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Charron

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[54] **VARIABLE DISPLACEMENT ROTARY HYDRAULIC MACHINES**

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[52] **U.S. Cl.** **60/487,** 60/493, 418/21

[51] **Int. Cl.** **F16h 39/46**

[58] **Field of Search** 60/445, 487, 493; 418/21

[56] **References Cited**

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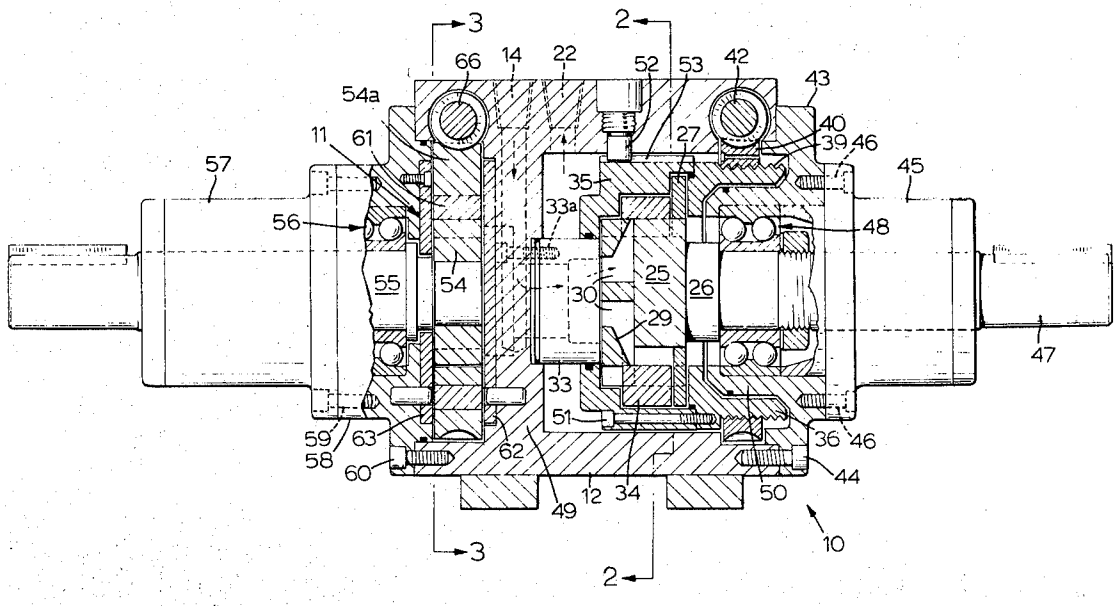
Attorney, Agent, or Firm—Ridout & Maybee

[57] **ABSTRACT**

A variable displacement pump or motor comprises a gerotor assembly, the inner and outer elements of which can be displaced axially in relation to one another, so that the capacity of the gerotor chamber can be varied. The gerotor chamber is defined by a locating ring, and a pair of end plugs which are respectively keyed to the inner and outer gerotor elements for rotation therewith. One end plug and one gerotor element are fixed in a certain axial position, while the other end plug and gerotor element are located by the locating ring which is axially movable.

7 Claims, 9 Drawing Figures



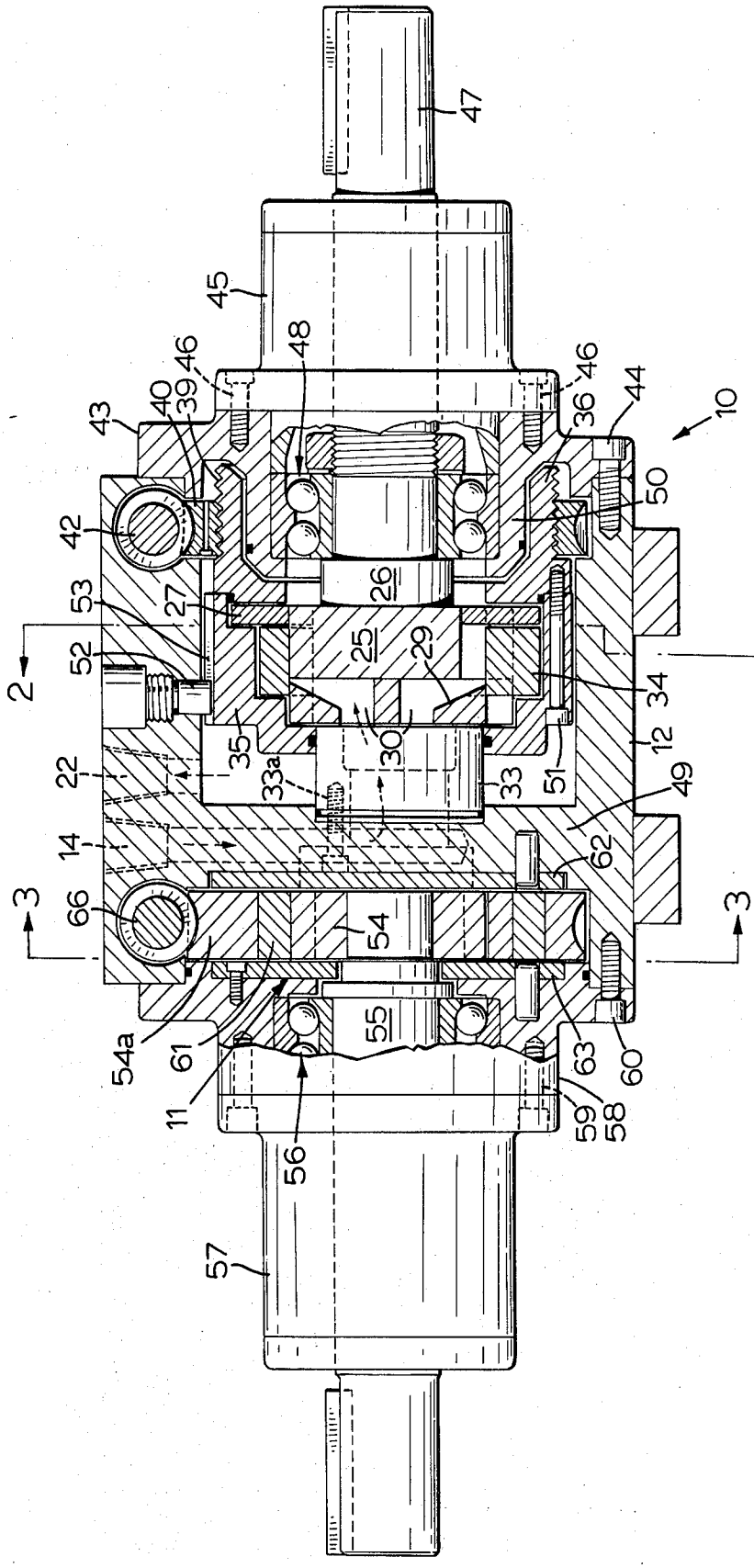

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FIG. 1

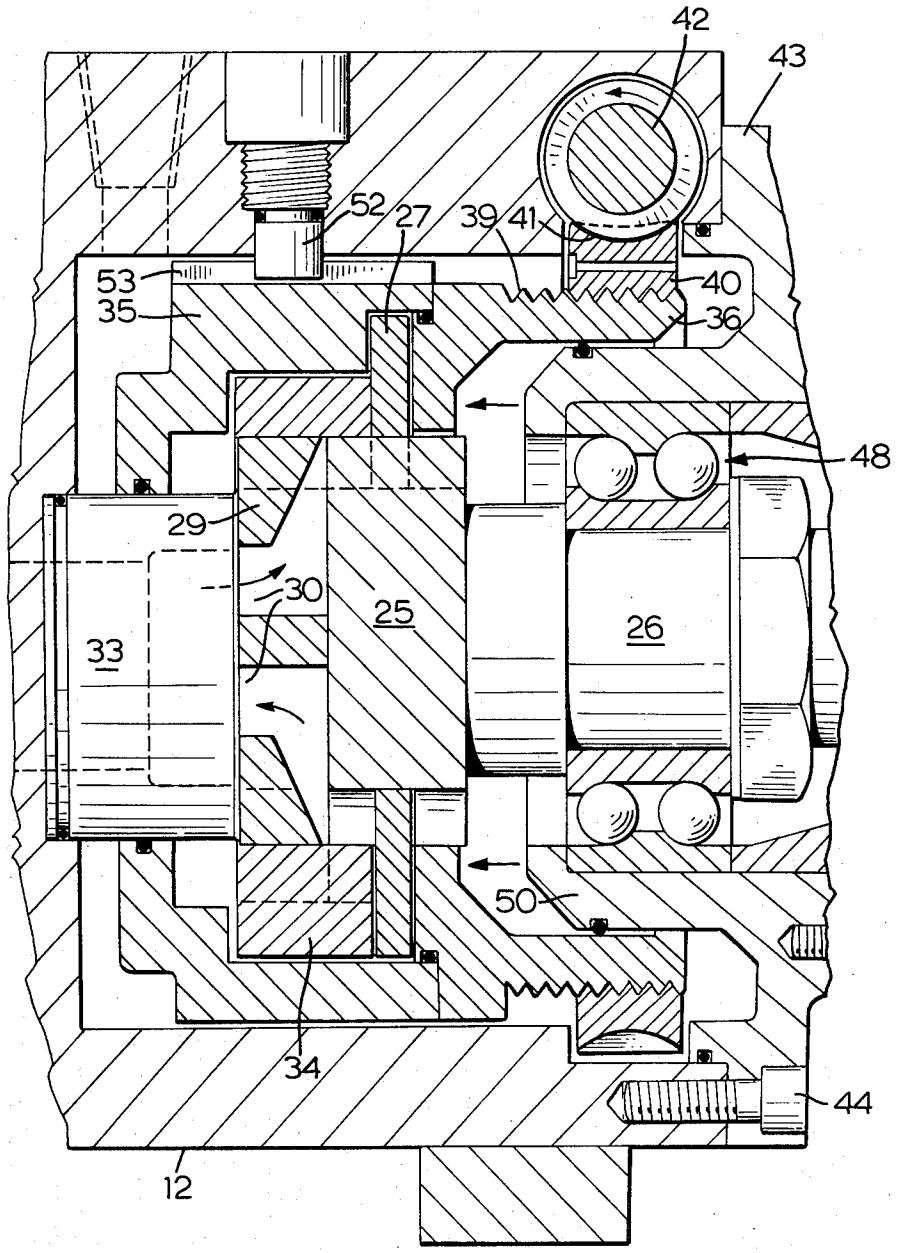


FIG. 1a

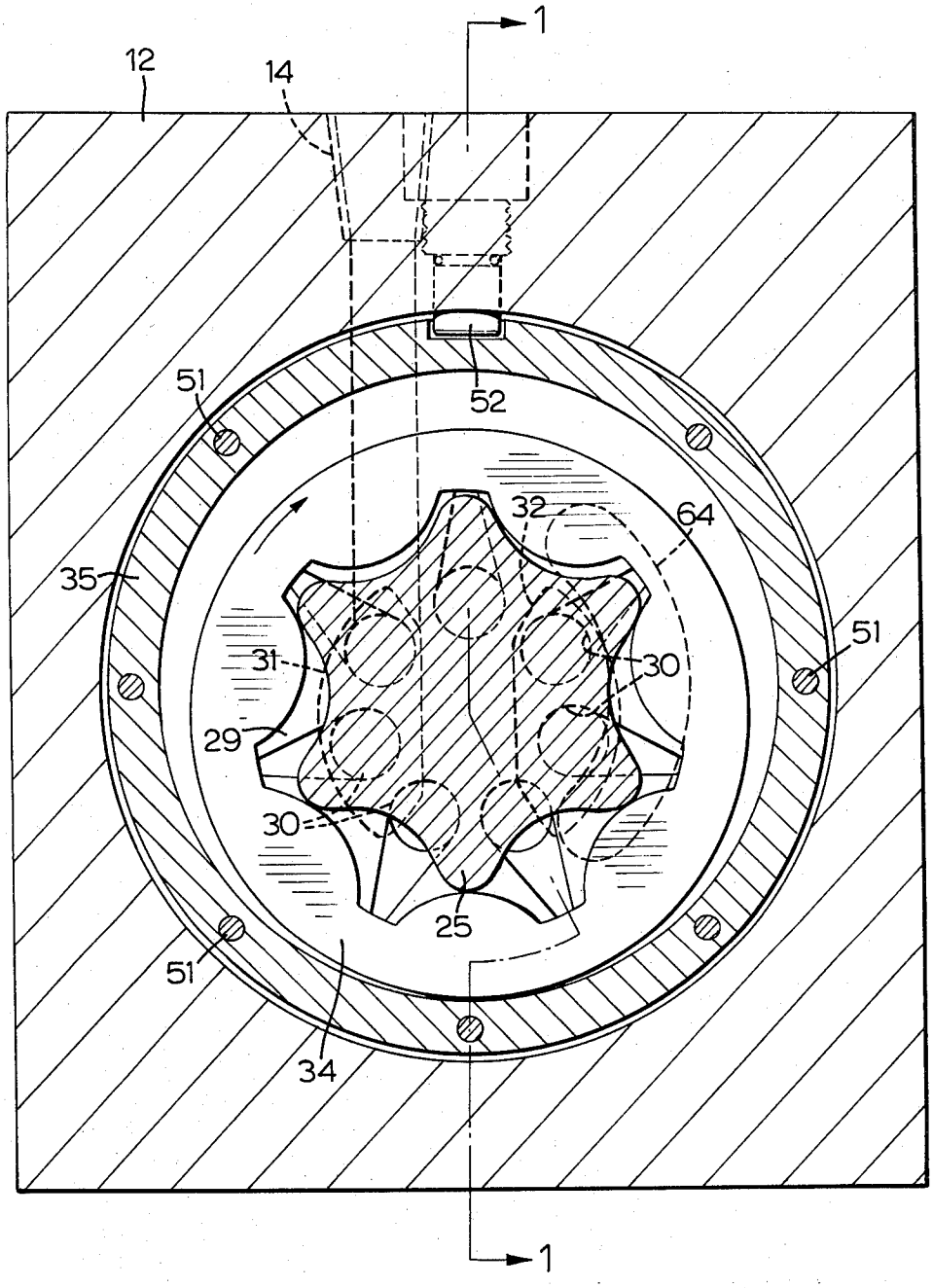


FIG. 2

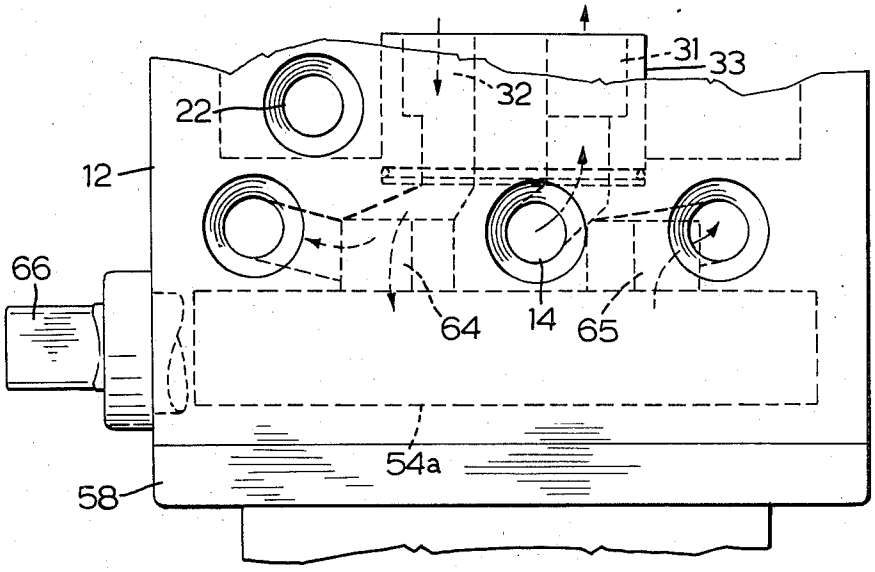


FIG. 4

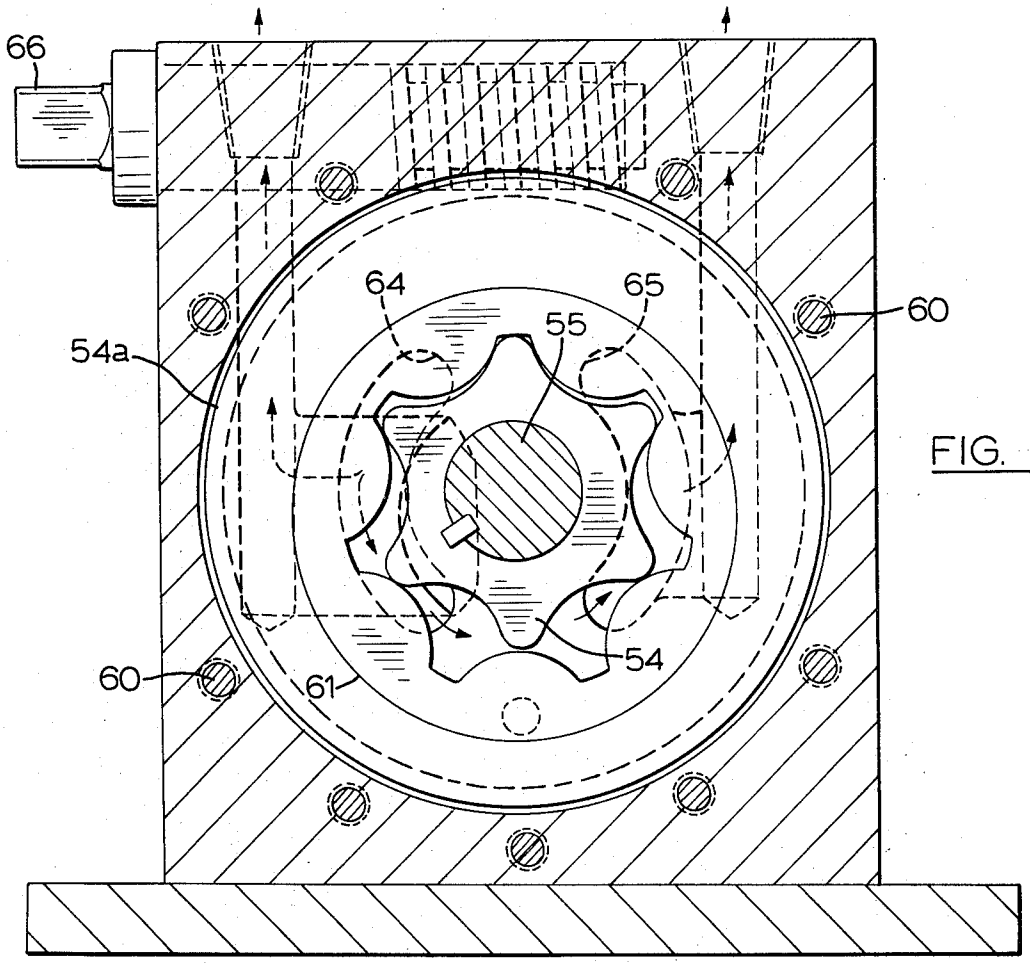


FIG. 3

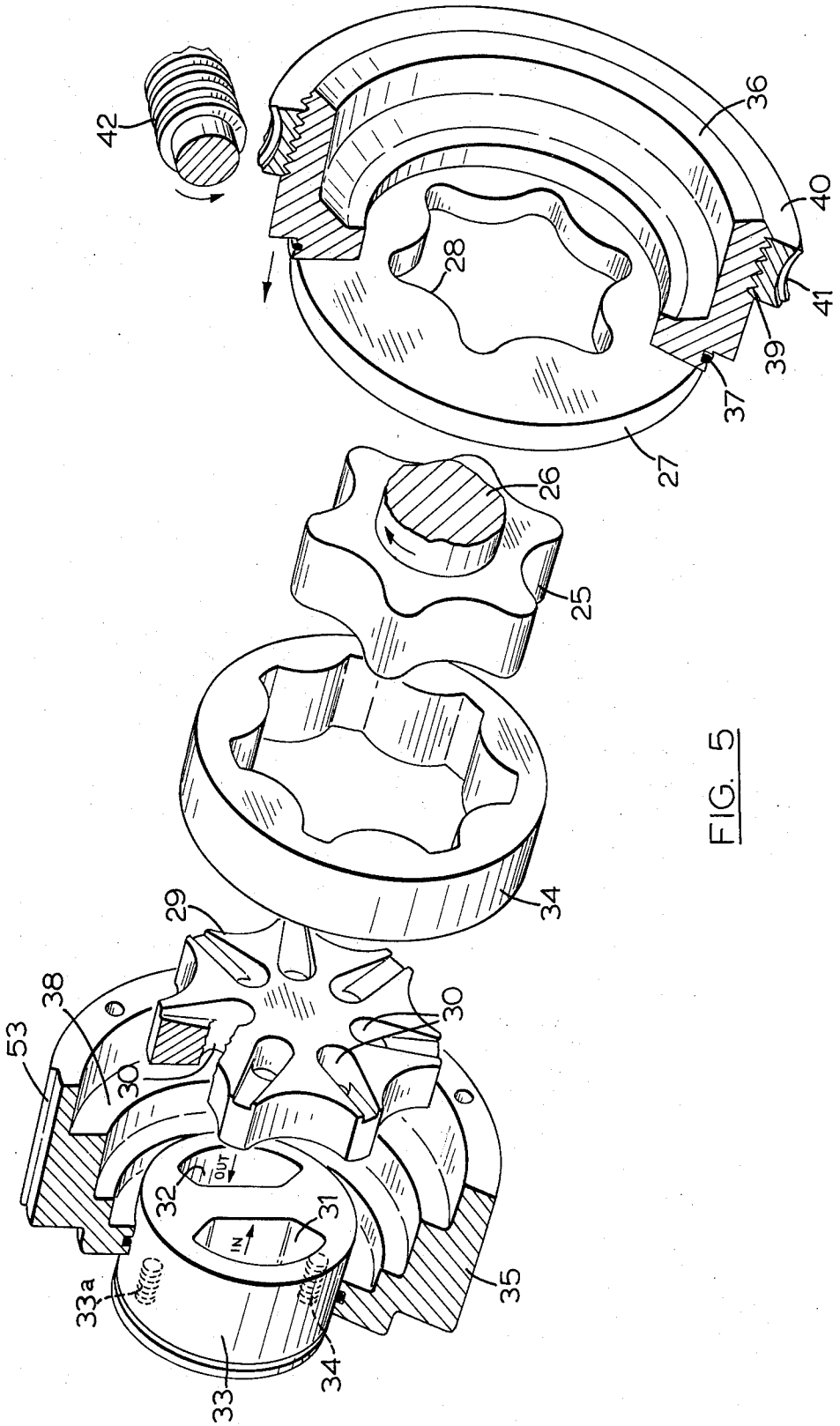
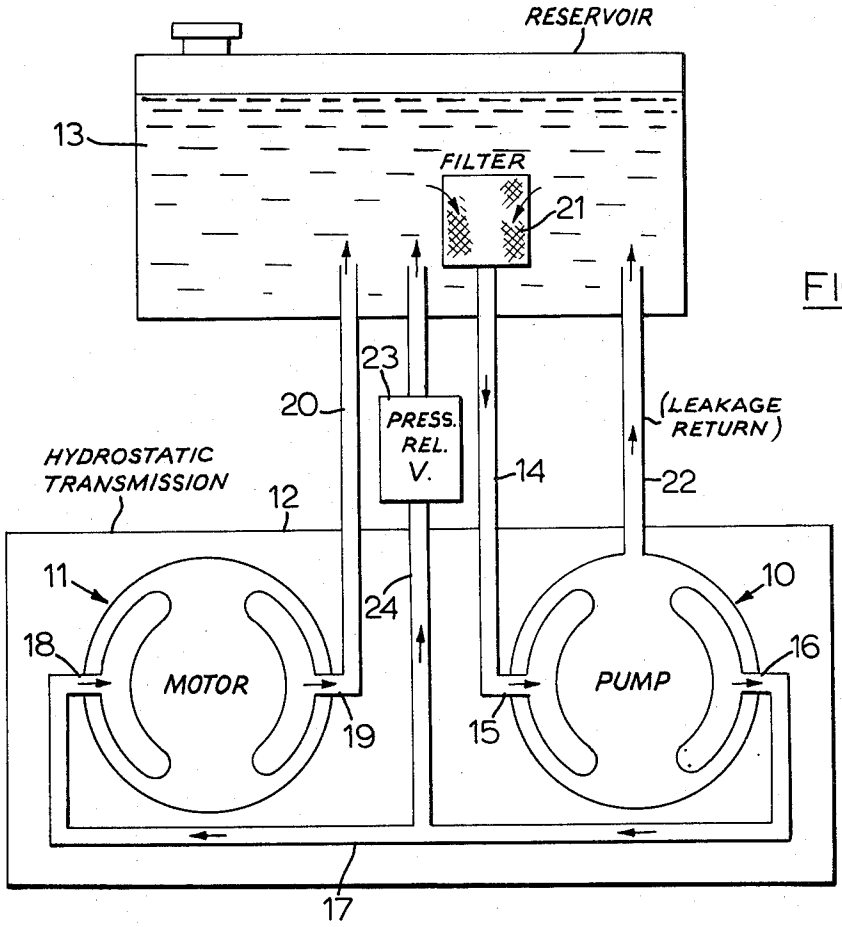


FIG. 5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(LEAKAGE RETURN)
HYDROSTATIC TRANSMISSION
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MOTOR
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FIG. 6

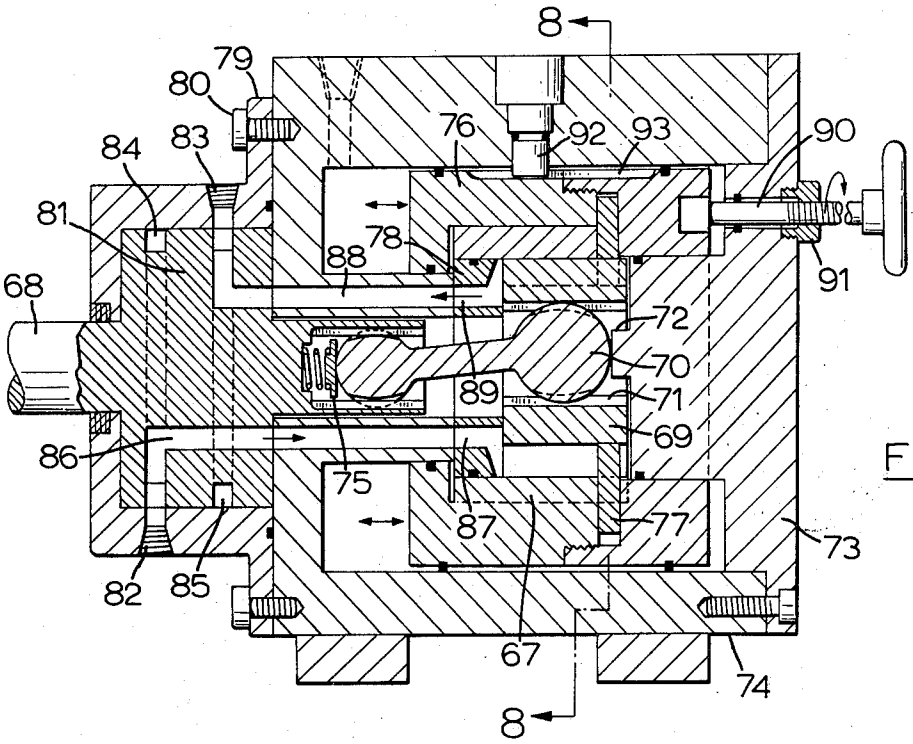
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FIG. 7

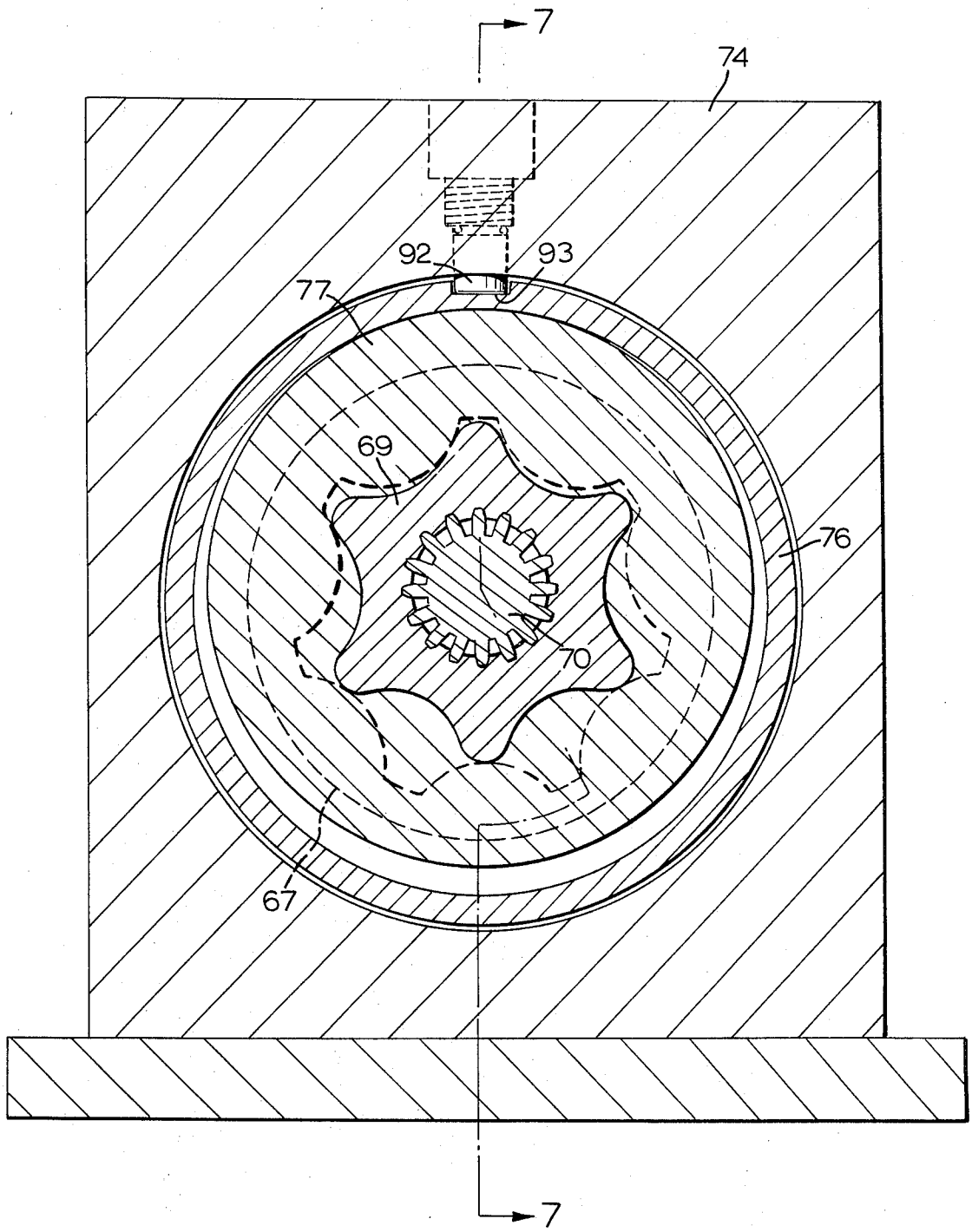

FIG. 8

VARIABLE DISPLACEMENT ROTARY HYDRAULIC MACHINES

This invention relates to a variable displacement rotary hydraulic machine, that is to say a variable displacement pump or motor.

The invention relates more particularly to variable displacement pumps and motors for use in hydrostatic transmissions. A hydraulic transmission set comprises a pump and a hydraulic motor, the pump and motor components being either directly connected or situated at different locations and interconnected by pipes or hoses for conveying the hydraulic fluid. Machines for this purpose include pumps and motors of the axial piston, radial piston, vane, and gear types; of these, machines the piston and the vane types suffer from the disadvantages of being relatively expensive, of being susceptible to wear on account of the close fit between the sliding surfaces, and of requiring a well filtered operating fluid. The gear type machines are relatively inexpensive, and on account of fairly large tolerances are less susceptible to wear than the other types and can function when the operating fluid contains a high concentration of contaminants. However, unlike the piston and vane types of machine, gear type machines cannot be contructed as variable displacement pumps and motors and so are not suitable for use in variable hydrostatic transmissions.

The present invention is based on an adaptation of the gerotor principle whereby to provide a variable displacement pump or motor which shares the principal advantages of gear type machines.

The gerotor principle has been known for many years and was perfected in the 1930's by W. H. Nichols. A gerotor assembly essentially comprises a pair of intermeshing, inner and outer gear-like elements whose rotational axes are offset so that one axis orbits around the other, the outer element having internal teeth in the form of part-circular lobes, and the inner element having external teeth which are one less in number than the lobes and matched to the shape of the lobes so as to make rolling contact. The elements are located in a cylindrical housing comprising a locating ring, which defines the rotational axes of the gears, and a pair of end walls or plugs. The locating ring and end walls, or plugs, define a chamber (herein referred to as the "gerotor chamber") in which the gear-like elements operate, the inner element being rotatable with a rotary shaft journalled in one end wall, and hydraulic fluid being supplied to and from the gerotor via ports which are usually in the other end wall.

Existing gerotor devices are essentially of the fixed displacement type. According to the present invention, however, a variable displacement rotary hydraulic machine includes a gerotor assembly wherein means are provided for effecting relative axial displacement of the gerotor elements so as to vary the capacity of the gerotor chamber.

In order that the invention may be readily understood, two embodiments of the invention will now be described by way of example with reference to the accompanying drawings. In the drawings:

FIG. 1 is a part-sectional side elevation of a hydrostatic transmission incorporating a variable displacement pump in accordance with the invention, the section being taken on line 1—1 in FIG. 2;

FIG. 1*a* is an enlarged sectional view of a detail of FIG. 1 showing the positions of the gerotor gears when the capacity of the gerotor chamber has been reduced;

FIG. 2 is a section on line 2—2 in FIG. 1;

FIG. 3 is a section on line 3—3 in FIG. 1;

FIG. 4 is a plan view of the detail shown in FIG. 3;

FIG. 5 is an exploded perspective view showing the essential elements of a gerotor assembly;

FIG. 6 is a schematic diagram of a hydrostatic transmission set in accordance with the invention;

FIG. 7 is a longitudinal sectional view of a modified variable displacement pump in accordance with the invention, the section being taken on line 7—7 in FIG. 8; and

FIG. 8 is a section on line 8—8 in FIG. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

General

Before examining the details of construction of the rotary hydraulic machines to which this invention relates, it will be instructive to consider the hydrostatic transmission set shown diagrammatically in FIG. 6, which represents one application of the invention. The hydrostatic transmission set comprises a pair of machines **10, 11** mounted in a common casing **12.** The machine **10** operates as a variable displacement pump, and the machine **11** operates as a motor receiving its operating fluid from the pump. A source of hydraulic fluid is constituted by a reservoir **13,** a supply duct **14** leading from the reservoir to the pump inlet **15.** The pump outlet **16** is connected by a duct **17** to the motor inlet **18,** and the outlet **19** of the motor is connected to a return duct **20** by which the fluid is returned to the reservoir **13.** A filter **21** is fitted to the inlet end of the supply duct **14,** to ensure a clean supply of operating fluid to the pump. A pipe **22** permits any fluid leakage at the pump to return to the reservoir.

The operating pressure of the hydraulic fluid at the inlet to the motor is limited by a pressure release valve **23** positioned in a flow path **24** between the duct **16** and the reservoir **13.**

The pump **10** and motor **11** have rotary shafts (not shown in FIG. 6) providing the input and output of the transmission. As the pump is driven from an external power source it generates a supply of pressurized fluid for the motor whereby to drive the motor, the operating fluid circulating as indicated by the arrows. The transmission ratio is determined by the relative settings of the variable displacement machines **10** and **11.**

VARIABLE DISPLACEMENT FEATURE

The variable displacement feature of each of the machines **10, 11** is accomplished by a gerotor assembly, the essential elements of which are shown in FIG. **5.** The gerotor assembly comprises an inner gerotor element **25** which is keyed to a rotary shaft **26,** the latter being a power input shaft in the case of a pump or a power output shaft in the case of a motor. The inner element **25** is arranged to mesh with an outer gerotor element **34,** the latter being constrained so that, in the embodiment shown, the rotational axis of the outer element orbits around the rotational axis of the inner element. A first plug **27** is formed with an inner peripheral edge **28** conforming to the shape of the inner element

whereby it is keyed to the inner element **25**, for rotation therewith. Similarly a second plug **29** has an outer peripheral edge conforming to the shape of the outer element **26** whereby it is keyed to the outer element for rotation therewith. The plug **29** is formed with seven (in this example) ports **30**, which cooperate cyclically with an inlet duct **31** and an outlet duct **32** of a valve body **33**. The valve body is secured against axial and rotational movement by bolts **34**.

A first ring member **35** and a second ring member **36** are bolted together with the interposition of a sealing ring **37** to form a composite locating ring. The locating ring being mounted, as hereinafter described, so as to be axially displaceable. The locating ring encompasses the outer gerotor element **24** and the plugs **27, 29**, so as to locate these plugs and element with respect to the inner gerotor element **25**. The locating ring and the plugs define a gerotor chamber in which the gerotor elements operate. The plug **27** is located axially by being clamped between the ring members **35, 36**, and the outer element **34** is located axially by being disposed between the plug **27** and an annular surface **38** in the ring member **35**. Therefore, when the locating ring is axially displaced the outer gerotor element **34** and plug **27** are displaced relatively to the inner element **25** and plug **29**; the gerotor chamber is thus of variable capacity.

For effecting axial displacement of the locating ring the ring member **36** is formed with external screw threads **39** which engage an internally threaded collar **40**. The collar **40** is formed with external transverse threads **41** which engage a worm gear **42**, the latter being mounted in the machine casing (see FIG. 1*a*) and being rotatable. In this way a very fine control of the relative axial positions of the gerotor elements is ensured.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference will now be made to FIGS. **1** to **4**, which show details of the construction of the first embodiment. The stationary casing **12** is provided with a pair of end walls. One end wall is formed by a bell member **43** which is bolted to the casing by bolts **44**, a seal housing **45** being bolted in turn to the bell member by bolts **46**. The input shaft **47** of the transmission set extends through the end wall and is journalled in bearings **48** for rotation about its axis. The shaft **26** to which the inner gerotor element **25** is keyed forms an extension of the input shaft **47** and is coaxial with it. The other end wall of the casing **12** is formed by a partition structure **49** which is provided with internal passages constituting the ducts **14, 17**. Between the end walls of the casing **12** the locating ring **35, 36** is located axially by a spigot-like portion **50** of the bell member **43**. It will be noted that the two ring members are secured axially by bolts **51**. The locating ring is secured against rotation by means of a key **52** projecting inwardly from the wall of the casing **12** and engaging in an axially extending slot **53** in the locating ring. As previously described, the locating ring can be moved axially for varying the capacity of the gerotor chamber, and hence the output of the pump, by the threaded collar **40** and worm gear **42**.

The motor **11** comprises a second gerotor assembly, the inner element **54** of which is keyed to a rotary shaft **55** constituting the output shaft of the transmission set. The rotary shaft **55** is journalled in bearings **56** for rotation about its axis, which is coaxial with the input shaft **47**, and extends through a second bell-shaped seal housing **57**. The seal housing **57** is bolted to a flanged member **58** by bolts **59**, the flanged member **58** being bolted to one end of the casing **12** by bolts **60**. The outer element **53** of the second gerotor assembly is constrained by a locating ring **61**, the latter being located between end plugs **62, 63**, and thus defining the chamber of the second gerotor assembly. The end plug **62** is formed with an inlet **64** and an outlet **65**, the positions of which relative to the orientation of the eccentric locating ring **61** can be varied by a worm gear **66** which engages external transverse threads on the locating ring. By rotation of the locating ring the positions of the motor inlet and outlet can be intercharged, thus affording a means to reverse the motor.

In the embodiment shown in FIGS. **7** and **8**, the outer gerotor element **67** is coaxial with the drive shaft **68** and the inner gerotor element **69** rotates about an axis which orbits around the axis of the drive shaft. The inner element **69** is splined to one end of a universal shaft **70** by splines **71**, the other end of the universal shaft being splined to the inner surface of a hollow end of the drive shaft **68**. The ends of the universal shaft respectively bear against a pad **72**, which forms an integral part of the end plate **73** of the housing **74**, and against a spring-loaded pad **75** inside the hollow end of the shaft **68**. The gerotor elements **67, 69** operate within a gerotor chamber defined by a locating ring **76**, a first end plug **77** keyed to the inner element **69** for rotation therewith and a second end plug **78** keyed to the outer element **69** for rotation therewith. A second end plate **79** is bolted to the housing **74** by bolts **80**. The end plate **79** is bell-shaped to accommodate an annular enlargement **81** of the drive shaft **68**, and is formed with a fluid inlet **82** and a fluid outlet **83**. The annular enlargement **81** has a pair of circumferential grooves **84, 85** cooperating with the inlet **82** and outlet **83**, respectively; an inlet duct **86** extends from the groove **84** to an inlet port **87** in the end plug **78**, and an outlet duct **88** extends from the groove **85** to an outlet port **89** in the end plug.

The locating ring **76** comprises a pair of ring members which are secured axially, as in the preceding embodiment. For varying the output of the pump (or motor, if the machine is adapted to operate as a motor) the capacity of the gerotor chamber may be varied by axially displacing the locating ring **76**. For this purpose one end of the locating ring is connected to an axially extending adjustment shaft **90**, which is threaded into a bush **91** at one end of the housing **74**. As in the preceding example, rotational movement of the locating ring **76** is prevented by a key member **92** engaging in an axially extending slot **93** in the locating ring.

What we claim as our invention is:

1. A variable displacement rotary hydraulic machine comprising

a. a stationary casing having first and second end walls;

b. a rotary shaft journalled in the first end wall for rotation about a predetermined axis;

c. a gerotor assembly mounted within the casing, the gerotor assembly comprising

i. intermeshing inner and outer gerotor elements, the inner element being connected to the shaft for rotation therewith,

ii. a first plug engaging the inner element for rotation therewith,

iii. a ported second plug engaging the outer gear for rotation therewith,

iv. an axially displaceable locating ring encompassing the outer element and the plugs for locating the same with respect to the inner element, the outer element and first plug engaging the locating ring for axial displacement therewith,

v. the plugs and locating ring defining a gerotor chamber of variable capacity;

d. valve means secured to one end wall of the casing, the valve means providing inlet and outlet ducts communicating with the ports of the second plug for leading hydraulic fluid to and from the gerotor chamber;

e. means cooperating with the locating ring for effecting axial displacement thereof whereby to vary the effective capacity of the gerotor chamber; and

f. means for preventing rotational movement of the locating ring within the casing.

2. A variable displacement rotary hydraulic machine as claimed in claim **1**, wherein the inner element is connected to the rotary shaft for rotation about said predetermined axis, the outer element being constrained by the locating ring to rotate about an axis which orbits around said predetermined axis.

3. A variable displacement rotary hydraulic machine as claimed in claim **1**, wherein the outer element is located by the locating ring in coaxial relation with said rotary shaft, the inner element being connected to said shaft by a universal coupling and being constrained by said first plug to rotate about an axis which orbits around said predetermined axis.

4. In combination with a variable displacement rotary hydraulic machine as claimed in claim **1**, the machine being adapted to operate as a variable displacement pump: a source of hydraulic fluid, a rotary hydraulic motor mounted on the second end wall of said casing, the motor having a fluid inlet and fluid outlet, a supply duct connecting said source with said inlet duct of the pump, means connecting said outlet duct of the pump with the inlet of the hydraulic motor, and a return duct connecting the outlet of the hydraulic motor with said source.

5. The combination claimed in claim **4**, wherein the hydraulic motor comprises a rotary motor shaft journalled for rotation about said predetermined axis, and a gerotor assembly comprising intermeshing inner and outer gerotor elements operating in a gerotor chamber within the motor casing, the inner element being connected to the motor shaft for rotation therewith.

6. The combination claimed in claim **5**, including means for reversing the fluid connections to the motor for effecting reversal of the motor.

7. A variable displacement rotary hydraulic machine as claimed in claim **1**, wherein the locating ring is formed with an axially extending threaded flange, said means for effecting axial displacement of the locating ring comprising a worm gear journalled in the casing and engaging said flange.

* * * * *