Nov. 23, 1954 O. F. QUARTULLO ET AL 2,694,982

HYDRAULIC MACHINE

Filed Sept. 13, 1951

3 Sheets-Sheet 1

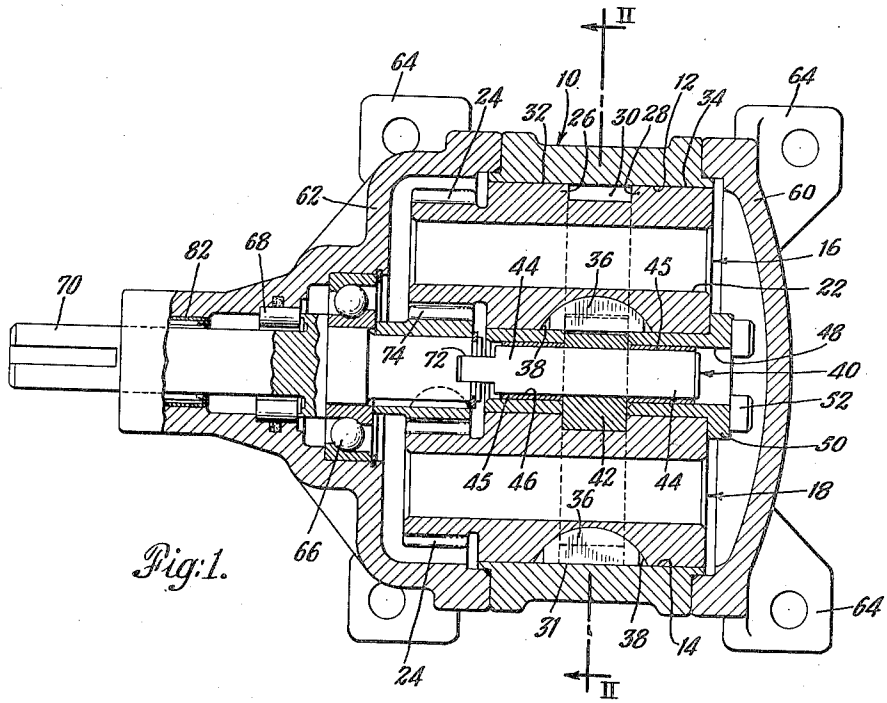


Fig:1.

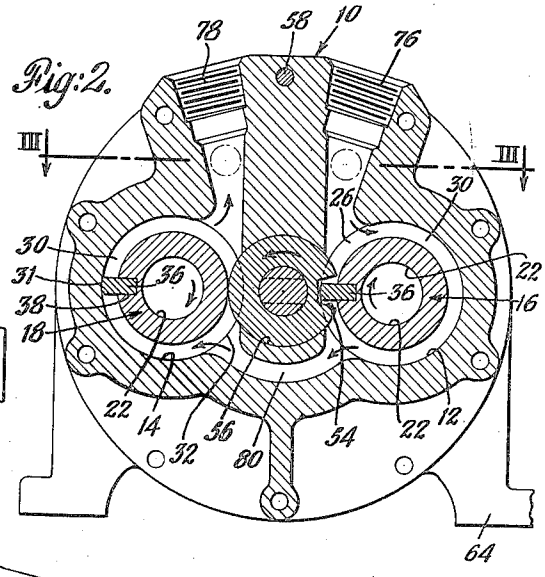


Fig:2.

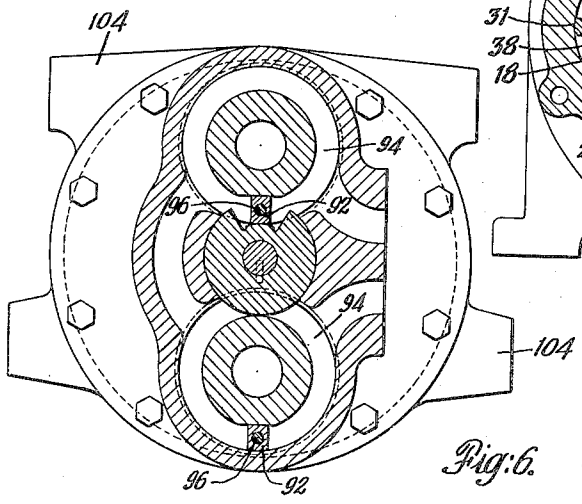


Fig:6.

INVENTORS
ORPHEUS F. QUARTULLO
HENRY BAADE
BY Donald W. Robertson
ATTORNEY

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3 Sheets-Sheet 2

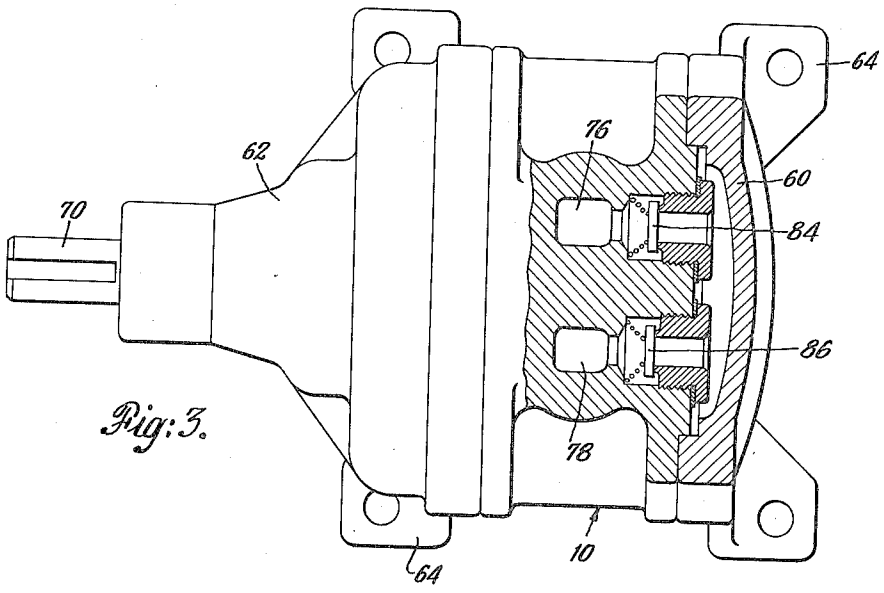


Fig. 3.

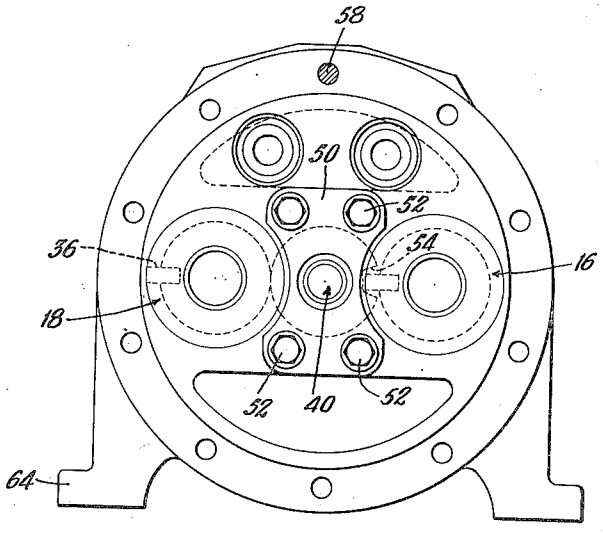


Fig. 4.

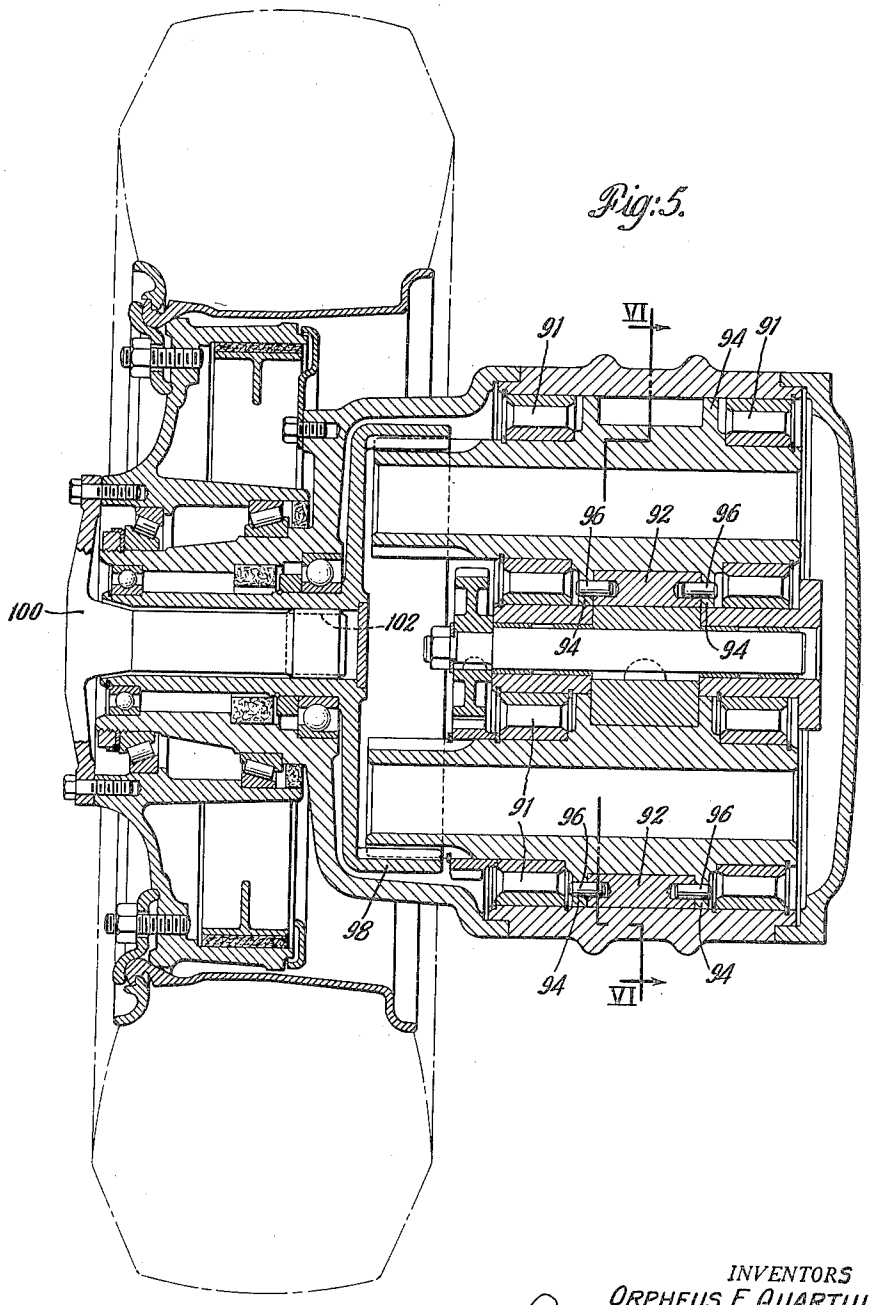
INVENTORS
ORPHEUS F. QUARTULLO
HENRY BAADE
BY Donald W. Robertson
ATTORNEY

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Fig. 5.



INVENTORS
ORPHEUS F. QUARTULLO
HENRY BAADE
BY Donald W. Robertson
ATTORNEY

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HYDRAULIC MACHINE

Orpheus F. Quartullo, South Euclid, and Henry Baade, Cleveland, Ohio, assignors, by mesne assignments, to Oliver Iron and Steel Corporation, Pittsburgh, Pa., a corporation of Pennsylvania

Application September 13, 1951, Serial No. 246,454

1 Claim. (Cl. 103—125)

This invention relates to an improved hydraulic machine which can be used either as a hydraulic pump or a hydraulic motor.

A number of hydraulic machines adapted to perform the function of this invention have been heretofore proposed employing some form of rotor having a vane or blade slidably engaging the inner surface of a cylindrical bore. While such pumps, or motors, as the case may be, are in theory quite simple, when designed to handle large amounts of power or fluid under high pressure, they have proved expensive and difficult to manufacture and keep in operation. This has been due, among other causes, to the close tolerances required between moving and stationary parts to maintain effective sealing against seepage of the fluid past the vane or past the end faces of the rotors adjacent the ends of the cylindrical bores.

Furthermore, it has been suggested in known devices of the type described to make the housing of the machine from a plurality of plates which are secured together by a number of tie-bolts but structures of this type offer extreme complications from a manufacturing and maintenance standpoint, particularly in view of the close tolerances required.

It is the general object of this invention to avoid and overcome the foregoing and other difficulties of and objections to prior art practices by the provision of an improved hydraulic machine of the double rotor and interposed valve type which is less expensive to manufacture and maintain and which is capable of operating at higher pressures than has heretofore been practical.

It is another object of the invention to provide a rotary hydraulic machine in which the rotors and valve assemblies operate within a single casting comprising a cylinder block housing, obviating the necessity of having carefully machined cylinder blocks with laminated side plates for closing off the ends of the cylinders and sealing the end faces of the rotors.

Another object of the invention is to provide a hydraulic machine of the type described wherein any fluid which escapes past the rotor-to-cylinder bore seal is returned back into the fluid system whereby the weight of the machine can be greatly reduced in any given horsepower size.

Another object of the invention is the provision of a rotary hydraulic machine characterized by high efficiency, low cost in manufacture and upkeep, light weight, and long life.

The aforesaid objects of the invention, and other objects which will become apparent as the description proceeds, are achieved by providing a rotary hydraulic machine comprising a main housing block having two axially-parallel, spaced bores therethrough, a rotor mounted in each bore, a pair of flanges spaced intermediate the ends of the rotor slidably engaging the wall of the bore whereby an annular fluid-receiving chamber is formed. A vane or blade is provided in the annular space which is secured between the flanges of the rotor and slidably engages the wall of the bore. A counterbored hole in the housing is provided intermediate the rotor-receiving bores in which one end of a rotary valve is journaled. The valve itself is cylindrical and is in rolling engagement with the rotors between the flanges, thereby forming a block controlling the flow of fluid in the annular space. A gear connected to the end of the valve meshes with gears on the rotors for effecting positive rotation between the valve and motors. A clearance notch is provided on the valve to receive the vane on each

rotor in turn and the relative angular position between the rotors and valve is such that the vanes in the rotors are received alternately in the valve notch as the several members rotate relative to each other. A fluid passage in the housing interconnects the two annular chambers adjacent one side of the rotary valve, and outlet and inlet passages connect with the annular chambers adjacent the opposite sides of the rotary valve. An end bell in sealed relation to the housing supports a drive shaft which is geared within the housing to the rotors. A fluid pressure seal is provided on the shaft to prevent leakage of any fluid from within the housing which collects in the space between the end bell and the main housing as a result of leakage across the flanges of the rotors where they engage the cylinder walls. A cover plate is provided to seal the opposite end of the housing, and spring-loaded relief valves in each of the inlet-outlet passages connect with the spaces at either end of the housing whereby any fluid accumulating within these spaces is returned back to the fluid system when the pressure within these spaces exceeds that in the low-pressure side of the hydraulic machine.

For a better understanding of the invention, reference should be had to the accompanying drawings, wherein:

Fig. 1 is a longitudinal cross-sectional view of one embodiment of the invention;

Fig. 2 is a transverse cross-sectional view taken substantially on the lines II—II of Fig. 1 and showing the fluid path through the hydraulic machine;

Fig. 3 is a fragmentary cross-sectional view taken substantially on the lines III—III in Fig. 2 showing the relief valves;

Fig. 4 is an end view of the hydraulic machine with the cover plate and relief valves removed;

Fig. 5 is a longitudinal cross-sectional view of another form of the invention designed to transmit tractive power to a vehicle wheel; and

Fig. 6 is a transverse cross-sectional view taken substantially on the lines VI—VI of Fig. 5.

With specific reference to the form of the invention illustrated in Figures 1, 2 and 3, the numeral **10** indicates generally the main housing in which spaced bores **12** and **14** are provided. Rotors, usually made of high-grade steel, indicated generally at **16** and **18**, are rotatably received in the bores **12** and **14** respectively. Each rotor has a hole **22** through its center forming a passage for fluid. A spur gear **24** is associated with each rotor, for example, by cutting the gear integrally with the rotor, and it is through the gear that torque is delivered to or from the rotor. Two flanges **26** and **28**, intermediate the ends of the rotor, are integrally formed thereon and closely but slidably engage the inner walls of the bores **12** and **14** around the periphery thereof, forming an annular chamber **30** through which the hydraulic fluid passes. A clearance of .0005", for example, may be provided between the bores and the flanges. Flanges **26** and **28** thus form the confining walls of the annular chamber **30**, and provide a reasonably effective practical seal against the pressure of the fluid within the annular chamber **30**, particularly when the flanges are relatively wide in an axial direction, as shown.

The ends of the rotors or the flanges on the rotors form bearings **32** and **34** which slidably engage the inner walls of the bores **16** and **18**. It will be understood that the rotors can be chrome-plated or case hardened if desired, and that the housing **10** is of a good grade cast iron alloy so that excellent bearing relationship is provided. Or separate bearings of the bronze or sintered metal type, or of ball or roller bearing type, may be provided for the rotors in the bores.

Each rotor is provided with a blade or vane against which the hydraulic fluid can react as the fluid passes through the annular chamber **30**. The blade or vane can be made integral with the rotor, but in the form of the invention shown, a vane insert **36** is employed having an edge **31** slidably engaging the bore wall, usually with a sliding clearance of about .0005" to hold leakage to a minimum. The vane **36** is received in a slot **38** cut into the rotor **20** in such a manner that the vane **36** bridges the annular chamber **30**.

Operating in conjunction with the rotors **16** and **18** to effect the flow of fluid through the annular chambers **30**

into operative engagement with the vanes **36** is a rotary valve assembly of high-grade steel, indicated generally at **40**, consisting of a main valve body **42** formed with trunnions **44**. The trunnions **44** are rotatably supported by means of sleeve bearings **45** which are pressed into the housing on either side of the main valve body **42** in holes **46** and **48**. Hole **46** is formed in the main housing **10** intermediate the two bores **12** and **14**. Hole **48**, in which the other bearing **45** is pressed, is formed in a cap **50** which is bolted to the main housing **10** after the rotors **16** and **18** and valve assembly **40** are assembled into position. The cap **50** is secured in place by four cap screws **52**. As above described in conjunction with the bearings for the rotors, the sleeve bearings **45** may be omitted with the trunnions of the valve body being journaled directly in the housing **10** and cap **50**, or ball or roller bearings may be used, particularly in higher horsepower machines.

The valve body **42** is substantially in the shape of a cylinder having a circumference preferably identical with that of the inner circumference of the annular chamber **30** on each rotor. The width of the valve body **42** is such that it has a running fit between the flanges **26** and **28**. As seen in Fig. 2, the rotors **16** and **18** have rolling contact with the outer periphery of the valve body **42**. In order that the vane of each rotor can turn past the valve body **42**, a notch **54** is provided in the periphery of the valve body. This notch alternately receives the vane **36** of each rotor, without the vanes contacting the notch.

The hole **46** in the main housing **10** is counterbored at **56** (see Fig. 2) to provide a cylindrical space in which the valve body **42** slidably rotates. It will be appreciated that the size of this counterbore is such as to intersect the bores **12** and **14** in the same way that the flanges of the rotors overlap or intersect the valve body **42**. This is best shown in Fig. 2.

Closing one end of the main housing **10** is a cover plate **60** and closing the other end is a drive shaft supporting bell **62**. Cap screws **58** extending through the cover plate **60**, holes in the housing **10**, and into tapped holes in the bell **62** secure the entire assembly together. Integrally formed with the cover plate **60** and supporting bell **62** are the supporting lugs **64** on which the hydraulic machine is mounted. The bell **62** rotatably supports, by means of bearings **66** and **68**, the drive shaft **70**. The shaft **70** is in line axially with the valve trunnion **44** and is engaged therewith by some suitable disconnect means, such as a tongue and groove coupling, as shown at **72**. A spur gear **74** is provided on the inner end of shaft **70**, and the gear may be cut directly on the end of the shaft if desired. The gear **74** engages the spur gears **24** on the rotors. The pitch diameter of the three spur gears is the same and equal to the diameter of the valve body **42** and the inner diameter of the annular chambers **30**. The relative angular positions of the rotors and valve are such that the vanes **36** alternately are received in the notch **54** but do not touch the walls of the notch.

Fluid connection to the hydraulic machine is provided through the pipe-threaded outlet-inlet passages **76** and **78** which communicate with the annular chambers **30** adjacent the rotary valve **42** substantially as shown in Fig. 2. A fluid passage **80** communicates with the annular chambers **30** adjacent the rotary valve on the opposite side from the outlet-inlet passages. As the hydraulic device can rotate in either direction, either passage **76** or **78** can act as an inlet for the hydraulic fluid.

In operation there is a certain amount of seepage of hydraulic fluid across the flanges **26** and **28** which accumulates in the open spaces at either side of the main housing **10** within the end plate **60** and drive shaft supporting bell **62**. To confine this fluid within the housing, a rotary pressure seal **82** is provided on the drive shaft **70**. After these spaces and the holes **22** through the rotors **20** become filled with fluid, it has been found that the pressure in the housing could gradually build up to approximately half the line pressure, but no greater, on the high pressure side of the hydraulic system. To confine the fluid at these pressures would require the rotary pressure seal **82** to be elaborate and expensive, and would also require the weight and strength of the housing to be materially increased inasmuch as the hydraulic pressures occurring in the normal use of the machine go to many hundreds of pounds per square inch.

To eliminate the building up of any appreciable pressure within the housing, spring-loaded relief valves **84** and **86** are provided in the main housing, one valve communicating with each one of the outlet-inlet passages **76** and **78**. When the pressure of the fluid within the housing spaces exceeds the combined force of the relief valve spring and the pressure within the low pressure side of the hydraulic system, one relief valve opens, permitting any excess fluid collected within the housing spaces to return to the hydraulic fluid system to thereby substantially equalize the pressure inside the housing with that at the low pressure side of the machine. Because either passage **76** or **78** may be the low pressure side of the machine, a relief valve is provided in each passage.

Assembly of the hydraulic machine is quite simple. The rotors are positioned at opposite sides of the valve **42** with the body of the valve between the flanges of the rotors, and the valve and rotors are moved together into the housing bores with the cover plate **60** removed. The rotors are axially located from the rotary valve **42**, which is in turn held against axial movement in one direction by the shoulder provided at the base of the counterbore **46** and in the other direction by the bearing cap **50** which is bolted into position after the valve and rotors are in operative position. The drive shaft supporting bell **62** and the cover plate **60** can be assembled or disassembled by virtue of the tongue and groove connection **72** between the drive shaft and the rotary valve trunnion **44**, without affecting the assembly of the rotors and rotary valve within the main housing block **10**.

In operation, the hydraulic machine described can function either as a hydraulic pump or a hydraulic motor and is completely reversible. When serving as a motor, for example, high pressure fluid entering inlet passage **76**, if the rotors and associated valve are in the position shown in Fig. 2, passes around the annular chamber provided in bore **12** through the passage **80**, where it comes in contact with the vane **36** and in so doing turns the rotor **18**. The rotor **18** in rotating, through the associated gearing, turns the rotary valve **40** and the rotor **16**. By the time the rotor **18** rotates around to the point where fluid escapes past the vane **36** into the outlet passage **78**, the vane **36** on the rotor **16** has reached the position where it seals off the annular chamber **30** associated with it against further flow of fluid from the intake passage **76**. At this time, the pressure of the fluid in the intake passage **76** engages the vane to rotate the rotor **16** around to a point where the fluid can flow into the passage **80** and thence into operative engagement with the vane **36** on the rotor **18**. In this manner, the cycle of operation is completed, and this cycle is continuously repeated with the fluid pressure acting alternately on the rotors to provide a continuous non-pulsating drive to the drive shaft **70**.

When the hydraulic machine of the invention is used as a pump, the shaft **70** is driven and the operation of the apparatus is the reverse of that just described, as will be understood.

Figs. 5 and 6 disclose a modified form of the invention in which the hydraulic machine can be used as a motor to supply traction power to a vehicle wheel. Construction and operation of this modified form is essentially the same as heretofore described. However, in the interest of more rugged or heavier horsepower construction, the rotors are rotatably supported within the housing bores by means of roller bearings **91**. The vane **92** on each rotor is made somewhat differently, being in the form of a bar or blade which is secured in position in the annular space between the flanges **94** of the rotors by means of dowels **96**. The power take-off is in the form of a ring gear **98** which is secured to the wheel hub **100** by means of an internal spline indicated at **102**. The housing of the motor is provided with projecting lugs **104** from which the complete wheel and motor assembly can be supported by parallel linkage and associated spring means from a vehicle frame (not shown).

It will be recognized that the objects of the invention have been achieved by providing a hydraulic machine which is completely reversible and non-pulsating, which can be used either as a pump or motor, which is rugged and compact in design but light in weight, which is comparatively simple and inexpensive to manufacture and maintain, and which is capable of operating with high efficiency under high fluid pressure and high mechanical torque over long periods without attention or repair.

While in accordance with the patent statutes, one best known embodiment of the invention has been illustrated and described in detail, it is to be particularly understood

that the invention is not limited thereto or thereby, but that the inventive scope is defined in the appended claim.

We claim:

In a rotary hydraulic machine comprising a main housing member having spaced cylindrical bores therethrough, a rotor having a pair of spaced flanges defining an annular recess therebetween extending around the periphery of the rotor, said rotor being received in one of said bores, said spaced flanges having cylindrical surfaces which in an axial direction are relatively wide with respect to said annular recess, said wide cylindrical surfaces being journaled in one of said spaced cylindrical bores of said main housing member and in direct sealing contact with said one bore, a vane carried by said rotor and extending axially across the annular recess thereof and extending radially to seal with the bore, and a rotary

valve body journaled in another of said cylindrical bores of said main housing member for substantially rolling contact with said rotor, said valve body having a recess to clear said rotor vane and said rotor and valve being geared together.

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