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C. M. MANLY.

STARTING MECHANISM FOR PRIME MOVERS.

(Application filed Nov. 23, 1901.)

(No Model.)

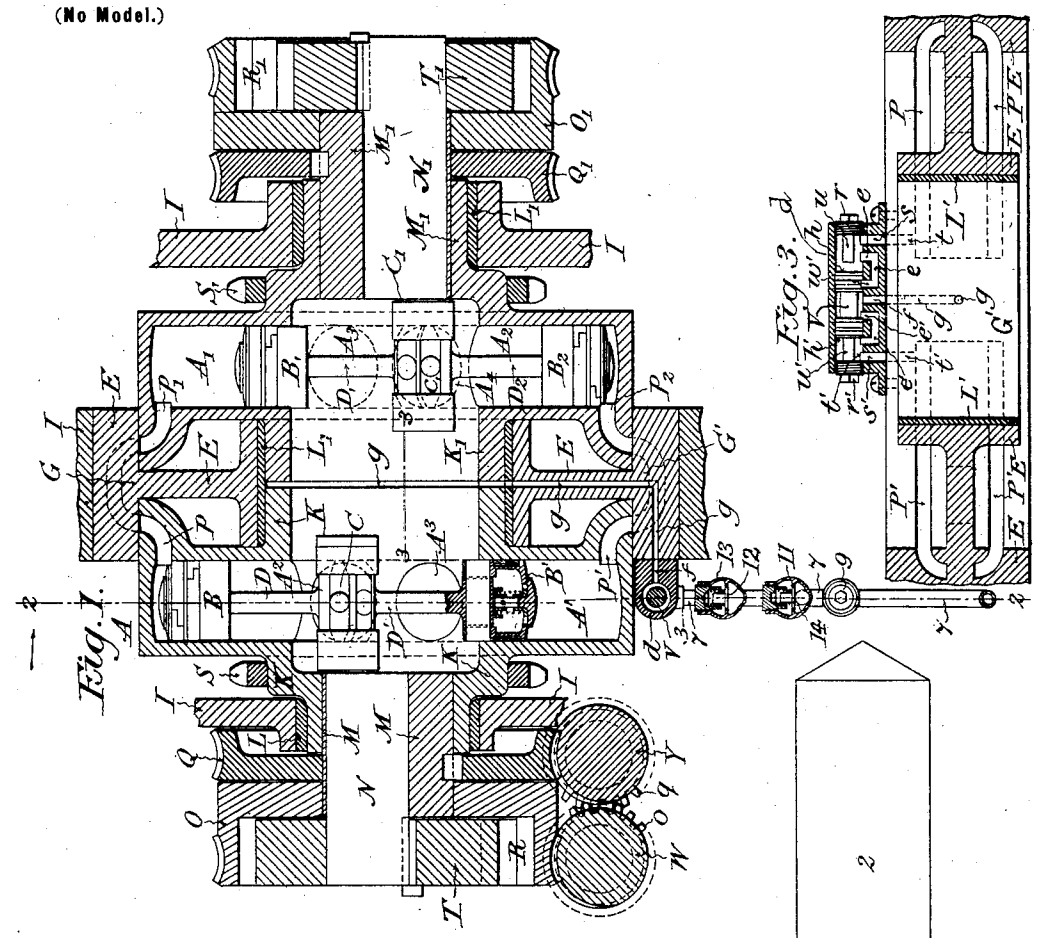


Fig. 1.

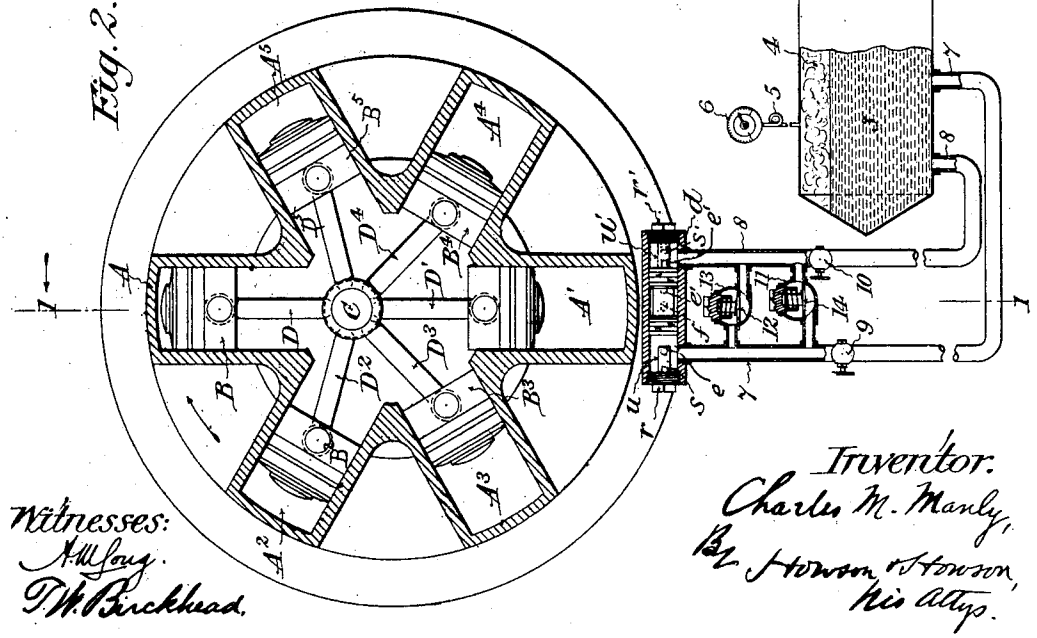


Fig. 2.

Fig. 3.

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UNITED STATES PATENT OFFICE.

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STARTING MECHANISM FOR PRIME MOVERS.

SPECIFICATION forming part of Letters Patent No. 710,486, dated October 7, 1902.

Application filed November 23, 1901. Serial No. 83,465. (No model.)

To all whom it may concern:

Be it known that I, CHARLES MATTHEWS MANLY, a citizen of the United States, residing at Washington, District of Columbia, have invented certain new and useful Improvements in Starting Mechanisms for Prime Movers, of which the following is a specification.

My invention relates to starting mechanisms for prime movers in which the prime mover is caused to store up energy by forcing a fluid under pressure by means of a pump into a reservoir, which stored energy is later used for starting the prime mover by allowing the fluid under pressure to flow back into and operate the pump, thus operating the prime mover to which the pump is connected.

My object is to provide simple and effective means in such mechanisms as that designated for permitting the prime mover to store up energy at any convenient time, so that without any exertion on the part of the operator or attendant beyond the simple opening of a valve the prime mover may be started at will at any future time and which shall be especially adapted for use in connection with various internal-combustion engines, such as are used on motor-vehicles and other structures where the necessity for starting the prime mover occurs very frequently and where it is especially desirable that it should not be necessary for the operator or attendant to start the prime mover by physical exertion.

With these objects in view my invention consists of a starting mechanism embodying a pump driven by a suitable connection with a prime mover, a reservoir containing a compressible fluid and connected to the pump by a fluid-circuit, means for causing the pump at some time while it is driven by the prime mover to store up energy in the reservoir in the form of fluids under pressure, and means for causing said fluids so stored up to pass back into the pump at will and drive it in either direction, and thereby drive the said prime mover until the prime mover either commences to operate under its own power or said energy so stored is exhausted; and my invention further consists in the novel construction and details thereof with reference to the accompanying drawings, as hereinafter described, and more particularly pointed out in the claims.

In the drawings, Figure 1 is a longitudinal sectional view through the center of my speed-gear on the line 1 1, Fig. 2, looking in the direction of the arrow. Fig. 2 is a transverse sectional view on the line 2 2, Fig. 1, and looking in the direction of the arrow, the pistons, rods, and pipes being shown in elevation; and Fig. 3 is a sectional plan view on the line 3 3, Fig. 1.

In the drawings I have shown my new starting mechanism as combined with a variable-speed gear such as described and claimed in my application for Letters Patent, Serial No. 79,582, filed October 22, 1901, as this combination of variable-speed gear and starting mechanism is especially adapted for use on motor-vehicles and other like structures, though it is to be understood that I do not confine my present invention to a use in combination with a variable-speed gear, such a combination being adopted herein mainly for the purpose of more clearly illustrating an important and valuable relation in which my starting mechanism may be used, or to any specific form of variable-speed gear.

Referring now to the drawings, in which the same reference characters relate to the same or corresponding parts in all the views, I will first sufficiently describe the essential parts of the variable-speed gear to enable any one skilled in the art to clearly understand the relation of my starting mechanism to such a speed-gear or any other speed-gear or mechanism of a similar kind.

The pump structure is on the left of the stationary valve E and the motor structure on the right in Fig. 1, and as the construction of both is similar a detailed description of the pump will be sufficient to clearly set forth the manner in which both are to be made.

The rotary-cylinder structure of the pump is provided with a plurality of cylindrical chambers A A′ A^2 A^3 A^4 A^5, constituting the pump-cylinders, which cylinders are radially disposed around the axial line of the structure, such axial line passing centrally through the valve structure and the trunnion-bearings of the pump and motor structures. The cylinders A A′ A^2, &c., are provided with suitable ports p p', &c., adapted to register successively with the ports P and P′ of the valve E during the rotation of the pump

structure. Pistons B, B′, B^2, B^3, B^4, and B^5 are slidably mounted in the cylinders and are connected to a relatively fixed but radially-adjustable crank-pin C by means of connecting-rods D, D′, D^2, D^3, D^4, and D^5, having a rocking connection with the pistons and adapted to turn on and around the crank-pin.

The cylinder structure K is rotatably mounted in its bearings and is rotated by driving connections with a prime mover—as, for example, by means of a sprocket S, fixed to the cylinder structure and driven by suitable connections with said prime mover.

The crank-pin C is eccentrically disposed with reference to the central axial line and is carried by a shaft N, mounted in the eccentric bore of a bush M, the outer or peripheral surface of which is concentric with respect to the trunnion-bearing L of the cylinder structure K, in which trunnion said bush is rotatably mounted. The bush M is fixed by means of a suitable key or other fastening means to a worm-gear Q, and the shaft N is similarly fixed to a spur-gear T, operating as an inner gear, meshing with internal teeth R on the worm-gear O, rotatably mounted upon the exterior surface of the bush M. The crank-pin C may be adjusted toward and from the axial line of the device by the rotation of the bush M and the shaft N in opposite directions by means of two worm-screws W and Y, meshing with their respective worm-wheels O and Q, said worm-wheels being connected together through two meshing spur-wheels *o* and *q*, mounted upon their respective worm-shafts and rotated by any suitable means.

The ports *p p′*, &c., of the cylinders A A′, &c., are adapted to register successively with the ports P and P′ in the valve structure, as hereinbefore indicated, so that when the cylinder structure is rotated, for example, in a direction as indicated by the arrow, Fig. 2, the upper cylinder A being at its upper dead-center, the lower cylinder A′ being at its lower dead-center, the ports of the cylinders A^4, A^5, and A will first register with the port P′ in the valve, and as the pistons are making the inward stroke said port P′ will act as an inlet-port to supply the said cylinders with fluid as the pistons respectively perform their suction-strokes, the cylinders A^2, A^3, and A′ following in succession. On the other hand, the ports of the cylinders A^3, A^2, and A′ will first register with the port P of the valve structure, and as the pistons during that part of the rotation of the cylinder structure are making their outstrokes or delivery-strokes the fluid contained in the cylinders will be forced outwardly through their ports into the port P of the valve structure, the cylinders A^4, A^5, and A following in succession. To prevent intercommunication between the pressure and suction ports of the valve E as the cylinder-ports pass the bridges, the bridges G and G′, which divide the ports P and P′, are made equal in width to the width of the cylinder-ports *p p′*, &c. The rotation, therefore, of the rotary cylinder structure on the left side of the valve structure causes the several pistons to operate as a hydraulic pump, fluid being drawn into one half of the cylinders while fluid is being forced out by the other half through the receiving and distributing ports of the said valve, and in order to cause said fluid to be circulated in a closed circuit and constitute a fluid or liquid connection between the driving element of a power-transmitting device connected to a prime mover and the driven element thereof the delivery from the pump operates a motor independently movable with respect to the pump structure and connected to the driven part or device, such a motor comprising a plurality of cylinders A_1 A_2 A_3 A_4, &c., mounted on a cylinder structure K_1, here shown as similar in all respects to the cylinder-pump structure and having trunnion-bearings journaled at the outer end in a sleeve L, secured in the frame I, and at the inner end in the bush or sleeve L_1, mounted in the valve structure E. Each cylinder has a corresponding reciprocating piston B_1 B_2 B_3, &c., connected by corresponding piston-rods D_1 D_2, &c., to a crank-pin C_1, carried by a shaft N_1, mounted in an eccentric bore of the bush M_1. The crank-pin C_1 of the motor structure is relatively fixed, but adjustable, and is here shown as located at a point below the axial line and one hundred and eighty degrees from the crank-pin C, and the cylinders are provided with ports p_1 p_2, &c., adapted to successively register with the ports P and P′ in the valve structure E, and said valve structure is so disposed that as one-half of the pump-cylinders is delivering fluid thereto one-half of the motor-cylinders is receiving the fluid so delivered, thereby giving the corresponding pistons in said motor-cylinders their inward stroke, and as the crank-pin C_1 is relatively fixed the pressure between the respective pistons and the heads of the motor-cylinders will cause said motor-cylinder structure to rotate in the same direction as the pump-cylinder structure, and while the other half of the pump-cylinders is drawing in fluid from the distributing-port P′ of the valve structure the other half of the motor-cylinder structure is exhausting fluid into said port, and thus a closed circuit of fluid may be maintained between the pump and the motor structures. The relatively fixed crank-pin C_1 is similarly located with respect to its shaft N_1, and the eccentricity of the bore of the bush M_1 is likewise similarly disposed with reference to the eccentricity of the crank-pin C_1, as in the pump structure, while the worm-wheels Q_1 and O_1 and the inner gear T_1 are all similarly connected to their respective parts, so that the crank-pin C_1 may be adjusted in a radial line with respect to the face of the valve structure E in exactly the same way as the crank-pin C of the pump structure.

It will be seen from the foregoing description that the crank-pin C may be adjusted by the rotation of the bush M and the shaft N in opposite directions from a maximum predetermined positive value through zero to a maximum predetermined negative value, the passage of the said crank-pin C through the central axial line of the structure, or zero, to the opposite side of the said line on which the crank-pin C is shown causing the ports P and P′ to change functions—that is, by such change in the position of the crank-pin C from above to below said axial line the port P will become the suction-port and the port P′ the pressure-port. It is readily seen that by having the crank-pins of both the motor and pump structures adjustable either may be used as a motor or pump. It is also apparent that by the adjustment of the motor crank-pin C_1 to the central axial line the said motor is rendered inoperative, as in such position all the cylinder-heads are equidistant from the crank-pin, and consequently the introduction of pressure between the pistons and the cylinder-heads from the fluid-circuit under the influence of the pump will have no effect tending to impart movement to the rotary-cylinder structure.

The interior space of the valve structure and the cylinder structures and the passages between the rotary-cylinder pump structure and the rotary-cylinder motor structure are intended to be supplied with fluid, preferably oil or water, in order to provide the closed fluid-circuit heretofore referred to.

A relief-chamber *d* is mounted on the exterior of the valve structure E, said relief-chamber *d* being connected to the ports P and P′, respectively, through the passages *t* and *t′*, said passages *t* and *t′*, respectively, opening into the relief-chamber *d* through the ports *s* and *s′*. This relief-chamber is bored to receive a piston-valve V, composed of a stem connecting two pistons *h* and *h′* and adapted to move back and forth in the bore of said relief-chamber, but which is limited in its extent of motion by the stops *u u′*, formed on the inner ends of the plugs *r r′*, closing the bore of said relief-chamber *d*. On that side of the relief-chamber *d* next to the valve structure E are formed channels *e* and *e′*, while the relief-chamber is also connected through the port *f* to a passage *g* in the bridge G′ of the valve-structure E, said passage *g* continuing from the bridge G′ down through the web of the valve structure E to the central space of the rotary-cylinder structures. To accomplish the relief of any excess of fluid in the suction-port of the valve E and at the same time to retain the pressure in the pressure-port of the valve structure E, the distance between the two piston-heads *h* and *h′* and the length of the stops *u* and *u′* on the plugs *r* and *r′* are such that when one head—say *h*—of the valve V covers the inner end of the channel *e* the other head *h′* of the valve V will rest in the position shown, thus allowing any excess of fluid which might be in the port P′ to pass out through the port *s′*, the channel *e′*, the port *f*, and the passage *g* into the central space of the rotary-cylinder structures, while the fluid which is under pressure in the port P of the valve E will pass into the other end of the relief-chamber *d*, but striking against the head *h* of the piston-valve V will keep said piston-valve forced against the projection *u′* of the plug *r′*, which in turn will cause the head *h* to close the inner end of the channel *e*, which, as is readily seen, will prevent any direct communication between the pressure-port of the valve E and the interior of the drum except in the proper way. It will thus be seen that the piston-valve V normally closes the pressure or delivery port of the valve E from the central space and normally opens the suction-port thereof to said central space. The interior of the cylinder structures, including the central space, and all the passages having been supplied with oil or water the pump-cylinder structure is rotated through the medium of the sprocket S, driven from a prime mover, by which operation the pistons are caused to reciprocate in the pump-cylinders as the said pistons are carried around the crank-pin C, thus acting upon the fluid in the cylinders to force the same through the respective cylinder-ports *p p′*, &c., into the port P in one half of the valve and to suck fluid from the port P′ in the other half of the valve and from the interior space of the cylinder structure. If the direction of rotation of the pump-cylinders is fixed, the radial position of the crank-pin C will determine the function of the ports P and P′ as delivery or pressure port and inlet or suction port, since these ports change functions as the crank-pin C in its adjustments is passed through the central axial line.

From the foregoing description it is obvious that as one half of the pump delivers fluid to one half of the motor-cylinders the other half of said motor-cylinders exhausts fluid into the passages and ports leading to the other half of the pump-cylinders and by adjustment of the crank-pin C or C_1, or both, the relative speed of rotation of the motor-cylinder structure with respect to the pump-cylinder structure may be varied.

I do not claim in this application any of the features of the speed-gear *per se*, as hereinbefore described, for they are claimed in my prior application, heretofore referred to, my present invention being limited to the starting mechanism, which I will now describe.

In order to apply my starting mechanism to a speed-gear of the type thus briefly described, I provide a tank or reservoir 2, suitable for containing fluids under pressure, which reservoir is preferably connected with and outside of the fluid-circuit of the speed-gear by means of two pipes or conduits 7 and 8, communicating with the said fluid-circuit through the relief-chamber *d*, said connect-

ing pipes or conduits 7 and 8 connecting with the relief-chamber in such a manner as to establish a fluid communication between the reservoir and opposite sides of the fluid-circuit. In order to provide means for preventing at will the passage of the fluid through either of said pipes 7 and 8, I interpose at some point in the said pipes the globe-valves 9 and 10, respectively, and in order to provide means for automatically preventing an excess of pressure in the reservoir above any predetermined point I connect the two pipes 7 and 8 together at some point between the globe-valves and the chamber *d* by branch pipes or conduits, in which are located two spring-closed relief-valves 12 and 14, confined within their respective valve-casings 11 and 13. One of these relief or safety valves 12 is adapted to automatically open and connect the pipe 8 to the pipe 7 when the pressure in said pipe 8 rises above a predetermined point, and the other of said valves 14 is adapted to connect the pipe 7 to the pipe 8 when the pressure in said pipe 7 rises above a predetermined point. In order that the operator or attendant may see at any time what pressure exists in the reservoir, a pressure-gage 6, placed at any convenient point, is connected to the reservoir 2 by means of a pipe 5. By means of the two pipes 7 and 8 and their respective globe-valves 9 and 10 it is possible to cause the fluid under pressure in the reservoir to pass to either side of the fluid-circuit, and consequently to run the pump in either direction as a motor, and therefore to drive the prime mover at will in either direction.

In the operation of the variable-speed gear it is advantageous to use a practically non-compressible fluid, such as oil or water, for the fluid-circuit, and it is also advantageous in the operation of the starting mechanism to have a similar fluid for the fluid-circuit which passes to and fro in the pipes 7 and 8, while for the storage of the power in the reservoir 2 it is advantageous to have a quantity of a lighter fluid, such as air or gas, in the said reservoir 2, so that said lighter fluid may be compressed to a greater extent, and consequently allow the storage of more energy in the same capacity of reservoir, and I have therefore indicated in the upper part of the reservoir a space 4, filled with a lighter fluid, such as air or gas, which normally occupies a considerable portion or all of the space in the reservoir, but which is here shown as compressed into the upper portion of the reservoir by the heavier fluid 3, which has been allowed to pass into it from the pressure side of the fluid-circuit of the variable-speed gear. It will be further understood that by combining the starting mechanism with a variable-speed gear energy may be stored in the reservoir which is not directly furnished by the prime mover and which would otherwise be practically wasted, since if the device or combination of devices is used in connection with a motor-vehicle or similar structure said energy may be stored by allowing the motor of the variable-speed gear to force fluid into the reservoir when the vehicle is going down hill or when it is desired to reduce its inertia, in either of which cases the pumping of the fluid into the reservoir by the motor of the speed-gear would cause the speed-gear to act as a brake, and thus tend to slow down the vehicle. The addition of the reservoir and its connections to a variable-speed gear will also materially contribute to the steadiness of operation of the driven device to which the speed-gear is connected if the fluid from the pump side of the speed-gear is allowed to have access to the reservoir, since the pressure in the reservoir will be then at all times practically the same as that in the pressure side of the fluid-circuit of the speed-gear, and the compressible fluid in the reservoir will tend to make the delivery of fluid to the motor of the speed-gear more uniform, and thus tend to reduce any fluctuations in the speed of said motor, and consequently of said driven device to which said motor is connected.

The operation of the device is as follows: Suppose the various parts of the variable-speed gear in the position shown in the drawings and that the pump-cylinder structure of the variable-speed gear is rotated by the prime mover in such a direction as to cause fluid to be forced into that side of the relief-chamber *d* which is connected to the pipe 7, and that the globe-valve 9, situated in this pipe circuit or conduit, is open, and the valve 10, situated in the pipe 8, connecting the opposite side of the relief-chamber *d* to the reservoir, is closed, and that the reservoir 2 is full of a compressible fluid, such as air or gas, at atmospheric pressure, a portion of the fluid from the fluid-circuit of the speed-gear can then pass through the pipe 7, the globe-valve 9, and into the reservoir 2, and since said fluid cannot pass out of the reservoir through the pipe 8, because the globe-valve 10 is closed, said fluid being forced into said reservoir under pressure will cause the air or gas in the reservoir 2 to be raised in pressure until either the pressure in the reservoir 2 equals that in the pressure side of the fluid-circuit of the speed-gear or until the safety-valve 14 opens and allows the excess of pressure to pass through its case 11 and into the suction side of the fluid-circuit of the speed-gear through the pipe 8, which latter would result if the predetermined pressure at which the safety-valve 14 is set to open were equal to the pressure then existing in the pressure side of the fluid-circuit. While the fluid is still under pressure in the reservoir 2, the valve 9 may be closed, thus shutting off all communication between the reservoir and the fluid-circuit of the speed-gear, and this energy in the form of fluids under pressure may be retained in the reservoir until any time at which it is desired to utilize it. Suppose now that the prime mover is at a standstill and

that the various parts of the pump structure of the speed-gear are in the positions shown and that the motor structure of the speed-gear is prevented from revolving either by adjusting its crank-pin C_1 so as to coincide with the axis of rotation of the motor structure or by the application of a brake to the driven device to which the motor is connected or by any such suitable means, and suppose that it is desired to cause the pump structure, and consequently the prime mover, to revolve under the pressure previously stored in the reservoir, it will be seen that by opening the valve 10 the fluid under pressure in the reservoir 2 will pass through the pipe 8 into the relief-chamber *d*, immediately causing the relief-valve V to cut off communication between that side of the relief-chamber and the interior of the speed-gear structures, and thus permitting the fluid to pass only into those cylinders which are in communication with the port P′ of the receiving and distributing valve E, which port is connected by ports and passages with that side of the relief-chamber *d* which is connected to the pipe 8, and since the motor-cylinder structure K_1 is prevented from turning, as previously explained, the fluid under pressure will act between the heads of the cylinders A^4 and A^5 of the pump structure and the heads of their respective pistons B^4 and B^5, thereby causing the pump-cylinder structure, and consequently the prime mover to which it is connected, to revolve in the direction shown by the arrow in Fig. 2, and which, we will suppose, is in the same direction as that in which the prime mover should be turned in order to start it, since it is the same direction in which we supposed the pump structure to revolve when it forced the fluid under pressure into the reservoir 2. The pump-cylinder structure being thus caused to rotate and in the direction shown by the arrow in Fig. 2, the cylinders A, A^2, A^3, and A′ will successively pass under the port P′ of the valve E and receive pressure from it until the pressure has been exhausted in the reservoir 2 or until communication between the fluid-circuit of the speed-gear and the reservoir has been cut off by closing the valve 10, while each cylinder will discharge into the port P, and thereby into the interior of the speed-gear structures, the fluid so received from the reservoir 2. If the prime mover should start with the valve 9 still closed and the motor structure of the speed-gear unable to revolve, owing to its being blocked, as previously explained, the fluid which is forced into the port P of the valve E will escape into the interior of the speed-gear structures by passing into the pipe 7, then into the valve-case 11, where, if its pressure be great enough, it may raise the spring-closed valve 14 and then pass into the pipe 8 and thence through the relief-chamber *d* and into the interior of the speed-gear structures. If the valve 10 in the pipe 8 is open when the fluid under pressure passes through the valve-case 11 and into the pipe 8, by raising the valve 14 a portion of it will pass into the reservoir 2 until the pressure in said reservoir becomes equal to that in the pipe 8. If the crank-pin of the pump structure is adjusted to its extreme position diametrically opposite to that shown in the drawings and it is desired to start the prime mover by the fluid under pressure in the reservoir 2, it will then be necessary to open the valve 9 in the pipe 7, allowing the fluid to pass into the port P of the valve E, if the prime mover, and consequently the pump structure of the speed-gear, are to be driven in the same direction as that indicated by the arrow in Fig. 2, and from this it will be readily seen that where a rotary pump whose stroke may be varied from a positive maximum to a negative maximum is used both the storage of the fluid under pressure from the pump and the later utilization of such fluid under pressure for driving the pump in either direction may be accomplished by means of only one conduit or pipe connecting the fluid-circuit of the pump to the reservoir, for it is apparent that the fluid may be stored in the reservoir under pressure by opening the connection between the reservoir and the pressure side of the pump while the latter is operating, thus permitting some of the fluid from said pressure side of the pump to pass into the reservoir, such connection being closed when the desired pressure in the reservoir is attained. When it is desired to utilize this pressure from the reservoir for the purpose designated, the stroke of the pump may be changed from its positive position—as, for example, by the shifting of the crank-pin C to the opposite side of the axial line—to its negative position, thus making it possible to admit the fluid-pressure through the same connection to that side of the pump which has by such change now become the suction side. If the pump structure is being revolved by the prime mover, with the crank-pin C of the pump adjusted to this position diametrically opposite to that shown in the drawings, the port P′ of the valve E will then be the pressure side of the fluid-circuit and communication between the reservoir and pressure side of the fluid-circuit will be obtained by opening the valve 10 in place of the valve 9, as in the previous description. If it is desired to allow the motor of the speed-gear to pump fluid into the reservoir 2 when said motor is being revolved by some external power, and if we suppose the crank-pin of the motor to be in the position shown in Fig. 1 and that the direction of rotation of the motor structure is the same as that attributed to the pump structure in the above description, it will be readily seen that the motor will deliver fluid to the port P′ of the valve E, and this fluid so pumped by the motor into the port P′ may be permitted to pass into the reservoir 2 by opening the valve 10, and it will also be readily seen that such pressure in the port P′ and in the reservoir 2, if

the valve 10 be open and the valve 9 closed, will thus act on the pump to drive it in the direction shown by the arrow in Fig. 2, which is the same direction that we supposed the prime mover to drive the pump, and therefore such driving of the pump by the motor will drive the prime mover in its proper direction, which, if it is desired, will enable the operator or attendant to shut off the power from the prime mover until the pump ceases to be driven by the fluid-pressure from the motor or until it is desired to cause the pump to revolve under power furnished by the prime mover.

As previously stated, my present invention is not limited to its combination with my variable-speed gear or to any specific fluid-pressure variable-speed gear, for it is evident that the combination of a prime mover with a pump which is adapted to force fluid under pressure into a reservoir in which such pressure may be stored and which is in turn adapted to be driven by such fluid-pressure stored in the reservoir would fall within the scope of my invention, and so, also, would any other specific form of hydraulic speed-gear adapted to coöperate with a reservoir for the storage of fluid under pressure derived from the fluid-circuit of the speed-gear in such a way as to permit the fluid under pressure in the reservoir to drive the prime mover or driving device through the medium of the said speed-gear.

I claim as my invention—

1. The combination with a variable-speed gear comprising a pump adapted to be connected to a prime mover and having a variable stroke, means for varying the stroke of the pump, a motor adapted to be driven by said pump, and a closed fluid-circuit between the pump and motor, of a reservoir outside of said fluid-circuit adapted to contain fluid under pressure, a connection adapted to establish fluid communication between said reservoir and said fluid-circuit, means for controlling said fluid communication between said fluid-circuit and said reservoir, whereby fluid under pressure may be stored under pressure in said reservoir and said fluid so stored may be at will permitted to return to drive said pump and cause it to operate as a starting device for the prime mover, substantially as described.

2. The combination with a variable-speed gear, comprising a pump adapted to be connected to a prime mover, a motor adapted to be driven by said pump, and a closed fluid-circuit between the pump and motor, of a reservoir outside of said fluid-circuit adapted to contain fluid under pressure, a connection adapted to establish a fluid communication between said reservoir and said fluid-circuit, means for controlling said fluid communication between said fluid-circuit and said reservoir, whereby fluid from the pressure side of said fluid-circuit may be stored under pressure in said reservoir and said fluid so stored may be at will permitted to return to drive said pump as a motor to cause said pump to operate as a starting device for said prime mover, substantially as described.

3. The combination with a variable-speed gear comprising a rotary-cylinder pump structure adapted to be driven by a prime mover, a rotary-cylinder motor structure adapted to be driven by the pump and a closed fluid-circuit connecting the pump and motor structures, of a reservoir outside of said fluid-circuit adapted to contain fluid under pressure, a connection adapted to establish fluid communication between the said fluid-circuit and reservoir, and means for controlling said fluid communication, whereby fluid from the pressure side of the said fluid-circuit may be stored under pressure in said reservoir and said fluid so stored may be permitted at will to return to drive said pump and cause it to operate as a starting device for the prime mover, substantially as described.

4. The combination with a variable-speed gear comprising a rotary-cylinder pump structure adapted to be driven by a prime mover, a rotary-cylinder motor structure adapted to be driven by the pump, and a closed fluid-circuit connecting the pump and motor structures, a valve between said pump and motor having ports therein through which a fluid may pass to and from said pump and motor, of a reservoir outside of said fluid-circuit adapted to contain fluid under pressure, a connection adapted to establish fluid communication between the said fluid circuit and reservoir, and means for controlling said fluid communication, whereby fluid from the pressure side of the said fluid-circuit may be stored under pressure in said reservoir and said fluid so stored may be permitted at will to return to drive said pump and cause it to operate as a starting device for the prime mover, substantially as described.

5. The combination with a variable-speed gear comprising a pump adapted to be connected with a prime mover, a motor adapted to be driven by the said pump, and a closed fluid-circuit between the pump and motor, of a reservoir adapted to contain fluid under pressure, conduits connecting the reservoir with the said closed fluid-circuit, valves in said conduits controlling the passage of fluid from said circuit on the pressure side of the pump to the reservoir, and from the reservoir to the suction side thereof, whereby the pump may be driven by fluid previously stored under pressure in the reservoir, substantially as described.

6. The combination with a variable-speed gear, comprising a pump adapted to be driven by a prime mover, a motor adapted to be driven by the pump, and a closed fluid-circuit between the pump and motor, of a starting mechanism, consisting of a reservoir outside of said fluid-circuit containing a compressible fluid connected with the closed fluid-circuit on the pressure and suction sides of

the pump, and means for causing the pump to force fluid from the closed circuit into the reservoir, thereby compressing the fluid therein and storing it under pressure in said reservoir, and means for admitting at will, the stored liquid to the suction side of the pump, substantially as described.

7. The combination with a variable-speed gear, comprising a rotary-cylinder pump structure adapted to be driven by a prime mover, a rotary-cylinder motor structure adapted to be driven by the pump, a closed fluid-circuit connecting the pump and motor structures, and a valve-chamber having a relief-valve therein interposed between the pressure and suction sides of the pump and adapted to relieve excess fluid in the fluid-circuit, of a reservoir adapted to contain fluid under pressure, conduits connecting the reservoir with the relief-valve chamber and adapted to connect the pressure and suction sides of the fluid-circuit with said reservoir through the relief-valve chamber, whereby fluid in the fluid-circuit under pressure from the pump may pass into the reservoir, and valves in said conduits, whereby fluid under pressure may be stored in the reservoir and utilized to operate the pump as a starting device, substantially as described.

8. The combination with a pump adapted to be driven by a prime mover, of a reservoir adapted to contain fluid under pressure, conduits connecting the reservoir with the pressure and suction sides of the pump, valves in said conduits for controlling the passage of fluid from the pressure side of the pump to the reservoir, and from the reservoir to the suction side of the pump, and means interposed between the two conduits for automatically permitting fluid to pass from one to the other when a predetermined pressure is attained therein, substantially as described.

9. The combination with a variable-speed gear, comprising a rotary-cylinder pump structure adapted to be driven by a prime mover, a rotary-cylinder motor structure, a closed fluid-circuit connecting the pump and motor structures, mechanism for adjusting the motor so as to render the same inoperative while the pump structure rotates, a valve-chamber communicating with the pressure and suction sides of the pump, and a relief-valve operating in said chamber to relieve excess of fluid in the suction side of the pump, of a reservoir adapted to contain fluid under pressure, conduits connecting said reservoir with the relief-valve chamber on opposite sides of the valve, and valves in said conduits for controlling the flow of fluid under pressure between the reservoir and the relief-valve chamber, substantially as described.

10. The combination with a variable-speed gear, comprising a rotary-cylinder pump structure adapted to be driven by a prime mover, a rotary-cylinder motor structure, a closed fluid-circuit connecting the pump and motor structures, mechanism for adjusting the motor so as to render the same inoperative while the pump structure rotates, a valve-chamber communicating with the pressure and suction sides of the pump, and a relief-valve operating in said chamber to relieve excess of fluid in the suction side of the pump, of a reservoir adapted to contain fluid under pressure, conduits connecting said reservoir with the relief-valve chamber on opposite sides of the valve, valves in said conduits for controlling the flow of fluid under pressure between the reservoir and the relief-valve chamber, and automatic means interposed between the two conduits for permitting the passage of fluid from one to the other when the pressure in either attains a predetermined point, substantially as described.

11. The combination with a variable-speed gear, comprising a rotary-cylinder pump structure adapted to be driven by a prime mover, a rotary-cylinder motor structure, a closed fluid-circuit connecting the pump and motor structures, mechanism for adjusting the motor so as to render the same inoperative while the pump structure rotates, a valve-chamber communicating with the pressure and suction sides of the pump, and a relief-valve operating in said chamber to relieve excess of fluid in the suction side of the pump, of a reservoir adapted to contain fluid under pressure, conduits connecting said reservoir with the relief-valve chamber on opposite sides of the valve, valves in said conduits for controlling the flow of fluid under pressure between the reservoir and the relief-valve chamber, relief-valves interposed between the two conduits adapted to automatically open communication between the conduits when the pressure in one conduit open to the reservoir reaches a predetermined point, substantially as described.

12. The combination with a variable-speed gear, comprising a pump adapted to be connected with a prime mover, a motor adapted to be driven by said pump, and a closed fluid-circuit between the pump and motor, of a reservoir adapted to contain fluid under pressure, conduits connecting said reservoir with said closed fluid-circuit, means interposed between the two conduits for automatically permitting fluid to pass from one to the other when a predetermined pressure in either is attained, and valves in said conduits for controlling the passage of fluid between said closed fluid-circuit and said reservoir, substantially as described.

13. The combination with a variable-speed gear, consisting of the rotary-cylinder pump structure K, adapted to be driven by a prime mover, the rotary-cylinder motor structure K_1 connected with the pump structure by a closed fluid-circuit, the relief-valve chamber d communicating with the pressure and suction sides of the pump, the relief-valve V operating in said chamber, of a reservoir 2 containing a compressible fluid, pipes 7 and 8 connecting said reservoir with the fluid-circuit

on the opposite sides of the valve V, and stop-valves 9 and 10 in said pipes, substantially as described.

14. The combination with a variable-speed gear, consisting of the rotary-cylinder pump structure K, adapted to be driven by a prime mover, the rotary-cylinder motor structure K_1 connected with the pump structure by a closed fluid-circuit, the relief-valve chamber *d* communicating with the pressure and suction sides of the pump, the relief-valve V operating in said chamber, of a reservoir 2 containing a compressible fluid, pipes 7 and 8 connecting said reservoir with the fluid-circuit on the opposite sides of the valve V, stop-valves 9 and 10 in said pipes, and relief-valves 12 and 14 interposed between said pipes 7 and 8, substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

CHARLES M. MANLY.

Witnesses:
CHAPMAN W. FOWLER,
R. T. FRAZIER.