actual construction of the pump is shown, although certain of the auxiliaries associated with it are shown in phantom. The pump **47** is comprised of a main housing assembly **68** which, in the illustrated embodiment, has a pair of opposed cylinder banks **69**. In the illustrated arrangement, each bank **69** contains one pumping assembly. It will be readily apparent to those skilled in the art, however, that the number of pumping assemblies employed can be increased, and one way in which this may be done will be described later, when the actual pumping mechanisms are described.

The banks **69** are each provided with respective cylinder heads **71** that are affixed thereto in any known manner. The cylinder head of one bank is provided with a T-shaped fitting **72** that receives the end of the conduit **54** for supply thereto. The T-fitting **72** has a branch that supplies a further conduit **73** which extends, as indicated at a, to a corresponding inlet fitting **74** of the cylinder head **71** of the other cylinder bank.

The construction of these cylinder heads **71** appears in most detail in FIG. **4**. It will be seen that each cylinder head

71 includes a delivery check valve **75** that cooperates with an inlet fitting **76** to permit the fuel to be drawn into a pumping chamber **77**. This pumping chamber **77** communicates with a pumping bore **78** in which one end of a pumping plunger **79** is slidably supported. An O-ring seal **81** encircles the pumping plunger **79** and provides a fluid seal therearound.

The pumping plunger **79** is reciprocated, in a manner to be described, and when the volume of the pumping chamber **77** is increasing, fluid will be drawn into this pumping chamber through die opening of the delivery check valve **75**. When the volume of the pumping chamber **77** is being decreased by the upward movement of the pumping plunger **79**, high pressure will be generated and it will open a discharge check valve **82** to permit fluid to be discharged through a fitting **83** to the conduit **57** which communicates with the accumulator chamber **58**. An outlet fitting **84** is provided for communication between the fitting **83** and the conduit **57**.

Turning now to the operation for reciprocating the pumping plungers **74**, it will be seen that the banks **69** of the housing assembly **68** are formed with bores **85** that are concentric with the pumping chamber portion **78**. The pumping plungers **100** have a shank portion **86** that has a yoke part **87** at its bottom end that A urged by a coil compression spring **88** into engagement with a piston or tappet-type actuator **89**. At the opposite end, the spring **88** acts against a closure plug **91** that closes the upper end of the bore **85** and which slidably supports the pumping plunger **79**. An O ring seal **90** seals the plugs **91** to the housing **69**.

The piston or tappet actuator **89** is held against rotation by means of a set screw **92** and carries a roller follower **93** which is journaled on a shaft **94** by a needle-bearing assembly **95**. The spring **88** in addition to urging the pump plunger yoke **87** into engagement with the actuating tappet **89**, also urges the tappet into engagement with a drive cam **96** of a pump drive shaft, indicated generally by the reference numeral **97**.

Referring now primarily to FIG. **3**, it will be seen that the housing assembly **68** has an upwardly extending cylindrical portion **98** and a downwardly extending larger diameter cylindrical attachment piece **99**. The upper portion **98** rotatably journals the pump drive shaft **97** through a first thrust bearing **101**. Disposed above the thrust bearing **101** is an oil set **102** that defines a lubricant receiving chamber **103**, for a purpose which will be described.

The pump drive shaft **97** continues upwardly into and through a cover plate **104** that is held in place by threaded fasteners **105**. This cover plate **104** permits the pump drive shaft to enter into a drive cavity formed by a timing drive cover **106** that is comprised of a lower portion **107** and an upper portion **108**, which may be of any known construction and which are shown primarily in phantom in the figures. Reference also should be had to FIG. **1** for this construction.

This contains a timing drive, indicated generally by the reference numeral **109**, which consists of a chain **111** or other flexible transmitter such as a toothed belt that is driven by a drive sprocket **112** that is affixed to either the upper or lower end of the crankshaft **27**. This drive chain **111** is in engagement also with a the sprocket **113** that is held to the upper end of the pump drive shaft **97** by means of a retainer plate assembly **114** and a nut **115** threaded onto the upper end of the pump drive shaft **97**. Finally, a drive key **116** interconnects the sprocket **113** with the pump drive shaft **97** to provide a timed driving connection therebetween.

Referring now again primarily to FIG. **3**, the lower end of housing attachment **90** as has been noted, is of a larger diameter than the upper portion **90** This is to permit it to form a combined oil reservoir and pump cavity **117**, the lower end of which is closed by a closure plate **118**. An oil pump assembly, indicated generally by the reference numeral **119**, is driven off of the lower end of the pump drive shaft **97**. This oil pump assembly **119** may be comprised of a gerotor-type pump that realms oil in a pumping cavity **121** from the reservoir **117** and pressurizes it. Oil is delivered through delivery ports **122** and **123**.

The oil is pumped under high pressure through a first conduit **124** that extends axially through the pump drive shaft **97** from the pumping cavity **121**, and specifically its outlet, to a cross-drilling **125** that communicates with the lubricant cavity **103** so as to lubricate the upper bearing **101**. This lubricant then flows downwardly so as to lubricate the cams **96**, roller followers **93**, needle bearings **95** and pin **94**. In addition, same of this lubricant will also lubricate the lower end of the pump driving pistons or tappets **89**. An oil cavity **126** is formed around the pump driving elements for assisting in this lubrication.

The lower pump housing portion **99** supports a second thrust bearing **127** which receives the down-flowing lubricant from the cavity **126** and permits it to drain back into the reservoir cavity **117**.

In addition to this lubricant path, the pump **119** further delivers lubricant under pressure through a passageway **128** formed between the pump housing member **99** and the cover plate **118**, which communicates with a further main supply passageway **129**. The main supply passageway **129** extends upwardly, as shown in FIG. **4**, and intersects a drilled passageway **131** which is drilled through the pump housing **69**, and is intersected by a pair of cross-drillings **132**, each of which extends to the respective plunger supporting closure elements **91**, These elements are provided with cross-drillings that extend from circumferential grooves **133** formed therein to inner circumferential grooves **134** that surround the pump plungers **79**. These cross-drillings are indicated by the reference numeral **135** in the drawings. This oil will flow into the bores **85** and can drain back into the cavity **126** for return to the reservoir **117**.

As should be readily apparent from the foregoing description, the configuration and orientation of the high pressure pump **47** permits it to be conveniently mounted in the valley between the cylinder heads **37** adjacent the pressure accumulator **58** so as to provide a very compact assembly and one which is located close to the actual fuel injectors **44** so as to minimize the length of the conduits. In addition, the vertical disposition of the pump drive shaft **97** permits it to drive its own lubricating pump off the lower end thereof, and lubricant can be returned to the reservoir of this pump through a gravity return system. Hence, the structure is not only compact, but it is also well lubricated and well protected.

A high pressure oil pump constructed in accordance with another embodiment of the invention is illustrated in FIGS. **5** and **6** and is indicated generally by the reference numeral **201**. The pump **201** is employed in a system of the type as previously described and thus, many components associated with this pump are the same or substantially the same and have been identified by the same reference numeral when that is the case.

In the previously described embodiment, the high pressure pump **47** was of the opposed piston type, whereas the embodiment of FIGS. **5** and **6** shows an in-line type of pump. Therefore, the pump body **202** is formed with in-line bores that receive the plunger mechanisms and which are closed by a cylinder head assembly, indicated generally by the reference numeral **203**. Each pumping unit is the same as that previously described and, for that reason, the components of the pumping elements which are the same in construction and operation as those already described have been identified by the same reference numerals and will be described again only insofar as is necessary to understand the construction and operation of this embodiment.

The drive for the pump shaft **97** is also the same as that previously described and, for that reason, this mechanism also will not be described again in detail. In this embodiment, since the outer housing **202** is formed with aligned cylinder bores that receive the pumping plunger actuating pistons or tappets **89**, it is higher than the previously described embodiment. However, because of this disposition, it is shorter in width and thus can be located, for example, on one side of one of the cylinder banks **24**. Such an alternative location is shown in FIG. **1** by the phantom line view.

In view of this location, a shorter drive chain **204** or a flexible timing belt may be employed, which is still driven by the crankshaft sprocket **112** and which drives the pump shaft **97** by a pump drive sprocket **113**. This type of pump lends itself better to an arrangement wherein it is utilized with an in-line engine, but can be utilized with a V-type engine with either a slot pump on one side of the one cylinder bank **24** or with individual pumps on one side of each cylinder bank, as illustrated.

As may be seen, the pump drive shaft, therefore, has three pump actuating cams **96-1**, **96-2** and **96-3**. As has been previously noted, the V-type or opposed-type pump, like the pump **47**, may also be employed with multiple plunger cylinders, and these would embody such an extended cam shaft having a greater number of pump plungers.

With this arrangement, however, there is a simpler disposition of the manifolding for supplying fuel to and from the pump **201** and accordingly, a single fluid inlet conduit **205** may be provided that supplies all of the delivery valves **75** for this embodiment. The communication between the delivery valves **15** can be formed internally in the cylinder head **203**. In addition, a single pump discharge fitting **206** can be mounted in the cylinder head **203** and is served by internal conduits which communicate with each of the pump delivery check valves **82**.

Because of the greater length of the pump shaft **97** in this embodiment, a different arrangement is provided for the lubricant and the reservoir therefore. In this embodiment, a gerotor-type pump, indicated generally by the reference numeral **207** and having a pumping cavity **208**, is formed between a lower housing member **209** that is fixed to the main housing member **202** in a suitable fashion, and closed by a closure plate **211**. A drain reservoir **212** below the lowermost pump drive shaft bearing **127** collects the oil and returns it to the pumping cavity **208** through a drain passageway **213**. The lubricant is then delivered under pressure by the pumping element of the gerotor pump **207** to a high pressure discharge **214** which communicates with a delivery passage **215**. The passage **215**, in turn, communicates with a fitting **216** and through a pressure responsive check valve **217** with an oil reservoir **218**. A port **219** in the housing piece **202** permits this communication.

A discharge passageway **221** extends from this reservoir cavity **218** to an oil delivery check valve **222** positioned in a pressure fitting **223**. The pressure fitting **223** communicates with a drilled passageway **224** (FIG. **6**) which, in turn, supplies oil to the oil delivery grooves **133** of each of the pump plunger supports **91** in this embodiment.

A separate passageway (not shown) may extend from the pump pressure cavity **214** to a point above the uppermost pump drive shaft support bearing **101** for its lubrication. Again, the oil will drain through the return path as aforedescribed.

The invention has been described thus far in conjunction with opposed-type and in-line-type of high pressure fuel pumps. Another embodiment appears in FIGS. **7** and **8** and provides a V-type high pressure fuel pump, indicated generally by the reference numeral **251**. This type of fuel pump may be easily incorporated in conjunction with a V-type engine, and one possible location is shown in phantom in FIG. **1**. In this location the pump can be disposed compactly to the engine **22** because of both units V shaped configuration as seen in FIG. **1**.

Again, be pump **251** basically has the same pumping plunger arrangements as those previously described and, for that reason, where components of this embodiment are the same or substantially similar to those previously described, will be identified by the same reference numerals, or the parts are not shown, because it is believed that those skilled in the art will readily understand the arrangement of the components. In this embodiment the pump **251** is designed for a four cylinder engine, but obviously this pump may be used with engines having any number of cylinders.

In this embodiment the pump **251** includes a cylinder block **252** that has a pair of aligned banks, each of which is adapted to receive a pumping assembly, indicated generally by the reference numerals **253**, which comprise the pumping plungers, delivery lines and actuators as previously described. One cylinder bank extends generally parallel to one of the engine cylinder banks **24**. The other pump cylinder bank is perpendicular to the first one.

These elements are mounted primarily in bores **254** formed at the lower portion of the pump receiving cavities, wherein the piston actuators, which are not shown, can operate with cam lobes **255** formed integrally on the cam shaft, which is indicated by the same reference numeral as previously applied, i.e., **97**.

In this embodiment, the accumulator chamber **58** may be formed by a bore **256** that is formed integrally in the cylinder block **252** in the area between the bores **253** that receive the pumping mechanism. Internal cavities **257** perform the function of the supply conduits **57** from the previously described embodiments which supply the high pressure fluid to the accumulator chamber **256**. A pressure regulator may be contained within this assembly and hence, the high pressure regulated fuel return line **67** is connected directly to the fuel tank **48** for this return.

This embodiment employs a more compact lubricant pump, which can have the same construction as that of the embodiments of FIGS. **5** and **6**, and which is, therefore, identified by the same reference numeral **207**. In all other regards, this embodiment is the same as those previously described.

A driving sprocket **258** is affixed to the upper end of the pump drive shaft **97** and is driven by a chain **259** or a flexible timing belt off of the crankshaft driving sprocket **112**, as shown in FIG. **1**.

In the embodiments of the invention as thus far described, the pumping plungers have all been actuated directly by cams on the pump drive shaft. FIG. **9** shows another embodiment which employs a rocker arm actuation and hence, can achieve greater strokes for a given cam lift or strokes which can be varied if desired.

A pump constructed in accordance with this embodiment is identified generally by the reference numeral **301** and is shown only in a single cross-sectional view, because it is believed readily apparent to those skilled in the art, from the foregoing description, how the invention may be employed with varying numbers of plungers and varying orientations for them, such as in-line, V-type, etc., as previously described.

In this embodiment, the pump **301** includes an outer housing assembly **342** which defines a cavity **303** in which the pump drive shaft **304** is journaled for rotation in a manner as previously described. The pump drive shaft **304** has one or more cam lobes **305** that engage the follower portion **305** of a rocker arm, indicated generally by the reference numeral **307**. The rocker arm or rocker arms, if more than one are employed, are rotatably journaled on a rocker arm shaft **308** that extends parallel to the axis of rotation of the pump drive shaft **304**. As with all of the previously described embodiments, this pump drive shaft **304** rotates about an axis that is parallel to the axis of rotation of the crankshaft **27** and which, accordingly, is vertically disposed.

The rocker arm **307** has a further arm portion **309** that carries an adjustable follower **311** having a spherical portion **312** that is engaged with a yoke portion **313** of the pumping plunger, indicated generally by the reference numeral **314**. The pumping plunger **314** has a shank or plunger portion **315** which is supported in a pump support element **316** which is affixed in the housing **302** and which has an O-ring seal **317** that provides a seal therewith.

A valve body and distribution member **318** is affixed to the main pump housing **302** with an O-ring seal **319** encircling the plunger supporting member **316** and providing a seal therebetween. A pumping chamber **3211** formed in the member **318** and receives the pumping end of the pumping plunger **315**. A return spring **320** acts between the plunger support member **316** and the yoke portion **313** of the pumping plunger **315** to urge it into engagement with the adjustable follower **312** and to return it on its intake stroke.

Fuel is delivered to the pumping chamber **321** through an inlet fitting **322** which communicates with a delivery port **323**. The low pressure regulator **324** communicates with this area and, as aforenoted, regulates the pressure from the low pressure pump by returning fluid to the fuel tank **48** through the return conduit **66**.

A delivery check valve **325** permits fuel to flow into the pumping chamber **321** when the pumping plunger **311** is moving downwardly and precludes reverse flow as it moves upwardly. Upon upward movement, the fuel is compressed and discharged through a delivery check valve **326** to the accumulator chamber **58** through a supply passage **327** and a supply fitting **328**.

Like the previously described embodiments, the mechanism is also lubricated by a lubricant pump that is driven off the lower end of the pump drive shaft **304** in a manner as previously described. The lubrication system for the pumping plunger **315** appears in this figure and it includes the outer supply game **329** that communicates with an inner lubricating groove **331** through a plurality of drilled passages **332**, as with the previously described embodiments.

FIG. **10** shows another type of pump plunger actuating mechanism, and since this type of mechanism may be employed with any of the pump assemblies as previously described, only the plunger actuating mechanism will be described. Unlike the previously described cam and follower mechanisms, this mechanism employs a Geneva or segmented gear-type drive, indicated generally by the reference numeral **351**. A segmented gear having teeth segments **352** is affixed for rotation with the pump driving shaft **353**. The teeth **352** are adapted to selectively engage follower ribs **354** formed on an extension **355** of the pump plunger, indicated generally by the reference numeral **356** to drive the plunger **356** sequentially. The pump plunger **356** has a shoulder portion **357** that is engaged by a spring **358** for urging the plunger to a retracted position in the pumping bore **359** formed by a cylinder head member **361**.

The opposite end of the spring **358** acts against a plunger retainer element **362** which, like the previously described embodiments, provides an arrangement for lubricating the pump plunger **356**. This member **362** has an O-ring seat **363** that engages the pump housing **364** for sealing therewith. A similar seal **365** is disposed between the end of the plunger supporting member **362** and the cylinder head **361**.

An oil supply game **366** receives oil from an oil pump driven off the lower end of the pump drive shaft **353**. This oil is then delivered to lubricate the plunger **356** through drilled passageways **367** and a lubricant supply groove **368** that extends around the pump plunger within the member **362**.

FIG. **11** shows another embodiment driven similar to the embodiment of FIG. **10**. In this embodiment, however, there are two Geneva gear mechanisms **401** and **402** that operate so that their teeth **403** and **404** are respectively out of phase with the ribbed members **354** on the pumping plunger. These Geneva gear mechanisms **401** and **402** are driven by a pump drive shaft (not shown) and rotate in the same direction and at the same speed, but at a different phase to each other as noted. Thus, this mechanism is capable of supplying more pumping strokes during a given cycle.

From the foregoing description, it should be readily apparent that the embodiments of the invention are extremely effective in providing a high pressure pump for a vertical engine that can have a compact construction and thus, may be conveniently placed-relative to the engine. In addition, the pump shaft rotates about a vertically extending axis to simplify the drive from the vertically extending output shaft to the engine. Lubricating systems are incorporated within the pump mechanism for its lubrication.

It should be readily apparent to those skilled in the art that the foregoing descriptions at don of preferred embodiments of the invention, and that various changes and modifications may be made without departing from the spirit and scope of the invention, as defined by the appended claims.

What is claimed is:

1. A fuel injected internal combustion engine having an output shaft rotatable about a vertically extending output shaft axis and driven by the combustion within the engine, a high pressure piston pump driven by a rotatable pump driving shaft journaled for rotation about a vertically extending pump drive axis and extending parallel to said engine output shaft axis, pump drive means for driving said pump drive shaft from said engine output shaft, and a lubricant pump driven off one end of said pump drive shaft for pumping lubricant to the elements of said high pressure pump.

2. The fuel injected internal combustion engine of claim **1**, wherein the engine is a reciprocating engine and the engine output shaft comprises a crankshaft.

3. The fuel injected internal combustion engine of claim **1**, wherein the lubricant pump is driven off the lower end of the pump drive shaft.

4. The fuel injected internal combustion engine of claim **1**, wherein the pump drive shaft drives at least two pumping plungers.

5. The fuel injected internal combustion engine of claim **4**, wherein the pumping plungers are disposed at an angle to each other, but in the same vertical plane.

6. The fuel injected internal combustion engine of claim **5**, wherein the pumping plungers are opposed to each other.

7. The fuel injected internal combustion engine of claim **4**, wherein the pumping plungers are arrayed in a vertical plane.

8. The fuel injected internal combustion engine of claim **7**, wherein each pumping plunger is driven by a separate cam lobe.

9. The fuel injected internal combustion engine of claim **3**, wherein the pump drive shaft is supported by a pair of spaced apart bearings and wherein the lubricant pump delivers lubricant to the bearings.

10. The fuel injected internal combustion engine of claim **9**, wherein the lubricant pump further delivers lubricant to the pumping plunger for the lubrication of the pumping plunger.

11. The fuel injected internal combustion engine of claim **10**, wherein the lubricant from the pumping plunger and the bearings is returned by gravity to the lubricant pump.

12. The fuel injected internal combustion engine of claim **2**, wherein the lubricant pump is driven from the engine output shaft by a flexible transmitter.

13. The fuel injected internal combustion engine of claim **12**, wherein the flexible transmitter comprises a chain.

14. The fuel injected internal combustion engine of claim **1**, wherein the engine comprises the power plant of a marine outboard drive.

15. The fuel injected internal combustion engine of claim **14**, wherein the engine is a reciprocating engine and the engine output shaft comprises a crankshaft.

16. The fuel injected internal combustion engine of claim **14**, wherein the lubricant pump is driven off the lower end of the pump drive shaft.

17. The fuel injected internal combustion engine of claim **14**, wherein the pump drive shaft drives at least two pumping plungers.

18. The fuel injected internal combustion engine of claim **17**, wherein the pumping plungers are disposed at an angle to each other, but in die same vertical plane.

19. The fuel injected internal combustion engine of claim **18**, wherein the pumping plungers are opposed to each other.

20. The fuel injected internal combustion engine of claim **17**, wherein the pumping plungers are arrayed in a vertical plane.

21. The fuel injected internal combustion engine of claim **20**, wherein each pumping plunger is driven by a separate cam lobe.

22. The fuel injected internal combustion engine of claim **16**, wherein the pump drive shaft is supported by a pair of spaced apart bearings and wherein the lubricant pump delivers lubricant to the bearings.

23. The fuel injected internal combustion engine of claim **22**, wherein the lubricant pump further delivers lubricant to the pumping plunger for the lubrication of the pumping plunger.

24. The fuel injected internal combustion engine of claim **23**, wherein the lubricant from the pumping plunger and the bearings is returned by gravity to the lubricant pump.

25. The fuel injected internal combustion engine of claim **15**, wherein the lubricant pump is driven from the engine output shaft by a flexible transmitter.

26. The fuel injected internal combustion engine of claim **25**, wherein the flexible transmitter comprises a chain.

27. The fuel injected internal combustion engine of claim **14**, wherein the engine comprises a reciprocating engine and the engine output shaft comprises a crankshaft driven by a pair of pistons slidably supported in a cylinder block having opposed cylinder banks, each defining at least one bore receiving respective one of said pistons.

28. The fuel injected internal combustion engine of claim **27**, wherein the high pressure pump is disposed in a valley between the cylinder banks.

29. The fuel injected internal combustion engine of claim **28**, wherein the high pressure pump has at least two plungers driven by the pump driving shaft and which are disposed in opposed relationship to each other.

30. The fuel injected internal combustion engine of claim **27**, wherein the high pressure pump is disposed adjacent one side of one of the cylinder banks of the engine.

31. The fuel injected internal combustion engine of claim **30**, wherein the pump has a plurality of pumping plungers disposed in a vertically arranged plane and which lie at a complementary angle to the angle of the cylinder bank.

32. The fuel injected internal combustion engine of claim **27**, wherein the high pressure pump has a pair of pumping plungers disposed at a V angle to each other and is disposed on one side of one of the cylinder banks.

33. The fuel injected internal combustion engine of claim **32**, wherein one of the pumping plungers reciprocates along an axis that is generally parallel to the axis of the cylinder bore of the adjacent cylinder bank and the other of the pumping plungers reciprocates along an axis that is generally perpendicular to the axis of the first pumping plunger.

34. An outboard motor comprised of a power head consisting of an internal combustion engine and a surrounding protective cowling and a driveshaft housing and lower unit containing a propulsion device within said lower unit depending from said power head, said engine being mounted within said protective cowling so that its crankshaft rotates about a vertically-extending axis, said crankshaft being coupled to a drive shaft that depends into said driveshaft housing and lower unit for driving said propulsion device, said engine being formed with a plurality of combustion chambers, a plurality of fuel injectors for injecting fuel directly into respective of said combustion chambers, a high pressure fuel pump contained within said protective cowling and having a pumping element reciprocating along a horizontal axis for pressurizing fuel for delivery to said fuel injectors, and a mechanical transmission for driving said pumping element from said crankshaft for delivering, high pressure fuel to said fuel injector.

35. An outboard motor as set forth in claim 34 wherein the pumping element is operated by a rotating cam.

36. An outboard motor as set forth in claim 35 wherein the rotating cam rotates about a vertically extending axis that is parallel to the axis of rotation of the crankshaft.

37. An outboard motor as set forth in claim 36 wherein the rotating cam is positioned externally of the engine body.

38. An outboard motor as set forth in claim 37 wherein the rotating cam is fixed for rotation with a camshaft that is directly driven by the crankshaft through a flexible transmitter.

39. An outboard motor as set forth in claim 34 wherein the engine is a spark ignited engine.

40. An outboard motor as set forth in claim 39 wherein the fuel injectors, inject fuel directly into the combustion chambers.

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