June 13, 1950 F. W. TORRANCE 2,511,135

REACTION AND FLUID LOCK ROTARY HYDRAULIC DRIVING UNIT

Filed May 2, 1945 8 Sheets-Sheet 1

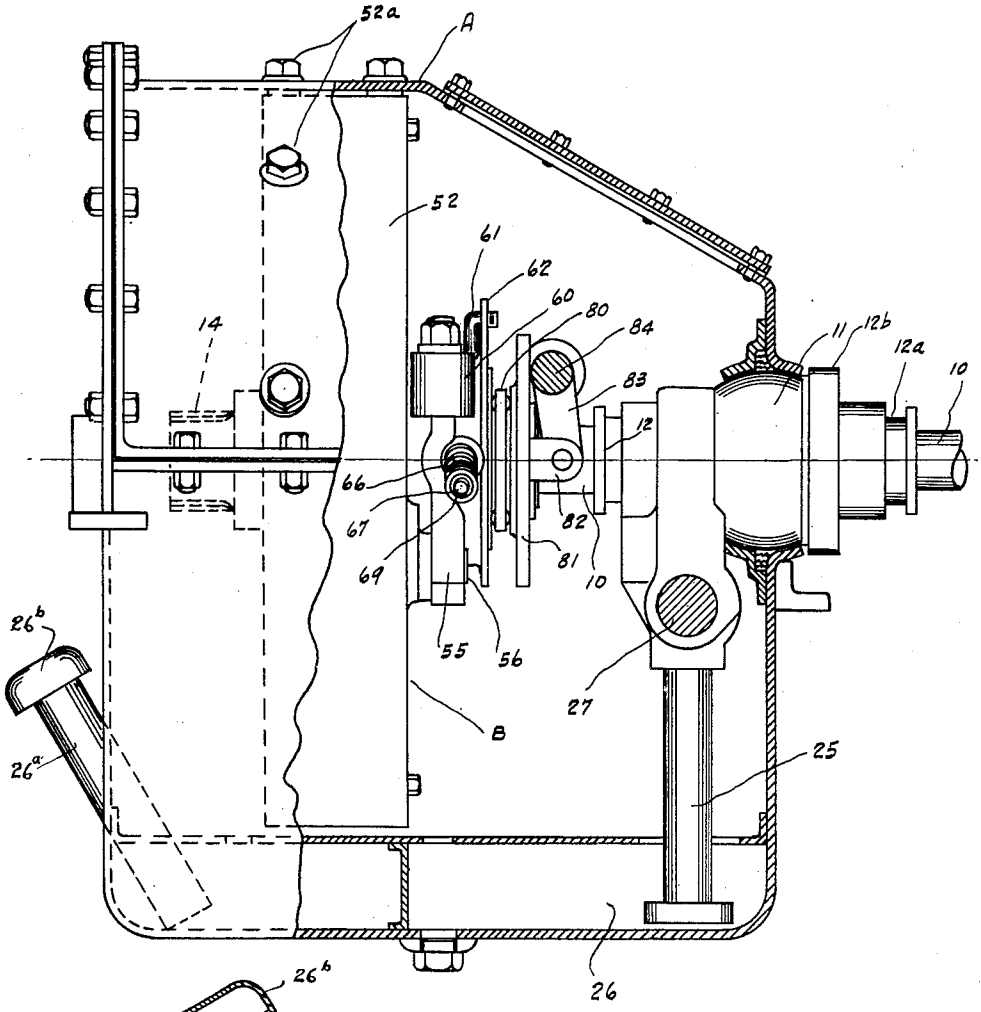


FIG.1

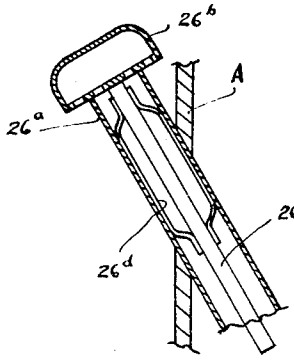


FIG.10

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REACTION AND FLUID LOCK ROTARY HYDRAULIC DRIVING UNIT

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8 Sheets-Sheet 2

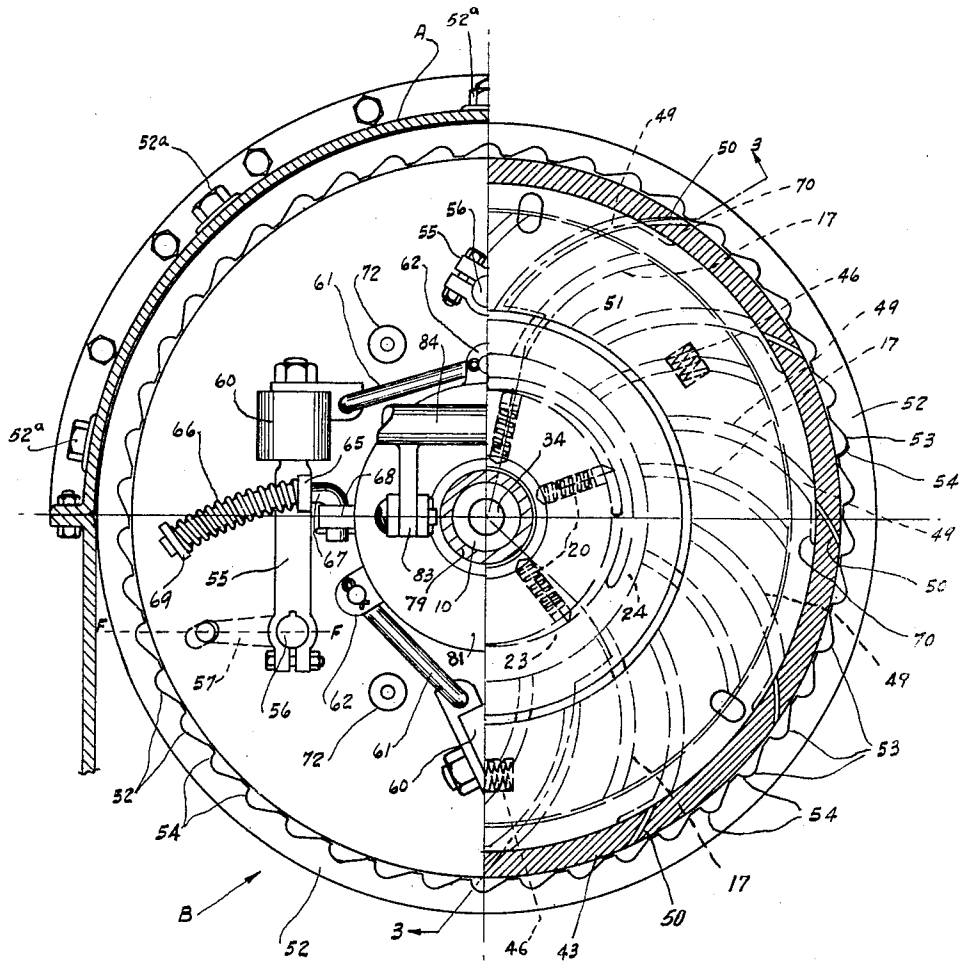


FIG. 2

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REACTION AND FLUID LOCK ROTARY HYDRAULIC DRIVING UNIT

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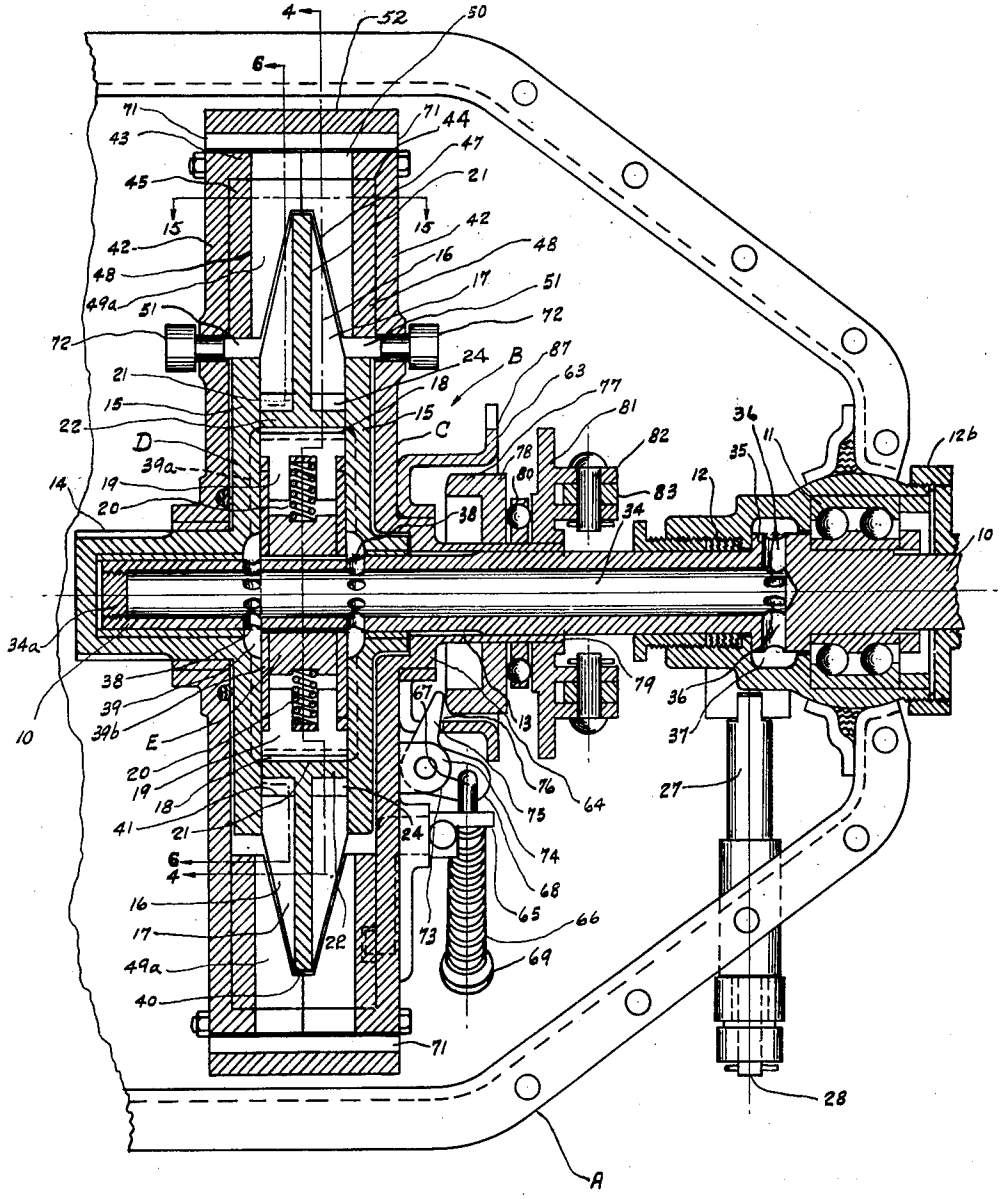


FIG. 3

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REACTION AND FLUID LOCK ROTARY HYDRAULIC DRIVING UNIT

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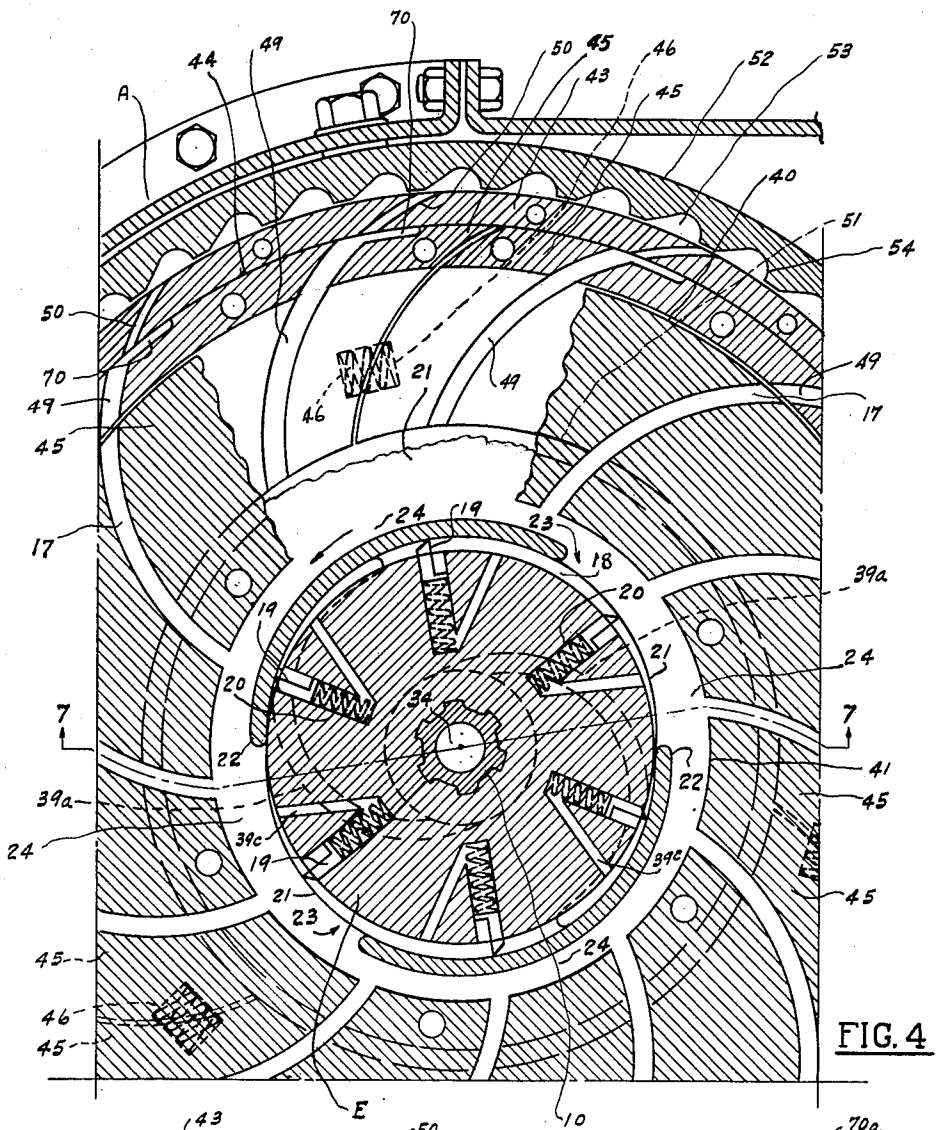


FIG. 4

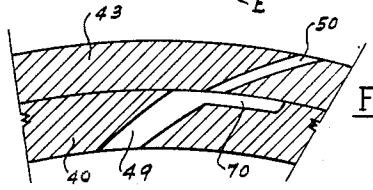


FIG. 16

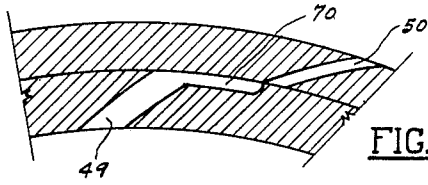


FIG. 17

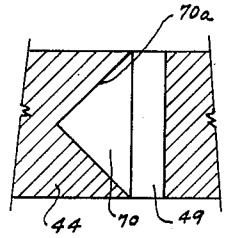


FIG. 18

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REACTION AND FLUID LOCK ROTARY HYDRAULIC DRIVING UNIT

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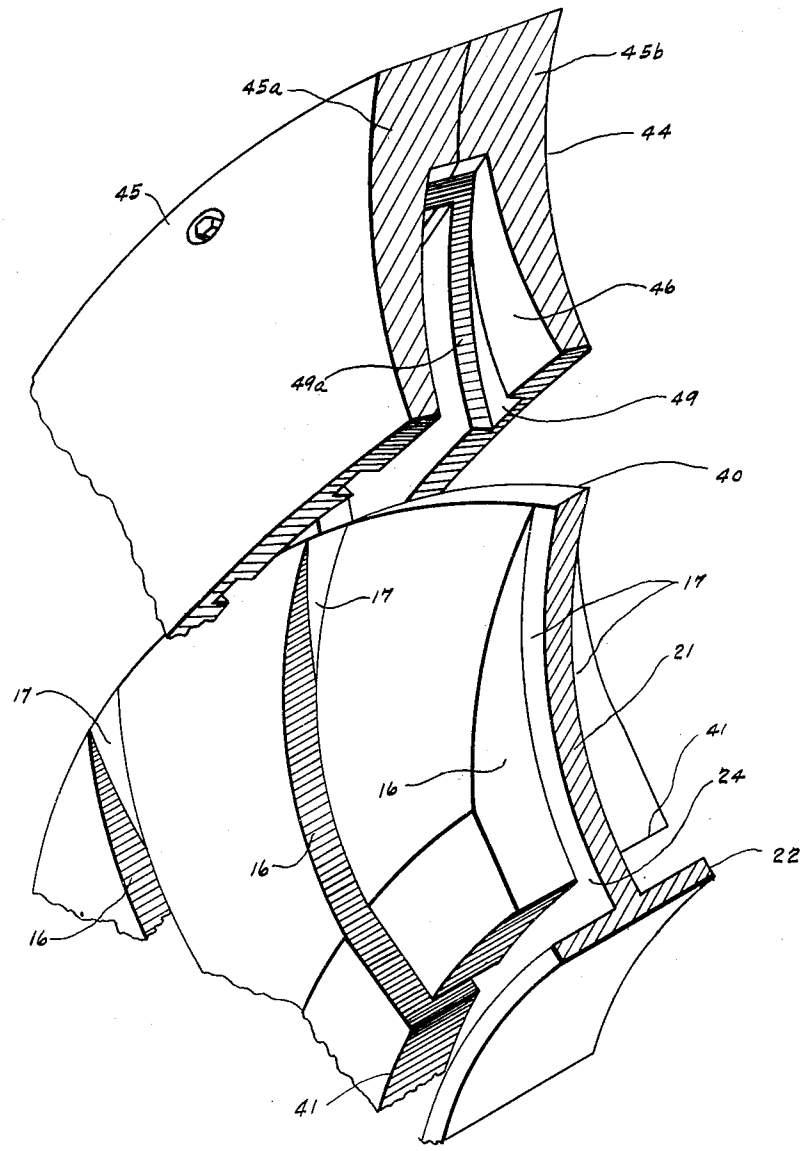


FIG 5

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REACTION AND FLUID LOCK ROTARY HYDRAULIC DRIVING UNIT

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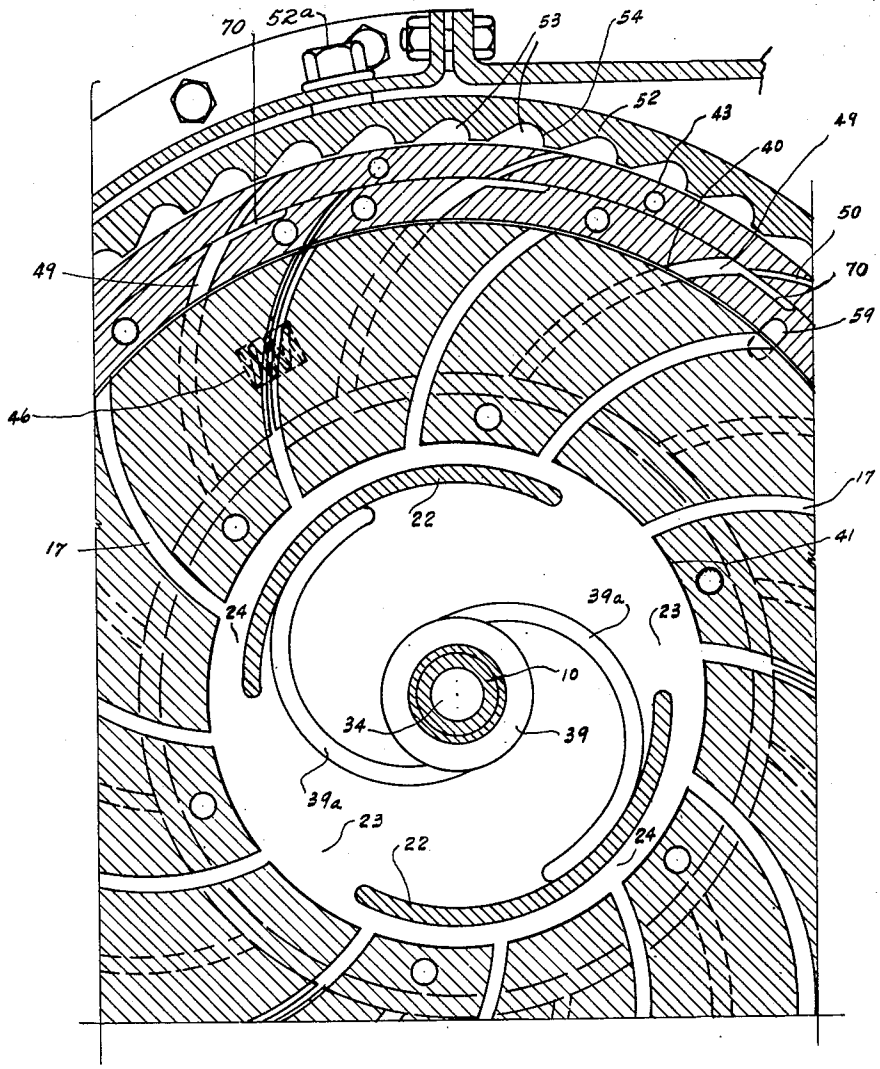


FIG. 6

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REACTION AND FLUID LOCK ROTARY HYDRAULIC DRIVING UNIT

Filed May 2, 1945 8 Sheets-Sheet 7

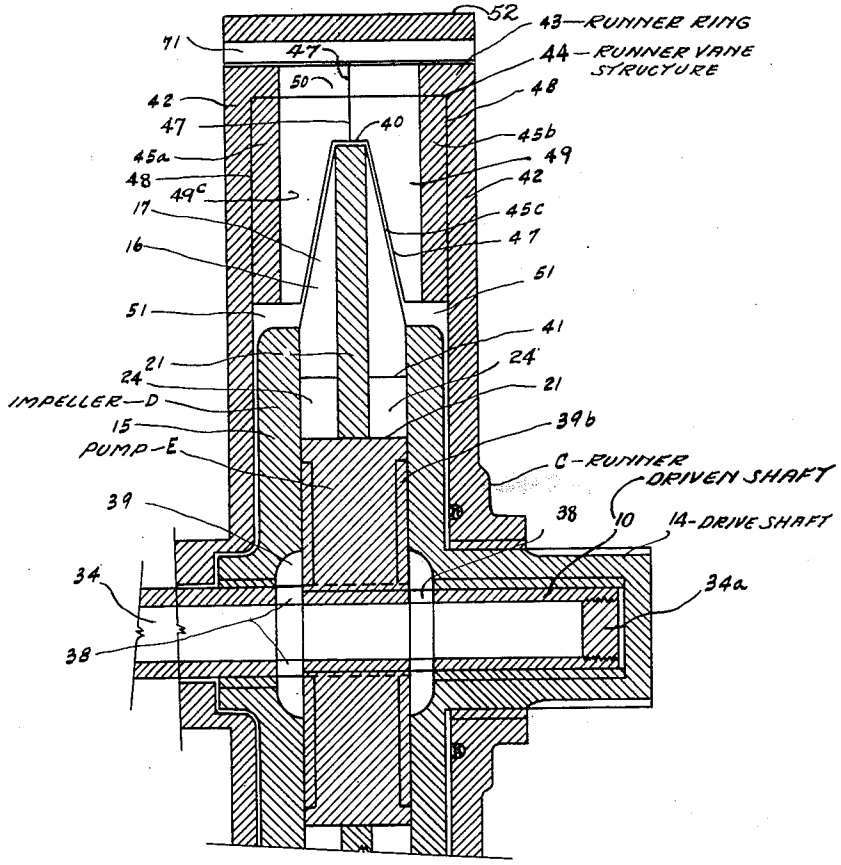


FIG. 7

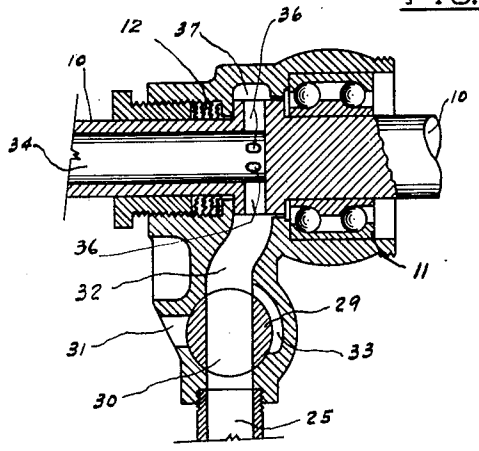


FIG. 8

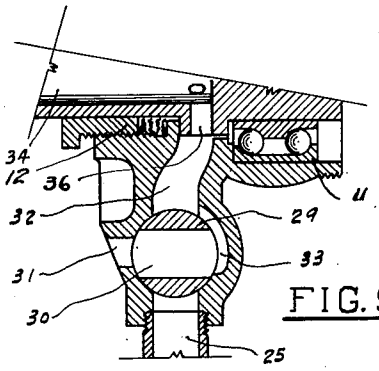


FIG. 9

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REACTION AND FLUID LOCK ROTARY HYDRAULIC DRIVING UNIT

Filed May 2, 1945 8 Sheets-Sheet 8

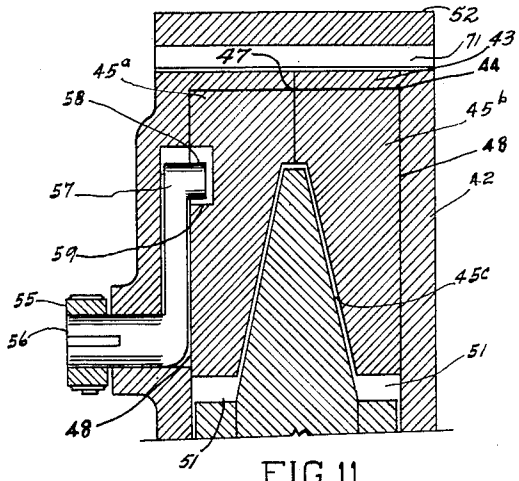


FIG. 11

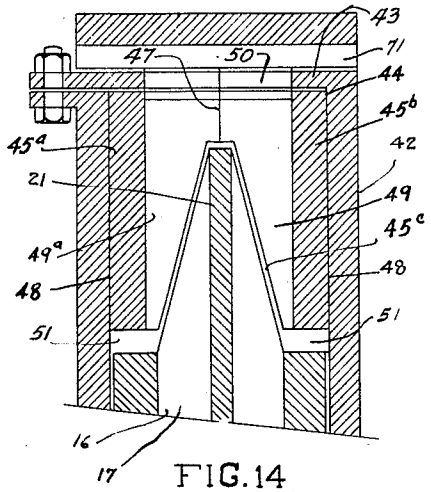


FIG. 14

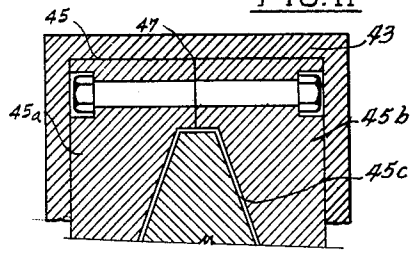


FIG. 13

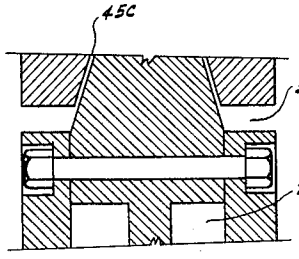


FIG. 12

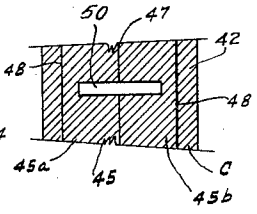


FIG. 15

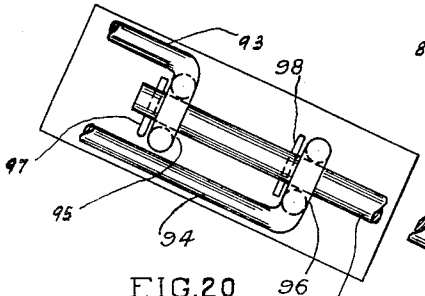


FIG. 20

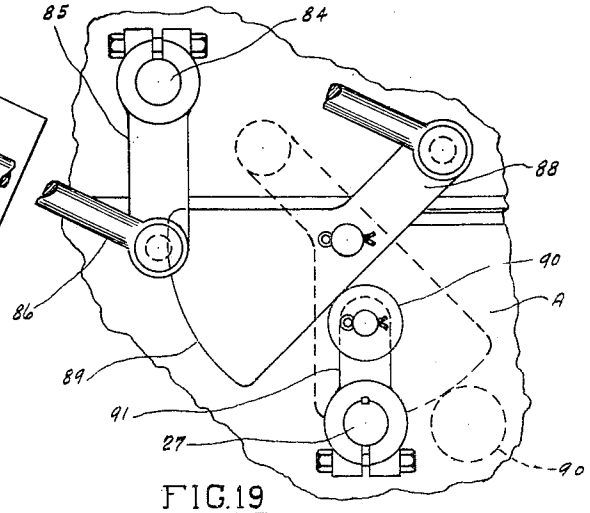


FIG. 19

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Patented June 13, 1950 2,511,135

UNITED STATES PATENT OFFICE

2,511,135

REACTION AND FLUID LOCK ROTARY HYDRAULIC DRIVING UNIT

Frank W. Torrance, Hamilton, Ontario, Canada

Application May 2, 1945, Serial No. 591,471

15 Claims. (Cl. 60—54)

1

This invention relates to hydraulic driving units in which power is transmitted from a driving to a driven member by a fluid medium, and in a varied manner.

Hydraulic or fluid drives have previously been proposed and largely would appear to fall in three main groups:

(*a*) Units incorporating a fixedly mounted drive pump, pipe connected to a fixedly mounted fluid motor in which any reasonable degree of torque or speed may be obtained by the relative proportions of the pump and motor, but, in terms of size, high torque and high speed are not practicable in the same unit while a substantial loss of power results due to friction in the pump, pipes, valve and motor.

(*b*) Units embodying a rotary or reciprocating pump axially mounted between the driving and driven members, having the case connected to one, and the rotor or piston connected to the other, wherein the driving connection is effected by restricting the pumped fluid, comparable in action to the slip of a friction clutch, producing a low starting torque, and power waste at all speeds below a direct 1 to 1 drive.

(*c*) Units in which two opposed driving and driven members axially mounted in a fluid chamber, transmit power by circulation of fluid in the chamber which produces a low starting torque, constant slip at all speeds and consequent heating of the fluid.

The present invention avoids such general disadvantages as noted in these several types and provides a unit of reasonable size in which a high torque drive may be produced at all intermediate speeds, the driving force being supplied by a combination of driving effects during the transitory driving range.

Of those fluid drives depending upon fluid lock, the characteristics which identify one from the other depend mainly upon the principles adopted to develop a sufficient torque at starting and in those ranges of operation intermediate of starting and fluid lock. Although the principle of fluid lock itself is well known, the means which have been used to accomplish this condition have varied widely. As to the conditions of the initial torque required, and the transitory condition building up to fluid lock, various means have been adopted in the past which have involved external mechanisms to control oil pressure or the adoption of a different driving principle until fluid lock is obtained.

It is, therefore, a main object of the present invention to produce a substantially simple hydraulic drive unit which depends upon the principle of changing the direction of a moving body of oil and deriving energy therefrom to produce a high torque at low and intermediate speeds and which further depends upon increasing the resistance to flow of the oil to diminish the relative rotation of the shafts and untimately fluid lock.

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Another object of the invention is to produce a substantially simple hydraulic drive unit which will produce a high torque drive in lower speeds, and a fluid locked drive at higher speeds, and which will operate efficiently at all speeds.

A further object of the invention is to provide a unit of this kind which is controlled automatically during operation, will engage and disengage quickly and completely under all conditions and may be controlled by simple connections to common operating media.

A further object is to provide a unit of this character automatically controlled by a governor in relation to the speed including control of centrifugal forces to produce a fluid tight unit with provision for selective normal governor control to produce other effects such as a free wheeling effect.

A still further object of the invention is to provide a self contained hydraulic drive unit of generally simple construction which lends itself to production line assembly and which may be employed in many fields.

With these and other objects in view the invention generally comprises a unit incorporating an impeller driven by a drive shaft from a source of power, an expansible chamber pumping unit housed within the impeller, one pumping component of which forms a part of the impeller, and a runner fastened to a driven or output shaft. The runner includes an inner movable vane structure of generally annular form extending about a portion of the impeller and having passages of spiral-like nature extending radially therethrough in a direction opposed to the desired direction of movement of the runner. The impeller has vane members defining passages in conjunction with the vanes of the runner vane structure to provide communication of fluid from the pump to the periphery of the runner vane structure. A runner ring constitutes the peripheral portion of the runner and has a plurality of passages designed to be aligned with passages of the runner vane structure near the peripheral zone of the latter in one position of relative adjustment of the runner vane structure within the runner. Suitable means are pro-

vided for causing the runner vane structure to move within the runner and its runner ring to cause the passages of the runner ring to move out of alignment with passages of the runner vane structure to shut off flow of fluid through the unit. The unit therefore, not only operates according to conventional fluid lock principles in conjunction with its pumping mechanism but also derives driving effect in the transitory range up to fluid lock by fluid friction coupled with the effect derived from displaced momentum of the fluid employed in the spiral-like passages of the runner vane structure. The invention includes various means of control for the practical application of the principles involved, details of which including the construction and operation, will be understood by reference to the following detailed specification taken in conjunction with the accompanying drawings.

In the drawings:

Fig. 1 is a side elevation of the transmission casing of a vehicle, the casing being partly broken away to show part of the driving unit according to the present invention and some of its operative parts including the feed line from the fluid sump of the casing.

Fig. 2 is an end elevation of the driving unit of the present invention showing part of the transmission casing, half of the wall of the runner being eliminated to show underlying parts of the unit.

Fig. 3 is a transverse section taken through the driving unit substantially along the line 3—3 of Fig. 2 and also illustrating a portion of the surrounding transmission casing.

Fig. 4 is an enlarged fragmentary sectional detail taken substantially along the line 4—4 of Fig. 3 and showing part of the impeller vane structure broken away to illustrate the underlying construction of the rotor vane structure, the impeller vane structure being shown in a position where the grooves thereof are aligned laterally with the grooves of the runner vane structure.

Fig. 5 is an enlarged fragmentary perspective view showing the runner vane structure in spaced relation to the impeller vane structure to illustrate the general structure of each and their corelation.

Fig. 6 is a fragmentary section taken substantially along the line 6—6 of Fig. 3, showing the spiral oil feeding passages to the pump and illustrating the vane structure in a different position to that shown in Fig. 4 so as to illustrate also the general location and arrangement of the grooves in the runner vane structure which are shown in dotted lines.

Fig. 7 is a transverse section taken substantially along the line 7—7 of Fig. 4 illustrating in particular the inward projection of the web of the impeller in contact with the pump rotor as well as other details.

Fig. 8 is a fragmentary sectional detail of the fluid intake pipe and fluid feeding passages of the unit illustrating the control valve in a position to permit feeding of fluid from the sump to the unit.

Fig. 9 is a substantially similar view to Fig. 7 but illustrating valve in closed position shutting off fluid feed from the sump but opening the feed passages to the atmosphere.

Fig. 10 is a sectional detail of the breather pipe construction entering into the oil sump.

Fig. 11 is a transverse sectional detail taken through the runner casing and runner vane

structure illustrating the mounting of the cranks used in conjunction with the governor arms for shifting the position of the runner vane structure.

Fig. 12 is a sectional detail taken through part of the impeller structure showing the manner in which the side walls of the impeller are bolted to the projecting vane structure thereof.

Fig. 13 is a fragmentary sectional detail taken through the runner vane structure indicating the manner in which the two parts thereof may be secured together by bolting.

Fig. 14 is a fragmentary section taken through the runner housing and the runner vane structure showing an alternative manner of securing the walls of the runner together at one side of the unit.

Fig. 15 is a fragmentary detail section taken substantially along the line 15—15 of Fig. 3 to illustrate in top plan view the opening through the rotor vane structure discharging from the fluid channels.

Fig. 16 is a fragmentary longitudinal section taken through the runner ring and the outer portion of the runner vane structure illustrating the path of discharge of fluid from the runner vane structure through the runner vane.

Fig. 17 is a similar view to Fig. 16 but illustrating the runner vane structure rotated to position to shut off communication between the channels of the rotor vane structure and discharge slots of the runner ring.

Fig. 18 is a transverse sectional view taken through the runner ring at one of the points where the channels of the runner vane structure open on the surface thereof and illustrating the shape of the recessed portion of this structure adjacent the outlet of the channel for gradually restricting the area of the discharge slots in the runner ring as the runner vane structure is rotated relatively to the latter.

Fig. 19 is a fragmentary side elevation of the controls operated by the accelerator pedal and brake pedal respectively to place the transmission unit in communication with the oil sump or to shut it off therefrom and means of varying the effect of the governor control through operation of the brake pedal; and

Fig. 20 is an enlarged fragmentary side elevation of a connecting means for varying the operation of the governor to require a greater rotor speed for the closing of the ports in the rotor ring to permit more power for special condition.

The invention is aptly illustrated by way of the transmission of a motor vehicle wherein A indicates the casing of the transmission from which the driven shaft 10 projects. This is suitably journalled in the casing as shown in Figs. 1 and 3 including the aligning bearing 11 and packing glands 12 and 12a and retaining ring 12b. The driven shaft passes into the fluid transmission unit generally indicated by the letter B and is connected by the spline 13 (Fig. 3) with the runner C so that upon rotation of the runner the driven shaft will rotate correspondingly.

The runner C is caused to rotate in normal driving conditions, as a result of a fluid driving connection between the impeller D and the runner C, the impeller being initially rotated by means of the splined hub or stub shaft 14 which is in direct driving connection with the crank shaft of the engine. The impeller is generally comprised by a cylindrical casing formed by spaced apart side walls 15 which secure there-

between and include the peripherally projecting impeller vane structure having vane surfaces 16 forming side walls of spiral passages 17 (Fig. 3) more detailed references to which will be had hereinafter.

Inwardly of the impeller vanes 16 and between the side walls 15 of the impeller casing, a pump chamber 18 is formed of substantially cylindrical contour. This is designed to house the cylindrical pump rotor E splined on driven shaft 10 and provided with a plurality of radially directed blades 19 spring pressed outwardly by the compression springs 20 and normally projecting from the periphery of this rotor. These blades are chamfered along one edge and are designed to make close contact with the inner edge of a web 21 projecting inwardly from the impeller vane structure which edge is eccentric relative to the periphery of the pump rotor E and carries the opposed laterally extending arcuate plates or shoes 22, the inner surfaces of which are flush with the edge of the web. The plates or shoes 22 are circumferentially spaced apart from one another to provide therebetween port areas 23 (Figs. 4 and 6). Consequently, in initial stages of operation, i. e. during rotation of the impeller, and non-rotation of the runner C and pump runner E the plates or shoes 22 rotating around the pump rotor E eccentrically thereto and engaging the blades 19 thereof will obviously create a partial vacuum condition which will cause the fluid to be sucked from the sump of casing A into the pump and to be discharged through the ports 23 to the distribution chamber 24 divided centrally by projecting web 21 as will be described in more detail hereinafter.

Let us assume that the impeller D is caused to rotate by the crank shaft of the vehicle. In this instance pumping action will immediately start as above referred to as soon as the motor turns over. However the feed of the driving fluid from the sump of the transmission case A is controlled by the accelerator pedal and, unless the accelerator pedal is depressed, air only will be drawn into the transmission unit B. For instance, upon referring to Fig. 1 the fluid intake pipe 25 communicating with the fluid sump 26 is controlled by a valve operated by the transverse shaft 27 (see Figs. 1 and 3). This latter shaft, as shown in Fig. 3 has an end 28 which projects outside the casing A. Suitable operating connection, therefore, may be made with the accelerator pedal from the projecting end 28 of this shaft and, by any suitable spring means, this shaft is normally located so that the valve which it rotates shuts off communication from the sump 26 and opens the oil feed passage to atmosphere. In this connection reference is made to Figs. 8 and 9.

In Fig. 9 the valve 29, formed with the feed passage 30, is disposed in the normal position of shaft 27 and passage 30 communicates through a port 31 with the atmosphere. The intake pipe 25 is therefore cut off from the feed passage 32 which leads to the fluid transmission unit, whereas, the port 31 is placed in communication with the fluid intake passage 32 by means of a suitable bypass 33. Therefore, in the initial stages of operation when the motor is running and idling, the pump blades 19 operating in pump rotor E will only cause intake of air. If, however, the accelerator is depressed, its operation of the shaft 27 will cause the latter to rotate and in turn rotate the valve 29 to the position shown in Fig. 8 wherein the port 30 is placed in communication with the intake pipe 25. The air port 31 is thus

cut off and therefore the fluid feed passage 32 is placed in direct communication with the fluid sump 26 via intake pipe 25 and valve feed passage 30. As a result, therefore, fluid will be drawn through the intake 25 and passed to the feed passage 32.

The driven shaft 10, as will be noted from Fig. 3 particularly, is formed with a hollow bore 34 over a portion of its length, closed at one end by the plug 34a and provided towards the other end with an enlargement 35 which is radially bored as at 36 to provide a plurality of radial passages leading into the bore 34. The radial passages 36 open into the fluid feed chamber 37 with which the fluid feed passage 32 communicates, so that fluid is therefore fed from the sump and through the bore 34 to be discharged through the series of openings 38 (Figs. 3 and 7) in the driven shaft as it extends within the fluid transmission unit B. These passages are located to discharge the fluid into the receiving chamber 39 of the impeller D (Figs. 3 and 7) the fluid being transferred from this chamber via the spiral passages 39a to the periphery of the pump rotor which latter element includes side plates 39b and pressure equalizing passages 39c (Figs. 3 and 4 respectively).

The main body of the impeller (vane structure) in longitudinal section between its side walls 15, takes the form of an annular member having its outer periphery indicated by the numeral 40 and its inner periphery indicated by the numeral 41 (see Figs. 4 and 6). This constitutes a solid body having a plurality of spiral passages 17 therein open throughout their extent on its side surfaces, to which reference presently will be had, and the inner periphery 41 of this member together with the side walls 15 of the impeller constitute the distribution chamber 24.

The spiral passages 17 are formed in this annular member inwardly from each side thereof, divided by the partition web 21 which, as previously indicated, extends inwardly beyond the inner periphery 41 (Fig. 4) to terminate in an edge disposed eccentrically to the periphery of the pump rotor E and carries at this point, as previously referred to, the opposed spaced apart arcuate plates or shoes 22. The spiral grooves or passages 17 as will be noted both from Figs. 3 and 4, extend from the distribution chamber 24 to the outer periphery 40 of this annular member and, therefore provide in each instance, a series of pairs of passages divided by a partition and located at uniformly spaced apart intervals throughout the circumference of the member. Consequently, as fluid is pumped to the distribution chamber 24, it is discharged from there into the grooves or passages 17 on each side of the web 21 and, due to this continuing pumping action, and, the effect of centrifugal force caused by the rotating impeller body, the fluid is caused to pass through these passages and is discharged therefrom into a series of substantially corresponding passages (later described) provided in the runner structure C from which it is discharged in the initial stages of operation to cause rotation of the runner in the same direction as the impeller hereinafter referred to in detail.

The casing of the runner C, as will be seen upon reference to Figs. 3 and 7 particularly, is made up of annular side walls 42 terminating at their outer peripheries in a runner ring 43 which, in effect, provides a substantially enclosed casing. This structure may be produced by forming the walls 42, at their outer peripheries, with a

laterally inwardly directed flange, the two parts being bolted together to form this casing. Within the casing thus formed a runner vane structure 44 is provided and encased adjacent the outer periphery of the casing.

This structure is preferably made up of a plurality of arcuate sections or segments 45 (Fig. 4) which are slightly spread apart from each other at the ends and held in this relation in suitable manner such as by the compression springs 46 which will permit heat expansion. The assembled sections or segments 45 provide a runner vane structure 44 of annular form which is preferably formed longitudinally in two annular halves, for assembly purposes, secured together so that each complete assembled segment 45 is made up of two pieces 45a and 45b (Fig. 11). Each of these pieces is cut inwardly from its inside surface 47 (Figs. 7, 11 and 14) to a point adjacent to its outside surface 48 to form a plurality of spiral passages or grooves 49 spaced apart circumferentially of the unit 44 thus forming the vane surfaces 49a curved coincidentally to the vane surfaces 16 of the impeller D. The inner side surfaces 47 of parts 45a and 45b are recessed or chamfered to form when these parts are assembled together as segments 45, the channel 45c. The channel 45c is of a contour in cross-section, corresponding to the cross-sectional outline of the peripheral portion of the impeller vane structure, to house the latter (Figs. 3, 7, 11 and 14) so that it may rotate therethrough, there being at least a practical working clearance between the peripheral parts of the impeller and the edges of channel 45c of the runner vane structure.

The grooves or passages 49 of the runner vane structure 44, open into the channel 45c and therefore it will be clear that as the impeller D rotates relatively to the runner vane structure 44, in initial stages of operation, the passages 17 of the impeller will intermittently become aligned with the passages 49 of the runner vane structure 44. Moreover, it will be noted that the runner ring 43 is provided with spiral slots 50 of a curvature corresponding or substantially corresponding to that of the grooves or passages 17 and 49 and consequently when the latter grooves are aligned or substantially aligned with the slots 50, a free discharge of fluid from these grooves to the exterior of the ring is produced during operation.

Initially when starting or at slow speed the fluid might not flow as readily as desired from impeller grooves 17 to the runner vane grooves 49 due to the rotation of the impeller D relative to the stationary or slowly moving runner C. Accordingly therefore ring like by-passing channels 51 (Figs. 2, 3, 4 and 6 and 14) are formed in the inner surface of the wall of the runner and disposed inwardly of the inner periphery of the runner vane structure 44 so that fluid passing outwardly in the grooves 17 of the impeller D will pass into these ring like channels 51 and therefore it will be freely fed to the grooves 49 of the runner vane structure 44 which intersect these channels. It will then, of course, pass outwardly through the grooves or channels 49 by reason of the action of the pump and, centrifugal force of the rotating impeller, to be discharged through the slots 50.

The spiral grooves 17 and 49, as well as the spiral slots 50, are, as previously indicated, uniformly spaced apart around the circumference of the transmission unit and spiral outwardly from the center thereof, inclining rearwardly in terms of the direction of rotation and consequently fluid is discharged, in a direction rearwardly to the direction of rotation, in a plurality of jets.

Surrounding the runner C is the stator ring 52, attached to the transmission casing by studs 52a (Figs. 2 and 6) which is formed with a series of channels 53 on its interior surface, the channels being formed as to provide a means of conducting oil, being disposed directly in the path of the jets of fluid which discharge through the series of slots 50 in the runner ring 43.

The slots 50 in the runner ring and the grooves 49 in the runner vane structure correspond in number as well as general profile while the grooves 17 in the impeller vane structure of the same general profile, may be of the same number although not necessarily. Preferably a greater number of grooves 17 in the impeller are employed as compared to the number in the runner vane structure 44, to eliminate possibility of vibratory effects as the grooved portions 17 of the impeller pass those of the runner vane structure. Any desired practical number of pockets 53 may be provided in the stator ring 52.

Upon rotation of the runner C, the driven shaft 10 is caused to rotate due to the driving connection therebetween. Moreover, due to the driving connection between the pump rotor E and the driven shaft 10, the pump rotor is caused to rotate, which rotation effects a decrease in the relative speed between the pump rotor E and the impeller D and the volume of fluid pumped starts to decrease. As the rim speed of the runner C is increased, the velocity of the fluid discharging through the slots 50 of the runner must increase correspondingly.

In order to change over operation, I provide a means for shifting the runner vane structure 44 to control the operative area of the slots 50. This is accomplished by a governor control. On the runner a plurality of governor arms 55 are provided (Fig. 2) secured at one end on the crank arms 56 of a plurality of cranks 57, the crank arms 56 being suitably journalled in one wall of the runner as shown, for instance, in Fig. 11. The opposite end of each crank is provided with a suitable boss or the like 58 which enters into a receiving slot 59 formed in one outer wall 48 of the runner vane structure 44.

The free end of the governor arms is provided with a weight 60 which is operatively connected by means of a link 61, in each instance, with a lug 62 carried by a control ring 63 (Fig. 3) which is rotatably mounted on an enlarged portion 64 of the runner housing. This provides for uniform operation of the governor arms. On each of these arms by any suitable means such as a lug 65, the governor arms are operatively connected with compression springs 66 preferably carried upon an arcuate guide support 67 which is anchored at one end, in each case, in a lug 68. The compression spring 66 is carried on the support 67 between the lug 65 of arm 55 and a suitable restraining washer 69 carried on the end of support 67. Consequently as the runner rotates and the governor arms are caused by centrifugal force to swing outwardly against compression of springs 66, their crank arms 56 will be rotated to a corresponding degree and consequently each crank will be turned in its journal so that the boss 58 of each crank, operating in the slots 59 of the wall 48 of the runner vane structure 44, will cause the runner vane structure to partially rotate, thus displacing the grooves or channels 49 from their direct registry

with the slots 50 of the runner ring 43. Ordinarily, in this case, if only the grooves 49 were provided, communication between the grooves 49 and the slots 50 would in effect, be cut off. It should be noted, however, that on the outer periphery of the runner vane structure, directly adjacent to each groove 49, a recess 70 is provided of a shape such as illustrated in Fig. 18, having the converging side walls 70a or of such other shape as to provide for a gradual restriction in effective discharge area of the slots 50 to cause an increase in velocity of the discharging fluid. Thus, as the runner C gradually picks up speed, the area of the slots 70 becomes correspondingly smaller until the runner has attained the speed of the driving shaft when communication is shut off between slots 50 and grooves 49 at which time the fluid within the grooves 49 locks the pump rotor and the impeller as a unitary driving element.

Upon decrease of power relative to the driven load, or increase of load relative to the available power, under normal conditions, the rotative speed of the unit will decrease and the governor arms 55, under pressure of their springs 66, will cause the runner vane structure 44 to move back toward normal starting position, as a result of the movement of the cranks 67. Therefore, communication will again be established between the slots 50 and the recesses 70 together with grooves 49 in the runner vane structure 44. This governor action will automatically adjust the necessary torque-speed ratio between the available power and the existing load. The speed of the driven shaft can therefore be increased or decreased, within the capacity of the unit, and available power, in a smooth and sensitive manner, by merely depressing or releasing the accelerator pedal to give the desired result.

As the effective area of the slots 50 gradually lessens due to the governor control of runner vane structure 44, upon increase in speed of the runner, and as the relative speed between impeller and the runner decreases, the fluid, flowing directly between the impeller vanes and the runner vanes, introduces a driving effect which I term a vane driving effect due to gradually increasing fluid friction and centrifugal force which imparts an inertial force to the fluid. Moreover it will be apparent that the pump E initially has but little driving function but, as the fluid pressure increases, it gradually operates as a driving element due to the restriction in flow of the fluid through the pump, as the slots 50 are reduced in area, which gradually produce a fluid locking effect, until finally the slots 50 are closed when a complete fluid lock occurs providing a direct drive for normal driving.

Consider the sequence of the effects causing driving forces during the transitory range and the manner in which they overlap. When the accelerator pedal is depressed, the unit B is caused to fill with fluid as previously explained, thus producing the initial driving effect. As the runner begins to gather speed the displaced momentum effect and vane driving effect begin to rise. Thus as the runner continues to gain speed the two forces build up each contributing to the resultant torque until finally, as the runner speed reaches about seventy-five per cent of its speed in the transitory range, the fluid locking means of fluid locking which becomes the main driving begins to close gradually producing a condition force, continuing with increasing effectiveness until a complete fluid lock is reached at which point the movement of the rotor vane structure 44 has reached its maximum and closed the ports 50 in the runner ring 43.

It will be noted that the vane driving effect contributes little at low speed in the transitory range but as the fluid is restricted by the movement of the runner vane structure 44 with consequent restriction of the ports 50 in the runner vane 43, pressure is built up which increases the resistance between the impeller vanes and runner vanes thus producing an increased vane driving effect which increases as ports 50 reduce in area producing a gradually effective and finally complete fluid lock between the impeller D and sump E.

The flow of the fluid through the driving unit from the sump, and its discharge through the slots 50 of the runner ring when in communication with the grooves 49 of the runner vane structure 44, is continuous and cyclic by reason of the fact that the sump is maintained with a substantial volume of fluid and the fluid discharging through the slots 50, to impinge against the channel surfaces 54 of the channels 53 of stator ring 52, is discharged from the stator ring by means of the discharge ports 71, the opening on the sides of the driving unit B between the outer periphery of the runner C and the inner periphery of the stator ring 52 the ports 71 being formed by leaving open the pockets 53 at each side of the driving unit B. Consequently the fluid after impinging upon the surface of the pockets 53 is discharged laterally of the driving unit through the ports 71 to return by gravity to the sump 26. Moreover, it will be appreciated that the unit is consequently lubricated fully, as external parts will be readily lubricated by this discharge of the fluid (preferably oil) while internal parts obviously are likewise well lubricated. Furthermore, in respect to pressure within the driving unit, caused by the fluid, suitable relief valves 72 are preferably incorporated (see Fig. 3) which may be placed in communication with the fluid by-pass rings or channels 51. A suitable fluid inlet pipe 26a is preferably provided to introduce fluid to the sump 26 and this is conveniently closed by the breather cap 26B which may be formed with a rod 26c carrying the opposed spring like members 26d. The sump 26 may therefore readily be maintained with sufficient volume of fluid.

It is preferable to provide for manual operation of the governor arms to produce substantial advantages and this is provided for in the present invention. In this case the lugs 68 to which the guide rods 67 are anchored, take the form of bell crank levers indicated generally by the numeral 73 which are suitably pivoted on brackets 74 carried on the runner casing, one arm of the levers being constituted by each lug 68, the other arm projecting substantially at right angles thereto and being indicated by the numeral 75. The arms 75 of these levers 73, in the present illustration, are designed to project through slots 76 in the control ring 63 and are disposed in the path of the flanged portion 77 of the pressure applicator plate 78 which is freely mounted on the projecting sleeve 79 of the runner C. This plate is designed to be engaged by a suitable thrust bearing 60 slidably mounted on the sleeve 79 which bearing is in turn engaged by the thrust plate 81 likewise freely mounted on the sleeve 79.

The thrust plate 81 preferably includes suitable lugs 82 pivotally to receive the depending arms 83 (Fig. 2) of the transverse shaft 84 (Figs. 1, 2

and 18). This shaft projects outside the casing A and is designed to connect with a lever arm 85 (Fig. 19) which is operated by the connecting link 86 from the brake pedal. As a result, therefore, depression of the brake pedal to a substantial extent, that is approximately to its full extent, moves the thrust plate 81 axially on sleeve 79 due to the consequent rotation of shaft 84 and the swinging of its arms 83. Movement of thrust plate 81 inwardly will frictionally engage the facing surface 87 of control ring 63, thereby retarding rotation of control ring 63 in relation to the runner C with consequent retraction of the governor arms 55 against the centrifugal force of governor weights 60 through the connection of links 61, attached to governor weights 60, and control ring 63. In this operation these arms will be retracted to their full extent causing the ports 50 to be fully opened. This action is effected without the use of the applicator plate 78 and the arms 75 employed for manual retraction of the governor arms, manual operation of the latter being omitted where desired.

As a result of this retarding action, a free wheeling principle may be established. For instance, upon releasing the accelerating pedal which then cuts off the source of fluid supply to the driving unit, by positioning valve 29 as shown in Fig. 9, and upon pressing the brake pedal to substantially full extent momentarily, the action just described will result causing the runner vane structure to return to normal starting position, establishing full communication between the ports 50 and the grooves 49 of the runner vane structure so that the fluid will be completely discharged from the driving unit B almost instantly. The release of the brake pedal will permit the governor to close passages 49 from communication with ports 50 and, as the fluid contact between driving and driven parts of the unit is removed, coasting or free wheeling results. However, reinstatement of normal driving conditions are readily achieved merely by pressing again upon the accelerator pedal to place the fluid driving unit again into communication with the fluid feed.

In stopping a vehicle employing this driving unit, a substantially similar action will take place except that the vehicle brake is used as needed by depressing the brake pedal to the required degree, and for the required interval, to stop the vehicle. In this case the engagement between the thrust plate 81 and the facing surface of the flange 87 of control ring 63 supplements the braking action in effect to give the supplementary speed retarding action supplied by the ordinary vehicle transmission while its clutch is engaged. The meeting faces of the thrust plate 81 and the control ring 63 may be given frictional characteristics if desired. It might be noted at this point also that more power may be developed for special conditions by partial depression of the brake pedal without causing engagement of these faces as will be referred to hereinafter.

As indicated previously, the driving unit B during idling, is open to the atmosphere to permit air only to be drawn therein and, is placed in communication with the oil sump to admit fluid only when the accelerator pedal is depressed. One preferred means of effecting this operation is by employing, as shown in Fig. 19, a cam lever 88 pivotally connected with the link 89 connected with the accelerator pedal. The cam lever 88 is provided with the cam surface 89 and one edge of this lever, in the normal position, is designed to abut the roller 90 rotatably carried on the arm 91 which is fastened to shaft 27 exteriorly of the transmission casing A. As a result, therefore, the depression of the accelerator pedal will cause the abutting edge of lever 88 to swing the arm 91 into engagement with its roller 90 so as to rotate shaft 27 in a clockwise direction, thus to establish communication by port 30 of valve 29 between the sump and fluid feed passage 32, as shown in Fig. 7, moving it from the idling position shown in Fig. 8. Moreover, as the accelerator pedal is depressed to an increasing extent the cam surface 89 of the lever 88 will come into engagement with roller 90 and maintain the arm 91 in its downward position as shown by means of the dotted line illustration of roller 90 (Fig. 8). Therefore, in all positions of depression of the accelerator pedal the arm 91 will be swung from the normal and will establish, by port 30, communication between sump pipe 25 and fluid feed passage 32.

Provision is also preferably made for the manual regulation of the governors by increasing the resistance of the compression springs 66 against the governor arms 55. This may readily be accomplished by any suitable lost motion connection and one suitable arrangement is shown in Figure 20. In this construction an operating link 92 is suitably connected with the applicator plate 78 so that axial movement of the rod 92 in one direction will cause the applicator plate to depress the arms 75 of the lever 73 and to pull the supporting guide 67 inwardly with consequent retraction of the governor arms 55. Thus, if by this means, the pressure of the coil springs 66 relatively to the normal operating position of the arms 55 of the governor is in effect increased, it will require a greater rotational speed of the runner C to return the arms 55 to normal driving position and thus permit the closing of the ports 50. This will therefore permit more power for special conditions.

Operation of the link 92 may be effected by means of a rod connection 93 to the foot pedal and/or a rod connection 94 to a hand lever. In the present Fig. 20 showing the rod connections, rods 93 and 94 formed with the eyelets 95 and 96, are designed to slide on the connecting link 92. In each instance, a suitable stop member, such as a cross pin 97 in the case of rod 93, and pin 98 in the case of rod 94, is carried on the connecting link 92. Therefore, by reason of the lost motion permitted by the sliding eyelet connection between the rods 93 and 94 and the connecting link 92, the springs 66 may in effect have their compression ratio relatively to the arms 55, increased upon a predetermined operation.

From the foregoing it will be appreciated that by a relatively simple, generally self-contained structure I am able to provide a driving unit which will provide a fluid locked drive under normal driving conditions, a high torque drive at lower driven speeds, and a drive which will quickly react and operate efficiently at all driving and driven speeds.

Moreover, it will be apparent that two driving effects are combined in the unit, each varying in accordance with the speed of the runner C and the discharge area of the slots 50 as controlled by the governor. Since, the vane driving effect is of little consequence until fluid resistance reaches a substantial value, the main driving force at low speeds is that derived from displacing oil from a straight path by curving the channels through which it flows in the sides of

the runner C. As soon as the governor acts to close the ports 50, this driving effect is reduced in proportion to the opposite effects of increasing speed of the runner and decreased velocity of the oil due to increase in friction and is reduced to a zero quantity at fluid lock.

There is thus a transition to a fluid locking effect which results in a locked, direct fluid drive upon final closing of the slots 50 at a predetermined speed by relative movement of the runner vane structure 44 to the runner ring 43. Finally, the unit provides for increased power for special conditions and readily also permits the effect of free wheeling by a simple operation to drain all fluid from the unit. In this latter instance, the principle is such that the fluid is completely drained from the unit when it comes to rest so that in starting again and idling, any tendency towards drag is completely eliminated, which otherwise would be the case if fluid remained in the unit.

It is, of course, apparent that changes may be effected in structure without departing from the principle of the invention. Moreover, while the invention has been illustrated in the present specification chiefly in conjunction with the transmission of a vehicle, it will be obvious that the hydraulic driving unit of the present invention has a wide application.

What I claim as my invention is:

1. A hydraulic driving unit comprising an impeller mounted on a drive shaft connected to a source of power, a runner concentrically mounted around said impeller and connected to a driven shaft, pumping means concentrically mounted within said impeller comprising at least a pair of components, one of which is operatively connected to said drive shaft, the other of which is operatively connected to said driven shaft, a fluid reservoir in communication with said pumping means, said impeller having passages designed to provide communication of fluid pumped from said fluid reservoir, by said pumping means from the latter, to said runner, means mounted concentrically about said runner and designed to communicate said fluid to said reservoir, said runner having a plurality of substantially radially curved passages for communicating said fluid from said impeller to said means communicating to said fluid reservoir, and closure means in connection with said runner for gradually increasing the resistance to flow in said passages of said runner in accordance with the increasing speed of the latter to control the driving effect between said drive shaft and said driven shaft during relative rotation between said shafts, said closure means being designed to cut off fluid flow to said reservoir to provide fluid lock in said unit between the components of said pumping means, and direct fluid drive between said drive shaft and said driven shaft.

2. A hydraulic driving unit comprising an impeller mounted on a drive shaft connected to a source of power, a runner concentrically mounted around said impeller and a fluid pump rotor concentrically mounted within said impeller, said runner and said fluid pump rotor being connected to a driven shaft, web means in said impeller eccentric about said pump rotor for pumping cooperation with said pump rotor upon rotation of said impeller relative to said pump rotor, means connecting said pump rotor with a fluid reservoir, said impeller having passages designed for communication of fluid pumped from said reservoir by said pump to said runner, a stator ring concentrically mounted beyond the periphery of said runner and designed to conduct fluid from the periphery of said runner to said fluid reservoir, said runner having a plurality of substantially radially curved passages for communicating said fluid from said impeller to said stator ring, said runner thereby absorbing the reaction energy of said fluid as it passes through said passages, means in connection with said runner for gradually increasing the resistance to flow of fluid in said passages in accordance with the increasing speed of said runner to increase the fluid friction in the unit and hence the driving effect between said drive shaft and said driven shaft during the period of relative rotation between said shafts, and means for shutting off flow from said runner to said stator to provide fluid lock between said pump rotor and said web means whereby said drive shaft and said driven shaft are caused to rotate together.

3. A hydraulic driving unit as claimed in claim 1 in which the radially curved passages of said runner terminate in discharge ports, said means in connection with said runner for gradually increasing the resistance to flow in said passages comprising means for restricting the area of said ports upon increase of speed of said runner, said restricting means closing said ports at a predetermined speed to produce fluid lock and direct drive between said drive and driven shafts at normal driving speeds.

4. A hydraulic driving unit as claimed in claim 1 in which the passages formed in said impeller and said runner for passage of fluid provide a plurality of vane surfaces, said passages of said runner terminating in discharge ports, said closure means in connection with said runner comprising a runner ring movable relatively to said runner and having passages normally registering with said ports, and governor means connected with said runner ring for moving the latter as the runner speed increases, finally to move said passages out of registry with said ports.

5. A hydraulic driving unit as claimed in claim 1 and valve means operable selectively to place said pumping means in communication with the atmosphere or said fluid reservoir, means normally urging said valve in communication with said atmosphere to cause idling of said unit during operation, and means for normally operating said valve to place it in communication with said fluid reservoir to pass fluid therefrom to said impeller during operation of the latter to cause said driving unit to function in a driving capacity.

6. A hydraulic driving unit as claimed in claim 2 in which said web means in said impeller comprises actuating plates carried by said impeller eccentrically of said pump rotor.

7. A hydraulic driving unit as claimed in claim 1 in which the passages formed in said impeller and said runner for passage of fluid provide a plurality of vane surfaces, said passages of said runner terminating in discharge ports, said closure means in connection with said runner comprising a runner ring movable relatively to said runner and having passages normally registering with said ports, governor means connected with said runner ring for moving the latter as the runner speed increases, finally to move said passages out of registry with said ports, said governor means including a plurality of pivotal weighted arms swingably mounted on the outside of said runner, spring means normally restrain-

ing movement of said arms and actuating means between the runner ring and said arms, said spring means causing return movement of said arms and again establishing communication between said passages of the runner ring and ports of the runner on reduction of speed of the runner to a given value.

8. A hydraulic driving unit as claimed in claim 1 in which the passages formed in said impeller and said runner for passage of fluid provide a plurality of vane surfaces, said passages of said runner terminating in discharge ports, said closure means in connection with said runner comprising a runner ring movable relatively to said runner and having passages normally registering with said ports, governor means connected with said runner ring for moving the latter as the runner speed increases, finally to move said passages out of registry with said ports, said governor means including a plurality of pivotal weighted arms swingably mounted on the outside of said runner, spring means normally restraining movement of said arms and actuating means between the runner ring and said arms, said spring means causing return movement of said arms and again establishing communication between said passages of the runner ring and ports of the runner on reduction of speed of the runner to a given value, said governor arms being connected to a control ring and operating collectively and uniformly.

9. A hydraulic driving unit as claimed in claim 1 in which the passages formed in said impeller and said runner for passage of fluid provide a plurality of vane surfaces, said passages of said runner terminating in discharge ports, said closure means in connection with said runner comprising a runner ring movable relatively to said runner and having passages normally registering with said ports, governor means connected with said runner ring for moving the latter as the runner speed increases, finally to move said passages out of registry with said ports, said governor means including a plurality of pivotal weighted arms swingably mounted on the outside of said runner, spring means normally restraining movement of said arms and actuating means between the runner ring and said arms, said spring means causing return movement of said arms and again establishing communication between said passages of the runner ring and ports of the runner on reduction of speed of the runner to a given value, means for manually retracting said governor arms, said unit also including manually operable control means for disconnecting said unit from a supply of operating fluid and placing it in communication with the atmosphere, said manual governor retracting means and the manual control means when operated respectively to retract said governor arms to cause said unit to communicate with the atmosphere producing a free wheeling effect.

10. A hydraulic driving unit as claimed in claim 1 in which the impeller includes a central web member, the passages of said impeller being disposed on opposite sides of the web member.

11. A hydraulic driving unit as claimed in claim 1 in which the runner is in the form of an annular vane structure comprised of a plurality of sector-like elements including spring means exerting pressure between the ends of said elements.

12. A hydraulic driving unit as claimed in claim 1 in which one of the pump components comprises a pump rotor having a plurality of radial reciprocal blades, the other of said components comprising means disposed eccentrically of said blades and mounted on said impeller and designed to engage said blades of said pump rotor upon rotation of said impeller.

13. A hydraulic driving unit as claimed in claim 1 and progressively acting means for applying braking effect to said rotor.

14. A hydraulic driving unit as claimed in claim 2 and means communicating said fluid reservoir with said pumping means including a hollow portion in said driven shaft placed in communication with said pump rotor and connecting conduit means communicating with said reservoir, and manually operable valve means for placing said shaft in communication with said reservoir and alternatively with the atmosphere.

15. A hydraulic driving unit as claimed in claim 1 in which the passages of said runner terminate outwardly in fluid discharge ports, said runner including an annular runner vane structure adjacent its periphery movable therewith and relatively thereto, said runner vane structure having a circumferential internal channel adapted to fit over and circumferentially enclose outer portions of said impeller, said runner vane structure having a plurality of internal substantially radially extending passages intersecting said channel and providing a plurality of vane surfaces, said runner vane structure also having discharge orifices at its periphery communicating between said passages and said discharge ports of the runner, the passages of said impeller forming vane surfaces and designed to communicate with the passages of said runner vane structure and a distribution chamber within said fluid driving unit communicating with the passages of said impeller and in communication with said pumping means.

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