W. E. LAPE.

HYDRAULIC TRANSMISSION.

APPLICATION FILED NOV. 1, 1915.

1,294,121.

Patented Feb. 11, 1919.

4 SHEETS—SHEET 1.

FIG. 1.

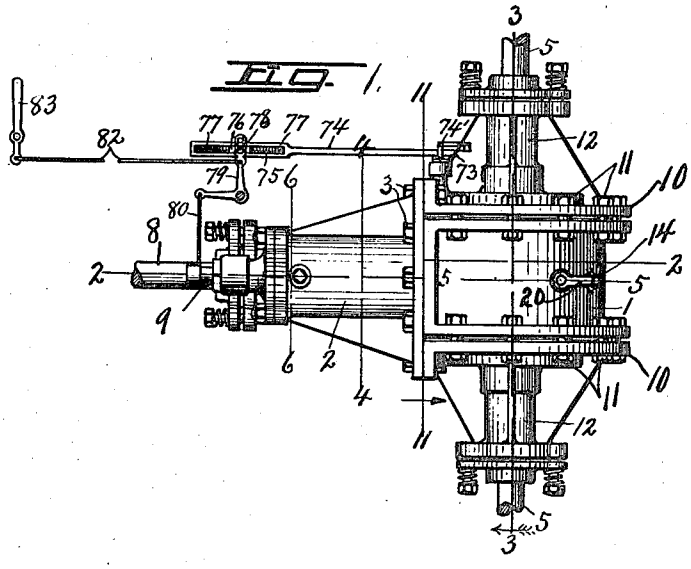
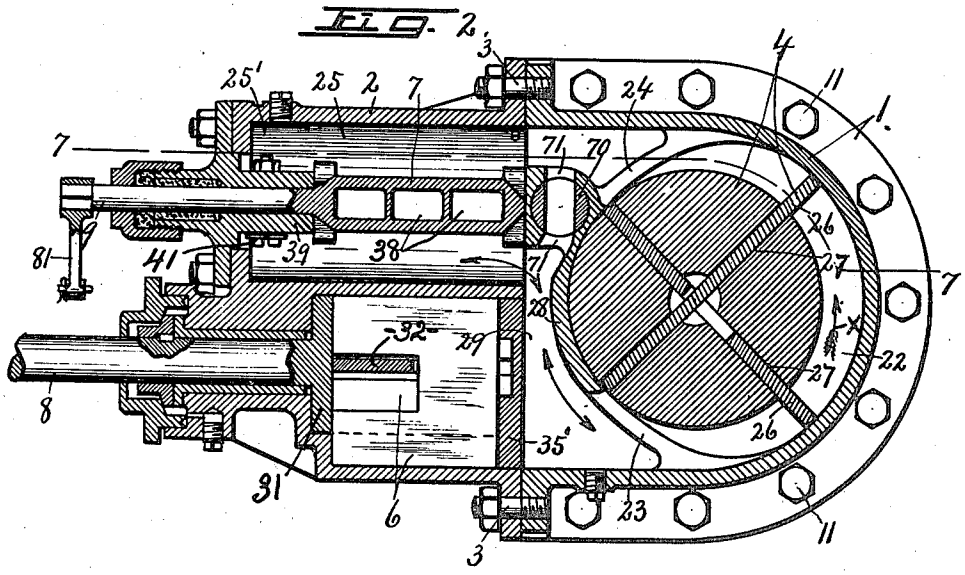


FIG. 2.



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4 SHEETS—SHEET 2.

Fig. 3.

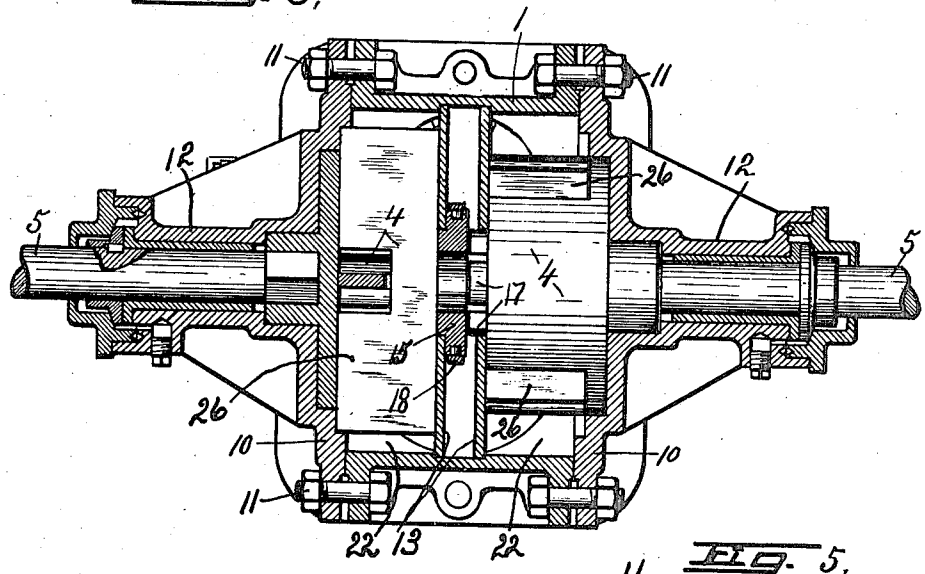


Fig. 4.

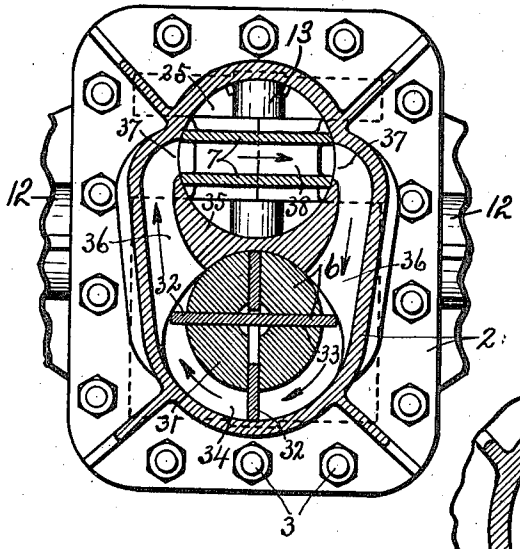


Fig. 5.

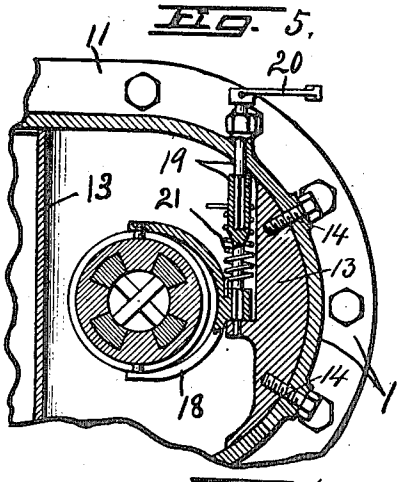
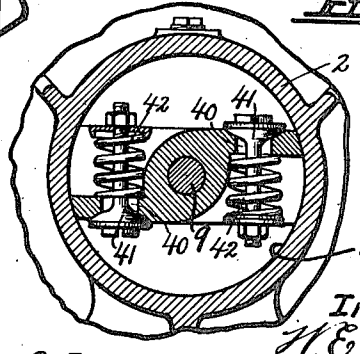


Fig. 6.



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4 SHEETS—SHEET 3.

Fig. 7.

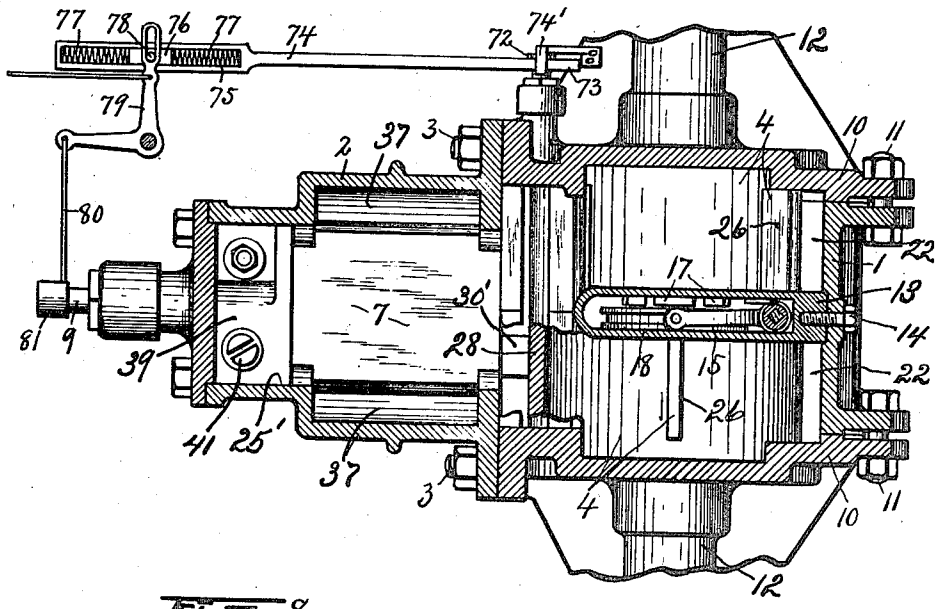


Fig. 8.

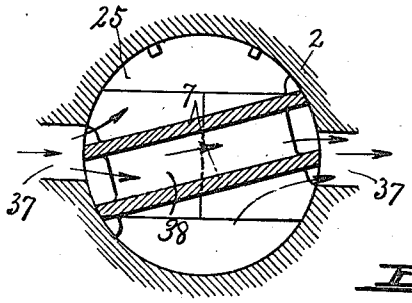


Fig. 9.

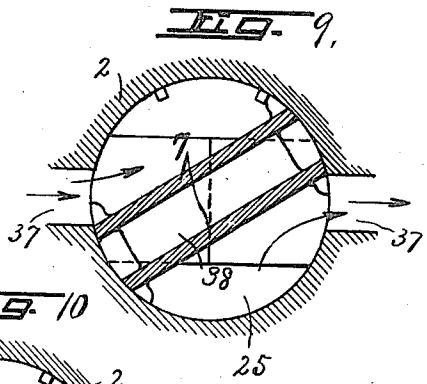
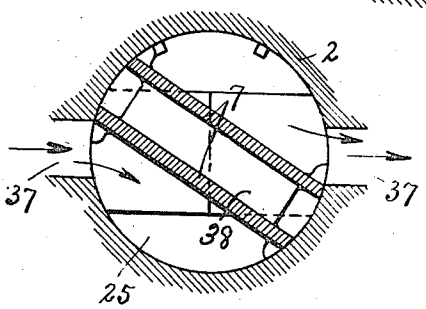


Fig. 10.



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4 SHEETS—SHEET 4.

FIG. 11.

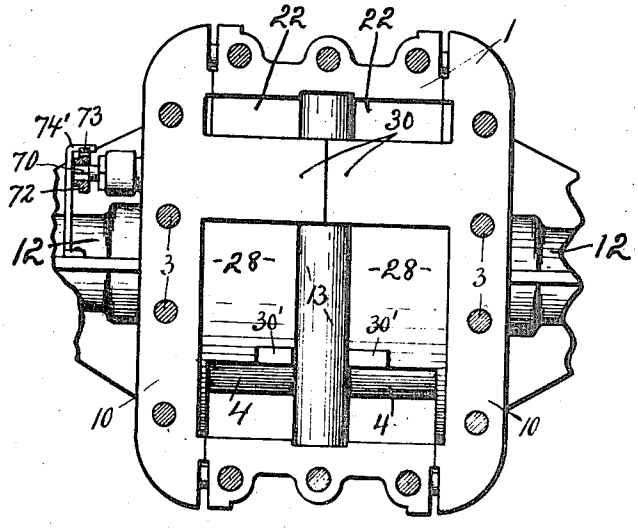


FIG. 12.

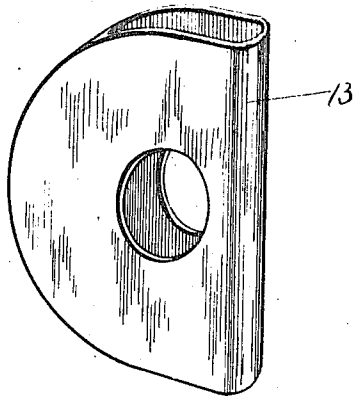
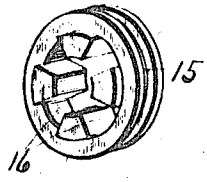


FIG. 13.



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UNITED STATES PATENT OFFICE.

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HYDRAULIC TRANSMISSION.

1,294,121. Specification of Letters Patent. Patented Feb. 11, 1919.

Application filed November 1, 1915. Serial No. 59,101.

To all whom it may concern:

Be it known that I, WILLARD E. LAPE, a citizen of the United States of America, and resident of Syracuse, in the county of Onondaga, in the State of New York, have invented new and useful Improvements in Hydraulic Transmission, of which the following, taken in connection with the accompanying drawings, is a full, clear, and exact description.

This invention relates to certain improvements in hydraulic power transmission as applied more particularly to engine-driven road vehicles to take the place of the usual variable speed gear transmission and gear differential mechanisms, the variable speed device being somewhat similar to that set forth in my Patent No. 1,168,216, issued January 11, 1916, while the combined variable speed mechanism and differential is somewhat similar to that set forth in my Patent No. 1,235,817, issued August 7, 1917.

The main object is to establish a direct hydraulic drive between the engine shaft and rear axle sections in such manner as to automatically produce a differential speed movement of the axle sections and traction wheels to compensate for the differential travel of the wheels in turning corners.

Another object is to provide simple means whereby the traction wheels may be caused to travel forwardly or rearwardly under variable speeds for propelling the vehicle in either direction under corresponding speeds.

A further object is to provide simple means controlled by the operator for causing both rear axle sections to be positively driven in the same direction and at the same speed when desired, as for example when one of the traction wheels tends to slip, while the other has a firm grip upon the road-bed, thereby assuring a more positive drive of the machine under all conditions within the range of power of the engine.

A still further object is to provide means for relieving the fluid conduits from excess pressure, as for example in sudden starting or stopping of the machine when the controlling valve is quickly opened or closed.

Other objects and uses relating to specific parts of the apparatus will be brought out in the following description.

In the drawings—

Figure 1 is a top plan of a portion of an engine-driven road vehicle showing my improved means of transmitting motion from the engine shaft to the rear axle sections.

Figs. 2, 3, and 4 are a longitudinal vertical sectional view and transverse vertical sectional views taken, respectively, on lines 2—2, 3—3, and 4—4, Fig. 1.

Fig. 5 is an enlarged lengthwise vertical sectional view taken on line 5—5, Fig. 1.

Fig. 6 is an enlarged transverse sectional view taken on line 6—6, Fig. 1.

Fig. 7 is a horizontal sectional view taken approximately in the plane of line 7—7, Fig. 2.

Figs. 8, 9 and 10 are detail sectional views of the valve case and valve showing the valve in different positions.

Fig. 11 is an enlarged transverse vertical sectional view taken on line 11—11, Fig. 1.

Fig. 12 is a perspective view of the detached hollow partition shown in section in Figs. 3 and 5 for separating the adjacent ends of the rotors on the rear axle sections and for receiving the clutch for locking the axle sections to each other.

Fig. 13 is a perspective view of one of the clutch sections shown in section in Figs. 3 and 5, and a top plan in Fig. 7.

Practically the entire mechanism forming the subject-matter of my invention is inclosed within a suitable housing, preferably of cast metal, and composed of separable sections —1— and —2— having substantially flat faces or ends secured together by clamping bolts —3— so as to form a substantially unitary structure when assembled, the section —1— constituting what may be termed the rotor case for receiving a pair of similar pistons or rotors —4— which in turn are secured to separate co-axial axle sections —5— carrying the traction wheels, not shown, while the other section —2— constitutes what may be termed the impeller-and-valve case for receiving the rotary impeller —6— and a rotary valve —7—.

The impeller —6— and valve —7— are arranged in their respective chambers one beneath the other to revolve about substantially the horizontal parallel axes at right angles to that of the rotors and rear axles, the impeller —6— being secured to and

driven by a shaft —8— of a suitable engine, not shown, while the valve —7— is provided with a stem —9— extending through the end wall of the valve case for connection with any suitable operating means under the control of the driver.

The rotor case —1— is provided with removable end heads —10— normally closing the outer ends of the chambers in which the rotors —4— are adapted to revolve, and tightly held in place by clamping bolts —11— to form an air and liquid tight joint and constituting a practically unitary part of the rotor case when in operative position, each head being provided with an outwardly extending bearing —12— in which the adjacent portions of the axle sections —5— are journaled.

The inner ends of the rotors —4— are spaced apart for receiving between them a hollow partition —13— which, for convenience of construction, is preferably made separate from the case and is closely fitted in suitable grooves in the lower, upper and rear sides of the central portion of the case held in operative position by one or more clamping bolts —14—, the front edge of the partition being closed and terminating a short distance beyond the corresponding faces of the rotors, but a sufficient distance to the rear of the adjacent end of the valve and impeller case to allow free flow of the impelling fluid from the valve chamber to both of the rotors.

The main purpose of this partition is to divide the inflowing fluid from the valve chamber and to direct the separate currents against their respective rotors and to keep such currents separated while traveling around the rotors to the outlet for imparting rotary motion thereto with approximately equal force when both wheels are traveling at the same speed under approximately the same traction resistance.

It is evident, however, that if the wheels are traveling at different speeds, as for example in turning corners, the resistance of the rotor corresponding to the slower moving wheel would cause the fluid to be diverted with greater velocity against the other rotor corresponding to the faster moving wheel, thereby automatically establishing a ratio of velocities of the fluid acting upon both rotors corresponding to the ratio of speeds of the wheels corresponding to said rotors and producing in effect a hydraulic differential which will perform its function with the same or greater degree of efficiency than the usual gear differential.

Another function of the partition —13— is to provide a convenient means for receiving the clutch by which the two rotors and their axles may be locked to each other in a manner presently described for positively driving both traction wheels when desired, as for example in case one traction wheel should tend to slip upon an icy, wet or soft bed, while the traction of the other wheel is more secure, under which conditions without the locking device the entire power would be diverted to the slipping wheel without propelling the machine, whereas by bringing the locking device into action the entire hydraulic power would act upon both rotors with the same degree of force and would in most cases assure the propulsion of the machine.

This locking device, as shown more clearly in Figs. 3, 5, 7 and 13, comprises a clutch section or collar —15— splined for sliding action co-axially upon the inner end of one of the rotors —4— within the hollow partition —13— and provided with recesses —16— for interlocking engagement with suitable clutch members —17— on the adjacent inner face of the other rotary section —4—.

The means for operating the clutch collar —15— comprises, in this instance, a rocking yoke —18— engaging in an annular groove in the periphery of the collar and secured to a rock shaft —19— which is journaled in the partition —13— and extends upwardly above the top of the case where it is provided with an operating member —20— for connection with any suitable actuating means within convenient reaching distance of and operated by the driver, said clutch being normally held in its inoperative position by a retracting spring —21—, Fig. 5.

The hollow partition —13— is preferably left open at the top and bottom to permit the clutch collar —15— with the yoke —18— and lower section of the rock shaft —19— to be properly installed therein before the partition is inserted in the case section —1—, said rock shaft being composed of lower and upper telescoping sections splined one upon the other so that the upper section may be connected to the lower section through the tube of the case after the clutch and lower section have been installed in the partition, as shown more clearly in Fig. 5.

When this partition is secured in place, it becomes for all practical purposes a unitary part of the case sections —1— and divides the interior thereof into separate chambers —22— for the rotors —4—.

These chambers —22— are provided with separate ports —23— and —24— leading, respectively, from the lower and upper sides of the rotors through the front of the case section —1— and communicating with the adjacent end of a valve chamber —25— at corresponding sides of the valve —7— which is movable in said valve chamber so that when the valve is adjusted to the position shown in Fig. 10 to allow the circulating fluid to pass from the lower side of the

chamber —25— through the port —23—, the rotors will be driven in one direction for propelling the machine forwardly, while on the other hand if the valve is adjusted to either of the positions shown in Figs. 8 and 9, the circulating fluid will pass from the upper side of the valve through the corresponding port —24— for driving the rotors in a reverse direction, thereby driving the machine backward.

The rotors —4— consist of similar circular drums secured co-axial to their respective axle sections and each provided with a pair of diametrically disposed plates —26— slidable endwise in diametric slots or ways —27— in their corresponding drums and having their outer ends contacting with the wall of the corresponding chamber —22— so as to form a fluid tight running joint therewith, said plates constituting wings or abutments against which the impelling fluid impinges for driving the axle sections and traction wheels connected thereto.

The chambers —22— are of greater cross sectional area than the corresponding area of their drums and are eccentrically disposed thereto in such manner that all diameters thereof extending through the axis of the rotors are equal to the length of the blades, the inner walls, as —28— of the chambers between the ports —23— and —24— being concentric with the axis of the rotors for contact with the peripheries thereof, thereby producing an automatic cut-off between said ports at the inlet and outlet sides of said chambers, and at the same time affording a passage —29— connecting the port —23— with the lower portion of the valve chamber —25—.

Direct communication between the passage —29— and port —24— is cut off by a partition —30— extending forwardly from the upper portion of the wall —28— and preferably forming a portion of the case section —1— and also a bearing for the inner end of the valve —7—, as shown more clearly in Fig. 2.

The ends of the rotors abut against the adjacent faces of the end heads 10— and partition —13— to form fluid tight running joints therewith.

The impeller —6— and chamber in which it is movable are similar, but somewhat smaller than the rotors —4— and their chambers, in that they consist of a circular drum —31— and diametrically extending blades —32— movable in corresponding guides —33— and having their outer ends contacting with the walls of a chamber —34— which is of greater cross sectional area than the corresponding area of the drum and eccentrically disposed thereto so that all diameters thereof passing through the center of the drum will be substantially equal to the length of the blades, thereby permitting the outer ends of the blades to form fluid tight running joints with the walls of the chamber.

The inner face of the upper wall, as —35—, of the chamber 34 is concentric with the axis of the drum 31 and is located between opposite passages —36— which connect the corresponding sides of the chamber with suitable ports —37— in diametrically opposite sides of the valve chamber —25—, as shown more clearly in Fig. 4, the latter being separated from the impeller chamber by the wall or partition —35—.

The inner end of the impeller chamber is closed by plate —35'— held in place by the adjacent end of the impeller and one or more shoulders —30'— extending forwardly from the inner wall —28— of the case section —1—, as shown more clearly in Fig. 7.

The opposite ends of the impeller —6— abut, respectively, against the inner face of the plate —35'— and outer wall of the impeller chamber to form fluid tight running joints therewith.

The valve —7— consists of a hollow plate disposed diametrically within the chamber —25— and extending from end to end thereof, said plate being provided with one or more transverse passages —38— therethrough from side to side for connecting the ports —37— and allowing the impelling fluid to circulate therethrough when the valve is in its neutral position, as shown in Fig. 4, the opposite edges of the valve plate being concentric with its axis of movement to form fluid tight turning joints with the valve case.

The thickness of the valve plate is considerably less than the diameter of the valve chamber in which it is movable so as to leave considerable space at opposite side thereof for communication with the ports —23— and —24—.

The inner end of the valve abuts against the adjacent face of the partition —30— cooperating therewith to form a fluid tight turning joint, and at the same time to cut off communication between the portions of the valve chamber at opposite sides of the valve, and also between the ports —23— and —24—, except as the fluid passes through the valve chamber, the outer end of the valve plate abutting against the outer end head of the valve chamber, as shown in Fig. 2, for the same purpose.

The stem —9— of the valve constitutes an operating means therefor and may be connected to any other actuating means within convenient reaching distance of and actuated by the driver when seated in the vehicle.

The case section —2— is provided with an auxiliary chamber —25'— forming an extension of the valve chamber —25— and is also provided with a transverse partition —39—

dividing said extension diametrically in approximately the plane of the valve when in its neutral position, said partition —39— being provided at opposite sides of the axis of the valve with separate ports —40— which are normally closed by reversely arranged valves —41— through the medium of comparatively stiff coil springs —42— so that if the pressure of the circulating fluid at either side of the valve —7— should exceed that at the other side of the valve, it would open the corresponding relief valve —41—, and thereby equalize the pressure, the purpose of the valves —41— being to prevent excessive pressure at either side of the valve —7—, thereby balancing said valve so that it may be operated freely at all times, and at the same time maintaining a uniform pressure of the fluid throughout the circulating system.

This excess pressure would be produced if the valve —7— were suddenly closed to its neutral position while the machine is in motion, particularly at high speed, during which the revolving traction wheels would become the driving means for the rotors —4— which would tend to ram the fluid into the valve chamber at one side of the valve —7—, thereby causing a sudden stoppage of the rotors and consequent skidding of the traction wheels until such pressure was partially relieved by the automatic opening of one of the valves —41— against the action of its retracting spring —42—.

Under these conditions, the machine will be brought to a sudden stop which, of course, would be detrimental to the machine and could only be prevented by the gradual closing of the valve —7—.

In order to overcome this objection and to allow the traction wheels and rotors to revolve freely with the power shut off, as in coasting, I have provided an auxiliary valve —70— located in the partition —30— and having a diametric opening therethrough movable into and out of registration with ports —71— in opposite sides of the chamber in which the valve —70— is mounted, the valve opening and ports —71— being common to both of the rotors —4—, and when the valve is open constitute a passage through which the fluid may be freely circulated by the rotors when the valve —7— is closed or in its neutral position.

It is desirable that the operation of the valves —7— and —70— should be approximately simultaneous so that when the valve —7— is moved to its neutral position to cut off communication between the impeller chamber and rotor chambers, the valve —70— will be opened and vice versa, and for this purpose the stem of the valve —70— is provided with a gear or toothed segment —72— meshing with a toothed rack —73— on one end of an operating bar —74—.

The other end of this operating bar is provided with an elongated slot —75— for receiving a sliding cross head —76— and opposite springs —77— between the opposite ends of the cross head and adjacent ends of the slot. This cross head is provided with a stud or pin —78— playing in an elongated slot in one arm of a bell crank lever —79—, the other arm of said lever being connected by a link —80— to a crank arm —81— on the stem —9— of the valve —7—.

The first-named arm of the bell crank lever —79— is connected by a link —82— to an operating lever —83— located within easy reaching distance of and adapted to be operated by the driver of a vehicle. By making an opening through the valve —70— it may be completely opened or closed by a quarter turn movement in either direction; and in order that this movement in either direction may be limited so as to assure the positive closing, the teeth of the pinion —72— are formed in approximately one-half of its periphery so that the opposite ends of the remaining uncut portion will form limiting stops coöperating with the rack —73— which will also limit the movement of the rack in either direction, said rack being held in mesh with the pinion by a bearing —74'.

The springs —77— are of sufficient tension to transmit motion from the bell crank —79— to the rack bar —74— for opening and closing the valve —70—, but are free to yield when the rack and pinion are brought to the limit of their movements in either direction for closing said valve, thus permitting a continued movement of the bell crank lever for additionally opening the main valve —7— to its full open position, it being understood that when the valve —7— is in its neutral position, the valve —70— is full open and that the operating mechanism is adjusted so as to close the valve —70— immediately upon the beginning of the opening of the main valve —7—.

In operation the entire circulating system is filled with a non-freezing liquid, as oil, which also constitutes a lubricant for the moving parts. The engine is then started in the usual manner, thereby driving the impeller —6— through the medium of the engine shaft —8—, and if the valve —7— is adjusted to the position shown in Figs. 2 and 7, it will cut off communication between the impeller chamber and rotor chambers and establish communication between the opposite sides of the impeller chamber through the passage —36, —38, and —36, thus allowing the fluid to be circulated in the direction indicated by the arrows without propelling the machine in either direction.

If it is desired to propel the machine for-

wardly, the valve will be adjusted to or toward the position shown in Fig. 10 to open communication between the port —37—, at the left-hand of Fig. 4, and the portion of the valve chamber —25— below the valve —7—, and to also open communication between the opposite port —37—and the portion of the valve chamber above the valve, thereby causing the circulating fluid to flow from the lower portion of the valve chamber through the passage —29— and port —23— to engage the rotor blades —26— and drive the rotors —4— and their corresponding axle sections and traction wheels in the direction indicated by arrow —X—, Fig. 2, the circulating fluid being returned over the top of the rotors through the ports —24— to the upper side of the valve chamber and thence back through the ports —37— and passage —36— at the right-hand of Fig. 4 and to the corresponding side of the impeller, thus completing the circuit which is repeated by the continued operation of the impeller in the same direction.

On the other hand, if it is desired to propel the machine backwardly, the valve —7— will be adjusted in the reverse direction, as shown in Figs. 8 and 9, so as to open communication between the port —36—, at the left-hand of Fig. 4, and the upper side of the impeller chamber above the valve —7—, and to also open communication between the passage —36— at the right-hand of Fig. 4 and lower portion of the valve chamber below the valve, whereupon the impelling fluid will be forced from the upper portion of the valve chamber through the port —24— and against the blades at the upper sides of the rotors, thence around the rear sides of said rotors and back through the ports —23— and passages —29— into the valve chamber at the lower side of the valve, whence it returns through the port —37— and passage —36— at the right-hand of Fig. 4 to the corresponding side of the impeller —6—, thus completing the circuit for reverse drive and permitting a continuation of the flow of the fluid in the same direction as long as the valve remains in the positions shown in Figs. 8 and 9, or in any other intermediate position, it being understood that the speed of movement of the machine will depend upon the degree of opening of the valve —7—.

It is now evident that if the traction resistance on both wheels is approximately the same as in ordinary driving, the hydraulic power applied to both rotors will be approximately equal and that when the machine is turning a corner with the result that the outer wheel will travel faster than the inner wheel, the differential speeds will cause the rotor corresponding to the traction wheel moving at the highest speed to be driven with a corresponding velocity, while that corresponding to the slower moving inner wheel will be driven with a slower motion corresponding to such reduced velocity, owing to the fact that the resistance to rotation of the slower moving wheel will be greater than that of the faster moving wheel, and that the fluid will follow the course of least resistance.

It is also evident that in endeavoring to drive the machine straight ahead or reverse if one of the traction wheels should slip and the other wheel maintain a firm traction grip upon the pavement, the resistance offered by the rotor corresponding to the gripping wheel would cause practically the full power of the circulating fluid to act upon the rotor corresponding to the slipping wheel, thereby driving the latter at a high rate of speed, while the gripping wheel would remain stationary, which, of course, would prevent driving of the machine in either direction, and in order to obtain the desired traction necessary to propel the machine under these conditions, the clutch —15— may be operated to lock both rotors and their axle sections together, thereby preventing the rotation of the slipping wheel and applying the full power of the circulating fluid to both rotors for rotating the gripping wheel, which, in most cases, will extricate the machine from the difficulty of propulsion, and as soon as both wheels are on solid ground or operating with the same degree of traction, the machine will move along in the usual manner.

If, for any reason, the pressure of the fluid at one side of the valve should become excessive, as for example by reversing the valve while the machine is in motion, this excess pressure would be exerted upon the corresponding valve —41— to open the same against the action of its retracting spring —42—, thereby relieving the strain upon the valve and other parts of the mechanism.

What I claim is:

1. In hydraulic power transmission, the combination of a fluid-driving element, coaxial fluid-driven elements, separate chambers for said elements, a valve chamber connected by certain passages to the chamber of the fluid-driving element and by other passages to the chamber of the fluid-driven element, and a valve controlling said passages so that in one position the fluid will be caused to travel through the second-named passages in one direction, and in another position the fluid will be caused to travel through the same second-named passages in an opposite direction, said valve having means for connecting the first-named passages when closing communication between the second-named passages, and means for opening communication between said second-named passages at a point between said valve and the fluid-driven element to

allow the latter to rotate freely when the valve is closed.

2. In hydraulic power transmission, the combination of a fluid-driving element, independently revoluble fluid-driven elements, separate chambers for said elements, a valve chamber connected by separate ports to the chamber of the fluid-driving element, a valve dividing said valve chamber into separate compartments communicating through separate ports with the chambers for the driven elements, said valve being adjustable to connect either compartment with either of the first-named ports, and the other compartment with the other first-named port.

3. In hydraulic power transmission, the combination of a fluid-driving element, independently revoluble fluid-driven elements, separate chambers for said elements, a valve chamber connected by separate ports to the chamber of the fluid-driving element, a valve dividing said valve chamber into separate compartments communicating through separate ports with the chambers for the driven elements, said valve being adjustable to connect either compartment with either of the first-named ports, and the other compartment with the other first-named port, and provided with a passage for connecting the first-named ports when adjusted to a certain position for cutting off communication between the first-named chambers.

4. In hydraulic power transmission, the combination of a fluid-driving element, a fluid-driven element, separate chambers for said elements, a valve chamber connected by separate ports with the chamber for the driving element, a valve dividing said valve chamber into separate compartments communicating through separate passages with the chamber for the driven element, said valve being adjustable to connect either port with either compartment and the other port with the other compartment, and automatic means for causing an equalization of pressure in both compartments in case that in one compartment should exceed that in the other compartment.

5. In hydraulic power transmission, separately rotatable co-axial pistons, and chambers therefor, in combination with engine-driven means for circulating a fluid through said chambers circumferentially around the pistons for driving the same, and means operable at will for locking the pistons to each other to prevent the rotation of one independently of the other.

6. In hydraulic power transmission for road vehicles, the combination with separately rotatable co-axial axle sections and separate pistons secured thereto, of a housing for said pistons having separate ports leading from one side of and circumferentially around the same, engine-driven means for circulating a liquid through said ports and around the pistons for rotating both pistons and their axle sections in the same direction, and means operable at will for locking the axle sections to each other to cause them to rotate at the same speed.

7. In a motor-driven vehicle, the combination with an engine-driven shaft and separate co-axial axle sections at right angles to said shaft, of hydraulic means for transmitting rotary motion from the shaft to the axle sections comprising a housing inclosing the adjacent ends of the axle sections and shaft, and containing an impelling fluid, an impeller in said housing secured to the shaft for circulating said fluid, separate co-axial rotors on the axle sections also within the housing and driven by said circulating fluid, clutch sections on the adjacent ends of the axle sections, and means for engaging and disengaging one clutch section with the other.

8. In a motor-driven vehicle, the combination with an engine-driven shaft and separate co-axial axle sections at right angles to said shaft, of hydraulic means for transmitting rotary motion from the shaft to the axle sections comprising a housing inclosing the adjacent ends of the axle sections and shaft, and containing an impelling fluid, an impeller in said housing secured to the shaft for circulating said fluid, separate rotors on the axle sections also within the housing and driven by said circulating fluid, and means for locking the rotors to rotate in unison.

9. The combination with an engine-driven shaft and separate co-axial axle sections of a motor-driven vehicle, a housing inclosing the adjacent ends of the axle sections and engine shaft and provided with separate rotor chambers, a valve chamber and an impeller chamber, separate co-axial rotors secured to the axle sections and movable in their respective chambers, a rotary valve movable in the valve chamber, a rotary impeller secured to the engine shaft within the impeller chamber, ports leading from the rotor chambers to the valve chamber at opposite sides of the valve, additional ports leading from opposite sides of the impeller to diametrically opposite sides of the valve chamber, said valve being provided with a transverse passage therethrough for connecting the last-named ports when the valve is in its neutral position, and means for adjusting said valve in either direction from its neutral position to connect either port with either side of the valve chamber.

10. In hydraulic power transmission for road vehicles, a pair of independently revoluble coaxial rotors, a housing therefor having fluid-circulating passages extending from one side of the piston around the opposite side thereof, a valve chamber having a valve dividing it into separate compart-

ments, and adjustable to connect either compartment with either passage and the other compartment with the other passage, and engine-driven means for circulating a motive fluid through said compartments and passages when the valve is so adjusted.

11. In hydraulic power transmission for road vehicles, the combination with a pair of independently revoluble coaxial pistons, and a housing therefor provided with separate inlet and exit passages extending through one side around the opposite side of the pistons, of an impeller chamber and a rotary impeller therein, a valve chamber having opposite ports communicating with opposite sides of the impeller chamber, a valve in the valve chamber dividing it into separate compartments and provided with a passage therethrough normally communicating with its ports, said valve being adjustable to close the passage therethrough and to connect either compartment with either port and the other compartment with the other port, each compartment communicating with one of said passages.

12. In a device of the character described, a housing having a rotor chamber, an impeller chamber and a valve chamber containing, respectively, a pair of independently revoluble coaxial rotors, an impeller and a valve, the valve chamber having opposite ports communicating with the impeller chamber at opposite sides of the impeller, said valve dividing its chamber into two compartments communicating through separate passages with the rotor chamber, the valve having a passage therethrough normally connecting said ports and adjustable to cut off communication between its passage and ports and to simultaneously connect one compartment with one of the passages and the other compartment with the other passage.

In witness whereof I have hereunto set my hand this 14th day of October, 1915.

WILLARD E. LAPE.

Witnesses:
H. E. CHASE,
ALICE M. CANNON.