May 14, 1957 L. A. SCHOTT Re. 24,317

DIRECT DRIVE VARIABLE RATIO HYDRAULIC TRANSMISSION

Original Filed Sept. 29, 1950 3 Sheets-Sheet 1

Fig. 1.

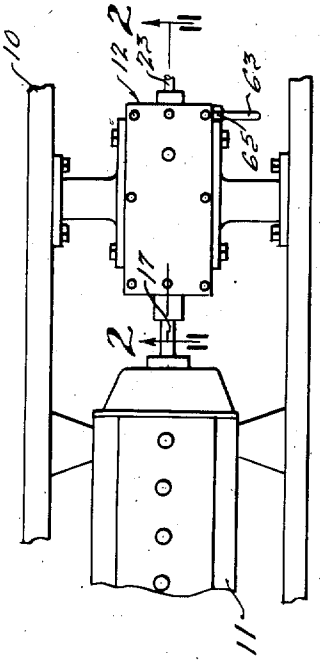
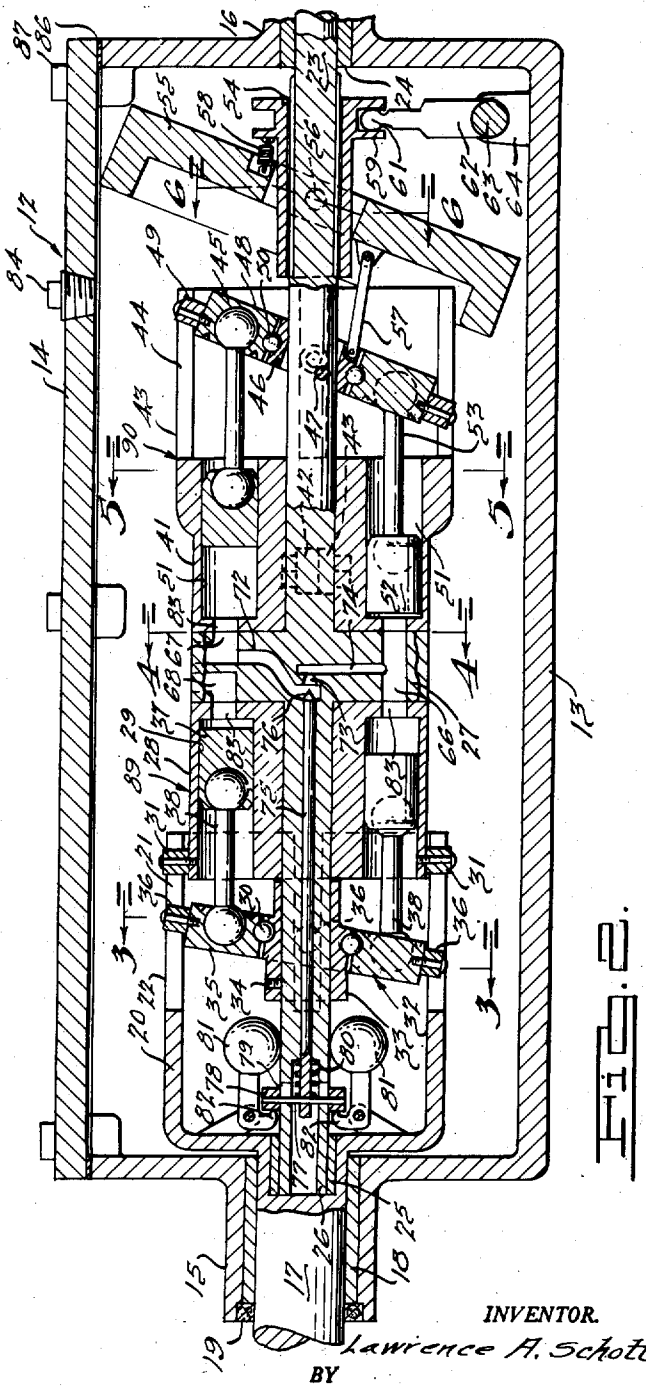


Fig. 2.



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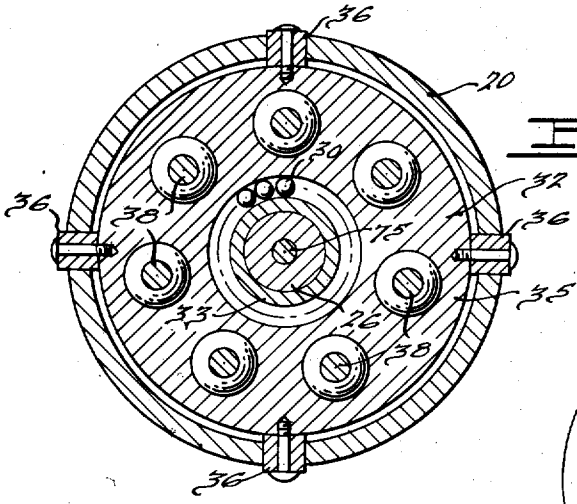


FIG. 3.

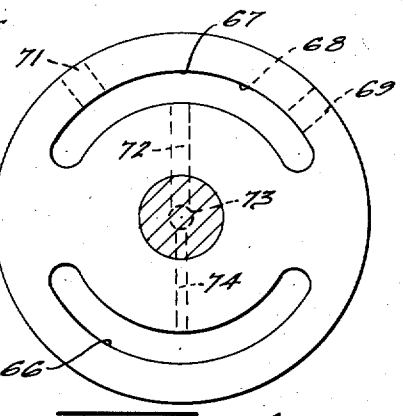


FIG. 4.

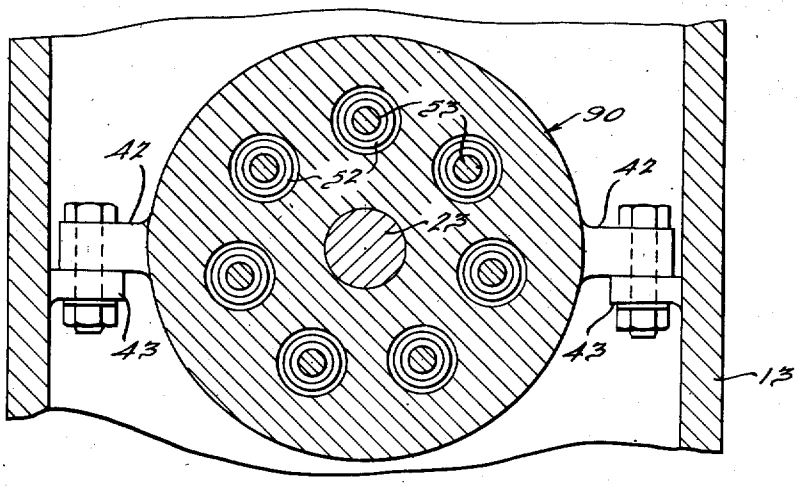


FIG. 5.

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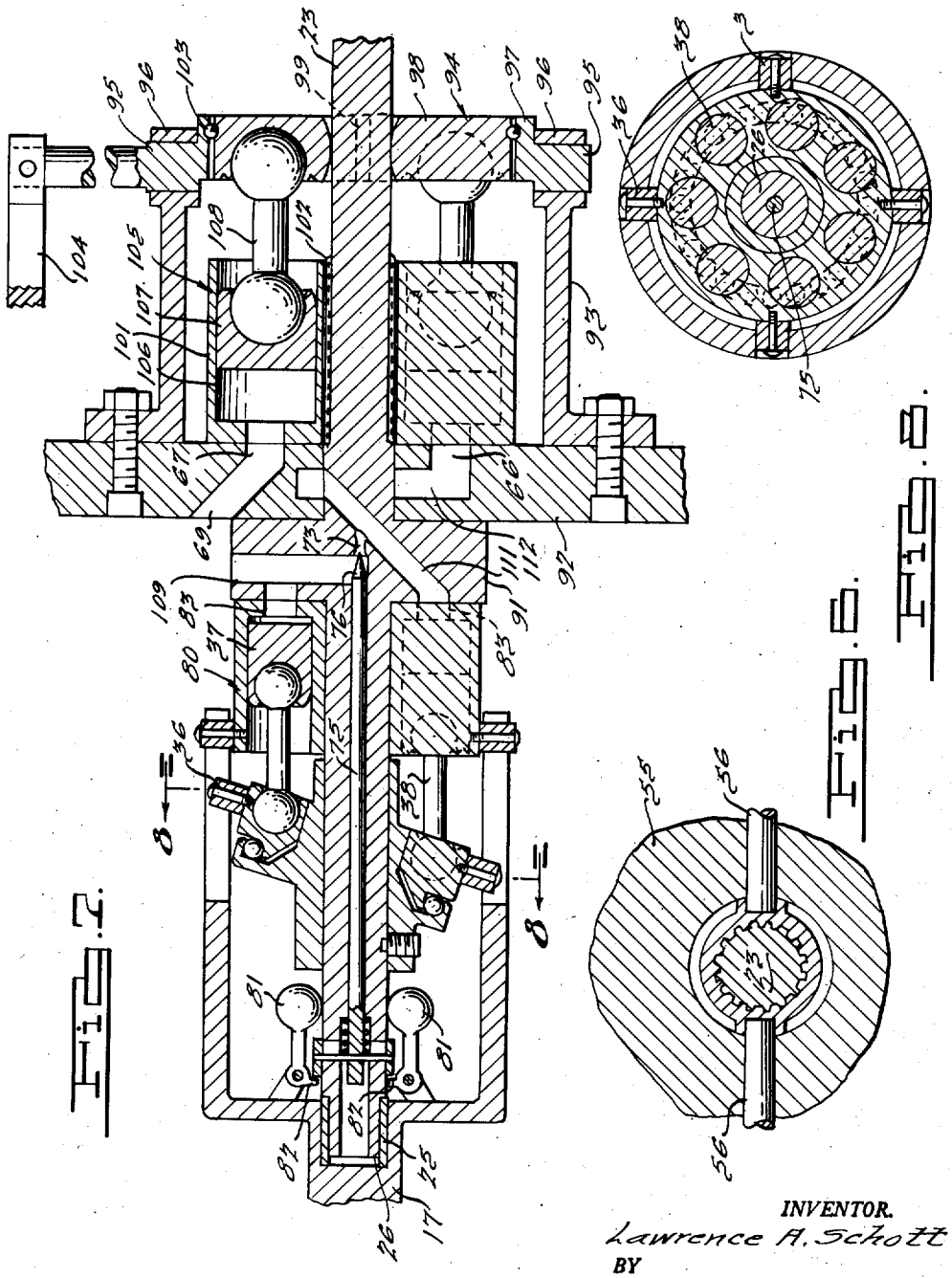


Fig. 4.

Fig. 5.

Fig. 6.

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DIRECT DRIVE VARIABLE RATIO HYDRAULIC TRANSMISSION

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Original No. 2,706,384, dated April 19, 1955, Serial No. 187,434, September 29, 1950. Application for reissue September 22, 1955, Serial No. 536,059

4 Claims. (Cl. 60—53)

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

This invention relates to transmissions, and particularly to a transmission of the fluid type.

The invention relates in particular to a hydraulic transmission which provides a variation of torque between the driving and driven shafts which varies from a maximum ratio to a direct drive without any feel of change of shift in the mechanism. The transmission is of such construction that as the torque requirement changes the speed and torque output changes and the resulting change occurs gradually and uniformly. As the torque requirement decreases and the speed increases, the difference in speed between the two shafts gradually decreases to zero and the shafts will move into coupled driving relation without any fluid flowing. The hydraulic part of the transmission is employed only to provide an increase of torque when additional torque is required, thereby eliminating a flow of fluid when the shafts are directly coupled, the fluid being employed only to that degree that a change of ratio of speed and torque has occurred between the drive and driven shafts.

This change will occur automatically if provisions are made for controlling the capacity of the variable volume fluid motor, or such change can be effected manually as torque requirements change. While the invention structurally may assume various forms, by way of example the invention embodies the use of a shaft driven from a source of power which operates the propulsion means of a pump. The reactance portion of the pump is secured to a driven shaft to which the propulsion means of a variable fluid motor is secured. In this relation of elements the body of the fluid motor is secured in fixed position, and fluid from the pump is delivered to the motor through a suitable porting member.

When no pumping can occur, the shafts are directly coupled, and when increased torque is required at the driven shaft this is obtained by increasing the motor capacity from zero to the degree required. This provision of increased motor capacity permits a change in speed between the shafts which produces a degree of pumping action which is relative to the change in speed between the shafts. The fluid from the pump is delivered to the motor to apply power to the propulsion means thereof to assist in driving the shaft, thereby increasing the torque on the shaft.

The percentage of lag permitted to the driven shaft relative to the drive shaft is equal to the percentage of the capacity of the pump per turn which is provided. Thus, if 50% capacity is permitted to be delivered each rotation of the driving shaft, the driven shaft will be permitted to lag one-half turn or 50%, thus providing a 2 to 1 ratio between the shaft speeds. The fluid from the pump is directed to the motor which assists the pump in turning the driven shaft this one-half turn. It is to be understood that a fixed capacity pump may be utilized with a fixed capacity motor or a plurality thereof to provide a transmission having a fixed ratio and a direct couple drive if one motor is employed and a plurality of different fixed ratios and a direct couple drive if a plurality of motors are employed.

When the torque requirement decreases after the shafts have been operating at different speeds, the capacity of the motor may be decreased, and as the same amount of fluid from the pump cannot be supplied to the motor, the driven shaft speed will be increased and the degree of pumping will be decreased. When the variable capacity motor has been shifted to inoperative position, the pump can no longer pump and the drive and driven shafts will be operating in direct coupled relation. When the variable fluid pump is provided with torque control means for varying the requirement for fluid in proportion to the torque requirement, the change in relative speed of the drive and driven shafts will thereby occur automatically. When additional torque is required on the driven shaft slowing up the shafts, the capacity of the motor changes automatically and the pump will operate to a degree proportionate to the difference of speed of the shafts. As the torque requirement is reduced, the speed of the shafts increases, the capacity of the fluid motor is decreased, and the relative pumping action also decreases so that the speed of the driven shaft will continue to build up until it is again directly coupled with the drive shaft.

Thus, it will be noted that the invention accomplishes a change of ratio between the driving and driven shafts through the control of hydraulic fluid. As the torque requirement increases, the ratio of rotation between the shafts increases, and as the torque requirement diminishes, the ratio decreases. In the example given, this automatic change is accomplished by centrifugal means, such as flywheels, governor balls and the like, or the change may be made manually, as pointed out hereinabove.

Another effect may be produced between the two shafts when the relationship between the propulsion means thereof is changed to cause the fluid motor to function as a pump and the pump to function as a fluid motor. This produces a flow of fluid from the motor to the pump which, functioning as a motor, causes the driven shaft to operate at increased speed but at reduced torque. This occurs when the capacity of the motor after having reached zero capacity has been moved to a reverse or pumping position which, up to a certain capacity, will drive the driven shaft faster than the driving shaft, thus acting as an overdrive. This overdrive effect can be built up until the capacity of the motor, acting in reverse, equals the capacity of the pump. When the capacity of the motor acting in reverse exceeds the capacity of the pump, a reversal of rotation of the driven shaft occurs relative to the direction of rotation of the driving shaft.

The ratio between the speed of the shafts, the overdrive and the reverse operation thereof can be illustrated as follows. If the capacity of the motor is adjusted to have five times the capacity of the pump, the pump will turn five times to supply fluid to produce one turn of the motor and one turn to keep up with the motor. Thus the ratio between the driving and driven shafts will be six to one. If the motor capacity is decreased to four times the capacity of the pump, the pump will turn four times to supply fluid to produce one turn of the motor and one turn to keep up with the motor. Thus the ratio will change to five to one. This relative relationship will continue until the capacity of the motor is zero, and as the pump need not turn to supply fluid it need only turn the one turn to keep up with the motor and the ratio is one to one, at which time the shafts are in direct coupled relation.

The operation of the motor in a reverse direction subtracts from the turn required of the pump to keep up with the motor and to this degree of difference will the driven

shaft increase its speed over the input shaft. This overdrive effect can be continued to a point where the capacity of the reversed motor equals that of the pump which can be indicated at the point of infinity. Going beyond the indicated infinity point, the motor will be operated by the fluid from the pump in a reverse direction with a speed depending upon the set capacity of the motor in reverse. For example, if the motor is set to full capacity in reverse at say five times the capacity of the pump, the pump must relatively rotate five times to supply the required fluid to the motor to produce one turn of the motor. Actually the pump is required to rotate only four turns, as a turn is picked up by the counteroperation of the shafts, thus producing a four to one reduction in ratio.

Initially upon starting the driving member at low speed, the system is so set that the fluid produced by the operation of the pump is by-passed to tank and no resistance is offered to pump operation. When the by-pass is shut off, the fluid builds up a pressure to a permissible amount, the reactance to which drives the shaft so that relative relationship exists between the pump revolution and shaft revolution relative to the rotation of the input shaft.

In a wobble plate type of motor, it is merely necessary to tilt the wobble plate in the opposite direction to that for direct drive to reverse the operation of the driven shaft. The volume of the motor must be larger, therefore, than the volume of the pump per revolution to cause the reversal of the propulsion means of the pump so that it will actually carry the reacting portion of the pump, and therefore the driven shaft, in a direction counter to the rotation of the input shaft.

The wobble plate on the fluid motor may be pivoted off-center relative to the driven shaft toward the side which produces thrust from the output pistons, which tends to force the wobble plate in a more angular position as the pressure increases on the piston. Thus, the ratio of supply and demand of fluid between the pump and motor tends to increase as the input torque increases, which is accomplished by increased throttle. The centrifugal force resulting from speed produced by the flywheel on the output shaft tends to straighten the wobble plate and in this manner tends to retain the driving and driven shafts in direct coupled relation. This condition may be balanced to any desired degree and will produce the effect of greater torque and increase of speed directly if more throttle is applied. When the throttle is increased, the increased power on the pistons of the fluid motor will cause its wobble plate to tilt due to the off-centered pivotal relation thereof and will counteract the flywheel which is tending to maintain the wobble plate in no-stroke position. Thus, the increase in throttle produces an increase in torque ratio which will be attempted to be overcome by the increase of centrifugal force in the flywheel. In the automobile, the increase in throttle produces an increase in torque which tends to produce an increase in speed. As the speed of the driven shaft increases, the centrifugal force of the flywheel overcomes the tilting force in the wobble plate, the wobble plate will be drawn to nonoperating position and thereby have no capacity. As a result, the pump can no longer pump fluid to the fluid motor and a lock occurs in the fluid system resulting from the fluid motor reaching no-volume capacity, and at this point the shafts are driven at the same speed directly without any fluid movement.

Accordingly, the main objects of the invention are: to provide a variable ratio hydraulic transmission which is directly coupled in such manner that it can be driven at high speed for long periods of time without developing any excess heat; to provide a transmission with a drive and driven shaft interlocked by a closed fluid system between a pump and motor when the shafts are driven at the same speed; to provide a transmission having a drive and driven shaft with a fluid system which is inoperative when the shafts are operating at the same speed and which is operative to produce a flow of fluid from the driven shaft to the drive shaft to increase the torque on the latter as the speed thereof decreases; to provide a transmission having a drive and driven shaft with a pump on the drive shaft and a variable capacity fluid motor on the driven shaft, the differential in speeds between the two shafts providing a proportional degree of operation of the pump which provides pressure to the fluid motor for increasing the torque on the driven shaft; to provide a transmission having a drive and driven shaft interconnected through a pump on the drive shaft and a variable capacity motor on the driven shaft, the capacity of the latter of which is controlled centrifugally to meet the torque requirements of the driven shaft when operating out of synchronism with the drive shaft; to provide a transmission having a drive and driven shaft interconnected through a pump and variable capacity motor, the operation of which increases with the increase in differential speed of operation between the shafts to provide increased torque to the driven shaft and which provides increased speed of the driven shaft over the drive shaft when the motor is in overdrive position and which produces a reversal of operation of the driven shaft when the fluid motor is in reverse position; and, in general, to provide a transmission which is simple in construction, positive in operation and economical of manufacture.

Other objects and features of novelty of the invention will be specifically pointed out or will become apparent when referring, for a better understanding of the invention, to the following description taken in conjunction with the accompanying drawings, wherein:

Figure 1 is a broken, plan view of an automotive vehicle having a transmission embodying features of the present invention;

Fig. 2 is an enlarged sectional view of the transmission illustrated in Fig. 1, taken on the line 2—2 thereof;

Fig. 3 is an enlarged sectional view of the structure illustrated in Fig. 2, taken on the line 3—3 thereof;

Fig. 4 is an enlarged sectional view of the structure illustrated in Fig. 2, taken on the line 4—4 thereof;

Fig. 5 is an enlarged sectional view of the structure illustrated in Fig. 2, taken on the line 5—5 thereof;

Fig. 6 is an enlarged sectional view of the structure illustrated in Fig. 2, taken on the line 6—6 thereof;

Fig. 7 is a view of structure, similar to that illustrated in Fig. 2, showing a further form which the invention may assume, and

Fig. 8 is a sectional view of the structure illustrated in Fig. 7, taken on the line 8—8 thereof.

Referring to Figs. 1 to 7, the transmission of the present invention is illustrated in Fig. 1 as being applied to an automobile. It is to be understood that the application of the transmission to an automobile and the specific structure employed in the transmissions is illustrated by way of example, as the transmission may be employed for many other applications and the form thereof may vary substantially from that herein described. A chassis frame **10** is of the conventional type, having an engine **11** supported thereon for operating through the transmission **12** of the present invention.

The transmission **12**, as illustrated in Figs. 2–6 inclusive, comprises a casing **13** having a removable cover **14** and bosses **15** and **16** at the opposite ends. A drive shaft **17** is journaled in a bearing **18** in the boss **15**, sealed against the passage of fluid from the inside of the casing **13** by a sealing element **19**. The shaft has a cuplike end **20** disposed within the casing, having four slots **21** in the cylindrical, inwardly extending wall **22** thereof. A driven shaft **23** is supported by bearings **24** in the boss **16** at the opposite end of the casing from the drive shaft **17** in alignment therewith. A bearing **25** is provided on the inner end of the drive shaft **17** in which the forward end **26** of the driven shaft **23** is supported. Medially of the ends of the shafts, a valve plate **27** is disposed in fixed relation therewith.

The forward end of the drive shaft **23** has a barrel **28** of a pump **89** mounted for rotation relative thereto. The barrel is provided with a plurality of cylinders **29** which are herein illustrated as being seven in number, but it is to be understood that any number of cylinders may be provided within the barrel. The barrel has four rollers **31** secured on the outer periphery thereof and each located within a slot **21** of the cup **20** on the drive shaft **17**. A swash plate **32** is mounted on the forward end of the shaft **23**, having an inner element **33** fixed to the shaft **23** by suitable means herein illustrated as by setscrews **34**. The outer element **35** of the swash plate has four rollers **36** secured to the outer peripheral surface thereof, each located within a slot **21** of the cup **20**. A piston **37** is mounted for reciprocation in each one of the cylinders **29** of the barrel **28**, having ball-ended connecting rods **38** connected to the piston **37** and the outer element **35** of the swash plate **32** in the conventional manner. The inner and outer elements **33** and **35** are connected in drive relation by balls **30** or other suitable means to transfer the reactive thrust of the pump to the shaft **23**. The location of the rollers **31** and **36** within the slots **21** produces the synchronized rotation of the swatsh plate element **35** and the barrel **28** relative to the shaft **23**.

A barrel **41** of a motor **90** is mounted for rotation on the rearward end of the shaft **23** on the opposite side of the valve plate **27** from that of the barrel **28**. The barrel is secured by a pair of arms **42** to a boss **43** on each side of the casing **13**. The barrel **41** has a cylindrical portion **43** extending therefrom, provided with four slots **44**. The inner element **46** of the swash plate **45** is secured to the shaft **23** by a pivot **47** which may be located on the center of the shaft but which is herein illustrated as being disposed in off-center relation therewith, for a purpose to be hereinafter described. The outer element **48** of the swash plate **45** is provided with four rollers **49** on the outer peripheral face thereof which operate in a slot **44** of the cylindrical extension **43** of the barrel **41**. The interconnection of the rollers **49** in the slots **44** retains the outer element **48** of the swach plate **45** from rotating so as to be maintained in alignment with the fixed barrel **41**. The barrel **41** contains a plurality of cylinders **51**, herein illustrated as being seven in number, although any number of cylinders may be utilized which may be of the same or greater capacity than the cylinders **29** of the barrel **28**. Each of the cylinders contains a piston **52** which is interconnected by ball-ended connecting rods **53** to the element **48** of the swash plate **45** in the conventional manner. The inner and outer elements **46** and **48** are interconnected by balls **50** or other suitable means to be in driving relation to each other. Thus, it will be seen that the barrel **41** is retained in fixed relation to the casing and that the swash plate **48** is retained in fixed relation to the barrel.

A sleeve **54** is splined to the rearward end of the shaft **23** for rotation therewith while being shiftable longitudinally thereon. A flywheel **55** is supported by trunnions **56** on the sleeve **54**. A link **57** is pivoted to the flywheel and to the inner element **46** of the swash plate **45**. A spring **58** interconnects the flywheel to the sleeve **54** diametrically opposite to the connection of the link **57** of the swash plate. A pair of flanges **59** extends outwardly from the sleeve **54**, providing a channel in which a roller **61** extends, the roller being mounted on an operating arm **62** mounted on an operating shaft **63** which is journaled in apertures in bosses **64**. The operating rod **63** extends through the casing and through a packing gland **65** in fluid tight relation therewith.

The valve plate **27** is provided with a fluid delivery passageway **66** on one half thereof and a fluid discharge passageway **67** and a fluid intake passageway **68** on the opposite half thereof. The fluid discharge slot **67** has a discharge aperture **69** and the fluid intake slot has an intake aperture **71**, the apertures **69** and **71** communicating with the interior of the casing **13**. The discharge slot **67** is

connected by a by-passageway **72** to a valve seat **73** on the center line of the shaft **23**. A by-pass passageway **74** interconnects the fluid delivery passageway **66** to the seat **73**. A rod **75** extends through the forward end of the shaft having a valve end **76** which is movable into engagement with the valve seat **73**. The rod has its forward end secured by a pin **77** to a collar **78** mounted exteriorly of the shaft **23**. The pin **77** operates within a slot **79** through the walls of the shaft. A pair of flyweight ball governors **81** is mounted on the drive shaft **17** on the base of the cuplike element **20** thereof, having fingers **82** disposed in engagement with the collar **78** for moving the collar and the rod **75** toward the rear end of the shaft **23**, thereby seating the end of the valve **76** on the seat **73** and cutting off the supply of oil from the delivery passageway **66** to the discharge passageway **67**. A spring **80** about the rod **75** retains the valve end **76** unseated and the governor **81** inoperative. Each cylinder **29** of the barrel **28** and each cylinder **51** of the barrel **41** has a passageway **83** at the end thereof which is relatively movable into and out of engagement of the passageways **66**, **67** and **68**, respectively. A fill plug **84** is provided in the cover **14** of the casing so that the casing may be maintained full of fluid after the cover is secured in sealed relation with the casing **13** by the gasket **86** and the plurality of screws **87**. The casing **13** is filled with a desirable fluid through the fill plug **84**, and the transmission is then in condition for operation. For the purpose of illustration, the valve **27** is shown offset from normal position. The outward movement of the pistons **37** should occur at the end of the slot **67**, but not at the center thereof, as shown.

Assuming the transmission to be employed on an automobile, when the engine **11** is started, the spring **80** retains the flyballs in inoperative position at idling engine speed. When the speed of the engine **11** increases, the flyballs overcome the tension of the spring **80** and start to seat the valve end **76**. When the valve end is unseated during the idling of the engine, the shaft **17** is rotating and the shaft **23** remains stationary. This permits the barrel **28** and wobble plate **32** to rotate relative to the shaft **23** and the wobble element **33**, thereby producing a pumping operation conforming to the speed of the drive shaft **17**. The pistons **37**, when in pumping position, discharge the fluid from the passageway **83** into the passageway **66** where it passes into the by-pass passageway **74** through the valve seat **73** to the bypass passageway **72** to the discharge passageway **67** and the discharge aperture **69**. In this manner, when the engine is idling, the pump is operating at the speed of the drive shaft, but is producing no driving force to the automobile as the fluid is directly by-passed back into the case.

When the speed of the engine increases and the valve seat **73** is being closed by the valve **76** due to the operation of the centrifugal device **81**, the reaction to the pump by the restriction to the flow of oil reacts on the driven shaft to produce its rotation. When the valve **76** reaches closed position, the fluid can no longer be by-passed and is directed from the passageway **83** of the pump to the passageway **66** of the valve into the passageway **83** of the motor. This produces a driving operation of the motor to an amount depending upon the degree of torque requirement on the shaft **23**, and as the torque requirement decreases, the speed of rotation of the shaft **23** will pick up until it reaches the same speed as the drive shaft **17** and the shafts will operate in direct coupled relation. This occurs by reason of the fact that the pumping of the fluid into the motor provides a drive force to the shaft **23** by the motor, the reactance to which applies a force back through the pump, which also produces a driving relation on the shaft **23**. As the speed of the shaft **23** increases, the centrifugal force of the flywheel **33** will reduce the capacity of the motor which will apply a further resistance to the operation of the pump, the reaction to which will further increase the speed of the shaft **23**, and if the torque load

permits the shaft **23** to continue to build up speed, the wobble plate **45** will be moved to neutral position so that the motor can no longer function, the pump can no longer pump and the two shafts will be operated at the same speed interlocked by the inability of the fluid to pass from the pump to the motor.

Should the torque requirement of the driven shaft thereafter increase, the operation of both shafts will slow down, the flywheel will tilt and shift the wobble plate of the motor to provide capacity thereto, and the pump will start operation to provide fluid to the motor as the driven shaft slows down. The fluid from the pump delivered to the motor adds torque to the shaft **23**, and if the shaft should further slow down due to the reduction in centrifugal force in the flywheel, the flywheel will be shifted by the spring **58** and the wobble plate **45** of the motor will be further shifted to further increase the motor capacity, the speed of the pump will be increased to supply fluid to the motor, which will add additional torque to the shaft **23** until a balanced condition is reached.

When the torque requirement on the shaft **23** is reduced, the speed of both shafts increases, increasing the centrifugal force of the flywheel **55** which operates to decrease the capacity of the motor, thereby forcing the fluid being pumped to react on the driven shaft to increase its speed, and as the speed of the driven shaft continues to increase as the torque requirement decreases, it will again become directly coupled with the drive shaft **17**.

When a reverse operation of the shaft **23** is desired, the operating rod **63** is actuated to move the arm **62** and shift the sleeve **54** toward the rear end of the shaft **23**, thereby reversing the slope of the wobble plate **45** and thereby reversing the action of the motor **90** when the capacity of the motor **90** is greater than that of the pump to cause the shaft **23** to operate in a reverse direction. In between the neutral position of the wobble plate **45** and its reverse position, an overdrive position obtains in a manner as pointed out hereinabove. The action above described occurs when the wobble plate element **45** is pivoted to the shaft **23** on the center line or when pivoted off-center thereof, as illustrated. When in off-center relation, an advantage is provided in that when the speed of the engine **11** is increased the increased supply of fluid from the pump **80** produces increased thrust on the piston of the motor **90** and the differential between the length of arm of the wobble plate element **46** and each side of the center of the shaft **23** tends to shift the wobble plate into a greater angular position and thereby apply an additional torque to the shaft **23**. The flywheel tends to counterbalance the tilting effect produced on the wobble plate due to the increased speed of the shaft **23**, thereby tending to bring the wobble plate to neutral position and the shafts in direct coupled relation. Thus, a greater torque can be applied to the shaft **23** through increasing the speed of the engine; that is to say, the same speed of driving of the automobile will be obtained by increasing the speed of the engine which will produce an increased speed of the drive shaft **17** over the shaft **23** and start operation of the pump **80** and the motor **90** until the torque requirement is overcome, at which time the engine speed can be reduced to have the shafts again run at the same speed or the shaft **23** will pick up additional speed to operate the automobile faster when the shafts are again running at the same speed due to the decrease of torque requirement.

Referring to Fig. 7, a different arrangement of the parts of the motor and pump is illustrated to show the possibility of employing different constructions, not only when utilizing the wobble type of pump and motor, but it is to be understood that different types of pump and motor may be employed and advantages provided thereby. In the illustrated construction, the fluid pump **80** is substantially the same as that illustrated in Figs. 2 to 6. A portion of a valve plate **91** is mounted to the driven shaft **23**, the other part **92** thereof being fixed to the casing **13** (not shown in Fig. 7). A cylindrical bracket **93** extends rearwardly from the plate **92** and is utilized for supporting a wobble plate **94** thereon by a pair of trunnions **95** which are journalled in bearings **96** on the element **93**. The trunnions are secured to the outer element **97** of the wobble plate **94**, the inner element **98** of which is secured to the shaft **23** by a key **99**, a universal joint or other connection which provides a drive connection therebetween while permitting the element **98** to rock relative to the shaft **23**. A barrel **101** is secured to the shaft **23** by splines **102**, so that the barrel and the element **98** of the swash plate rotate in synchronism with each other and the shaft **23**. The elements **97** and **98** of the swash plate are interconnected by a plurality of ball bearings **103** or other mechanism strong enough to withstand the strain of operation. Suitable mechanism, herein illustrated as a lever **104**, is employed for tilting the swash plate **94** to thereby vary the capacity of the motor **105** which embodies the barrel **101** and swash plate **94**.

The barrel **101** contains a plurality of cylinders **106** in which reciprocating pistons **107** are mounted and connected by ball-ended connecting rods **108** to the swash plate element **98**. The passageways **83** from the pump **89** communicate with an inlet passageway **109** on the intake side of the pump and with the discharge passageway **111** on the pressure side of the pump. The bypassing of fluid from the passageways **111** to the passageway **109** is cut off when the valve end **76** is seated on the valve seat **73**. Thereafter, delivered fluid from the passageway **111** enters a cylindrical passageway **112** in the valve plate **92** from which it is delivered to a valve passageway **66** and the motor **105** from which it is discharged into the valve passageway **67** and exhausted from the discharge passageway **69** into the casing **13**, not shown.

The structure illustrated in Figs. 7 and 8 operates in the same manner as the structure illustrated in Figs. 1–16, and is herein illustrated and described for the purpose of showing the use of different capacities of motors and pumps and the different arrangement of the parts. It will be noted that the barrel **101** and the inner element **98** in the wobble plate **94** rotate with the shaft **23**, and that the valve plate part **92** is fixed to the casing **13**. It has been pointed out hereinabove that the parts of the pump and motor may be of any form that is suitable and that the connection may be made to the shafts in any desirable manner, just so that the shafts can be directly coupled when no fluid is flowing and when fluid is flowing during the time the shafts are operating at different speeds, the fluid is utilized for applying torque to the driven shaft. The greater capacity of the motor over the capacity of the pump was found to be necessary to reverse the direction of operation of the driven shaft relative to the drive shaft when the direction of operation of the motor is reversed. It is to be understood that in the construction illustrated in Figs. 1–6, the capacity of the motor and pump may be changed, one relative to the other, to meet the specific requirement of output speed and torque.

What is claimed is:

1. In a transmission, a drive shaft, a driven shaft, a fixed capacity pump having first and second relatively movable elements secured to said drive and driven shafts and operated by the relative rotation therebetween as the driven shaft is rotated in the same direction as the drive shaft through the pump, a variable capacity fluid motor having first and second relatively movable elements disposed about said driven shaft and driven by the fluid from the pump, means interconnecting the driven means of said fluid motor to said driven shaft for driving the shaft in the same direction as said shaft is driven through the pump, fluid control means operated by said driven shaft for controlling the flow of fluid between said pump and motor, and means actuated by the drive shaft for controlling the delivery of the pump fluid to said motor when

the speed of the drive shaft is increased above a predetermined speed.]

[2. In a transmission, a drive shaft, a driven shaft, a fixed capacity pump having first and second relatively movable elements secured to said drive and driven shafts and operated by the relative rotation therebetween as the driven shaft is rotated in the same dirction as the drive shaft through the pump, a variable capacity fluid motor having first and second relatively movable elements disposed about said driven shaft and driven by the fluid from the pump, means interconnecting the driven means of said fluid motor to said driven shaft for driving the shaft in the same direction as said shaft is driven through the pump, fluid control means carried by said driven shaft for controlling the flow of fluid between said pump and motor, and means operated by the driven shaft for varying the capacity of said fluid motor.]

[3. In a transmission a drive shaft, a driven shaft, a fixed capacity pump having first and second relatively movable elements secured to said drive and driven shafts and operated by the relative rotation therebetween as the driven shaft is rotated in the same direction as the drive shaft through the pump, a variable capacity fluid motor having first and second relatively movable elements disposed about said driven shaft and driven by the fluid from the pump for applying torque to the driven shaft, means interconnecting the driven means of said fluid motor to said driven shaft for driving the shaft in the same direction as said shaft is driven through the pump, fluid control means carried by said driven shaft for controlling the flow of fluid between said pump and motor, centrifugal valve means operated by the drive shaft for controlling the delivery of the pump fluid to said motor, and means actuated by the driven shaft for varying the capacity of the fluid motor.]

4. In a transmission, a drive shaft, a driven shaft, a fixed capacity pump having first and second relatively movable elements secured to said drive and driven shafts, respectively, and operated by the relative rotation therebetween as the driven shaft is rotated in the same direction as the drive shaft through the pump, a variable capacity fluid motor having first and second relatively movable elements disposed about said driven shaft and driven by the fluid from the pump for applying torque to the driven shaft, one of said elements being a wobble plate interconnecting the driven means of said fluid motor to said driven shaft for driving the shaft in the same direction as said shaft is driven through the pump, a fluid control means carried by said driven shaft for controlling the flow of fluid between said pump and motor, means actuated by said drive shaft for actuating said control means to control the delivery of the pump fluid to said motor when the speed of the drive shaft is increased above a predetermined speed, a sleeve splined to said driven shaft, a flywheel supported for pivotal movement on said sleeve and which is shiftable axially with said sleeve to vary the capacity of said motor, and means positioned radially of the axis of said wobble plate for interconnecting said plate with said flywheel whereby tilting of said wobble plate is responsive to pivotal movement of the flywheel.

5. In a transmission, a drive shaft, a driven shaft, a fixed capacity pump having first and second relatively movable elements secured to said drive and driven shafts, respectively, and operated by the relative rotation therebetween as the driven shaft is rotated in the same direction as the drive shaft through the pump, a variable capacity fluid motor having first and second relatively movable elements disposed about said driven shaft and driven by the fluid from the pump for applying torque to the driven shaft, one of said elements being a wobble plate interconnecting the driven means of said fluid motor to said driven shaft for driving the shaft in the same direction as said shaft is driven through the pump, fluid control means carried by said driven shaft for controlling the flow of fluid between said pump and motor, means actuated by said drive shaft for actuating said control means to control the delivery of the pump fluid to said motor when the speed of the drive shaft is increased above a predetermined speed, a sleeve splined to said driven shaft, a flywheel supported for pivotal movement on said sleeve and which is shiftable axially with said sleeve to vary the capacity of said motor, means positioned radially of the axis of said wobble plate for interconnecting said plate with said flywheel whereby tilting of said wobble plate is responsive to pivotal movement of the flywheel, said means for interconnecting said wobble plate with the flywheel comprising a link pivotally connected at one end to said flywheel and at the other end to said wobble plate, and yieldable means interconnecting said flywheel to said sleeve and which yieldable means is disposed diametrically opposite to said link pivotal connection with the flywheel.

6. In a transmission, a drive shaft, a driven shaft, a fixed capacity pump having first and second relatively movable elements secured to said drive and driven shafts, respectively, and operated by the relative rotation therebetween as the driven shaft is rotated in the same direction as the drive shaft through the pump, a variable capacity fluid motor having first and second relatively movable elements disposed about said driven shaft and driven by the fluid from the pump for applying torque to the driven shaft, one of said elements being a wobble plate interconnecting the driven means of said fluid motor to said driven shaft for driving the shaft in the same direction as said shaft is driven through the pump, a fluid control means carried by said driven shaft for controlling the flow of fluid between said pump and motor, means actuated by said drive shaft for actuating said control means to control the delivery of the pump fluid to said motor when the speed of the drive shaft is increased above a predetermined speed, a sleeve splined to said driven shaft, a flywheel supported for pivotal movement on said sleeve and which is shiftable axially with said sleeve to vary the capacity of said motor, and means positioned radially of the axis of said wobble plate for interconnecting said plate with said flywheel whereby tilting of said wobble plate is responsive to pivotal movement of the flywheel, said control means for controlling the delivery of pump fluid to said motor comprising a centrifugally operated valve.

7. In a transmission, a drive shaft, a driven shaft, a fixed capacity pump having first and second relatively movable elements secured to said drive and driven shafts, respectively, and operated by the relative rotation therebetween as the driven shaft is rotated in the same direction as the drive shaft through the pump, a variable capacity fluid motor having first and second relatively movable elements disposed about said driven shaft and driven by the fluid from the pump for applying torque to the driven shaft, one of said elements being a wobble plate interconnecting the driven means of said fluid motor to said driven shaft for driving the shaft in the same direction as said shaft is driven through the pump, fluid control means carried by said driven shaft for controlling the flow of fluid between said pump and motor, means actuated by said drive shaft for actuating said control means to control the delivery of the pump fluid to said motor when the speed of the drive shaft is increased above a predetermined speed, a sleeve splined to said driven shaft, a flywheel supported for pivotal movement on said sleeve and which is shiftable axially with said sleeve to vary the capacity of said motor, means positioned radially of the axis of said wobble plate for interconnecting said plate with said flywheel whereby tilting of said wobble plate is responsive to pivotal movement of the flywheel, said control means for controlling the delivery of pump fluid to

said motor comprising a centrifugally operated valve, and yieldable means interconnecting said flywheel to said sleeve and which yieldable means is disposed diametrically opposite to said link pivotal connection with the flywheel.

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