Oct. 18, 1960 R. W. BRUNDAGE 2,956,506

HYDRAULIC PUMP OR MOTOR

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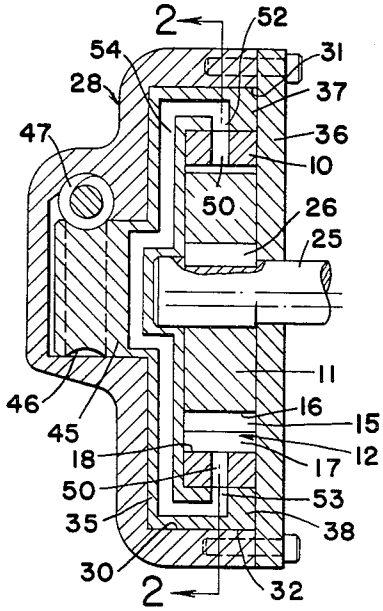


FIG. 1

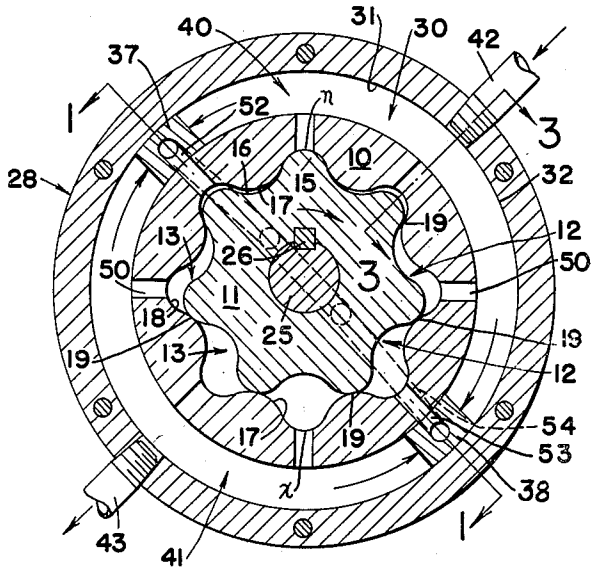


FIG. 2

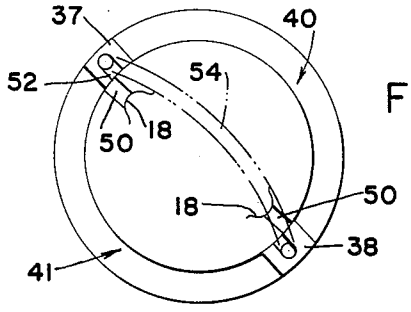


FIG. 4

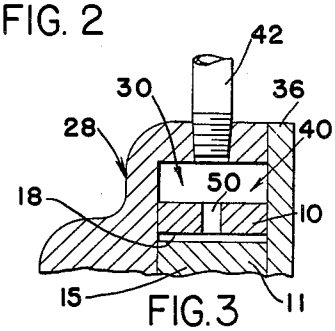


FIG. 3

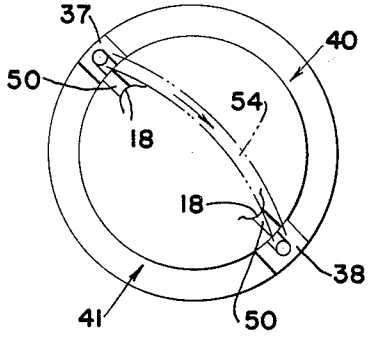


FIG. 5

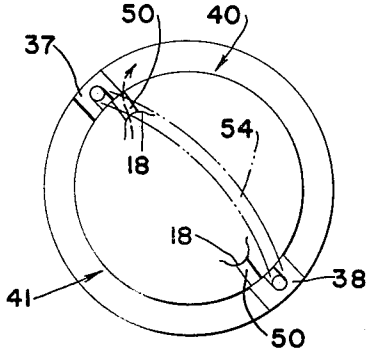


FIG. 6

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HYDRAULIC PUMP OR MOTOR

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FIG. 9

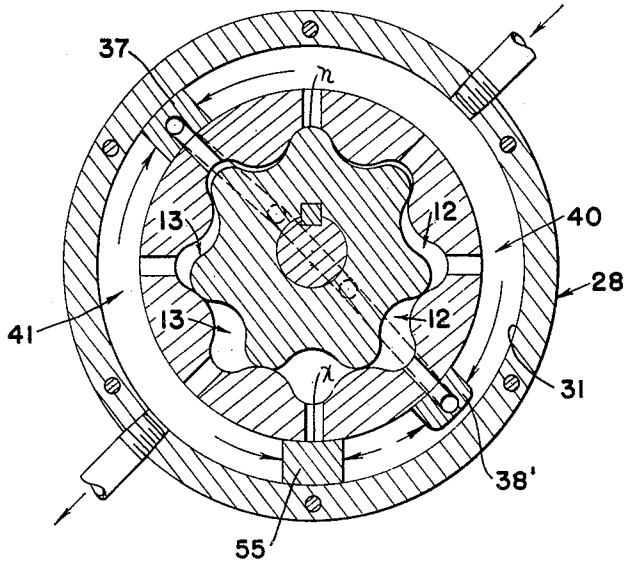
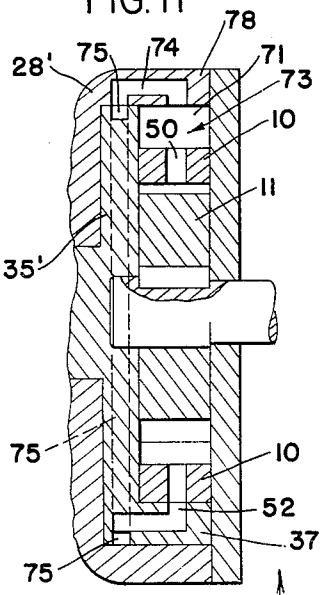


FIG. 11



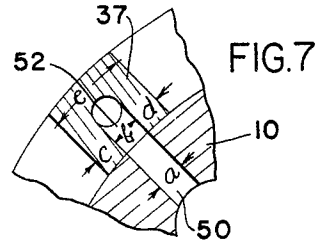


FIG. 7

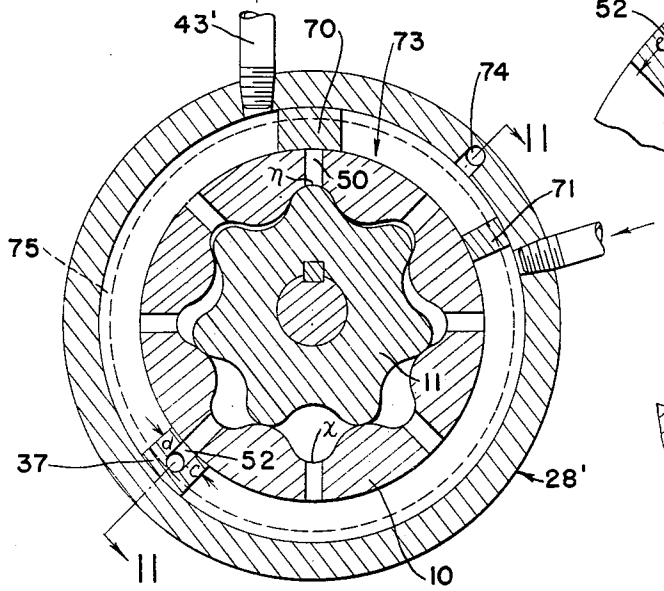


FIG. 10

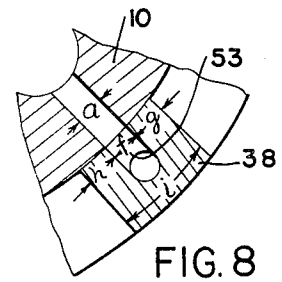


FIG. 8

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FIG. 12

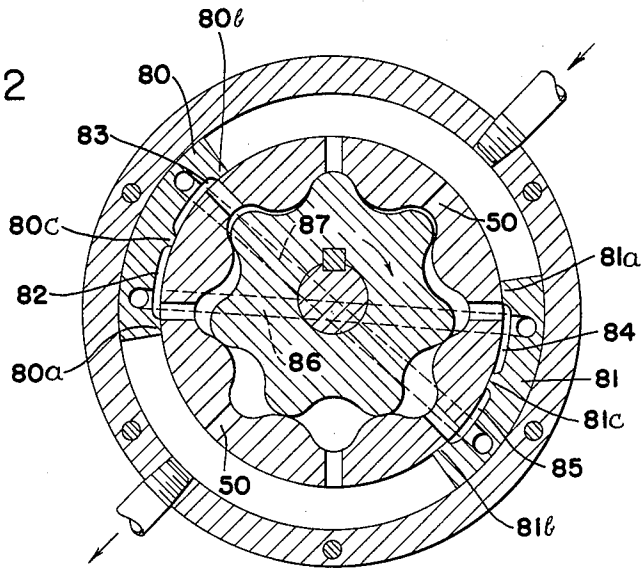
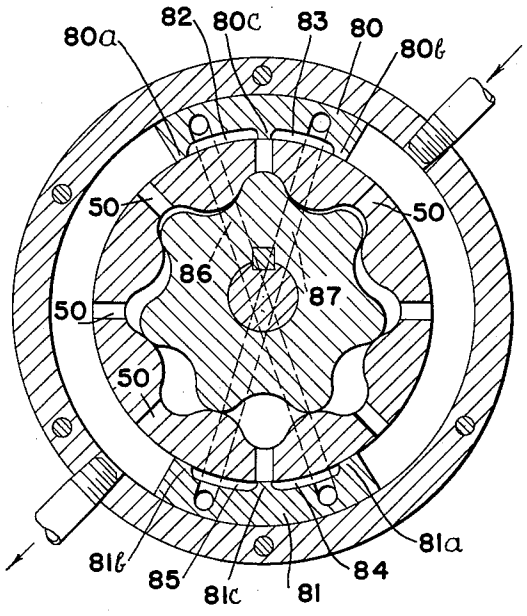


FIG. 13



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United States Patent Office 2,956,506 Patented Oct. 18, 1960

2,956,506

HYDRAULIC PUMP OR MOTOR

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Filed Nov. 21, 1955, Ser. No. 548,022

2 Claims. (Cl. 103—120)

This invention pertains to the art of hydraulic pumps or motors and more particularly to rotary positive displacement hydraulic pump or motor of the type having constantly increasing and decreasing volume chambers which are commutated by lands from inlet to outlet manifolds and vice versa.

The invention is particularly applicable to internal-gear type rotary pumps or motors and will be described as applied thereto although it will be appreciated that the invention is equally applicable to, without limitation, vane or barrel type pumps or motors.

Such pumps or motors are normally comprised of a plurality of members relatively movable to each other and defining a plurality of pumping or motor chambers revolving in a fixed closed path of movement which gradually increase and decrease in volume to thus receive and discharge a hydraulic fluid. Each chamber has an opening or passage movable therewith for communicating it with one or the other of the manifolds. The manifolds are separated by lands which momentarily close the openings or passages as the openings move from one manifold to the other.

The width of these lands relative to the width of the passages communicating the chambers with the manifolds in the direction of movement heretofore has been a very important part of pump design and operation.

Thus, if the width of the land is narrower than the width of the passage, then for an instant in the arc of rotation of the passage past the land, fluid can leak from the outlet manifold to the inlet manifold around the land through the passage. With high pressure pumps substantial amounts of fluid can leak past the land in such event. This is ordinarily called "leakage."

If the land is wider than the passage and for example, the land is positioned adjacent a point in the movement of the chambers where they are decreasing in volume, it will be appreciated that for an instant in the arc of rotation no fluid can leave the chamber and very high pressures within the chamber can result. This is ordinarily termed "trapping" and is considered very detrimental in pumps of the type to which this invention pertains. Trapping is the principal problem with which the present invention deals.

If the land is wider than the passage and is adjacent a point in the arc of movement of the chambers where their volume is increasing, there is an instant when fluid cannot enter the chamber and a "vacuum" results. A vacuum produces only relatively small pressure differentials from that which ordinarily exist and is not considered particularly detrimental. The present invention in some instances makes use of this vacuum to alleviate the problem of trapping.

Because of the problems of trapping and vacuum, it has heretofore been conventional to position the lands opposite the point of minimum and maximum volume where the problems of trapping and vacuum are minized. Here the rate of volume change per arc of rotation is relatively low. Also, with the land positioned adjacent the point of maximum volume, there is a vacuum created in the chamber as it approaches the point which offsets the trapping which would occur after the chamber goes from increasing volume to decreasing volume.

However, in substantially all pumps of the type to which this invention pertains there is a problem of leakage between the individual chambers, one exposed to a high pressure and the other to a low pressure, between the surfaces which separate the two chambers. It has been considered desirable to increase the width of a land, either positioned adjacent the points of minimum and maximum volume or otherwise in the pump, so that the land will cover a span of two or more chambers. In such a case, however, the problem of trapping becomes a very serious problem.

This problem of trapping also exists in a serious way where the lands are of a width to prevent leakage and are moved from the points of minimum and maximum volume so as to adjust the volume of fluid passing through the pump or motor for a given arc of rotation or per unit movement.

One method and arrangement for preventing some of the difficulties referred to above has been described in my copending patent application Serial Number 497,779, filed March 29, 1955, now Patent No. 2,898,862. In this application, an arrangement is described wherein only the land normally located adjacent the point of minimum chamber volume is adjustable in the direction of rotation, that is, in the direction of increasing volume. The other land, namely the one adjacent the point of maximum volume of the chambers, remains fixed. With such an arrangement, some of the fluid under pressure in the outlet manifold flows into some of the increasing volume chambers. These increasing volume chambers then act as a motor to recover the energy of the fluid or at least part of it.

The present invention contemplates a rotary pump or motor of a positive displacement type wherein the lands may be of any relative width relative to the passages communicating the chambers with the manifolds, which is efficient, which avoids the problems of trapping and leakage and is simple in construction.

In accordance with the invention, a positive displacement hydraulic pump or motor is provided comprised of a plurality of members relatively movable to each other and defining a plurality of pumping chambers revolving in a fixed closed path of movement, inlet and outlet manifolds and an opening or passage movable with each chamber communicating the chambers with either the inlet or outlet manifolds, a pair of lands sealingly separating the manifold and having a line-of-movement width greater than the line f movement width of the passage communicating each chamber with the two manifolds, and a passage closed to the inlet and outlet manifolds, having a first opening progressively communicating with the decreasing volume chambers and a second opening progressively communicating with the increasing volume chambers, when adjacent to their respective lands.

With this arrangement fluid, which would ordinarily be trapped in the decreasing volume chamber, can flow into the passage and thence into an increasing volume chamber, whereby the trapping pressures are prevented.

Further, in accordance with the invention, the passage openings may be simultaneously in communication with decreasing and increasing volume chambers providing that the increasing volume chamber is increasing in volume at a rate equal to or greater than the rate of decrease of decreasing volume chambers.

Further, in accordance with the invention, the passage opening may communicate, first, with an increasing

volume chamber and, then, with a decreasing volume chamber, whereby a vacuum is first created in the passage to prepare the passage to receive fluid from the decreasing volume chamber when the passage opening next comes into communication therewith.

Still further, in accordance with the invention, either one or both lands may be made adjustable over the entire arc of movement of the chambers whereby the volume of fluid passing through the proper motor for a given arc of rotation may be adjusted.

Still further, in accordance with the invention, either one or both lands may each have a width greater than the span between two chambers and a pair of passages closed to each other and the manifold, and having openings communicating progressively with the chambers having a volume change in opposite direction, whereby to relieve the trapping which would ordinarily occur.

Still further, in accordance with the invention, each land is comprised of two spaced auxiliary lands having a width in the direction of movement less than the line of movement width of the passage and the space between the lands is the passage opening.

The principal object of the invention is the provision of a new and improved hydraulic pump or motor of the type where the increasing-decreasing volume chambers thereof are commutated from one manifold to another by lands wherein the lands may be of any width and may be positioned relative to the points of minimum and maximum volume of the chambers without difficulties from trapping or vacuum.

Another object of the invention is the provision of a new and improved hydraulic pump of the positive displacement type which, for a fixed drive speed, has a variable volume output at higher efficiency than heretofore obtainable.

Still another object of the invention is the provision of a new and improved hydraulic motor of the positive-displacement type which for a fixed or predetermined flow of fluid has a variable output speed at higher efficiency than heretofore obtainable.

Another object of the invention is the provision of a new and improved hydraulic pump or motor of the positive displacement type wherein one or more of the lands are adjustable and the difficulties with trapping and leakage are alleviated.

Another object of the invention is the provision of a new and improved positive displacement hydraulic pump or motor having a wide stop adjustable over at least portions of the arc of decreasing-volume chambers and means are provided for receiving trapped fluid from a decreasing-volume chamber when trapping would occur and flowing it to an increasing-volume chamber.

Another object of the invention is the provision of a new and improved hydraulic pump or motor having an adjustable land or lands for the purpose of controlling the volume of fluid or the speed of the motor wherein means are provided for bypassing any trapped fluid to the increasing-volume chambers.

The invention may take physical form in certain parts and arrangements of parts, all differing radically in appearance one from the other, preferred embodiments of which will be described in detail in this specification and illustrated in the accompanying drawings, which is a part hereof and wherein:

Figure 1 is a side cross-sectional view of an internal gear type pump or motor embodying the present invention.

Figure 2 is a cross-sectional view of Figure 1 taken approximately on the line 2—2 thereof.

Figure 3 is a fragmentary detail view of Figure 2 taken approximately in the line 3—3 thereof.

Figures 4, 5 and 6 are schematic views similar to Figure 2 showing the relationship of the parts at three different points in the arc of rotation.

Figures 7 and 8 are fragmentary enlarged views of the stops of Figure 2 to show the relationship of certain critical dimensions.

Figures 9, 10, 12 and 13 are views similar to Figure 2 but showing alternative embodiments of the invention, and

Figure 11 is a fragmentary enlarged view of Figure 10 taken approximately on the line 11—11 thereof.

Referring now to the drawings wherein the showings are for the purposes of illustrating a preferred embodiment of the invention only, and not for the purposes of limiting same, Figures 1 and 2 show a plurality of, in this case two, members 10—11 relatively movable to each other and so formed as to define a plurality of chambers 12, 13 which respectively increase and decrease in volume as the members move. The reference character 12 indicates those chambers which are increasing in volume and the reference character 13 indicates those which are decreasing in volume.

The members 10—11 could be either the relatively movable members of a vane type pump, the movable members of a reciprocating rotatable cylinder or wobble plate type pump, or any other form of pump wherein there are a plurality of chambers which progressively increase and decrease in volume as the members move, and part of the chambers are continuously in communication with the input manifold and another part of continuously in communication with an output manifold.

In the embodiment of the invention shown, an internal gear type pump is employed comprised of an inner-gear which will be referred to by the reference character 11 and an outer-gear which will be hereinafter referred to by the reference character 10, and these two gears rotate relative to each other, with the direction of rotation being assumed for the purposes of describing the invention as clockwise.

The inner-gear 11 has a plurality of teeth 15, and intermediate roots 16 which mesh with teeth 17 and roots 18 of the outer gear 10. There is one less tooth 15 on the inner gear 11 than there is on the outer gear 10, and the shape of the teeth and roots is so arranged that at all times each tooth 15 will have a point 19 of sealing engagement with the tooth 17 of the outer gear 10. Obviously there could be greater than one tooth differential.

The axes of rotation of the two gears 10, 11 are offset one from the other and in the embodiments shown there is a point n of minimum volume and a point x of maximum volume of the chambers 12, 13. It will be noted that a line through the points n, x divides the chambers 12 and the chambers 13 from each other. Obviously, when the chambers are exactly opposite either the point n or x, there is no relative increase or decrease of volume although just prior to and after passing by these two points there is a slight change of volume.

The inner gear 11 is mounted for rotation on a drive shaft 25 and is keyed thereto by means of a key 26.

The two gears 10, 11 are of the same axial thickness and are mounted for rotation in a housing 28 having a circular cavity 30 of a diameter somewhat greater than the outer diameter of the gear 10 and an outer peripheral surface 31 concentric with the outer surface 32 of the gear 10.

A control member 35 in the form of a circular plate and having a diameter generally equal to the diameter of the cavity 30 is disposed at the base thereof and with the gears 10, 11 substantially fills the cavity 30. A cover plate 36 fits over the cavity 30 and is in sealing engagement with the right hand side of the gears 10, 11 as viewed in Figure 1, as is the control member 35 which is in sealing engagement with the left hand side of the gears 10, 11 as viewed in Figure 1.

The control member 35 has two lugs or lands 37, 38 which extend axially into the space between the surfaces 31, 32 and are in sliding but sealing engagement therewith, and divide the space between the surfaces 31, 32 into an inlet manifold 40 and an outlet manifold 41.

Pipes 42, 43 communicate through the wall of the housing 28 with the inlet and outlet manifold 40, 41 respectively to provide an inlet and outlet passage for the pumps. It will be noted that the pipes 42, 43 are located about 45 degrees in the direction of rotation from the point of minimum and maximum volume *n, x*. Obviously the pipes 42, 43 could be otherwise located but because of the adjustability of the stops 37, 38 this location of the inlet and outlet points is particularly advantageous to give maximum range of adjustability with a maximum degree of efficiency.

The control member 35 is rotatably supported in the housing 28 and has a boss 45 extending into a counter bore in the housing 28. The boss 45 has worm teeth 46 formed in its surface engaged by a worm wheel 47 having a shaft not shown which extends through the side of the housing 28 and is accessible from the outside so that the control member 35 may be fixedly adjusted to any desired point.

It will be noted that the shaft 25 extends into a recess in the right hand face of the control member 35 for the purpose of providing a physically strong rotatable assembly.

Each chamber 12, 13 has a passage 50 extending radially outwardly from each root 18 through the outer surface 32 of the gear 10 communicating either with the inlet manifold 40 or the outlet manifold 41 as the gears rotate.

In operation, as the gears 10, 11 rotate the chambers 12 constantly increase in volume thus creating a suction effect. Hydraulic fluid, not shown, flows inwardly through the pipe 42 to the inlet manifold 40, then through the passages 50 to the chambers 12.

Hydraulic fluid also flows out of the decreasing volume chambers 13 through the passages 50 into the outlet manifold 41 and then through the pipe 43. The lands 37, 38 prevent communication between the inlet and outlet manifolds 40, 41. In effect the passages are commutated as they pass the lands.

If the lands 37, 38 are positioned adjacent the points of minimum and maximum volume *n, x* respectively, the pump would pump its maximum capacity. Thus all the enlarging chambers 12 would be in communication through the passages 50 with the inlet chamber 40 and all of the decreasing-volume chambers 13 would be in communication with the outlet manifold 41.

In accordance with the present invention, however, the lands 37, 38 are adjustable away from the points *n, x* to provide an adjustable output volume for the pump for a given constant rotational speed. Thus if the lands 37, 38 are adjusted to the position shown in Figure 2, it will be seen that for a portion of the arc of rotation, the increasing-volume chambers 12 will be in communication with the outlet manifold 41, thus decreasing the volume of fluid flowing through the pipe 43. In a like manner, over a portion of the arc of rotation, the decreasing-volume chambers 13 will be in communication with the inlet manifold 40 and the fluid being discharged from these decreasing-volume chambers will not flow through the conduit 43 and the volume of the output of the pump will be further reduced.

If the lands 37, 38 were adjusted to a point oriented 90 degrees from the point *n, x*, then the pump would have zero volume output. If the lands were adjusted still further from the indicated position, fluid would be pumped in the opposite direction, that is to say, the inlet manifold would become the outlet manifold and vice versa.

It will be noted that the passages 50 each have a width *a* in the direction of movement. The relationship of the width of the lands 37 in relation to the dimension *a* form an important part of the present invention. It should be noted that if the width of the land 37 is equal to or greater than the dimension *a*, then for a fraction of the arc of rotation fluid cannot be discharged nor

taken into the passage 50*a*. In the case where discharge of fluid is prevented, a situation, as previously referred to, called "trapping" arises wherein extremely high pressures internally of the decreasing-volume chamber 13 can result.

On the other hand, if the width of the land 37 is made less than the dimension *a* then for a small fraction of the arc of rotation fluid can flow from the outlet manifold around the land through the outer portions of the passage 50 to the inlet manifold 40. Leakage results. The present invention deals directly with this problem. Thus the stop 37 is actually comprised of a plurality of minor or auxiliary stops, stops 37*c* and 37*d*, two being shown, with a space 52 having a width *b* separating these two lands. In a like manner the stop 38 is comprised of two spaced stops, 38*g* and 38*h*, with an intermediate space 53 having a dimension *f* therebetween. The dimensions *b* and *f* are generally not critical and may be either greater or less than the dimension *a*. It will also be noted that the openings 52, 53 are oriented 180 degrees from each other which is preferably the case with an arrangement having an even number of chambers 12, 13. If an odd number of chambers 12, 13 were employed, then the stops 37, 38 are preferably oriented relative to each other so that the openings 52, 53 communicate with a passage 50 at the same time. The criterion for the stop orientation is that the rate of volume decrease of the chamber 13 adjacent the land 37 must be equal to or less than the rate of volume increase for the chamber 12 with which it is communicated.

It will be noted that if opening 53 communicates with an increasing volume chamber while the opening 52 is sealed from a decreasing volume chamber, a vacuum will be created within the passage 54. Thus, when the opening 52 reaches a passage 50 in communication with a decreasing volume chamber, the passage 54 will be conditioned to receive fluid from the chamber 13 and trapping will be either eliminated or considerably alleviated.

In accordance with the invention, the minor lands 37*c* and 37*d* have a width equal to or preferably slightly less than the width *a* of the passage 50. Thus no trapping can occur because of the width of these lands.

Further in accordance with the invention, the space 52 is made to communicate with an increasing-volume chamber 12 whenever the passage 50 is in communication therewith. Thus the fluid from the decreasing-volume chamber 13, when in communication with the passage 52, flows to an increasing-volume chamber. The energy of this fluid acts like a motor in the increasing volume chambers and its energy is recovered.

Further preferably in accordance with the invention, the lands 38*g* and 38*h* have a width equal to but preferably slightly greater than a width *a* of the passages 50. With these relative dimensions for a short arc of the rotation of the gear 10 there will exist a situation where no fluid can flow into the passage 50 and the adjacent increasing-volume chamber. A slight vacuum will result in this particular chamber but ordinarily vacuum is not considered detrimental in the operation of a pump. Also the vacuum creates a condition wherein the chamber is prepared to receive fluid from a chamber 13.

The operation of the invention for three different relative positions of the outer gear 10 to the lands 37—38 is shown in Figures 4, 5 and 6. Figure 4 shows the passage 50 opposite the land 37 which has a width less than its width *a*. With this arrangement normally it would be possible for fluid under pressure to flow around the land 37*c* to the passage 52. In accordance with the invention, however, the passage 52 opens to a closed passage or is in communication by means of the passages 53, 54 to an increasing-volume chamber. As shown in Figure 4, preferably the first condition holds.

Immediately, however, upon the passage 50 being cut off

from the input manifold **41**, as is shown generally in Figure 5, it comes solely into communication with the passage **52**. The invention requires that the passage **52** either has just been in or is in communication with an increasing-volume chamber **12** through the passage **54** and the passage or space **53**. As the increasing volume chamber is or was increasing in volume at the same or a greater rate, fluid can flow from the decreasing-volume chamber **13** into the passage **54**, and no trapping will occur.

Figure 6 shows the situation when the passage **50** is opposite the land **37***d* which is here also of a width somewhat less than the width *a*. It is to be noted that the lands **38***g* and **38***h* being wider than the width *a* of the passage **50** at all times prevent leakage around the stops. The vacuum which results, as above indicated, is not a problem.

The passages **50** in the embodiment shown are round drilled holes. It should be pointed out that the axial width of the passages **50**, **52** and **53** may be as desired and there is nothing critical about their relative axial dimensions. On the other hand, the relative circumferential dimensions, that is to say, in the direction of movement of the passage **50** and the spaced lands **37***c*, **37***d*, **38***g*, **38***h* is relatively critical, for the reasons above pointed out.

Thus the width of the spaces **52**, **53** may be greater than that shown. In fact, the width of the spaces **52**, **53** may be increased so that two or more passages **50** will communicate with the spaces **52**, **53** at the same time. In some respects such an arrangement may be considered desirable because there are then two or more chambers between a chamber exposed to the inlet pressure and a chamber exposed to the outlet pressure. Improved sealing between the two manifolds thus results, it being appreciated that particularly in a gear type pump of the type herein described, leakage can always occur past the points of contact of the inner gear **11** and the outer gear **10**. It is to be noted that the spaces **52**, **53** need not be in the radially inward facing surface of the lands **37**, **38** but could be in the surface of the control member **35** facing the chambers **12**, **13**.

It will thus be seen that an arrangement has been described wherein the output volume of a positive displacement type pump can be readily varied by adjusting the position of one or both stops while the problems of trapping and leakage have been entirely overcome.

Obviously the arrangement described can be applied to a motor wherein the output speed of the motor may be readily varied with a constant flow of fluid and the invention may equally be applied to a vane type hydraulic pump or motor or a rotating cylinder type motor of the reciprocating-piston, wobble-plate type.

Figure 9 shows an alternative embodiment of the invention where in effect only one land is adjustable, namely the stop **37** which, for maximum volume, would be positioned opposite the point *n*.

The other land **38'** is so modified that its outer surface is not in sealing engagement with the surface **31** of the cavity. Thus the land **38'** moves within the inlet manifold but does not divide the manifold into two manifolds each sealed from the other. In this embodiment a fixed land **55** is provided positioned opposite the point *x*, namely the point of maximum chamber volume. This land **55** is fixed to the housing **28** and divides the outlet manifold **41** from the inlet manifold **40**. The operation of the pump shown in Figure 9 is generally identical to that of the embodiment shown in Figures 1 through 8 with the exception that the increasing volume chambers **12** communicate with the inlet manifold **40** over approximately 180 degrees of arc. On the other hand, the decreasing volume chambers **13** communicate with the outlet manifold over an adjustable arc less than 180 degrees. Thus as the land **37** is moved in a counterclockwise direction, that is against the direction of rotation, a greater and greater number of the decreasing-volume chambers **13** are cut off from the outlet manifold and communicated to the inlet manifold **40**. The output volume of the pump is thus decreased.

The function of the spaced lands and the intermediate space on both stops **37** and **38'** is as before.

Figure 10 shows a still further alternative embodiment of the invention.

In this embodiment of the invention, the control member **35'** has a land **37** thereon constructed identically to the land **37** of Figure 2. The opposite land is comprised of in effect two fixed and spaced minor lands, a minimum volume land **70** of a width to prevent leakage and, inasmuch as trapping is not a problem at this point *n*, of a substantial width and a land **71** substantially spaced from the land **70** to provide a space **73** therebetween which communicates with the passages **50** as the gears rotate. The space **73** also communicates continuously with the opening **52** through passage **74** and a passage **75** formed in the periphery of the control member **35'**.

It will be further noted in Figure 10 that the discharge pipe **43'** has been moved so as to be adjacent to the land **70**. It will be noted that in effect the land **37** is movable from the point of maximum chamber colume *x* in the direction of rotation so as to reduce the pump volume and thus the output pipe **43** must be so positioned.

It will be seen that the general operation of the pump shown in Figure 10 is quite similar to that of the preferred embodiment. Whenever trapping would occur, the opening or space **52** communicates through the passages **74**, **75** to the space **73** which at all times will be in communication with a passage **50** leading to an increasing-volume chamber **12**. It will also be appreciated that during portions of the arc of revolution the increasing-volume chambers **12** will be shut off to a supply of fluid and a vacuum will then result but as above pointed out such vacuum is not detrimental to the successful operation of pump shown.

Figures 12 and 13 show a still further alternative embodiment of the invention, Figure 12 showing the pump adjusted for reduced output volume and Figure 13 showing the pump with stops adjacent to points of minimum and maximum volume.

Thus, in Figures 12 and 13 there is provided a land **80** opposite the decreasing volume chambers and a land **81** opposite the increasing volume chambers. The land **80** is comprised of three minor stops, **80***a*, **80***b* and an intermediate land **80***c*.

The land **81** likewise is comprised of two outer minor lands **81***a* and **81***b* and an intermediate minor land **81***c*. A space **82** exists between the lands **80***a* and **80***c* and a space **83** exists between the lands **80***c* and **80***b*. In a like manner a space **84** exists between lands **81***a* and **81***c* and a space **85** exists between the lands **81***c* and **81***b*. The spaces **82** and **84** are intercoupled by a closed passage **86** and the spaces **83** and **85** are interecoupled by a closed passage **87**.

The minor stops **80***a*, **80***b* and **81***c* are all preferably less in width than the width of the passage **50**. The lands **81***a* and **81***b* may be equal to or slightly greater than the width of the passages **50**.

Figure 13 shows the identical construction with the lands **80**, **81** being located opposite the point of minimum and maximum volume respectively.

The arrangement shown has the land **80** and the land **81** spanning the width of two chambers **13**, **12** respectively. The result of the construction shown is that there are always two chambers between a point of high pressure and a point of low pressure in the pump. There is a tendency for leakage to occur between the lines of engagement of the outer gear **10** and the inner gear **11**. With the arrangement shown in Figures 11 and 12 there are two such lines of engagement between a point of high pressure and point of low pressure. The leakage is thus substantially reduced.

In all the embodiments shown, passages 50 have been shown as leading from each increasing or decreasing volume chamber 12 or 13 and the discharge to these chambers is from the periphery of the outer gear 10. It will be appreciated that the inlet and discharge from these chambers can be axial rather than radial as shown. In such event lands will have to be provided on the sides of the members 10, 11 which lands will have to have a width at least equal to the circumferential width of one of the chambers and at least somewhat greater. The same principles will apply however in that the total width of the lands will be greater than the circumferential width of a chamber and a space will be provided which will communicate to the diametrically opposite stop.

The embodiments of the invention described are obviously preferred embodiments and are used for the purposes of illustrating the invention only. It will be appreciated that other embodiments of the invention differing radically in appearance from those shown will occur to others upon a reading and understanding of this specification, and it is my intention to include all such modifications and alterations insofar as they come within the scope of the present invention.

Having thus described my invention, I claim:

1. A positive displacement hydraulic device comprised of a plurality of members movable relatively to each other and defining a plurality of chambers revolving in a fixed, closed path of movement, said chambers gradually increasing in volume after they pass a fixed point of minimum volume on said path of movement until they reach a fixed point of maximum volume on said path of movement, and then gradually decreasing in volume until they reach said fixed point of minimum volume, means defining an arcuate inlet and an arcuate outlet manifold including first and second lands, one at each arcuate end of said manifold and sealingly separating said manifolds one from the other, the manifolds and lands being disposed circumferentially along the path of movement of the chambers, and an opening for each chamber which revolves therewith, each of said openings moving past said lands to alternately shift communication of its associated chamber to either said inlet or said outlet manifold, at least said first land being adjustable along the path of movement of said decreasing volume chambers so as to change the point in the path of movement of such chambers in which each opening moves past said first land and shifts communication of its decreasing volume chamber from one manifold to the other, the improvement which comprises said first land having a line of movement width greater than the line of movement width of said openings, and is such that trapping will occur in a decreasing volume chamber as its opening moves past said first land, said second land is fixed adjacent the point of maximum chamber volume and said device includes a third land movable in said inlet manifold and arranged to momentarily close said openings as said openings move therepast, said third land being adjustable along the line of movement of said chambers so as to change the point in the path of movement in which each opening moves past said third land, said first land and said third land each having ports which communicate with each opening as each opening moves past said first and third lands, and means intercommunicating said ports whereby to communicate a decreasing volume chamber with an increasing volume chamber when the openings of said chambers move past said first and third lands.

2. A positive displacement hydraulic device comprised of a plurality of members movable relatively to each other and defining a plurality of chambers revolving in a fixed, closed path of movement, said chambers gradually increasing in volume after they pass a fixed point of minimum volume on said path of movement until they reach a fixed point of maximum volume on said path of movement, and then gradually decreasing in volume until they reach said fixed point of minimum volume, means defining an arcuate inlet and an arcuate outlet manifold including first and second lands, one at each arcuate end of said manifold and sealingly separating said manifolds one from the other, the manifolds and lands being disposed circumferentially along the path of movement of the chambers and an opening for each chamber which revolves therewith, each of said openings moving past said lands to alternately shift communication of its associated chamber to either said inlet or said outlet manifold, at least said first land being adjustable along the path of movement of said decreasing volume chambers so as to change the point in the path of movement of such chambers in which each opening moves past said first land and shifts communication of its decreasing volume chamber from one manifold to the other, the improvement which comprises said first land having a line of movement width greater than the line of movement width of said openings, such that trapping will occur in a decreasing volume chamber as its opening moves past said first land, said second land is fixed adjacent the point of minimum chamber volume and said device includes a third land sealingly separating said inlet manifold into first and second inlet manifolds, said first manifold communicating with said increasing volume chambers immediately after they pass said minimum volume point, said second manifold communucating with said increasing volume chamber just before they reach the maximum volume point, said first land having ports which communicate with each opening as each opening moves past said first land, and means intercommunicating said port with said first inlet manifold whereby to communicate a decreasing volume chamber with said first inlet manifold when the openings of said chambers move past said first land.

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