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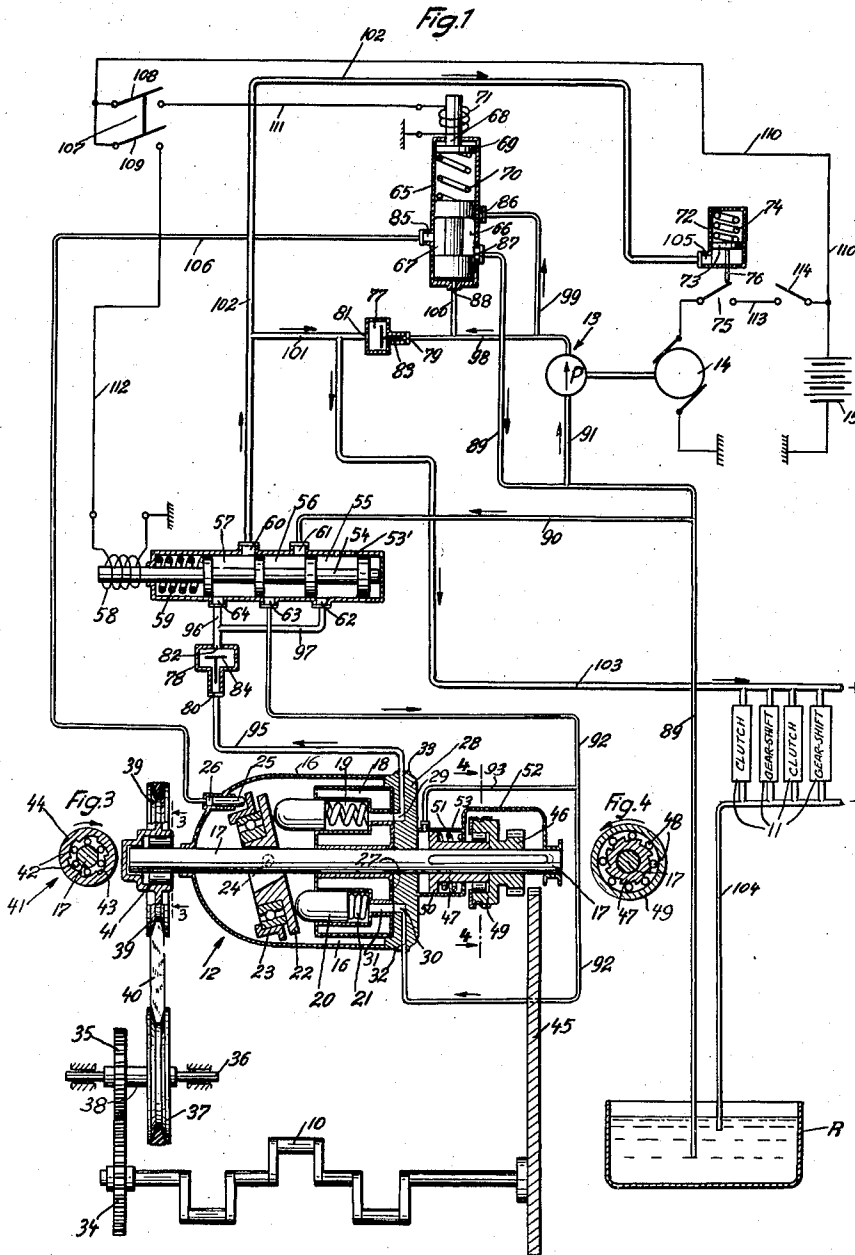
HANS-JOACHIM M. FORSTER

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STARTING AND CONTROL SYSTEM FOR A POWER PLANT

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2 Sheets-Sheet 1



Inventor
HANS-JOACHIM M. FÖRSTER
BY *Dicke and Cray*
ATTORNEYS

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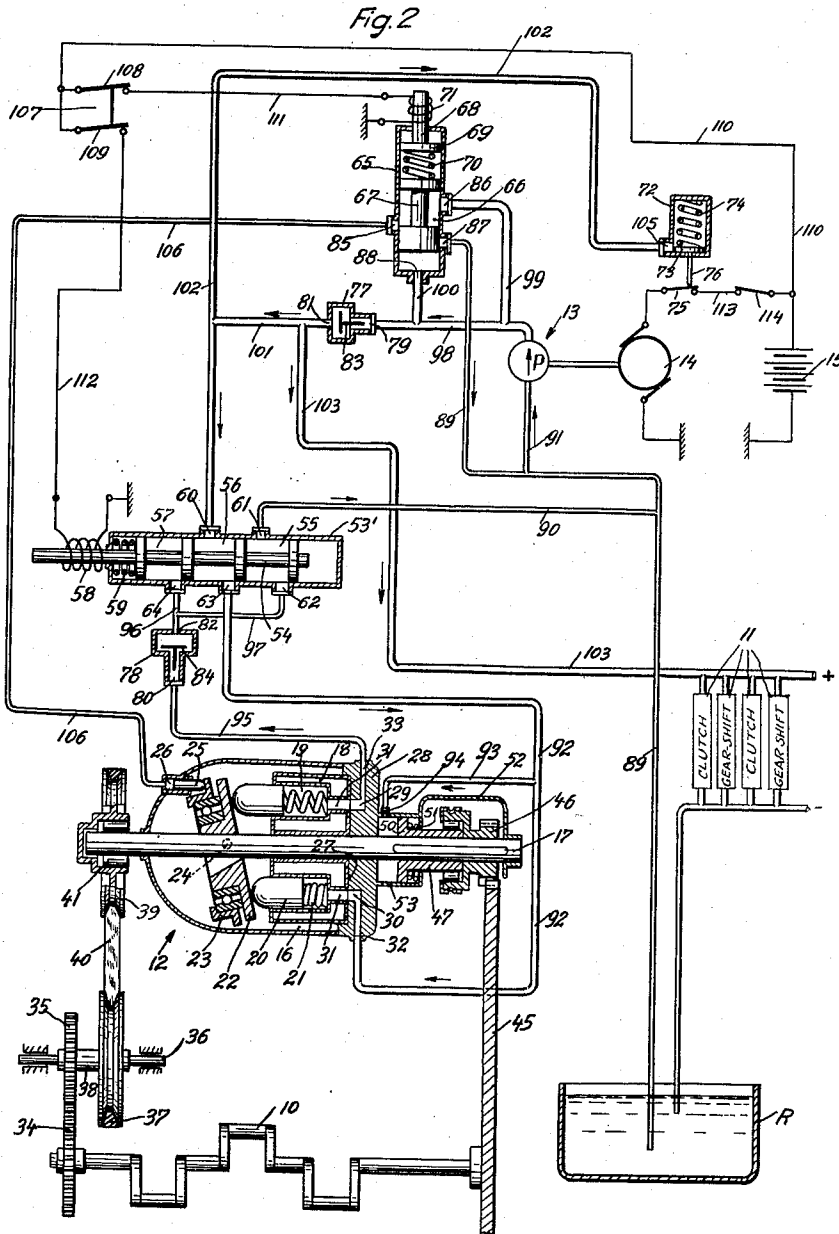
HANS-JOACHIM M. FORSTER

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Inventor
HANS-JOACHIM M. FORSTER
BY *Lick and Craig*
ATTORNEYS

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STARTING AND CONTROL SYSTEM FOR A POWER PLANT

Hans-Joachim M. Forster, Stuttgart-Bad Cannstatt, Germany, assignor to Daimler-Benz Aktiengesellschaft, Stuttgart-Unterturkheim, Germany

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My invention relates to a starting and control system for a power plant, more particularly for an automotive power plant, comprising an internal combustion engine, a main pump driven thereby and constituting a source of pressure fluid, such as oil under pressure for the operation of controlling mechanisms, such as gear-shifting means, and further comprising an auxiliary pump driven by an independent source of power and serving to deliver oil under pressure when the internal combustion engine is at rest.

It is an object of the present invention to provide means by which the two pumps and the independent source of power may be utilized to start the engine. It is another object of the present invention to provide an improved starter motor formed by a pump and operable by a source of liquid under pressure. It is a further object of the present invention to provide controlling means whereby the main pump, which during operation of the engine supplies liquid under pressure for the operation of gear-shifting and other controlling mechanisms, may be used as a starter motor to start the engine.

Further objects of my invention will appear from the description following hereinafter of a preferred embodiment of the present invention as applied to an automotive power plant, it being understood that such detailed description serves the purpose of illustrating the invention rather than that of restricting the same. In the drawings,

Fig. 1 shows a more or less diagrammatical axial section taken through the main pump and represents the crankshaft of the internal combustion engine, the fluid-operable controlling mechanisms of the motor vehicle, the auxiliary pump, and the associated conduit system equipped with valves as well as the electric circuit arrangement in a mere diagrammatic fashion, the system being in the condition in which the engine of the motor vehicle is running, whereas the auxiliary pump is at rest,

Fig. 2 is a representation of the system similar to that of Fig. 1, but differing therefrom in that it shows the system in the condition in which the engine is being started by the main pump acting as a fluid motor under operation by the liquid fed by the auxiliary pump,

Fig. 3 is a partial section taken along line 3—3 of Fig. 1, and

Fig. 4 is a partial section taken along line 4—4 of Fig. 1.

The automotive power plant to which the present invention is applicable comprises an internal combustion engine, of which crankshaft 10 only has been shown diagrammatically, and an automatic transmission including fluid-operable controlling mechanisms 11, such as clutches, gear-shifting elements, etc. Liquid under pressure is supplied to the mechanisms 11 by a main pump 12 when the engine is running, and by an auxiliary pump 13 preparatory to and during the starting of the engine. The auxiliary pump is geared to an electric motor 14 fed by the battery 15 of the vehicle. The main pump 12 is a pump of the volumetric type, preferably a variable displacement piston pump.

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In the embodiment shown, the pump has a stationary housing 16 in which a shaft 17 is journaled. A rotor 18 fixed to the shaft 17 is provided with nine circumferentially distributed cylinder bores 19 extending parallel to the shaft 17 and accommodating plungers 20 and helical springs 21 which urge the plungers into contact with a disk 22 which is rotatably mounted in a wobble ring 23 provided with a pair of opposite coaxial trunnions 24, the axis of said trunnions extending transversely to shaft 17. The trunnions are journaled in the housing 16. A spring not shown acts on the wobble ring 23 tending to tilt the same into contact with a control member formed by a plunger 25 which is slidable in and projects from a cylinder 26 which is fixed to the housing 16 and extends parallel to shaft 17. The plane end face 27 of rotor 18 is mounted in contact with the face of a stationary end plate 28. Two arcuate recesses 29 and 30 are provided in the contact face of end plate 28 and adapted on rotation of rotor 18 to alternately communicate with each of the cylinders by bores 31 which extend from the cylinder bores 19 in the axial direction thereof to ports provided in end face 27.

On rotation of shaft 17 and of the rotor 18 fixed thereto each of the plungers 20 will reciprocate. During outward travel of each plunger 20 its cylinder bore 19 communicates with the recess 30, and during inward travel its cylinder bore communicates with recess 29. The recess 30 communicates through a suitable bore in end plate 28 with an inlet port 32. Similarly, recess 29 communicates through another bore with an outlet port 33. Therefore, oil sucked through port 32 into the cylinder bores 19 of the outwardly travelling plungers 20 will be later forced out of the outlet 33 when the plungers travel inwardly again. The piston displacement depends on the angle of inclination of ring 23, such angle being determined by the adjustment of plunger or ram 25.

A shiftable two-speed transmission is provided which gears the crankshaft 10 of the engine and the main pump 12 to each other. In the embodiment shown, this two-speed transmission comprises two trains of motion-transmitting elements of different ratios of transmission, each train being adapted to constitute a driving connection of said pump and said engine. One train of said pair of trains of motion-transmitting elements comprises a gear 34 fixed to the front end of the crankshaft 10, a gear 35 meshing therewith and mounted to revolve about a stationary axis 36, a pulley 37 fixed to gear 35 by a common hub 38, a second pulley 39 mounted for rotation about the axis of shaft 17, a belt 40 extending around the pulleys 37 and 39, and a free-wheeling clutch 41 connecting pulley 39 and shaft 17 for common rotation.

The free-wheeling clutch comprises a plurality of clamping rollers 42 housed in internal pockets 43 provided in the hub 44 of the pulley 39, the roller-contacting faces of the pockets extending at an acute angle to the periphery of the hub, the arrangement being such that on rotation of pulley 39 in clockwise direction viewed as indicated by the arrows 3, the rollers 42 will be firmly clamped against shaft 17 clutching the same to the pulley, whereas shaft 17 is free to overtake pulley 39 when revolving in the same direction at a higher speed.

The other train of motion-transmitting elements of the two-speed transmission interposed between the crankshaft 10 of the engine and the main pump 12 comprises a gear 45 fixed to the rear end of the crankshaft 10 and forming the orthodox flywheel thereof, a pinion 46 mounted on shaft 17 and adapted to mesh with gear 45, a bushing 47 splined on shaft 17, but axially movable thereon, and a free-wheeling clutch adapted to connect pinion 46 with bushing 47 for rotation of pinion 46 in anticlockwise direction viewed in the direction of arrows

4. The free-wheeling clutch is similar to that described with reference to Fig. 3 comprising a plurality of clamping rollers 48 accommodated and inserted between bushing 47 and an annular flange 49 integral with pinion 46, the bushing 47 being provided with external teeth having slanting faces engaging the clamping rollers. Therefore, the bushing 47, when driven by shaft 17 in the direction indicated by the arrow in Fig. 4, will be clutched to pinion 46 and adapted to drive same. The free-wheeling clutch 41, 42, 43, 44 is so disposed in the train of motion-transmitting elements 34 to 39 that this train is able to drive the pump 12, whereas the free-wheeling clutch 47, 48 is so disposed in the train of motion-transmitting elements 45, 46, 47 as to enable the latter train to drive the engine when shaft 17 is driven by the pump 12 acting as a fluid motor. The pinion 46 is connected with the bushing 47 for common axial displacement upon shaft 17 by suitable means.

The bushing 47 has a flange 50 on its left end which is urged to the left by a spring 51 which is braced against a stationary housing 52 and tends to keep bushing 47 and pinion 46 in the position illustrated in Fig. 1 in which the pinion 46 is disengaged from the gear 45. The flange 50 constitutes a piston movable within a cylinder 53 which is integral with the housing 52 and has an inlet port 94 adjacent to the end plate 28. When liquid under pressure is admitted to such inlet port, the bushing 47 is urged in a direction away from the end plate 28 and tends to shift pinion 46 into engagement with gear 45. Therefore, the bushing 47 constitutes fluid-operable shifting means coordinated to the two-speed transmission and adapted to render the second train 45, 46, 47 of motion-transmitting elements effective, while the train 34 to 39 is disabled by function of the free-wheeling clutch 42, 43. Normally, however, the spring 51 keeps pinion 46 disengaged from gear 45.

A conduit system is provided which is adapted to connect the outlet of the auxiliary pump 13 to the inlet 32 of the main pump 12 and to connect the outlet 33 of the latter to the inlet of the auxiliary pump 13 for the purpose of starting the engine. Such conduit system which includes a number of valves will now be described.

A cylindrical valve housing 53' accommodates a slide valve member formed by a stem 54 integral with four equally spaced pistons confining valve spaces 55, 56 and 57 between them. The stem 54 projects out of the housing 53' and is surrounded by a solenoid coil 58. A helical spring 59 is inserted between the left end wall of the housing 53' and the adjacent piston and tends to hold stem 54 in the position shown in Fig. 1. Upon energization of coil 58 the stem 54 is pulled into the position shown in Fig. 2 in which spring 59 is compressed. The housing 53' is provided with five ports 60, 61, 62, 63 and 64, the exact location of which will appear later on from the description of the function of the valve.

Another valve housing 65 which may be integral with the housing 53', if desired, has a cylindrical bore accommodating a valve member 67 consisting of a stem and two pistons integral therewith confining a valve space 66 between them. Moreover, the housing accommodates a movable spring support composed of a stem 68 integral with a plate 69. A helical spring 70 is inserted between the plate 69 and the valve member 67 and tends to keep the valve member 67 in the position shown in Fig. 1. The stem 68 constitutes the armature of a solenoid coil 71 which is so arranged as to push stem 68 downwardly from the position shown in Fig. 1 into that shown in Fig. 2 when it is energized by an electric current. The housing 65 has four ports 85, 86, 87 and 88.

Moreover, the system includes a fluid-operable switch comprising a cylindrical housing 72 accommodating a piston 73 and a helical spring 74 tending to depress the piston into the position shown in Fig. 2. The piston 73 has a piston rod 76 extending out of the housing 72 and being suitably linked to the arm of a switch 75

holding the switch either in closed condition as shown in Fig. 2 or in open condition as shown in Fig. 1. At its bottom, the cylinder 72 is provided with a port 105.

Finally, there are two housings 77 and 78, each having an inlet port 79, and 80 respectively, and an outlet port 81, and 82 respectively, and accommodating a check valve 83, or 84 respectively.

A reservoir R containing a supply of a suitable liquid, such as oil, is connected with a pipe 89 which leads to port 87 and has two branches, one branch 90 leading to port 61 and the other branch 91 leading to the inlet of auxiliary pump 13.

A pipe 92 leads from port 63 to the inlet 32 of the main pump 12 and has a branch 93 that leads to the inlet port 94. The outlet 33 of the main pump is connected by a pipe 95 with check valve inlet 80, while check valve outlet 82 is connected with port 64 of valve housing 53' by a pipe 96 which has a branch 97 leading to port 62. From the outlet of the auxiliary pump 13 to the check valve inlet 79 there leads a pipe 98 having two branches 99 and 100, one branch leading to port 88 and the other branch leading to port 86.

A pipe 101 which leads from check valve outlet 81 joins a pipe 102 and has a branch 103 which leads to the inlet of the fluid-operable mechanisms 11, the outlets of the latter discharging into a return pipe 104 leading to the reservoir R.

The pipe 102 connects the port 105 of cylinder 72 with port 60 of valve housing 53'.

Port 85 of valve housing 65 is connected by a pipe 106 to the cylinder 26 of the piston displacement adjusting ram 25.

The valve in housing 53' is controlled by suitable starter means operable by the driver when he wants to start. In the embodiment shown, such starter means comprise an electrical two-pole switch 107 including two coupled switch arms 108 and 109.

One pole of the battery 15 is grounded. The other pole is connected by a wire 110 to the two switch arms 108 and 109, the contact cooperating with switch arm 108 being connected by a wire 111 to one terminal of coil 71, the other terminal of which is grounded. The contact cooperating with switch arm 109 is connected by a wire 112 to one terminal of coil 58, the other terminal of which is grounded. A wire 113, which may be connected with wire 110 by a switch 114, is connected by the fluid-operable switch 75 to one terminal of motor 14, the other terminal of which is grounded.

The operation is as follows:

In normal operation, when the internal combustion engine is running, the main pump 12 is driven by the internal combustion engine by means of the train of elements 34 to 41, as described hereinabove. The starter switch 107 is open, as shown in Fig. 1, and the valve member 67 is in its lowermost position. Spring 59 keeps valve stem 54 in its right hand position. The main pump 12 sucks oil from reservoir R through pipes 89, 90, port 61, valve space 56, port 63, pipe 92 into inlet 32 and feeds the oil under pressure from outlet 33 to the fluid-operable mechanisms 11 via pipe 95, check valve housing 78, pipe 96, port 64, valve space 57, port 60, and pipes 102, 101 and 103. In this manner, the main pump functions during normal operation of the engine to supply the oil under pressure that is required for gear-shifting and other controlling operations in the motor-driven vehicle.

Oil under pressure is supplied by pipe 102 to port 105 of cylinder 72 thereby keeping piston 73 raised and keeping switch 75 open. Therefore, the motor 14 and the auxiliary pump 13 coupled therewith are at rest and no pressure prevails in pipe 98, the check valve 77 being closed.

Spring 51 acting on piston 50 is extended and keeps pinion 46 disengaged from gear 45, since no pressure is prevailing in pipe 93 and in the cylinder space confined by piston 50.

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When the power plant is out of operation, the internal combustion engine and both pumps 12 and 13 being at rest, and when the driver wishes to start the vehicle, he will close the switch 114 which is preferably coupled with the ignition switch not shown. Since no pressure exists in pipe 102, piston 73 is in its lowermost position and switch 75 is closed. Therefore, closing of switch 114 will start electric motor 14 and the auxiliary pump 13 coupled therewith. The pump supplies liquid under pressure to the fluid-operable mechanisms 11 via pipe 98, check valve housing 77 and pipes 101 and 103. Moreover, fluid under pressure is conducted from the auxiliary pump 13 through lines 98 and 100 beneath valve member 67 raising the same to a position slightly above that shown in Fig. 2 thereby closing port 85, while just still covering port 87 interrupting the communication of pipe 106 with the valve space 66 which is maintained through duct 99 under the pressure produced by the auxiliary pump 13. When the pressure exceeds a certain limit of say 500 lbs./sq. in., valve member 67 will be raised so as to uncover port 87 permitting the surplus oil to be discharged through return pipe 89. Since the auxiliary pump 13 is connected in a liquid circuit with the fluid-operable controlling mechanisms 11, these mechanisms are fully operative preparatory to the starting operation proper. The driver initiates this operation by closing switch 107. This has the dual effect of compressing spring 70 to thereby raise the pressure in line 98 to 700 lbs./sq. in. and of shifting the valve stem 54 to the position shown in Fig. 2. When this happens, the outlet of the auxiliary pump 13 is connected to the inlet 32 of the main pump, and the outlet 33 of the main pump is connected to the inlet of the auxiliary pump, while the auxiliary pump remains in a liquid circuit with the mechanisms 11. The connection established between the outlet of the auxiliary pump 13 and the inlet 32 extends via pipe 98, check valve housing 77, pipes 101 and 102, port 60, valve space 56, port 63, and pipe 92. The connection from outlet 33 to the inlet of the auxiliary pump extends via pipe 95, check valve housing 78, pipes 96 and 97, port 62, valve space 55, port 62, and pipes 90 and 91. Oil under pressure is supplied from pipe 92 through pipe 93 to the cylinder 53 causing displacement of piston 50 into the position shown in Fig. 2, whereby pinion 46 is engaged with gear 45. The main pump 12 acts as a fluid motor and imparts rotation to the crankshaft 10.

In fact, the pump 13 and the fluid motor constituted by pump 12 constitute a variable fluid transmission, the ratio of which depends on the adjustment of ram 25. As the speed of crankshaft 10 increases, the ram 25 is progressively moved to the right to reduce the piston displacement and to permit pump 12 to run at an increasing speed. As the speed of the crankshaft 10 increases, the main pump 12 tends to take up a larger volume of liquid than supplied by the auxiliary pump 13, whereby the pressure in line 98 drops permitting valve member 67 to be downwardly displaced by spring 70, for instance to the position shown in Fig. 2. As a result, pipe 106 is connected to valve space 66 to which liquid under pressure is supplied from the auxiliary pump 13 via pipe 99. In this manner, liquid under pressure is supplied to the ram 25. The consequent reduction of the piston displacement of pump 12 results in an increase of the pressure in pipe 98, whereby valve member 67 is raised again until balance is restored. In this manner, the piston displacement is automatically so adjusted that the pressure produced by the auxiliary pump is kept more or less constant in the neighborhood of 630 lbs./sq. in. The torque produced by the main pump 12 acting as a motor is kept inversely proportional to the speed of the main pump 12.

As soon as the internal combustion engine produces power, it will drive the main pump causing an abrupt reduction of pressure in pipes 98 and 99 and valve space 66 thus permitting ram 25 to return to the position shown.

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The driver will now open starter switch 107, whereby valve stem 54 will be returned to the position shown in Fig. 1. This causes switch 75 to be opened, whereby the motor 14 driving the auxiliary pump 13 will be stopped. At the same time, the stem 68 and valve member 67 will return to the position shown in Fig. 1 whereby valve space 66 will establish a communication between ports 85 and 87 permitting spring-controlled wobble ring 23 to restore piston 25 to the position shown in Fig. 2 causing the same to discharge liquid from cylinder 26 through pipes 106 and 89. Now, all of the elements are in the position shown in Fig. 1 in which the main pump 12 functions to supply fluid pressure for the mechanisms 11.

From the foregoing description of the embodiment of the invention illustrated in the drawings it will be appreciated that in the novel starting and control system the main pump provided to supply diverse fluid-controlled mechanisms with pressure oil may be employed as a fluid motor fed by the auxiliary pump for starting the internal combustion engine whereby a separate starter, more particularly the orthodox electrical starter, may be dispensed with.

For this purpose, the conduit system connecting the two pumps and the fluid-operable control mechanisms is provided with a valve shiftable to a starting position in which it connects the intake port of the main pump with the outlet port of the auxiliary pump and the outlet port of the main pump with a return line communicating with the inlet of the auxiliary pump. When such valve is shifted to the starting position, the pressure produced by the auxiliary pump is adjusted to a higher limit, for instance by increasing the spring load acting on a relief valve. Moreover, by shifting the first-mentioned valve to starting position, the pinion driven by the main pump through a free-wheeling clutch is engaged with the starter gear of the internal combustion engine by a member actuated by the liquid pressure produced by the auxiliary pump. Preferably, the main pump is a variable displacement pump, the displacement being adapted to be automatically varied to meet the demand for fluid under pressure existing at any time.

The novel starting and control system involves the advantage that during the starting operation less current from the battery will be consumed than with the orthodox starter motor. As a result, a smaller electrical reserve power will suffice for the starting operation.

While I have described my invention with reference to a specific embodiment thereof, I wish it to be clearly understood that the same is in no way limited to the details of such embodiment, but is capable of numerous modifications within the scope of the appended claims.

Thus, for instance, another source of power, such as a hand crank, may be substituted for the motor 14 and pipe 98 may be connected with a pressure accumulator thus permitting the engine to be started by manual power. This may be desirable where the power plant is not of the automotive type, but is stationary.

What I claim is:

1. In a starting and control system for a power plant of the character described, the combination comprising an internal combustion engine, fluid-operable controlling mechanisms, a main pump of the volumetric type geared to said engine, an auxiliary pump, a source of power independent of said engine connected to said auxiliary pump, feed conduits connecting each of said pumps to said fluid-operable controlling mechanisms, conduits for establishing an unrestricted communication between the outlet of said auxiliary pump and the inlet of said main pump and for establishing an unrestricted communication between the outlet of said main pump and the inlet of said auxiliary pump, and starter means rendering said conduits operative whereby said auxiliary pump will operate said main pump as a fluid motor to start said engine.
2. The combination claimed in claim 1 in which said source of power is an electric motor.

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3. The combination claimed in claim 1 in which said pump of the volumetric type is a piston pump.

4. The combination claimed in claim 1 in which said pump of the volumetric type is a variable displacement piston pump.

5. The combination claimed in claim 1 in which said conduits for establishing an unrestricted communication between the outlet of said auxiliary pump and the inlet of said main pump and for establishing an unrestricted communication between the outlet of said main pump and the inlet of said auxiliary pump include a valve shiftable to either one of two positions and constructed so that when in one position it will connect each of said pumps in a liquid circuit with said fluid-operable controlling mechanisms and, when in another position, it will establish the communication between the outlet of said auxiliary pump and the inlet of said main pump and the communication between the outlet of said main pump and the inlet of said auxiliary pump and will simultaneously connect said auxiliary pump in a circuit with said fluid-operable controlling mechanisms, and further comprising actuating means connected with said valve for shifting the same and connected with said starter means to be controlled thereby.

6. The combination claimed in claim 1 combined with a pressure-limiting device responsive to the pressure produced by said auxiliary pump for setting a limit to the pressure produced thereby, and controlling means operatively connected with said device and controlled by said starter means for adjusting said device to increase said limit, when said starter means renders said conduits operative for starting said engine.

7. The combination claimed in claim 1 combined with a spring-loaded relief valve responsive to the pressure produced by said auxiliary pump for setting a limit to the pressure produced thereby, and controlling means operatively connected with said spring-loaded relief valve and cooperatively connected with said starter means for control thereby and being operative, when the latter renders said conduit system operative for starting said engine, to increase the spring load of said relief valve thereby causing the same to increase said limit.

8. The combination claimed in claim 1 combined with a shiftable two-speed transmission gearing said engine and said main pump to each other, and with shifting means cooperating with said transmission for shifting the latter to a higher speed ratio of said main pump to said engine when said main pump is operated as a fluid motor to start said engine, and for shifting said transmission to a lower speed ratio of said main pump to said engine when said main pump is functioning as a pump feeding fluid through said feed conduits to said fluid-operable control mechanisms.

9. The combination claimed in claim 1 comprising a shiftable two-speed transmission gearing said engine and said main pump to each other, and fluid-operable shifting means cooperating with said transmission for

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shifting the latter and controlled by fluid pressure in said conduit system so as to shift said transmission to a higher speed ratio of said main pump to said engine when said conduit system is operative, and to shift said transmission to a lower speed ratio of said main pump to said engine when said conduit system is inoperative.

10. The combination claimed in claim 1 combined with a fluid pressure-responsive means for controlling said source of power and responsive to the pressure produced by said main pump for cutting off said source of power when said pressure reaches a predetermined limit.

11. In a system of the character described, the combination comprising an internal combustion engine, a piston pump, two trains of motion-transmitting elements of different ratios of transmission, each connecting said pump and said engine, each of said transmissions including a free-wheeling clutch, the latter being so disposed in one of said trains as to enable the latter to drive said pump and in the other one of said trains as to enable said other train to drive said engine, said other train of motion-transmitting elements including a pair of gears relatively shiftable in axial direction, fluid-operable means for shifting said gears into engagement, a source of fluid under pressure, and valve means for connecting said source to both said fluid-operable means and said piston pump, causing the latter to act as a motor for starting said engine through the intermediary of said gears.

12. In a starting system for a power plant of the character described, the combination comprising an internal combustion engine, a fluid pump-motor unit of the variable piston displacement type geared to said engine, a control member for adjusting the piston displacement of said pump-motor unit, a pump, a source of power independent of said engine connected to said pump for driving the same, a hydraulic load, a conduit system connecting said pump in a circuit with said hydraulic load and with said pump-motor unit to drive said pump-motor unit by fluid pressure of said pump, and servo-motor means responsive to the pressure produced by said pump in said conduit system for maintaining the pressure in said conduit system essentially constant during starting by moving said control member and causing the latter to reduce the piston displacement of said fluid pump-motor unit when said pressure drops below a predetermined limit.

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