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Dorff et al.

[11] **3,834,842**

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[54] **HYDRAULIC POWER TRANSLATING DEVICE**

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[52] **U.S. Cl.** **418/75,** 418/71, 418/171, 418/189

[51] **Int. Cl.** **F04c 29/00,** F04c 17/06

[58] **Field of Search** 418/166, 171, 71, 80, 75, 418/79

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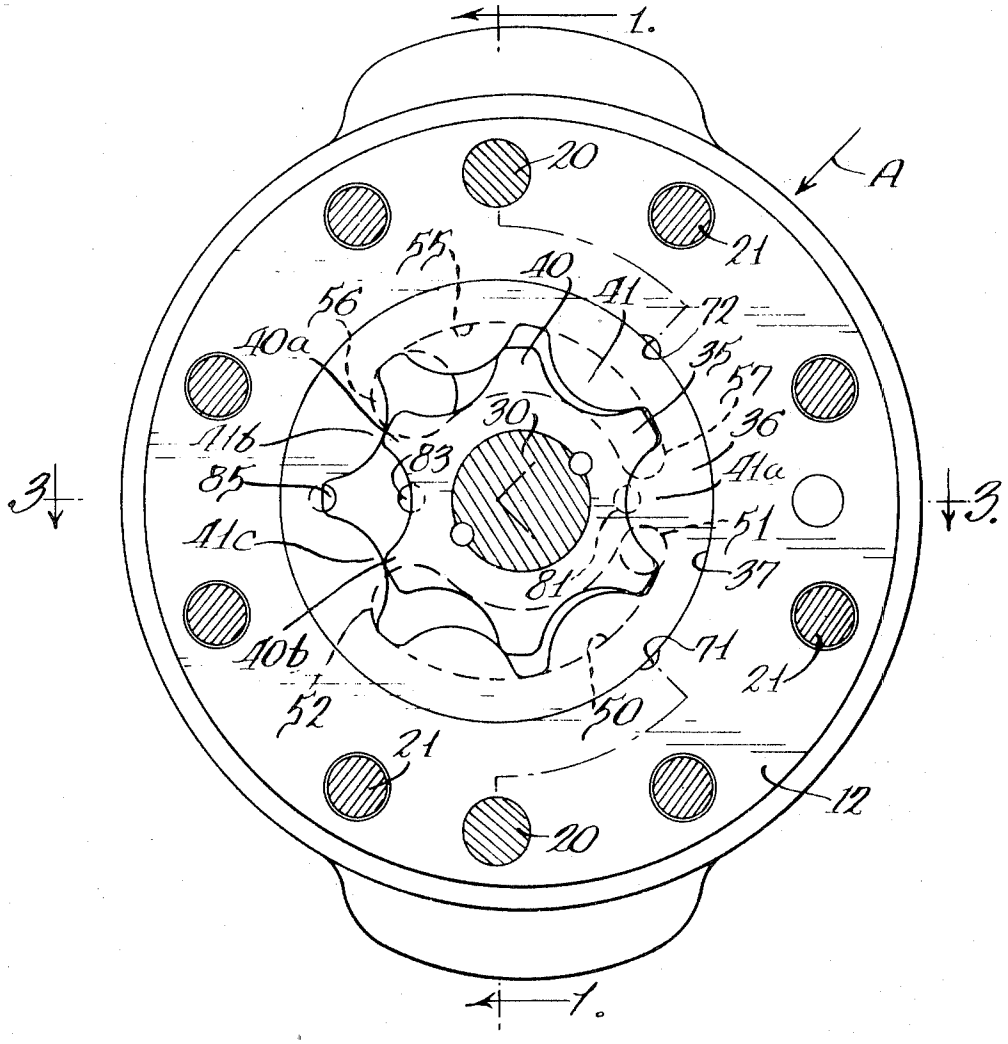
Attorney, Agent, or Firm—Wegner, Stellman, McCord, Wiles & Wood

[57] **ABSTRACT**

A hydraulic power translating device of the gerotor type having inner and outer rotatable partially meshing gear elements with a pressure fluid passage surrounding a major part of the exterior periphery of the outer gear element to obtain radial balance of the outer gear element upon start up in motor operation and with a plurality of recesses formed in the case of the device and at the cross-over areas which operate as fluid accumulators of limited capacity to reduce the noise of operation of the device as well as torque variations and to compensate for tolerance and natural frequency variations in the mechanical structure and to also axially balance the gear elements.

10 Claims, 3 Drawing Figures



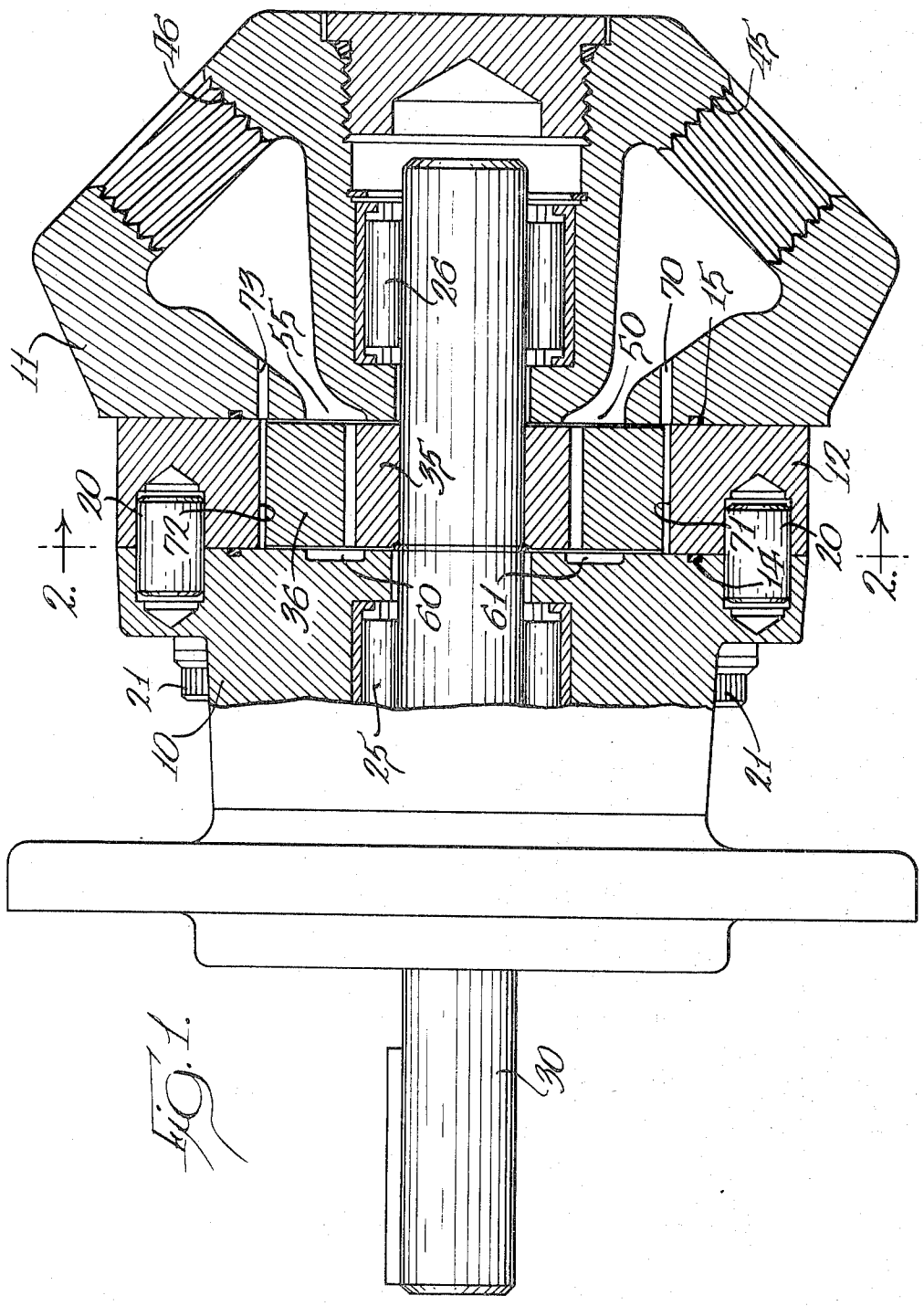


FIG. 1.

Fig. 2.

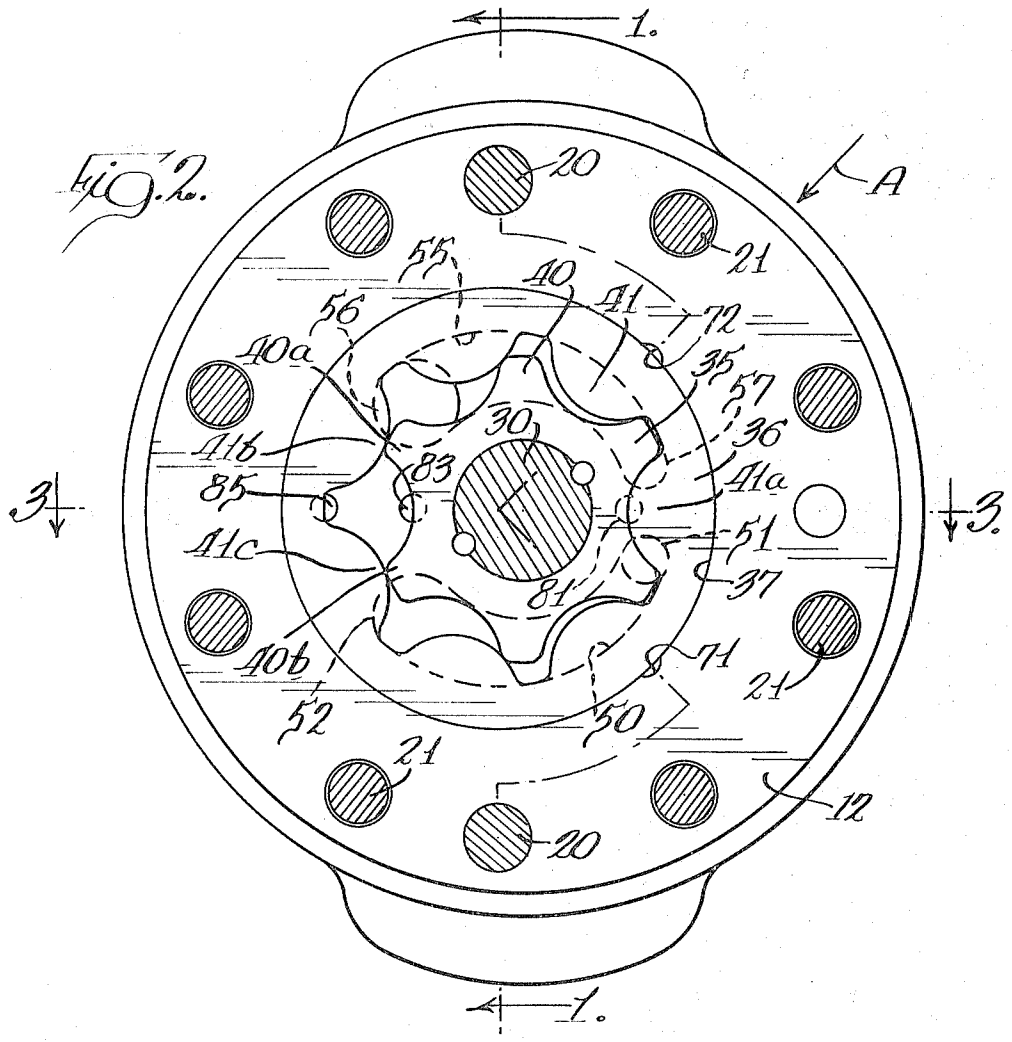
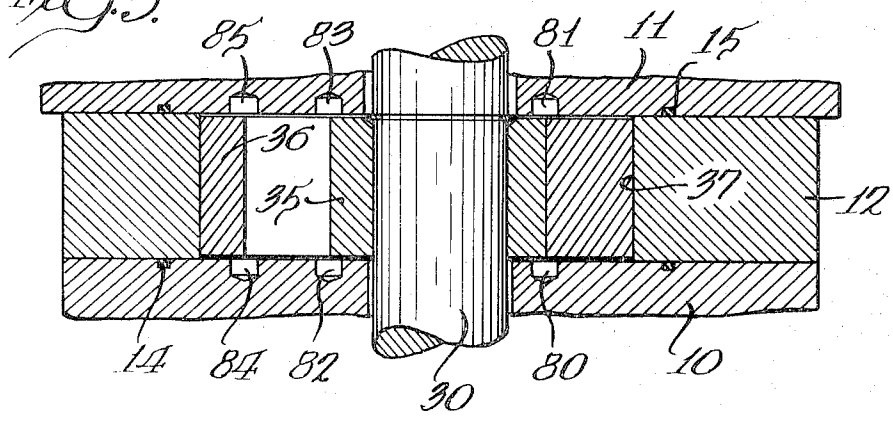

1.
A
20
21
55
40
41
72
56
40a
35
57
30
36
41b
83
85
41a
3
3.
51
41c
37
81
71
40b
21
52
50
21
12
20
1.

Fig. 3.


85
83
81
11
15
36
35
37
12
14
84
82
30
80
10

HYDRAULIC POWER TRANSLATING DEVICE

BACKGROUND OF THE INVENTION

This invention pertains to hydraulic power translating devices and, more particularly, to a hydraulic pump or motor of the gear type and particularly the gerotor type with partially meshing inner and outer gear elements rotatable within a case and with the outer gear element being eccentric of the inner gear element and to improvements therein providing for smoother, quieter operation with reduction in torque variations and with provision for improvement in starting torque when the device is used as a motor.

A gerotor type of pump or motor is well-known. Existing units have had a resistance to starting when used as a motor. This has resulted from a radial imbalance of forces on the outer gear element when fluid pressure is applied to the motor with the result that the outer gear element tends to bind against the adjacent wall of the case. Additionally, such devices when used as a pump have been noisy in operation and have had torque variations with these conditions resulting from the trapped condition of fluid in the cross-over areas of the device. The foregoing shortcomings of the prior art devices are overcome by the invention disclosed herein.

SUMMARY

An object of this invention is to provide a new and improved hydraulic power translating device which overcomes the shortcomings of the prior art in providing for a smoother, quieter operating device and which when used as a motor has improved starting torque characteristics.

Another object of the invention is to provide a hydraulic power translating device wherein the improvements in the starting torque characteristics of the device when used as a motor are provided by means subjecting the peripheral exterior of the outer gear element to fluid pressure by means of a limited fluid flow giving a controlled pressure drop to obtain radial balance thereof upon initial start-up of the motor.

Another object of the invention is to provide a hydraulic power translating device as defined in the preceding paragraphs wherein the improved sound and operating characteristics are provided by accumulator means of limited capacity positioned at the cross-over areas which communicate with opposite sides of both the inner and outer gear elements of the device as well as any space existing therebetween whereby fluid pressure is applied to the opposite sides of said gear elements for axial balance thereof and the accumulator means provide for utilization of the bulk modulus of the fluid to effectively provide variation in the total space confining the fluid in the cross-over areas.

A further object of the invention is to provide a hydraulic translating device as defined in the preceding paragraph of the gerotor type wherein the radial balancing of the outer gear element and the provision of accumulator means are provided by simple machining operations on the case of the device to provide flow passages from the inlet and outlet ports of the device to the space exteriorly of the outer gear element and to provide relatively small cavities formed in the walls of the case at opposite sides of the inner and outer gear elements for the accumulator means.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is an elevational view of the hydraulic power translating device with a part thereof being shown as a section taken generally along the line **1—1** in FIG. **2**;

FIG. **2** is a vertical section, taken generally along the line **2—2** in FIG. **1**; and

FIG. **3** is a section, taken generally along the line **3—3** in FIG. **2.**

DESCRIPTION OF THE PREFERRED EMBODIMENT

The hydraulic power translating device is shown in particular in FIGS. **1** and **2** wherein a multi-part case has outer parts **10** and **11** mounting a case ring **12** therebetween with a fluid seal between the parts being provided by O-rings **14** and **15.** The case ring **12** of the case is aligned with outer case part **10** by a series of aligning pins **20** and with there being a series of bolts **21** extending between the outer case parts **10, 11** and through the case ring **12** to hold the case in fluid-tight assembled relation. The outer case parts **10** and **11** each have a bearing **25** and **26,** respectively, rotatably mounting a shaft **30** which is a drive shaft when the device is operating as a pump and which is an output shaft when the device is operating as a motor.

Disposed between the outer case parts **10** and **11** and surrounded by the case ring **12** are a pair of gear elements of the gerotor type. These elements include an inner gear element **35** which is keyed to the shaft **30** and is concentric with the axis of rotation of the shaft. The second element is an outer gear element **36** which is rotatably mounted within a chamber defined by opposed faces of the outer case parts **10** and **11** and by an internal wall **37** of the case ring **12.** This internal wall is cylindrical, but has its center offset eccentrically from the axis of rotation of the shaft **30** and the inner gear element **35.** This is conventional in a gerotor-type hydraulic power translating device. With the six teeth **40** on the inner gear element **35** and the seven internal teeth **41** on the outer gear element **36** there is thus established a plurality of fluid chambers in spaces between the gear elements.

The outer case part **11** has a pair of fluid passages having threaded openings **45** and **46** at the outer ends thereof for pipe connections and at their internal ends are shaped to define a pair of kidney-shaped fluid ports in the face of the outer case part **11** adjacent to one side of the gear elements **35** and **36.** One of these fluid ports **50** is shown in FIG. **1** and in broken line in FIG. **2.** With rotation of the gear elements in a clockwise direction as viewed in FIG. **2,** the leading end of the fluid port **50** is at **51,** while the terminus thereof is at **52.** When the device is operating as a pump, this is a suction port connected to a source of fluid. The second fluid port **55** is shown in broken line in FIG. **2** and, with the direction of rotation of the gear elements as set forth above, has a leading end **56** and a terminus **57.** In the pump application, this is the pressure port. The relation of the gear elements provides for two cross-over areas wherein fluid communication between the fluid ports **50** and **55** is blocked as well as communication between fluid chambers which are then in fluid communication with the respective fluid ports.

In FIG. **2,** a tooth **41***a* of the outer gear element **36** is shown in close relation with the mating tooth space

of the inner gear element **35** at one cross-over area. The other cross-over area is defined by engagement of a pair of teeth **40***a* and **40***b* of the inner gear element **35** with teeth **41***b* and **41***c* of the outer gear element **36.** Again with the rotation of the gear elements in a clockwise direction, there is a gradually increasing space between the gear elements in moving from the cross-over area defined by tooth **41***a* of the outer gear element to the other cross-over area to draw fluid into the pump and with the fluid chambers beyond the latter cross-over area gradually decreasing in size to pump fluid from the device until they reach the cross-over area having tooth **41***a.*

As is well known, the fluid connections to the device can be reversed to have the fluid port **50** connected to a source of fluid under pressure whereby the device will function as a motor to drive the output shaft **30.**

The face of the outer case part **10** is provided with kidney-shaped recesses **60** and **61** shaped similarly to the fluid ports **50** and **55** to balance forces acting on the gear elements because of the fluid ports **50** and **55.**

When the hydraulic power translating device is operated as a motor with pressure fluid supplied to port **50,** there is a hydrostatic condition existing on start-up wherein the forces applied hydraulically to the gear elements resultingly force the outer gear element **36** generally in the direction of the arrow A, shown in FIG. **2.** This tends to bind the outer gear element **36** on start-up. Improvements in starting torque are obtained by exerting fluid pressure on the exterior periphery of the gear element **36.** The pressure is applied on the exterior of the outer gear element by a restricted fluid flow through a conducting passage surrounding the outer gear element and defined therewith by the adjacent faces of the outer case parts **10, 11** and the wall **37** of the case ring **12.** The restricted flow provides a controlled pressure drop to obtain radial balance of the outer gear element **36** by the particular location of the entry and exit points of the fluid flow into the path partially surrounding the outer gear element **36.** As shown particularly in FIGS. **1** and **2,** the fluid port **50** is the pressure port when the device is operating as a motor and a passage **70** connects the inlet opening **45** with a recess **71** formed in the internal wall **37** of the case ring **12.** Controlled limited flow then passes about the exterior of the outer gear element **36** until the flow reaches a recess **72** formed on the internal wall **37** of the case ring **12.** The recess **72** communicates with the fluid outlet **46** through a passage **73** in the outer case part **11.**

The film of fluid rolls with the outer gear element **36** and moves the latter element away from the case ring **12.**

The location of recesses **71** and **72** is approximately coincident with the beginning **51** of fluid port **50** and the terminus **57** of fluid port **55.** With the entry of pressure at location **71** there is a force acting in opposition to the lockup force represented by arrow A.

The hydraulic power translating device also has improved structure providing for reduced torque variations or torque ripple with quieter, smoother operation. This structure is in the form of accumulator means of limited capacity defined by a series of recesses formed in the faces of outer case parts **10** and **11.** These are arranged to axially balance the inner and outer gear elements. The accumulator means is in the form of three pairs of recesses with one recess of each pair being formed in the outer case part **10** and the other recess of each pair being formed in the outer case part **11.** These pairs of recesses are shown in FIG. **3** with a first pair of recesses being identified at **80** and **81,** the second pair at **82** and **83,** and the third pair at **84** and **85,** with the recesses **80, 82** and **84** being in outer case part **10** and recesses **81, 83,** and **85** being in outer case part **11.**

The pair of recesses **80** and **81** are located in the cross-over area having the tooth **41**a of the outer gear element **36** and with the center of the circularly-dimensioned recess being centered on the root diameter of the inner gear element **35** whereby fluid within the recesses **80** and **81** act equally upon generally equal areas of the sides of both the inner and outer gear elements.

The second and third pair of recesses are at the other cross-over area. The pair of recesses **82** and **83** are centered on the root diameter of the inner gear element **35,** while the third pair of recesses **84** and **85** are centered at the root diameter of the outer gear element **36.** The pairs of recesses communicate with the fluid chambers at the cross-over areas wherein trapped fluid is subjected to compression as well as cavitation. The pairs of recesses provide additional fluid-holding areas wherein the bulk modulus of fluid held therein can function to provide an accumulator action to compensate for compression, cavitation, and tolerance and natural frequency variations in the mechanical structure. Additionally, the recesses function as balancing ports to provide axial balance for the inner and outer gear elements **35** and **36.**

The capacity of the recess pairs **82–85** must be limited to a fluid-holding capacity since, if too large, the action provided thereby would be too slow (in trying to control the rate of compression) and result in a sloppy system.

The recesses must be of sufficient capacity whereby the total effect of the bulk modulus of the fluid will provide the desired results. By test it has been found that satisfactory operation will occur if recesses **82–85** have a total fluid volume in a range generally 3–20 percent of the volume of a fluid chamber of maximum size, with optimum capacity being preferably in the range of 5–10 percent.

The pairs of recesses **80–85** are out of communication with the fluid ports **50** and **55** at all times. The series of recesses formed in each of the case parts lie along a line which is radial of the shaft **30** and inner gear element **35** and which is also the line along which the gear elements are eccentrically offset.

We claim:

1. A hydraulic power translating device comprising, a case, partially meshing inner and outer gear elements rotatably mounted in said case with said outer gear element being internally toothed and eccentrically mounted relative to the inner gear element whereby a series of fluid chambers are defined between said gears and with said gears having their teeth interrelated at two cross-over areas wherein fluid communication is blocked between said fluid chambers at either side of said cross-over areas, a pair of kidney-shaped fluid ports in said case intermediate said cross-over areas, means subjecting the circumferential exterior of said outer gear to fluid pressure to obtain radial balance thereof, and accumulator means positioned at said cross-over areas communicating with opposite sides of

both the inner and outer gear elements and with the space defined therebetween whereby said elements are axially balanced and noise of operation is reduced as well as torque variations.

2. A hydraulic power translating device as defined in claim **1** wherein said device is a motor and said means for obtaining radial balance of the outer gear element includes means defining a restricted fluid flow path from the fluid port receiving pressure fluid to the outlet fluid port with said path extending around the exterior of the outer gear element from a location near the leading end of the pressure fluid port to a location near the terminus of the outlet fluid port.

3. A hydraulic power translating device as defined in claim **2** wherein said restricted fluid flow path includes a pair of passages in said case extending one from each of said fluid ports and each communicating with one of a pair of recesses formed one at each of said locations in a part of the case surrounding said outer gear.

4. A hydraulic power translating device as defined in claim **1** wherein said accumulator means comprises recesses formed in said case.

5. A hydraulic power translating device as defined in claim **1** wherein said accumulator means comprises three pairs of recesses with the recesses of a pair being formed in said case at opposite sides of said gear elements, all three pairs of recesses being in the cross-over areas with one pair of recesses being centered on the root diameter of the inner gear element at the cross-over area where the tip of an outer gear element tooth and the adjacent root of the mating tooth space of the inner gear element are closely adjacent, the second and third pair of recesses being at the other cross-over area, the second pair of recesses being centered on the root diameter of the inner gear element and the third pair of recesses being centered on the root diameter of the outer gear element, and all of said recesses at one side of the gear elements lying along a line which is radial of said inner gear element.

6. A hydraulic pump of the gerotor type comprising, a case, an inner gear element and an outer gear element rotatably mounted in said case with said outer gear element eccentrically mounted relative to the inner gear element whereby a series of fluid chambers are defined between said gears and with said gears having their teeth interrelated at two cross-over areas wherein fluid communication is blocked between said fluid chambers at either side of said cross-over areas, a pair of kidney-shaped fluid ports intermediate said cross-over areas for completing a flow path through the device, and recesses in said case for fluid positioned at said cross-over areas communicating with opposite sides of both the inner and outer gear elements and with the space defined therebetween whereby said elements are axially balanced and noise of operation is reduced as well as torque ripple.

7. A hydraulic power pump as defined in claim **6** wherein there are three pairs of said recesses with a recess of each pair being formed in said case at a side of said gear elements, a pair of recesses being at opposite sides of said gear elements, all three pairs of recesses being in the cross-over areas with one pair of recesses being centered on the closely adjacent tip of an outer gear element tooth and the adjacent root of the mating tooth space of the inner gear element at one cross-over area, a second pair of recesses being bisected by a mating tooth space on the inner gear element, the third pair of recesses being bisected by a mating tooth space of the outer gear element, and the last two pairs of recesses being at the other cross-over area.

8. A hydraulic power pump as defined in claim **7** wherein the last two pairs of recesses are generally circular limited depth recesses to hold a limited amount of fluid in the range of generally 3–20 percent of the volume of a maximum fluid chamber size and preferably in the range of 5–10 percent.

9. A hydraulic pump of the gerotor type as defined in claim **6** wherein there are three pairs of said recesses of limited size with the recesses of a pair being formed in said case at opposite sides of said gear elements, all three pairs of recesses being in the cross-over areas with one pair of recesses being centered on the root diameter of the inner gear element at the cross-over area where the tip of an outer gear element tooth and the adjacent root of the mating tooth space of the inner gear element are closely adjacent, the second and third pair of recesses being at the other cross-over area the second pair of recesses being centered on the root diameter of the inner gear element and the third pair of recesses being centered on the root diameter of the outer gear element, the second and third pair of recesses having a total volume of approximately 10 percent of the volume of a fluid chamber of maximum size, and all of said recesses at one side of the gear elements lying along a line which is radial of said inner gear element.

10. A hydraulic pump of the gerotor type comprising, a case, an inner gear element and an outer gear element rotatably mounted in said case with said outer gear element eccentrically mounted relative to the inner gear element whereby a series of fluid chambers are defined between said gears and with said gears having their teeth interrelated at two cross-over areas wherein fluid communication is blocked between said fluid chambers at either side of said cross-over areas, a pair of kidney-shaped fluid ports intermediate said cross-over areas, a pair of recesses formed in said case at one of said cross-over areas, two additional pairs of recesses in said case at the other of said cross-over areas where there is a maximum size fluid chamber, all of said recesses communicating with opposite sides of both the inner and outer gear elements and with the space defined therebetween whereby said elements are axially balanced and said recesses provide small fluid accumulators to reduce the noise of operation as well as torque variations.

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